



STRUCTURAL AND STRATIGRAPHY OF MANGANESE ORES OF KUMSI, SHIMOGA SCHIST BELT, KARNATAKA, INDIA

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ABSTRACT

The late Archaean manganese ore bodies occurring in the Shimoga schist belt of Dharwar super group of Karnataka state, India. Have been discussed in the present investigation, characterization of the physiographical aspects and structural features of metasedimentary and infiltration ores of the Kumsi area. The Dharwar group in the Shimoga schist belt consists of steeply dipping metasedimentary formations and volcanic rocks including stratiform manganese and iron formation, phyllite/argillite, quartzite, greywacke, metabasalt, basic and ultrabasic intrusive. Contains metasedimentary and lateritoid ores have been In the study area, the supracrustal rocks have been subjected to greenschist to lower amphibolite facies metamorphism.

KEYWORDS: Mining block, Shimoga, Kumsi area, lateritoid manganese ores, amphibolite facies.

INTRODUCTION

Precambrian terrains, the world over, are bestowed with metasedimentary manganese mineralization belonging to oxide, silicate, carbonate or mixed facies. In several such terrains, the metasedimentary manganese ores have been subjected to lateritization, which brought about changes in texture, mineralogy and chemical composition of manganese ores. Structural features exhibited by manganese ores offer an insight into the genetic processes involved in their formation. Manganese ores of the late Archaean period, being of the metasedimentary type, bear specific structural imprints of sedimentary, diagenetic and metamorphic processes. Further, lateritization of the metasedimentary manganese ores involved their residual alteration and development of secondary manganese ores within the weathered supracrustal rocks and on the contemporary land surface. Thus lateritization gave rise to diversified structural features conditioned by their mode of formation, place of formation, nature of ore solutions and other factors. Recognition and elucidation of structural features are therefore significant in deciphering the evolution of diversified manganese ore types of the study area. The manganese ores of the Shimoga area have received greater attention compared to those of the Chikkanayakanahalli region. Sreenivas and Srinivasa Rao (1964) reported colloform, replacement, pisolitic, oolitic/concretionary and fracture/open space-filling features. Naganna (1971) identified three types of structures, viz., schistose, colloform and replacement in the manganese ores of the Shimoga regions. (Krishna Rao *et al.*, 1982) identified colloform, replacement, recrystallisation, cavity filling and banded structures in the manganese ores. Janardhana (1991) described bedded and banded structures in the metasedimentary and colloform, box work and replacement structures in the lateritoid manganese ores of the Shimoga area. In the present investigation,

characterization of the structural features of manganese ores of the Shimoga area has been used to decipher the ambient physico-chemical environment responsible for the formation of these ore types. The term structure has been used here to refer to features visible to the naked eye, whereas textural features refer to those observed under the microscope. The structural features of metasedimentary (unaltered and altered), infiltration type ore are described.

Physiography of Shimoga Schist Belt

Manganese deposits of Shimoga schist belt (Fig.1) are encountered between the latitudes 13°50' and 14°10'; and longitudes 75°15' and 75°30'. The Shimoga schist belt is a broad, open trough and covers an area of about 6000sq.km. A large part of the study area is a fairly rugged terrain, excepting the eastern part, which is a relatively plain country. The rugged terrain is made up of linear ridges and hills consisting of schists and the low-lying areas are characterized by greywackes. The area receives moderate rainfall of 700 to 1200 mm per annum and falls under semitropical climate. There are no agricultural lands and the entire rugged area is clad with a fairly thick jungle of teak, bamboo and sandalwood trees. A large part of the area is drained mainly by Kumudvathi River and its numerous tributaries.

Geological Setting of Shimoga Schist Belt

The Dharwar group in the Shimoga schist belt is represented by narrow belts of steeply dipping metasedimentary formation and volcanic rocks, including stratiform manganese iron formation, phyllite/argillite, quartzite, greywacke, metabasalt, basic and ultrabasic intrusive (Fig.1). They are surrounded by peninsular gneiss, which constitute the basement of the Shimoga schist belt. Enclaves of Sargur group of rocks are encountered in the peninsular gneiss. The stratigraphic succession of the rock types encountered in the Shimoga area is provided in table. 1.

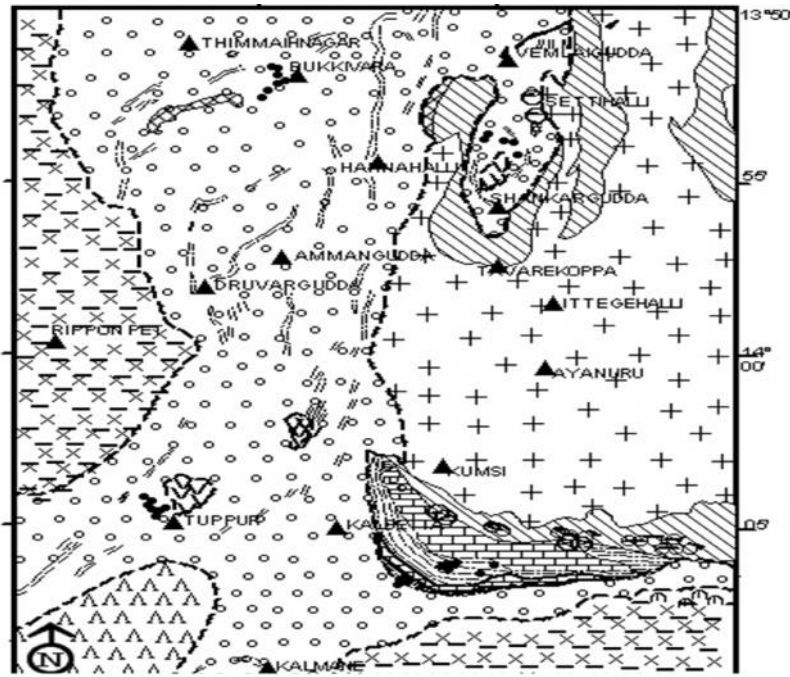


Fig.1. Geological map of Shimoga area showing locations of Manganese deposits

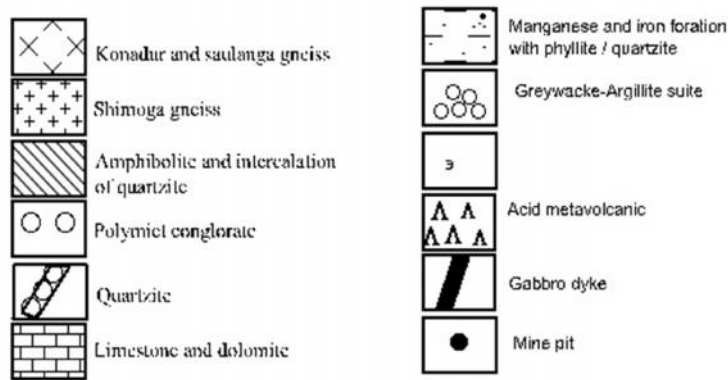


TABLE 1. Stratigraphic successions of rock formations of the Shimoga region. (Janardhana, 1991)

Recent	Soil and subsoil with ferromanganese float ores
To	Sandy clay formation with boulder bed of
Sub recent	ferromanganese (palaeofloat) at the base

C	Granite, pegmatite, Dolerite and Quartz veins
H G	Greywacke-argillite-chert-volcanic suite
I	Banded ferruginous chert (BIF) with
T R	Quartz-chlorite schist/phyllites
R	Phyllites interbanded with manganiferous chert
A O	Limestone and dolomite
D	Chloritic schist with banded quartzite
U U	Polimict conglomerate interbedded and
R	underlain by
G P	chlorite-quartz schist

BABABUDAN GROUP	Amphibolite, metaultramafite with thin bands of phyllite and quartzite

	Peninsular gneiss

Peninsular gneiss along with younger granite encompass the eastern, western and northern parts of the study region and referred to variously as Shimoga gneiss, Konandur gneiss and Saulanga gneiss respectively. The Shimoga gneiss exposed in and around Kumsi has been regarded as a domal structure having a granodiorite composition (Syed Ali and Divakara Rao, 1980). It is leucocratic; medium to coarse grained and foliated. Mineralogically, the gneiss consists of quartz, feldspar and biotite mica and negligible amounts of hornblende. At places, the biotite schist and amphibolite belonging to Sargur Group, occur as enclaves. Younger intrusions in the form of grey granite and pink granite are present at several places. Numerous quartz and pegmatite veins traverse these rocks. The structural, textural and petrographic characteristics of the Konandur and Saulanga gneisses are similar to that of Shimoga gneiss. All the three granitic and gneissic masses represent the basement highs and are referred as “mantled gneiss” dome by Pichamuthu (1967) and as “basement gneissic dome” by Swaminath *et al.* (1974). The granitic gneisses are encircled by polymict conglomerate and shelf facies assemblages consisting of quartzite and limestone belonging to Chitradurga group. These basement highs were uplifted by block movement along faults (Swaminath *et al.*, 1976) and the upliftment was accompanied by local reactivation (Chadwick *et al.*, 1981). Whole rock Rb-Sr isochron of Saulang gneiss has yielded an age of 2900 + 120 M.Y. (Venkatasubramanian and Narayana swamy, 1974), corresponding to the major post-Sargur migmatization event of the basement gneissic complex. Amphibolites, with thin bands of quartzite and quartz-sericite ± muscovite schist belonging to Bababudan group, occur as linear and arcuate outcrops to the north of Kumsi and north of Shankaragudda-Harnahalli. Amphibolite is fine-grained, dark green in colour and shows massive to foliated fabrics. Intercalated quartzite, exhibiting prominent bedding parallel to foliation, is grayish white in colour, fine grained, hard and compact. Primary sedimentary structures like ripple marks, lamination, cross bedding etc, are recorded in the area northeast of Harihole located to the south of Kalkoppa (Burhanuddin *et al.*, 1987). Chitradurga group of rocks in the Shimoga area is represented by shallow water sedimentary rocks, chemical precipitates and volcano-sedimentary rocks. The chief lithounits include polymict conglomerate, current bedded quartzites, limestone/dolomites, banded iron formation, banded manganese formation, phyllites and greywackes. Polymict conglomerate marks the beginning of Chitradurga group in the Shimoga region. The siliceous pebbles of the conglomerates are believed to have been derived from quartzite beds, which are part of the underlying Bababudan group. (Harinadha Babu *et al.*, 1981) proposed that the polymict conglomerate bed in the Shimoga belt indicates sudden uplift of the area following cessation of Bababudan cycle and a consequent break in sedimentation.

Quartzite, interbedded with chlorite schist, overlies the conglomerate bed. It is hard, compact and contains negligible amounts of sericite mica. Quartzite is followed upwards by phyllites that are interbedded with thin bands of dolomitic limestone, manganiferous and ferruginous cherts, interleaved with thin beds of volcanogenic chloritic

schists. Limestone/dolomite is well exposed in Kumsi and Shankaragudda areas, where they occur as discontinuous lenses and commonly exhibit laminations. Compositionally the limestone/dolomite varies from high calcium limestone to dolomite and possesses a brownish crust with a typical crocodile-skin weathering. Vasudev *et al.* (1989) reported the presence of stratified stromatolites exhibiting columnar structures in the dolomites of the Kumsi area. The stromatolitic limestone and dolomites are succeeded by phyllites and quartzites with interbedded manganiferous formation. Manganiferous formation occurs both as massive lensoidal bodies and also as macro/ meso/ micro banded layers interbedded either with phyllites or quartzites. The manganiferous formation is variably weathered along with host phyllite and quartzite. Banded iron formation (composed of hematite and goethite with minor magnetite) alternating with bands of either chert/quartzite/ sericitic/chloritic/phyllites, overlies the manganiferous formation. The width of each band in BIF varies from less than a meter to as much as ten meters. In the study area, BIF occurs as thick discontinuous bands generally occupying the ridge portions.

Greywacke-argillite-chert-volcanic suite consisting of fine grained, thin-bedded argillite is widespread in the study area. Greywacke is grey to grayish green in colour and composed mainly of quartz, chlorite, biotite and hornblende. Extensive but isolated masses of acid volcanic rocks, intercalated with greywackes, have yielded Pb/Pb age of 2625+ 28 Ma. (Taylor *et al.*, 1988). Dolerite dykes are coarse grained and melanocratic and trend in a NW-SE direction. These dykes are well exposed to the south of Vemaligudda and northwest of Bukkivara. The supracrustal rocks have been subjected to supergene alteration due to tropical/subtropical weathering and the lateritized crust that resulted from the alteration has been subjected to erosion at many places. At places, sandy-clay formation and soil horizon (varying in thickness from less than 1m to 20m) unconformably overlie the weathered and eroded surface of the manganiferous formation, phyllites and BIF. The sandy clay/soil horizon often consists of loosely packed boulders/pebbles and oolites / pisoliths of massive lateritoid ferromanganese ore. Chadwick *et al.* (1988) recognized LS fabrics in the basement gneisses and attributed them to movement of basement blocks during post depositional deformation of the supracrustal rocks. The above investigators favoured an ensialic, oblique slip mobile belt regime with transgression giving rise to variable subsidence and uplift during the depositional and volcanic phases of the supracrustal rocks. The mineral assemblage in basement gneisses *viz.*, quartz, orthoclase, microcline, biotite, chlorite and actinolite, hornblende, oligoclase, garnet and tremolite suggest that the rock formations of the area have undergone lower amphibolite facies metamorphism. Chitradurga group of rocks are characterized by the presence of chlorite, muscovite, K-feldspar and garnet in pelitic and quartzo-feldspathic rocks and hornblende, diopside, sphene and epidote in the calcareous rocks and suggest greenschist to lower amphibolite facies metamorphism. Shivaprakash (1983) reported temperatures of the order of 300-400°C and pressures of 2-4 Kb corresponding to greenschist facies conditions during the metamorphism of the Chitradurga

group of rocks. From the above findings, it can be concluded that the supracrustal rocks of the Shimoga area have undergone greenschist to lower amphibolite facies metamorphism.

Structural Features

Structural features exhibited by manganese ores offer an insight into the genetic processes involved in their formation. Manganese ores of the late Archaean period, being of the metasedimentary type, bear specific structural imprints of sedimentary, diagenetic and metamorphic processes. Further, lateritization of the metasedimentary manganese ores involved their residual alteration and development of secondary manganese ores within the weathered supracrustal rocks and on the contemporary land surface. Thus lateritization gave rise to diversified structural features conditioned by their mode of formation, place of formation, nature of ore solutions and other factors. Recognition and elucidation of structural features are therefore significant in deciphering the evolution of diversified manganese ore types of the study area.

Earlier works on structural aspects of different types of manganese ores of the Shimoga area are meager and do not incorporate the necessary details to interpret their genesis. A brief review of previous literature on structural aspects is presented. The manganese ores of the Shimoga area have received greater attention compared to those of the Chikkanayakanahalli region. Sreenivas and Srinivasa Rao (1964) reported colloform, replacement, pisolitic, oolitic /concretionary and fracture/open space-filling features. Naganna (1971) identified three types of structures, viz., schistose, colloform and replacement in the manganese ores of the Shimoga regions. (Krishna Rao

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Metasedimentary ore

Metasedimentary manganese ores of the Shimoga area in unaltered type exhibit bedded and banded structures, and the altered metasedimentary type, in addition to the above, exhibits evidences of replacement of the primary minerals by supergene minerals.

Bedded Structure

In bedded structure, concordant beds and lenses of metasedimentary manganese ores occur within the manganiferous formation (Fig.2A). These ores are massive and compact and vary in thickness from less than a meter to a few meters. They generally possess a sharp contact with the adjacent phyllite/quartzite beds. This type of ore is encountered in the Kumsi, Kumudvathi-Shankargudda and Haranhalli blocks of Shimoga area.

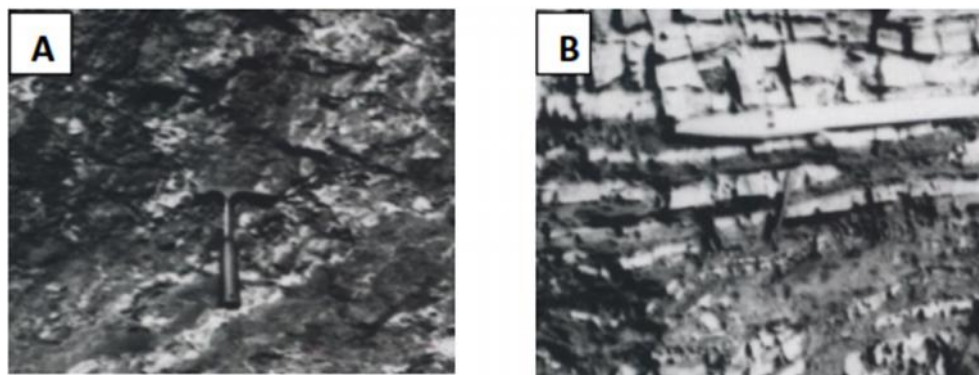


FIGURE 2: A – banded types metasedimentary manganese ore
B – banded type metasedimentary manganese ore

Banded Structure

Metasedimentary manganese ores exhibiting banded structure resulted from deposition of alternate layers of manganese- rich and manganese- poor material (Fig.2B). The manganese-rich layers are composed of manganese minerals admixed with minor amounts of clastic material, whereas manganese-poor layers comprise of mainly of quartzite and rarely phyllite. The layers (bands) vary in thickness from less than a cm to several tens of cm. Banded metasedimentary ores are similar in appearance to BIF encountered elsewhere in the study areas. This type of ore is encountered in the Kumudvathi-Shankargudda and Haranhalli mining blocks of Shimoga.

Infiltration Type Ores

Infiltration type ores are formed from lateritization/partial dissolution of the pre-existing metasedimentary manganese ores, due to precipitation of manganese and iron minerals from Mn- and Fe- rich meteoric waters. The metal-bearing waters migrated vertically downwards and laterally along the structurally weak planes (fractures, joints, vugs, cavities and schistosity/bedding planes) of weathered quartzites and phyllites. Manganese ores resulting from the above processes exhibit structures, which are characteristic of low-temperature replacement and cavity filling. The structures of infiltration type ores were also governed by the nature of ore-bearing solutions,

which ranged from essentially true solutions (forming non-colloform ores) to rare colloidal solutions (forming colloform ores).

Non-Colloform Type

These ores resulted from permeations of true solutions charged with manganese \pm iron minerals in the adjoining country rocks (Fig.2C&D). The non-colloform manganese ores of the infiltration type exhibit box-work replacement laminated and vein structures.

Box-work structures (Fig.2E) formed from precipitation of manganese \pm iron minerals along a network of short, closely spaced, and randomly oriented joints and fractures

in altered quartzites and phyllites. Variable amounts of phyllite and quartzite relicts are commonly present. The quartzites associated with such manganese ores are highly friable and comprise of loosely held quartz grains.

Replacement structures (Fig.2F) resulted from the replacement of the cementing material of the quartzite (and phyllite) by manganese- and/or iron- minerals. Relict islands consisting of primary minerals of the host rock and early-formed supergene manganese (and iron minerals) in a matrix of later formed supergene manganese minerals are also noticed, as will be described in the later section on textures.

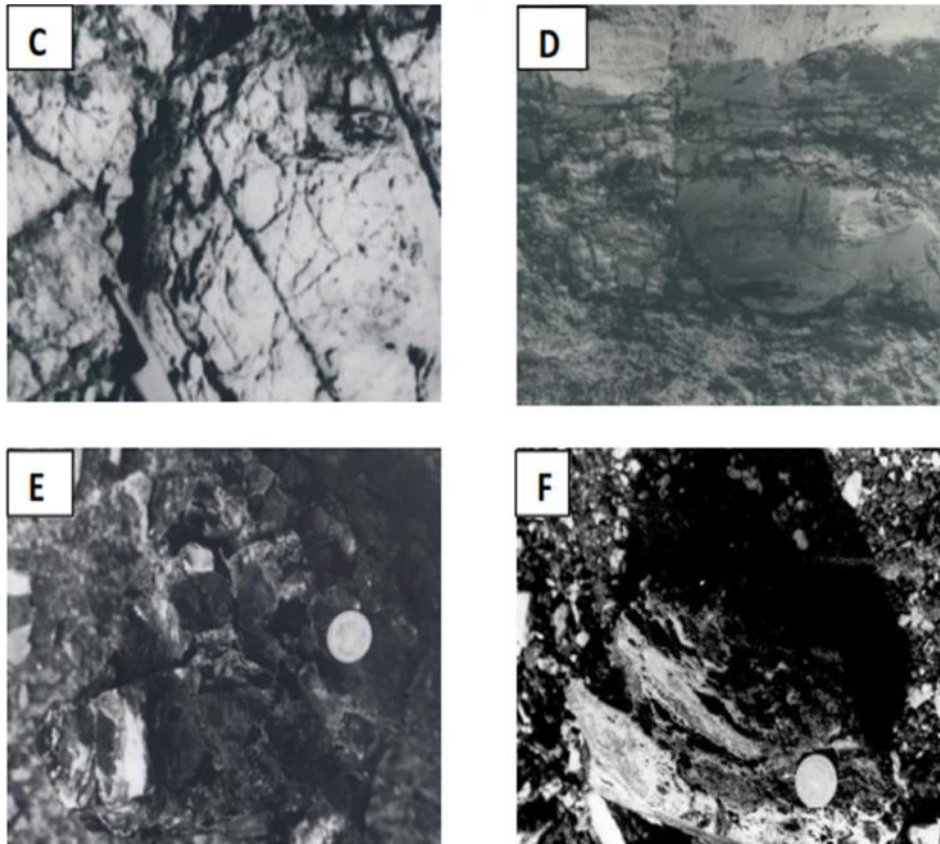


FIGURE 2C: – infiltration- type non-colloform manganese ore showing permeations of Mn-rich solutions in joints within weathered quartzite.

D – Altered, banded, metasedimentary manganese ore interbedded with weathered quartzite

E – Hand boulder of infiltration type (non-colloform variety) manganese ore showing the relics of host rock (quartzite) amidst manganese (\pm iron) mineral mass.

F – Hand specimen photo of infiltration – type manganese ore exhibiting box work structure in weathered phyllite

Laminated structure resulted from precipitation of manganese-rich material alternating with layers of weathered argillaceous rocks. The individual layers vary in thickness from < 1 mm to 5mm and the contact between the layers are sharp. Manganese ores occurring in the form of veins are found either as single vein or as a network (fig.2G). The individual veins generally vary in thickness from a few millimeters to a few centimeters, depending on the size of the cracks and joints in the host rocks.

Colloform Ores

Colloform ores formed from precipitation of manganese- and iron- rich colloidal solutions in open spaces (Fig.2H) and commonly exhibit botryoidal structure. Botryoidal structure refers to aggregates of rounded to subrounded masses of manganese- and iron- minerals resembling a bunch of grapes.

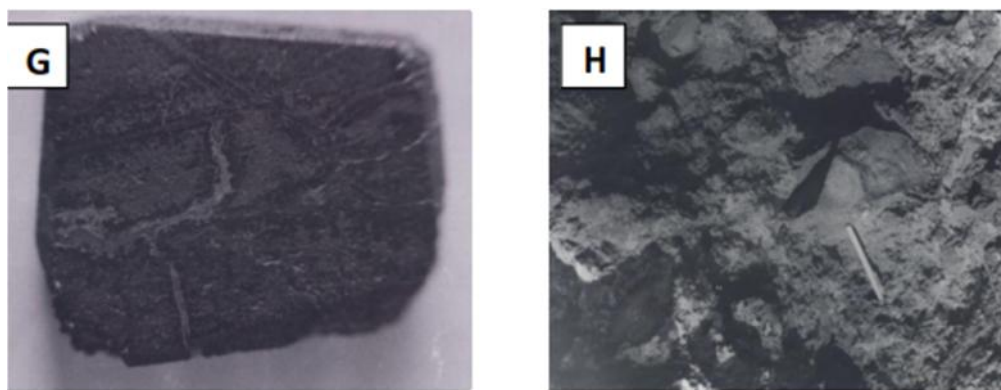


FIGURE 2G: - Hand specimen photo of infiltration – type manganese ore exhibiting veinlets of manganese – rich material

H - infiltration- type colloform ore exhibiting colloform banding

CONCLUSION

Late Archaean manganese formation and associated supracrustal rocks of the Chitradurga group in the Shimoga area rest unconformably over the peninsular gneiss. The Dharwar group in the Shimoga schist belt consists of steeply dipping metasedimentary formations and volcanic rocks including stratiform manganese and iron formation, phyllite/argillite, quartzite, greywacke, metabasalt, basic and ultrabasic intrusives.

The late Archaean manganese formations in Shimoga area are spatially associated with carbonates (stromatolitic limestone and dolomite) and oxide facies banded iron formation. In the study areas, the supracrustal rocks have been subjected to greenschist to lower amphibolite facies metamorphism. Manganese formation and the spatially associated BIF and phyllite in the study areas have been subjected to varying degrees of supergene alteration. Metasedimentary manganese ores exhibit bedded and banded structures. Ores exhibiting bedded structure are composed of massive and compact manganese beds and lenses varying in thickness from less than a meter to a few centimeters within the manganese formation. Metasedimentary manganese ores exhibiting banded structure resulted from deposition of alternate layers of manganese-rich and manganese-poor material (quartzite and rarely phyllite). The layers (bands) vary in thickness from less than a cm to several tens of cm. Altered metasedimentary ores comprising of manganese-rich material and hosted in weathered phyllite/quartzite occur in the Shimoga area. Non-colloform variety of infiltration-type ores resulted from permeations of true solutions charged with manganese \pm iron minerals in the adjoining country rocks. They exhibit box-work, replacement, and vein textures. This variety occurs in the Shimoga area. Colloform variety of infiltration-type ores are formed from precipitation of manganese- and iron- rich colloidal solutions in open spaces. These ores commonly exhibit botryoidal structure, banded, and globular structure. These varieties occur in the Shimoga area.

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