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General article : views and analysis

Genesis and geology of alpine type of cuban chromite deposits.

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1. Introduction

CHROMITE ($FeCr_2O_4$) Iron Chromium Oxide, Class- Oxide and Hydroxides Group-Spinel. Hardness-5.5, Colour-Brownish black to greenish black, Crystal System-Isometric, Transparency-opaque, Specific gravity- 4.2-5.0, Lustre-metallic to dull. The principle ore of Chromium, as a refractory component, as a dye and as mineral specimen. Chromite is the most important ore of chromium from which it derived its name. Chromium is an important metal and has a wide range of industrial uses.Chromite forms in deep ultra-mafic magmas and is one of the first mineral to crystallize. It is because of this fact that Chromite is found in some concentrated ore bodies. It is the only source for the metallic element chromium, which is used in the metallurgical, chemical and refractory industries.

Following Thayer (1960), chromite deposits associated with ultramafic igneous rocks are commonly classified according to their forms and textures as (a) Stratiform deposits and (b) Podiform deposits. These two deposits are quite distinct in terms of geologic setting. The stratiform deposits occurs as conformable layers, usually of great lateral extent, in Precambrian layered intrusions emplaced within continental crust and are characterised by cumulus textures. The podiform deposits comprise a more heterogenous group. Typically they occur as irregular (mostly lenticular), concordant or discordant chromite rich bodies in tectonically-emplaced alpine type peridotite complexes (ophiolites) that formed originally in oceanic setting.

The most valuable of these deposits is the Podiform Chromite deposits. Podiform Chromite deposits are small magmatic chromite bodies formed in the ultrabasic section of an ophiolitic complex in the oceanic crust. These deposits have been found in mid oceanic ridge, off ridge and suprasubduction tectonic setting. Most Podiform chromite deposits are found in dunite or peridotite near the contact of the cumulate and tectonic zones in ophiolites.

Podiform Chromite deposits are an important source for chromite, which is the only ore for Chromium, and they are the primary source for high chromium, low aluminium ore used in metallurgical applications and high aluminium , low chromium ore, used in refractories (Thayer, 1946:Thayer 1963: Dickey, 1975). Concentrations of Chromite as small masses or lenses were first called pods by Wells and others (1940) and later referred to as Podiform by Thayer (1960). These deposits are found in alpine type peridotites formed in oceanic crust and tectonically emplaced as ophiolites along continental margins (Thayer, 1960; Coleman,197; Roberts and others, 1988; Coleman, 2000). Podiform Chromite mines have produced 57.4 percent of the world's total chromite production (Stowe, 1987b)

2. Cuban type of chromite deposits

Cuban type or the Alpine type of Chromite deposits have been developed from the end of 19th century. But the detailed work started only after 1920. These type of Chromite deposits has wider international distribution than the platform type of chromite deposits. It was T.P. Thayer who recognised this type of Chromite deposits as a distinctly separate genetical group and termed as Alpine type of deposits.

The type areas of such deposits were first described in detailed from Qunite province of Cuba. Therefore they are also known as Cuban type of deposits.

Such podiform chromite deposits in Cuba located in a series of hill ranges extendly along east, west direction of which the Moa range having an altitude of about 3000 feet is important. It is thickly soil covered hill range and chromite occurrences are visible along the V-shaped river gorges.

3. Geology of the area

The country rocks of the hill ranges are of middle

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to upper cretaceous age which have been injected by diorite rocks. The basement complex is composed of chromite, schist, metamorphosed volcanic tuffs with intercalated thin impure marbles. This rock and also the sedimentary rocks have been penetrated by the ultramafic rocks comprising primarily of peridotite, dunite and pyroxenite. The less mafic phases are represented by Gabbro and anorthosite. The ultramafic are highly serpentinize, whereas the feldspar in the feldspathic phases are altered to Zoisite.

The Chromite ore bodies are enveloped by dunites which have an average thickness of 5-10 feet. The rocks are well striated and show streaks of feldspar parallel to the boundary of the contact. The rocks are well jointed but no definite system of joints have been determined. The join planes in the country rock and sometimes in the ore bodies are filled with uvarovite and grossularite garnet.

4. Geology of the chromite ore deposits

The ore bodies are primarily podiform may also occur as tabular and lenticular shaped bodies of variable dimension. The dimension may range upto 700 feet along 300 feet wide and 90 feet thick.

T.P. Thayer has morphologically divided the ore bodies into following groups:

1. Podiform or Lensoid ore
2. Lenticular ore bodies
3. Orbicular ore bodies
4. Nodular ore bodies
5. Graded or Cummulus ore bodies
6. Disseminated ore bodies

The Podiform or Lensoid ore show the maximum production whereas the disseminated ores do not have any commercial value. The total quantity of ore which have been economically exploited is nearly 5 lakh ton during 1940-47. Commercially these ore bodies are the primary raw materials for refractory industries.

5. Host rocks and structure

Chromite ore bodies are hosted in dunite, serpentine, or peridotite (Wells and others, 1946). Peridotite host rocks include harzburgite and lherzolite in the tectonite section of ophiolites and wehrlite in the overlying cumulate sequence. Some chromite bodies occur in dunite layers at the tectonite and cumulate contact (Yigit, 2008). Within the peridotite bodies, chromitite is almost always associated with dunite, troctolite, or serpentine bodies that are near gabbro (Thayer, 1961; Rossman, 1970) or pyroxenite (Wells and others, 1940) and or with chromite-rich channels in dunite in the cumulate layers (Leblanc, 1987; Yigit, 2008). This has led some investigators to conclude that podiform chromite deposits tend to occur at or near (within 1 km) the Moho discontinuity, or transition zone between the overlying cumulate and underlying tectonite zones of ophiolite sequences (Thayer, 1961; Dickey, 1975; Greenbaum, 1977; Engin and others, 1987; Stowe, 1987a; Yigit, 2008). Chromite ore may have a sharp or gradational contact with its hosting rock (Wells and others, 1940; Pearre and Heyl, 1960; Thayer, 1961, 1963). Some deposits are accompanied by a halo of serpentinized alteration, while others are not (Diller, 1922; Allen, 1941; Lipin, 1984).

The deposits are often associated with shear zones, formed in or around zones of weakness in preexisting chromitite bodies, and may themselves be displaced by faulting and intensely deformed by tectonic processes (Maxwell, 1949; Thayer, 1961; Page and others, 1984). Apparently, some deposits have been greatly disturbed by faulting or are in tectonic mélange zones, such that their size has been significantly reduced, as for example the notably podiform chromite deposits in California and Oregon (Stowe, 1987a). There appears, however, to be no relation of the size of the deposits to the size of the ultramafic host rock (Wells and others, 1946; Haeri, 1960; Stowe, 1987a; Economou-Eliopoulos, 1993).

Some deposits appear to be structurally controlled such as the plastic folding of chromite layers in high-temperature mineral fabrics in Xerolivado, Greece (Roberts and others, 1988), and in southern New Caledonia (Cassard and others, 1981) and the ductile-brittle structures associated with mylonitic rocks at Voidolakkos, Greece (Roberts and others, 1988). Some researchers have recognized zones of chromitite concentrations that parallel the fabric orientation of the host rocks, while others have demonstrated crosscutting relationships (Allen, 1941; Zengin, 1957; Pearre and Heyl, 1960; Thayer, 1960, 1963; Rossman, 1970; Cassard and others, 1981; Christiansen, 1986; Engin and others, 1987; Roberts and others, 1988).

6. Minerology

Chromite crystals vary from anhedral to euhedral, but most are anhedral, and they range in size from less than 1 mm to as much as 10 mm in diameter (Thayer, 1963). Minerals associated with chromite include olivine, pyroxene, serpentine, magnetite, ferrochromite, chlorite, talc, magnesite, uvarovite, kammererite, and others (Allen, 1941; Thayer, 1961). Interstitial nickel and copper base-metal sulfides and alloys may also be present as millerite (NiS), pentlandite ((Ni,Fe)9S8), heazlewoodite (Ni3S2), godlevskite ((Ni,Fe)7S6), awaruite (Ni2-3Fe), native copper, polydymite ((Ni,Fe,Co,Cu)Ni2S4), bornite (Cu5FeS4), digenite (Cu9S5), and others (Page and others, 1984; Akbulut and others, 2010; Uysal and others, 2009).

Ophiolite chromitite is usually enriched in osmium (Os), iridium (Ir), and ruthenium (Ru), but it can also be enriched in platinum (Pt), palladium (Pd), and rhodium (Rh), Platinum group minerals include Os, Ir, and Ru alloys, laurite (Ru(Ir, Os)S2), erlichmanite (OsS2), irarsite (IrAsS), hollingworthite (RhAsS), and Pt-, Pd-, and Rh-bearing minerals, such as isoferroplatinum (Pt3Fe), cooperite (PtS), sperrylite (PtAs2), geversite (PtSb2), hongshiite (PtCu), stibiopalladinite (Pd5Sb2), native Pd, and others (Page and others, 1984; Prichard and others, 2008; Akbulut and others, 2010).

7. Genesis of alpine type of chromite deposits

The unusual structure and texture of these ore bodies can particularly they be enveloped in an ultramafic sheet podiform distribution and abundance of Chromite nodule may be difficult to fix a definite genetical model of its formation.

It must be remembered that -

a. Alpine type of chromite world wide are mostly confined from the upper cretaceous to probably the lower most eocene.

b. This Chromite ores are typical in their occurrence along all the major mountaneous region affected by the Alpine orogenic cycle.

They are also found in Transasia mountain range extending from Tiensung of western China down to the Patkai range and further extending upto Andaman and Nicobar island.

T.P. Thayer (1947-69) has proposed that the Podiform Chromite ore deposits have intruded into the country rocks in the form of semi crystalline magmatic mass accompany the ultramafic and subsequently the mafic magma. Later he accepted that atleast a part of the ore body showing cumulus structure must have been deposited insitu from the fluid magma by the process of magmatic segregation.

Later on, he proposed that these ore bodies must have been uplifted from lower crusted zone in a subsided zone along the convergent plate boundary where the broken ore bodies and the ultramafic rock were tectonically emplaced.