

LAYERED SEQUENCES IN SOUTHERN PART OF NUGGIHALLI SCHIST BELT, DHARWAR CRATON: POSSIBLE SOURCE FOR MULTIMETALS INCLUDING PAGES

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Abstract

Layered igneous complexes are significant loci for metallic deposits. Most of the world's Cr, Ni, I, V, Co and other metals found host rocks in them. Great Dyke of Zimbabwe, Stillwater complex in USA and Bushveld igneous complexes provide a few classic examples of layered nature and their metal potential.

Like the mineralised cratons elsewhere in the world, Dharwar craton in Karnataka is also known for its mineral wealth. In the central part of Karnataka state, Nuggihalli schist belt - a linear Archaean greenstone belt extends from Kempinkote in the south to Arsikere and beyond in the north with predominant ultramafic components. This belt has attained importance because of the concentration of chromite, mined at a number of places, besides sporadic mining of titaniferous magnetite. Indications for copper and PGEs and known occurrence for gold also highlight the importance of this belt.

The Nuggihalli schist belt mainly consists of basic and ultrabasic rocks with significant amounts of chemical and detrital sediments. The general trend is NNW-SSE to NW-SE. Peridotite, serpentinite, talc-tremolite schist, amphibolite, titaniferous-magnetite, dunite, and anorthosites occur and are found to serve as host rocks for mineralisation. This belt is surrounded by biotite and feldspathic gneisses which form the basement.

PGE minerals have been reported in chromite from Tagadur, Jambur and Byrapur of Nuggihalli schist belt. The geological setup with high concentration of chromium and nickel associated with sulphides in anorthosite bodies indicate that this belt has high potential for PGE mineralisation which needs further probing. The lithological set up and the metallogenic indications and its (Nuggihalli belt) similarities to other layered complexes elsewhere in the world provide a strong ground for detailed study of this belt for its fuller metallogenic understanding.

Keywords - Layered complexes; Dharwar Craton; Nuggihalli belt; Polymetal deposits

1. INTRODUCTION

Layered igneous complexes world over are the repositories of metallic deposits. The best example perhaps is the Palaeoproterozoic Bushveld Complex, which is known for its ore deposits of chromium, vanadium and PGEs, besides sporadic base metal bodies especially Ni-Cu type deposits. Over 75% of the world's PGE production and reserves are in the Bushveld Complex (Kinnaird et al., 2002) followed by the differentiated Great Dyke of Zimbabwe and the Stillwater complex, Montana, USA (Zeintek et al., 2002). The host bodies for the mineralization are large, sheet-like to upward-flaring intrusions of Archean to Palaeoproterozoic period in the cratonic blocks. Intrusions range from 30 km² to 100s of km² in the Bushveld Complex.

Like the mineralised cratons elsewhere in the world, layered sequences rich in multimetallic deposits in India are (1)Baula-Nuasahi in Keonjhar District, (2)Sukinda complex in Jajpur District, (3)Singhbhum-Odisha Craton and (4)Amjori Hill in Keonjhar District (Mukherjee, 1962). Here

ultramafic, chromite bearing areas are shown to be containing anomalous PGE values. However, in addition to above four targets, the incidence of the platinum group of mineralization (PGM) is found to be reported at two other localities of Odisha viz. Bastar Craton located at western Odisha and Eastern Ghat Granulite Belt located at southern part of Odisha (Mondal et al. 2001). Preliminary assessment of PGMs in Sukinda ultramafic field indicated isolated anomalous values in chromite. Platinum values of 2 to 400 ppb and palladium values of 1 to 500 ppb were established on analysis. In Sittampundi Complex, Salem district, Tamil Nadu, analysis of chromite bands showed 0.03 to 0.75 ppm Pt and 0.1 to 1.0 ppm Pd. Platinum group elements are also found to be associated with ultramafic rocks from Pindar in Madawara Igneous Complex of Bundelkhand massif in central India.

In Dharwar craton, several metalliferous deposits are found to occur in rocks of older supracrustals (~3.3. Ga) to younger (~2.5 Ga) greenstones (Ramakrishnan M., 1981).

But a notable layered sequence with proven metal potential lies in Nuggihalli schist belt, an older Supracrustal belt of Sargur Group affinity. The Nuggihalli schist belt, a linear Archaean greenstone belt, extends from Kempinkote in the south to Arsikere and beyond in the north with predominant ultramafic components. This narrow linear belt is about 2 km wide and 60 km long (Fig.1).

2. LITHOLOGY AND MINERAL POTENTIAL OF NUGGIHALLI BELT

The Nuggihalli schist belt mainly consists of basic and ultrabasic rocks as basement units overlain by chemical and detrital sediments. The general trend of the rocks is NNW-SSE to NW-SE. Peridotite, serpentinite, talc-tremolite schist, amphibolite, titaniferous-magnetite, dunite, and anorthosites occur in the lower parts of the belt and have been invariably altered (Figs. 6 & 7). Metasedimentaries, mainly of quartzites, quartz-mica-chlorite schists, fuchsite-quartzites, and quartz-staurolite-mica schists occur in the upper parts (Damodaran 1975). Some of the ultramafic rocks exhibit spinifex texture with komatiitic composition (Varadarajan, 1969). Different phases of anorthositic activities like pre-syn- and post-tectonic intrusions have been recorded in this area. This belt is surrounded by biotite and feldspathic gneisses which form basement complex.

Nuggihalli belt has attained importance because of its multi-metal potential, chief being the concentration of chromite, mined at a number of places. Vanadium bearing titaniferous magnetite (Fig. 4) occurs as bands and lenses with anorthosite and gabbro all through the belt (Raghuveera, 1991). Copper mineralization, associated with gabbroic anorthosite near Tagadur is also indicated. Ancient workings for gold are seen near Kempinkote at the southern end of the belt. Calc-alkaline lamprophyres associated with basalts and basaltic-komatiites reported from this belt have many similarities with other mineralized Archaean terrains (Devaraju et al., 2009). The southern part of this belt is significantly important from the point of mineralization. The various mineralisation possibilities, from the point of future perspectives are discussed below.

2.1 Chromite Deposits of Present and the Future

Chromite has been the principal ore being exploited from different sites especially in the southern part of this belt. It is mined mainly at Byrapur, Jambur, Tagadur, Bhaktharahalli and near Ranganathaswamy Betta. Chromite ore bodies occur within the host serpentinite as layers, lenses, pods or stringers, which vary in their size and magnitude. The pods and lenses are as small as a cm across (Fig. 2. – Field photo showing small pods of chromite in serpentinite) to ones measurable in meters. Chromite is also found within chromitite, dunite, peridotite, gabbro and anorthositic bodies. It displays wide variety of textures under microscope (Figs. 8 & 9). Chromite which is thought to have deposited as thin layers and rafts, has been redistributed in the above said patterns, largely due to structural deformation and redistribution. Sometimes chromite is strongly mylonitised and stretched along with the host layers of schistose

serpentinite (Fig. 3.) and deformation features include pinch and swell structures, but all within the major structural disposition of the host rocks. Crushing and brecciation are common. The major bodies of chromite show lenticular shape which is considered to be a tectonic feature. Our recent field work in the chromite bearing areas of this belt has revealed the occurrence of vein-like bodies of chromite cutting across the regional grain of the belt. It probably indicated that episodic injection of chromitite and other ultramafic layers occurred, after the main event of layered magmatism.

Morphologically chromite ore of Nuggihalli belt is classified as massive, layered, disseminated and altered (Rashmi, et al. 2010). It is presumable that the chromite ore bodies are spread in the entire length and breadth of the Nuggihalli belt especially in the serpentinite and chromitite horizons, because of the more or less similar geological set up throughout. Incidence of high chromite content in random pits outside the working mines, to the tune of 34% Cr (personal communication with Chandrashekhar, 2012) testifies this view. Also, random field checks in the serpentinite bearing bodies enhanced this possibility. Hence there is a great potential of chromite ore in the Nuggihalli belt than what has been perceived so far. But the biggest constrain to ascertain this is that most part of the belt is covered with crop lands which is a big hurdle for geological exploration and mining.

2.2 Magnetite-Rich Iron Ore

Magnetite bands of considerable thickness make a strongly layered body in the Nuggihalli schist belt and are well exposed in southern parts. They can be traced for over 15 km from Ranganathaswamy Betta in the extreme southwestern end to further of Bhaktharahalli mining spot. They trends along N 10-15° W with very steep dips of 70-85°E. The bands are juxtaposed with gabbro, and sometimes with anorthosites. Magnetite content is high in the core of the band and progressively diminishes as it grades into gabbro/anorthosite. Thus the contact, though appears to be sharp between magnetite and gabbro/anorthosite bands, it is not, when the magnetite content is considered. In the magnetite band they are coarse grained, massive and concentrated, whereas in gabbro, the magnetite grains are granular, coarse and disseminated. Hence there is a potential to mine the magnetite rich gabbro/anorthosite and could be blended with the high grade magnetitic Fe ore, achieved from magnetite band, which can enhance the reserves. The thickness of the band is variable with 10-20 feet. With iron content ranging from 50-60%, it adds a great metal value to the belt. Besides, it has a great by-product value owing to its titanium (10 %) and vanadium (0.4-0.8%) association. Hence the iron ore needs to be valued keeping in mind these two strategic metals, at the time of exploration, mining and selling. Also, metallurgical innovations need to be developed, when this ore is utilised by the domestic industries.

2.3 Ni-Cu Sulfides and PGE Associations

Layered igneous complexes and other mafic igneous intrusions are known to host sulfides, especially Ni-Cu sulfides and offer possibilities of PGE associations in them. Sudbury deposits in Canada (Stewart, 2010), Norilsk in Russia (Starostin, 2011), Kambalda region of Australia (Leshner, 2002) have already been shown to be strongly mineralized. The ultramafic/mafic magmas with strong enrichment of these metals, derived at the time of partial melting of mantle with high content of sulfur, undergo sulfidation process and enable chalcophile elements to precipitate.

In the southern part of Nuggihalli belt, a good possibility of Ni-Cu and PGEs prevails, especially in the magnetite bands and in the contacts of gabbro. During a recent detailed field work in the area, strong development of malachite and azurite (Fig. 4.) was noticed and it reflected the possibility of their (magnetite bands) sulfidic nature. Hand specimen samples also reveal the presence of pyrite, chalcopyrite and arsenopyrite. The magnetite band has a greater extension and could provide considerable tonnage value. With the realisation of PGMs in layered sequences, Nuggihalli belt assumes greater importance, owing to its layered nature and proven sulfidic endowments. PGEs could not only be associated with sulfides, but also in chromitites and in other contact zones of gabbros and anorthosites (Fig. 5.) Preliminary studies by Geological Survey of India (Case study report of GSI, 2012) indicate the PGE values (Pt 5-

420 ppb; Pd 5-185 ppb) in the bedrock samples. However they have analysed an average PGE of 231 ppb in chromitite horizons. Further these values in trench samples are indicated to be higher (Pt 5-1545; Pd 5-960 ppb). Thus, Nuggihalli belt appears to be an ideal setting for PGE with its favorable characteristics like (1) The entire belt is a layered sequence, (2) Ultramafic sequences are predominant lithologies, (3) Gabbro-anorthosite-norite contacts are favorable horizons and (4) Both oxide and sulfide enrichments invoke the possibility of their PGE associations.

2.4 Gold Mineralisation

One of the earliest ventures of gold mining in Karnataka was from Nuggihalli belt. In the southern contact of this belt near Kempinkote has provided significant clue for its auriferous nature, besides its other metal potential mentioned above. Gold is associated with ultramafic sequences including chromitite and its concentration was reported to be 2 gm/tonne (Geological report of MECL, 2016). A pilot scale underground section has been developed for extracting gold, and due to various reasons the mining operations have been stopped since several years. However, now with the gold prices shooting up, and country's gold position is dismal, this auriferous zone need to be explored further. Though, the entire area is soil covered, detailed geochemical and geophysical studies may help to ascertain the fuller extent of the belt for gold mineralization.

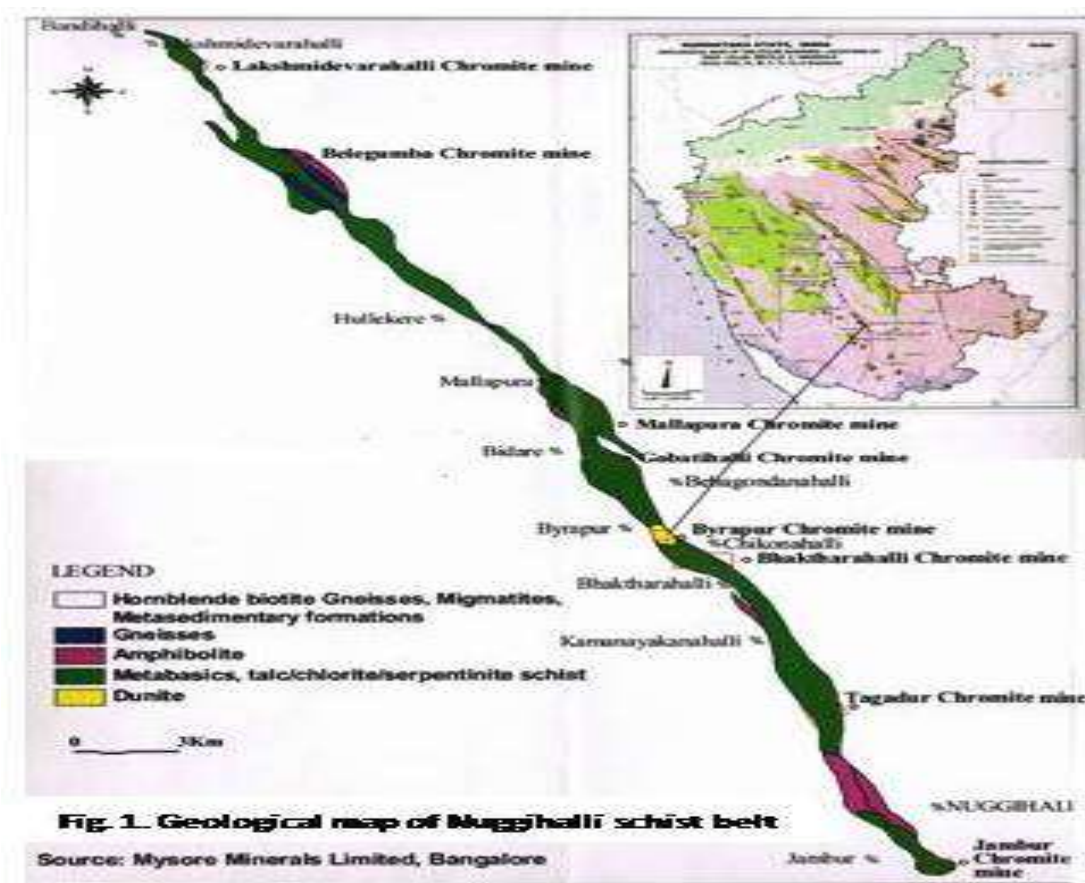




Fig 2: Field photo showing small pods of chromite in serpentinite in Jambur mine pit.



Fig 3: Field photo showing strongly sheared serpentinite in Tagadur area.



Fig 4: Field photo showing vanadium bearing titaniferous magnetite with strong development of malachite and azurite near Kamanayakanahalli.



Fig 5: Field photo of anorthositic body as exposed in Jambur mine pit

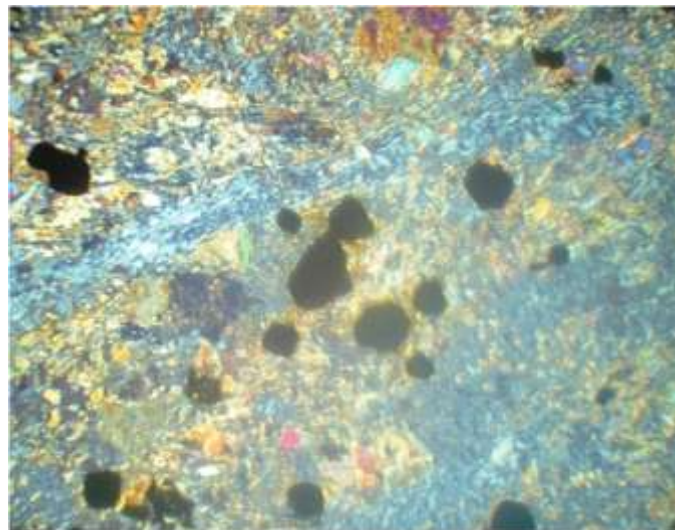


Fig 6: Strongly serpentinised dunite under microscope showing chromite grains

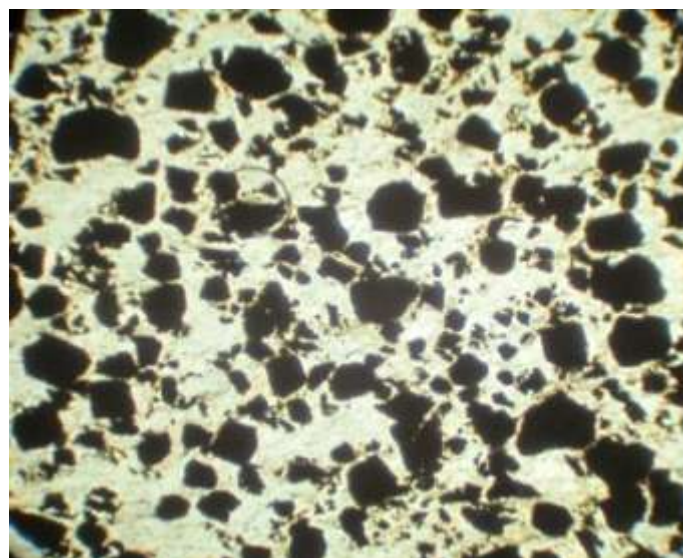


Fig 7: Euhedral to subhedral grains of chromite dispersed in the matrix of chromitite

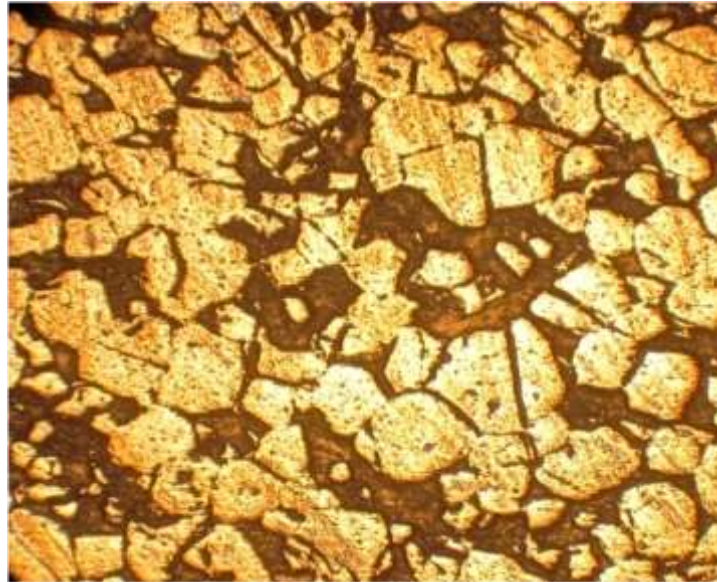


Fig 8: Photomicrograph of chromite showing antileopard texture

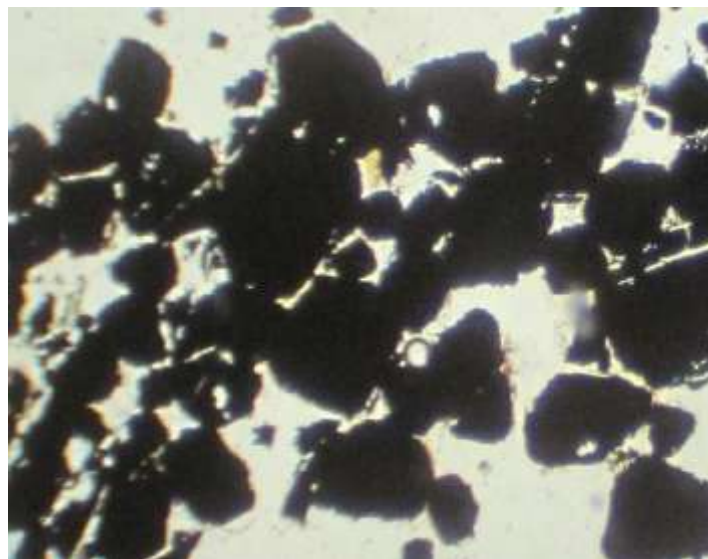


Fig 9: Chain texture in Chromite

3. DISCUSSION AND CONCLUSION

Precambrian terrains all over the world are the metallogenic sites and their appraisal for various metals is realized and extensive exploration is the order of the day to prove the enhancement of the ore bearing zones, as most of the known reserves are depleted due to continuous mining and exploitation. Innovations in metallurgy have helped to mine the leaner grade ores which could enhance supplies especially of strategic metals like Ti, V, PGEs, Co and Ni. By global standards, the exploration activities in India are far behind as we have not been able to prove any new deposits in recent times. In this background, layered igneous complex like Nuggihalli belt assumes greater importance. In this direction rationalised and conceptual approach needs to be pursued rigorously which should help in the complete understanding of the metallogenic potential of the belt with realistic estimates. But from the point of immediate mining, priority has to be set for critical minerals like copper, nickel

and cobalt and strategic minerals like V, Ti and PGEs, because the country is spending huge import costs on them. Similarly, gold mining has to be prioritised, as here is a huge imbalance, the country is facing from the point of demand and supply. Other essential minerals like chromite and iron ore also need to be explored, but can be taken up on sustained pace, as we have adequate reserves from other areas.

Thus, Nuggihalli belt offers an excellent ensemble of layered sequences to appraise multi metal possibilities through geological, geophysical and geochemical techniques. Equally important is the stringent mineral legislation which can ensure the leasing out of land for prospecting, irrespective of whether it is under private or public holding, since developing a strong mineral base is vital for country's economic growth, more so for country's defense. The dependence on imports for strategic and critical minerals can be greatly reduced when indigenous deposits are measured

and developed, which in turn could help to invest on priority areas. From the focal point of aforesaid issues, Nuggihalli schist belt could be in the forefront of multi- metal potential of the future.

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