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Mineralogy of Banded Iron Formations at and around Kammatturu, Sandur Schist Belt, Karnataka.

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Abstract:- The banded Iron Formations form a peculiar part of the sandur schist belt, Karnataka craton in Archean Indian Shield, which are exposed at and around Kammatturu Village. The iron and manganese ores are confined to eight mountain ranges namely, Copper Mountain (Vibhutigudda), Donimalai, Ettinahatti, Kumaraswamy, Thimmappanagudi, Ramandurg (Ramgad), North Eastern Block (NEB) range and Devagiri range. The Sandur schist belt is one of the Dharwar type Precambrian supracrustal belts in the Karnataka craton of South India (2900 to 2600 m.y.). This is the smallest of the three basins and covers an area of just 960 sq. km. It is structurally highly disturbed and squeezed out of shape by the intrusion of Younger granites. Shelf facies as in the other basins is confined to the western margin. Well-developed mafic magmatism and strong development of manganiferous greywacke, phyllite and numerous bands of banded heamatite quartzites (BHQ) characterize the basin. In Sandur Schist Belt the iron and Manganese deposits are concentrated along the hilltop and ridges ranging between 600 to 1100m in altitude. Well-developed mafic magmatism and strong development of manganiferous greywacke, phyllite and banded iron formations characterize the basin. The basin is known for its rich accumulation of iron and Manganese Ores. The average grade of the Iron Ore in this area is 58-60% Fe. The mineralized zones are variable in size, ranging from few metres to nearly kilometre scale in width. The Iron ore mineralization is characterized by oxidation, sedimentation and metamorphism. These banded iron formations have a typical mineralogy envisaged by hematite, goethite, martitized magnetite, garnet, feldspar, cherty quartz, gibbsite, siderite, ferruginous clay, tourmaline, cliachite (bauxite) which have been studied in detail and described here.

Keywords:- Kammattutru Iron Ores, BIF, Sandur Schist Belt, Dharwar craton.

I. INTRODUCTION

Banded Iron Formation (BIF) is one of the dominant litho-units of Archaean greenstone belts all over the world. They are believed to be derived from marine chemical precipitates and terrigenous derived sediments. BIFs have been classified on the basis of their mineralogy (James 1954; James 1966), tectonic setting (Gross, 1965) and depositional environment (Kimberley, 1978; Simonson, 1985). James' (1954) original facies concept included oxide, silicate and carbonate-facies iron formation.

The striking feature of Sandur Schist Belt is that it has various litho-units, both metasediments and metavolcanics. In Sandur Schist Belt Kammatturu Iron Ore formations formulates one of the significant deposit in Devagiri formation ($N50^0W$-$S50^0E$). The association of Iron mineralization of Sandur Schist Belt which has a wide mineralogical and chemical composition provide a unique opportunity to understand the formation types.

Banded iron formations (BIFs) are important but enigmatic rocks of the early and middle Precambrian. Their virtual confinement (James, 1983) to the Precambrian and absence of modern analogues have made these rocks extremely useful for the understanding of the ancient exogenic processes. Manikyamba, C. et al. (1993). have stated chert, ferruginous cherts, cherty banded iron formations (BIF), shaly BIF and shales are found interbedded at the eastern part of the Sandur schist belt. The geothermal regime of Archean resulted in rapid production of the oceanic crust (Abbott et al. 1994; Abbott, 1996; Hoffmann, 1996). In between the mass of cummingtonite-grunerite, relicts of cherty BIFs in various stages of recrystallization are found. C. Manikyamba. (1998).

Since thick BIF sequences were not generally found in Archean greenstone belts, the formation of granular iron formation is rare in Archean supracrustal rocks. C. Manikyamba. (1999). In India, deposition of BIF is mainly confined to greenstone belts and peak of BIF deposition is found around 2.7 Ga. C. Manikyamba. (1999).

II. GEOLOGY OF THE KAMMATTURU IRON ORE FORMATION:

India is bestowed with large resources of Iron Ore. Iron ore occurs in different geological associations. However, in India, like in most other countries belonging to the Gondwana Supercontinent, major economic deposits of Iron ore are found associated with volcano-sedimentary Banded Iron Formation (BIF) of Precambrian age. The major "Hematite" type iron ore deposits in India occur in the states of Jharkhand,

Chhattisgarh, Orissa, Karnataka, Goa, Maharashtra, Andhra Pradesh and Tamil Nadu. Minor deposits are located in the states of Andhra Pradesh, Madhya Pradesh and Assam. Apart from that there is a laterite bodies are present which can be used as Iron ore.

The Iron ore deposit of Kammatturu area is confined to the banded Iron formations of Archaean age. These Iron ores are in Devagiri formation of Ramanmala hill range. Iron ore occur as hard, laminated and soft friable ore within ferruginous phyllites/shale. Ore is of tabular deposits and in regular habit. The approximate strike length of ore body is 1150 mtr. (3500 mtr. as per the recent data collected from working mines) and dipping on an average 50° due northeast. The width of ore body is about 500m. Deposited ore is having 47 to 66 % Fe.

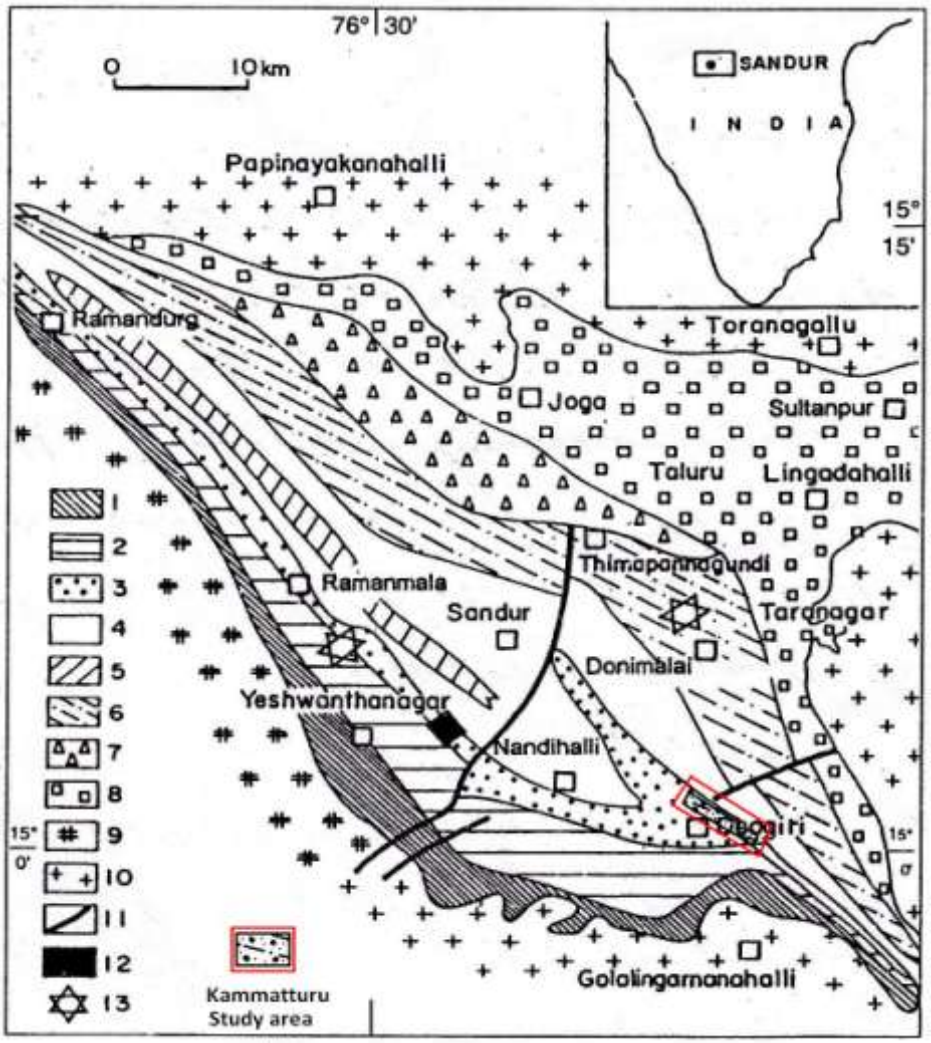

Fig. 1: Location of study area in the Geological map of Sandur schist belt.

Index- 1) Yeshwanthanagar Volcanic Block (YVB), 2) Deogiri Block (DB), 3) Western Volcanic Block (WVB), 4) Central Volcanic Block (CVB), 5) Greywackes in Central Volcanic Block, 6) Eastern Volcanic Block (EVB), 7) North Central Acid Volcanic Block (NCAVB), 8) Sultanpura Volcanic Block (SVB), 9) unclassified gneisses and granites, 10) Granites, 11) fault planes, 12) closed block represents the area where BIF-GIF are exposed and the location of the samples, 13) represents the occurance of BIF at Ramandurg and Donimalai ranges. Last legend is created by Author i.e. Kammatturu Study area shown in red colour square.
Source- C. Manykyamba et al.

Kammatturu iron formation is parallel to sub parallel with Donimalai block occurce in Devagiri formation of Ramanamala range in Sandur schist belt. This Iron ore zone is designated as Kammatturu block-A, B and C in accordance with strike direction. Kammatturu Iron ore formation is hosted by highly disturbed BIFs, phyllite, ferruginous shale, metavolcanics. The Iron ores have been classified on their physical characters like Massive hematite ore, Flaky or biscuity ore, Laminated ore, Powdery ore, Laterite ore, Goethite ore, Shaly ore, BHJ, BHQ and BMQ.

III. MINERALOGY OF THE KAMMATTURU IRON ORES

The Iron ore mineralization is characterized by oxidation, sedimentation and metamorphism (mainly BHQ/Hematite). Mineralogically Kammatturu iron ores of Devagiri formations are made up of hematite, magnetite, limonite, goethite, martite and specularite along with gangue minerals like chert and clay/shale of different type.

a. Microscopic studies:

The different types of Iron ores of the Kammatturu area are systematically studied under the ore microscope and the different ore minerals were identified. The mineralogical properties of each mineral present in the sample are studied under reflected light and are given below.

1. Lumpy/Massive Iron Ore: Lumpy/Massive Iron Ore predominantly consists of hematite, Goethite. Ferruginous clay, gibbsite and quartz are found in minor to trace amounts (Fig. 2). Hematite is fined grain (10 to 150 microns) present as granular aggregates. Hematite is altering to goethite along the grain boundaries and cleavage planes. At places relics of magnetite are noticed within the hematite. Goethite is present as patches and veins within the hematite. Ferruginous clay is present in the cavities of hematite. The minerals and their approximate percentage are tabulated in table I.

Table I: Approximate percentage of different mineral constituents in Lumpy/Massive Iron Ore

Mineral	Percentage
Hematite	**85-90**
Goethite	**7-10**
Ferruginous clay	**2-3**
Gibbsite	**1-2**
Quartz	**Traces**

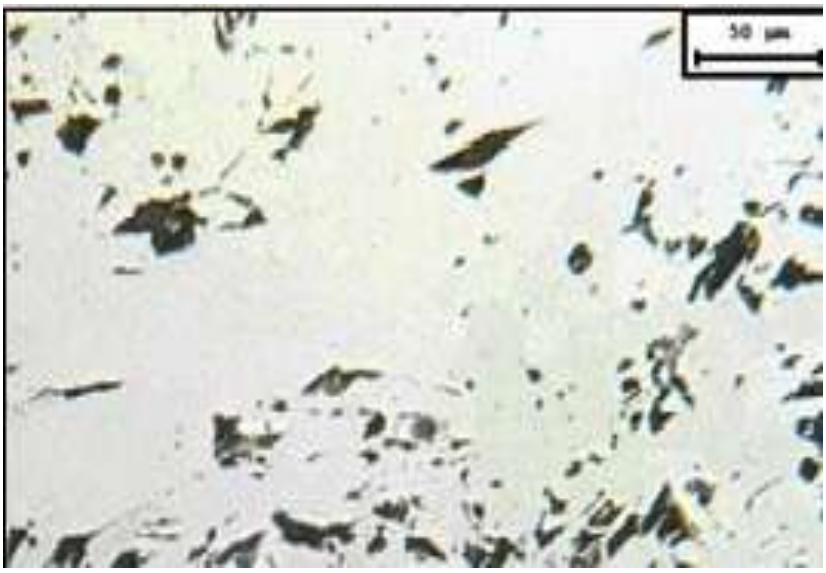

Fig. 2: Photomicrograph showing the micro-platy hematite grains in compact/massive iron ore.

2. Powder/Friable Iron Ore: This Iron Ore predominantly consists of hematite, Goethite, Ferruginous clay (Fig. 3). Cherty quartz and gibbsite are found in minor to trace amounts. Hematite is fine grained (10 to 150 microns) present as granular aggregates. At places hematite is also present as discrete grains within the ferruginous clay. Hematite is altering to goethite along the grain boundaries and cleavage planes. Goethite is present as flakes/patches within the hematite. These are similar to the soft laminated ore. Minerals and their approximate percentage are tabulated in table II.

Table II: Approximate percentage of different mineral constituents in Powdery Iron Ore.

	Percentage
Hematite	**85-90**
Goethite	**7-10**
Ferruginous clay	**2-3**
Cherty quartz	**Traces**
Gibbsite	**Traces**

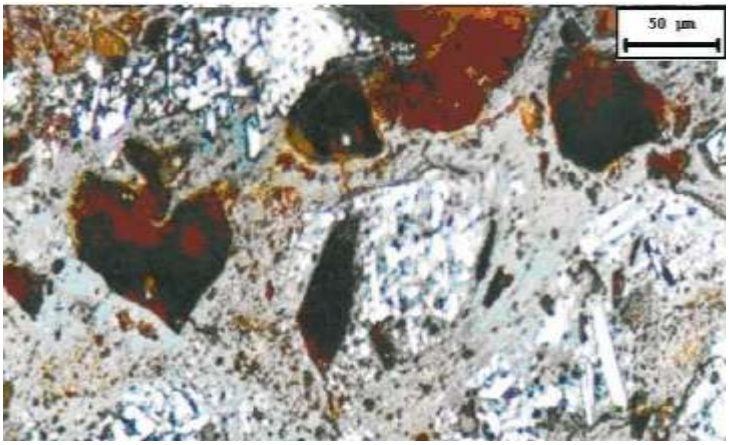

Fig. 3: Photomicrograph showing the hematite and goethite flakes in friable ore.

3. Banded Hematite Quartzite: Banded Hematite Quartzite consists of cherty quartz and hematite as the major minerals present in the sample. Goethite, martitized magnetite (Fig. 4). Garnet and feldspar are found in minor to trace amounts. Cherty quartz is fine grained present as granular aggregates as pockets and bands. In these cherty bands inter-granular spaces are filled with hematite. Hematite is fine grained (10 to 150 microns) present as discrete grains and granular aggregates as pockets and bands. In hematite bands inter-granular spaces of hematite grains are filled with quartz. Hematite is also present as fine (5 to 20 microns) inclusions within the quartz. Goethite is present as groundmass. The minerals and their approximate percentage are tabulated in table III.

Table III: Approximate percentage of different mineral constituents in Banded Hematite Quartzite.

Mineral	Percentage
Cherty quartz	50-55
Hematite	40-45
Goethite	3-4
Martitized magnetite	Traces
Garnet	Traces
Feldspar	Traces

Fig. 4: Photomicrograph showing the the bands of specular hematite in hard laminated ore.

4. Massive Banded Magnetite Quartzite: Massive Banded Magnetite Quartzite predominantly consists of Magnetite/ martitized magnetite and quartz + feldspar are the major minerals presents in the sample with sub-ordinate amounts of siderite. Goethite, chloride and pyrite are found in minor to trace amounts (Fig. 5). Martite/martitized magnetite are fine grained (10 to 150 microns) present as discrete grains in the inter-granular spaces of quartz + feldspar. They are also present as granular aggregates as pockets and bands. At places they are also present as fine (20 to 70 microns) inclusions within the goethite. Magnetite is altering to hematite along the grain boundaries and cleavage planes. Siderite is fine grained (20 to 200 microns) present as discrete grains and granular aggregates as pockets and veins. At places siderite shows fine inclusions (less than 20 microns) of magnetite/martitized magnetite. Goethite is present as patches in the quartz + feldspar and martitized magnetite groundmass. The minerals and their approximate percentage are tabulated in table IV.

Table IV: Approximate percentage of different mineral constituents in Massive Banded Magnetite Quartzite.

Mineral	Percentage
Magnetite/Martitized magnetite	35-40
Quartz + feldspar	35-40
Siderite	10-15
Goethite	7-10
Chloride	Traces
Pyrite	Traces

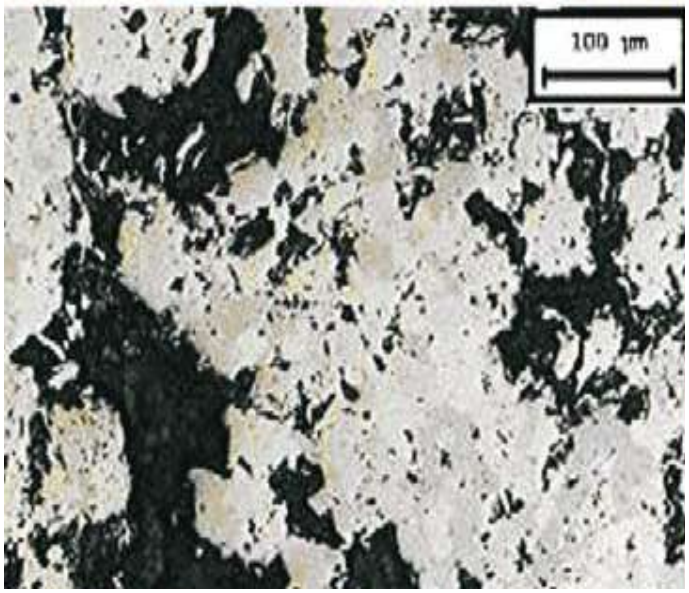

Fig. 5: Photomicrograph showing Martite in hard/massive iron ore.

5. Intrusive body: Intrusive body (weathered) sample predominantly consists of altered silicates with sub-ordinate amounts of goethite. Hematite, martitized magnetite, quartz + feldspar and tourmaline are found in trace amounts.

Table V: Approximate percentage of different mineral constituents in Banded Hematite Quartzite.

Mineral	Percentage
Altered silicates	85-90
Goethite	10-15
Hematite	Traces
Martitized magnetite	Traces
Quartz + feldspar	Traces
Tourmaline	Traces

b. Observations:

The mineralogical aspects observed give us the detailed information about the processes for Iron ore formations like Hematite is altering to goethite. Inter-granular spaces of hematite grains are filled with quartz in hematite bands. Magnetite is altering to hematite along the grain boundaries and cleavage planes. Relics of magnetite are noticed within the hematite etc., in different types of banded iron formations. These are formed by processes like oxidation, sedimentation and metamorphism. At some areas hematite is enriched near igneous bodies. In support of this view, several occurrences of iron ores along with igneous intrusions and the distortions in the stratified sequence are seen in the field, which might be due to the force full intrusion of igneous bodies.

IV. CHEMICAL ANALYSIS OF THE KAMMATTURU IRON ORES

Samples from Kammatturu area have been analysed for their major elements by XRF technique. Details of the analytical procedures, precision and standard error in the analysis have been given by Gnaneshwar Rao and Naqvi(1995). Chemical composition of the minerals constituting mixed oxide silicate facies banded formation of the Kammatturu formation of Sandur schist belt. All most samples are made up of SiO_2, Fe and other elements are present in insignificant quantity including Al_2O_3 and TiO_2. The depletion in TiO_2 and Al_2O_3 substantiates the inference of non-deposition of terrigenous debris along with these layers. Low content of MgO suggests that volcaniclastic input was also negligible when these layers were precipitated. High percentage of SiO_2, Al_2O_3 Fe and TiO_2 in the last sample (igneous body) shows some anomaly, formation of Hornblende is possible if Al_2O_3 is present. So this may be formed by segregation or by agglomeration process.

Table VI: Major elements in Kammaturu Iron ores values in percentage.

Sample	SiO_2	Al_2O_3	Fe (T)	MgO	TiO_2	Na_2O	K_2O	P	S (T)	Mn	LOI
L/MIO	0.76	0.57	67.86	0.017	0.15	0.017	0.05	0.05	Trace	0.21	1.07
P/IOF	1.01	0.58	67.76	0.012	0.16	0.015	0.06	0.01	Trace	0.20	1.08
BHQ	52.02	0.56	32.52	0.012	0.09	0.016	0.03	0.07	Trace	0.20	0.50
BMQ	37.63	1.06	38.18	0.65	0.17	0.066	1.66	0.016	Trace	0.17	3.31
I B	37.95	29.61	9.10	0.63	2.84	0.06	0.01	0.01	Trace	0.41	12.94

Note: L/MIO=Lumpy/Massive Iron Ore. P/IOF= Powdery/Iron Ore Fines. BHQ= Banded Hematite Quartzite. BMQ= Banded Magnetite Quartzite. IB= Igneous body.

V. CONCLUSION

The Kammatturu Iron ores of Devagiri formations in Sandur schist belt are constituted by several ore types of Iron hosted by different litho-units. The mineralogical aspects studied lay emphasis on the presence of rich hematite in lumpy and powdery ore types, slightly reduced concentration of hematite in other types of BIF and Ferruginous shale. The comparison between mineralogical aspects and the chemical analysis of major elements also supports the enrichment of hematite content at places, and depletion or slightly reduction in others. The ore microscopic study reveals that the disposition of hematite in particular ore types as granular masses, patches and its alteration to goethite at borders/cleavage plains and presence of other ferruginous minerals which might be due to the several stages of oxidation, sedimentation and metamorphic processes enacted during the genesis of iron ore formations. The earlier work of several researchers is also taken in to consideration while explaining this fact. The igneous bodies which have intruded in the formations might have enriched the ores in there hematitic content either by segregation or by agglomeration.

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