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Field and Petrographic Aspects of Banded Iron Formation of Noarmundi- Koira Basin , Singhbhum-Odisha Craton Eastern India and their Genetic Significance

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ABSTRACT

The Banded Iron Formations (BIFs) are one of the most important and mysterious resource in the earth's geological history. In India, large BIF successions in Precambrian greenstone belts host economically significant iron ore resources, with major iron ore districts in the states of Chhattisgarh, Jharkhand, Odisha, Goa and Karnataka. We collected 45 BIF samples from active mines. The Noamundi- Koira Basin (NKB) BIFs, which are preserved in a horseshoe-shaped synclinorium, are of enormous commercial value since they contain Fe in excess of 60%. According to mineralogical investigations, magnetite was the primary iron oxide mineral, which is now a relict phases that, has been retained in the BHJ as Martite. XRF was used to determine the major elements, whereas ICP-MS was used to determine the trace elements and rare earth elements. EPMA was used to evaluate the mineral composition of thin sections of representative samples under both reflected and transmitted light. Magnetite was found to be the most common iron oxide mineral, according to mineralogical research. Desilicification of the Cherty Banded Iron formation and the Shaly Banded Iron formation is the consequence of hydrothermal fluid action. According to mineralogical investigations, magnetite was the primary iron oxide mineral, but it is now a relict phase whose depositional history is retained in BHJ as Martite. The NKB has a larger concentration of transition elements including V, Ni, Cr, Zn, Co, and Cu, as well as a lower concentration of incompatible elements like Rb, Nb, Th, and Ga. The most abundant element is Zr, whereas the least abundant element is U, indicating that they obtained Fe from a Mafic source. The lower Ni and Cr concentrations in the Cr vs. Ni plot when compared to Paleo and Neo-archean concentrations indicate that the Noamundi-Koira Basin BIF was deposited during the Proterozoic period. The Eu/Eu vs. Gd/Yb figure also depicts BIF deposition during the Proterozoic period. According to the NI-ZN-Co triangle diagram, the Noamundi-Koira basin BIF is made up of hydrothermal deposits linked to submarine volcanism. The overall Field and Petrographic features of the BIF of the NKB strongly suggest that the mineralization is of hydrothermal origin.*

Keywords: *BIFs, Noamundi-Koira Basin, Transition elements, incompatible elements, Petrography*

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INTRODUCTION

India, the sixth largest high-grade iron ore miner, reportedly produces approximately 80 million tonnes a year with a reserve of 10 million tones [1-3]. Major Indian reserves are located in BIF-bearing Precambrian successions of the Singhbhum, Dharwar and Bastar Cratons. The origin of the BIF hosted high grade iron ore in India is widely believed to be due to geologically recent deep lateritic weathering processes. Whilst this may be true for Soft and Friable ores[3&5], hard hematite and martite rich ores, on the other hand, may be of ancient hydrothermal or ancient supergene origin [4]. Origins of these BIF are considered as the product of Supergene enrichment processes or hydrothermal mineralization processes. The Noamundi Koira Basin BIF hosts strong BIF content (62 percent Fe), and covers approximately 45 percent of the global supply of BIF. These deposits have recently been the subject of extensive analysis and hints to establish a model for their BIF genesis and age, To enhance techniques for quality management and discovery. One of the generating deposits represents the NKB close Jharkhand town. Any parts where the interaction between iron ore and banded iron formation protolith is well exposed have been exposed recently by mining activity in the NKB. The key purpose of this paper is to reflect on and interpret the essence of BIF mineralization and its petrography in terms of BIF genesis or ore genesis. One of the generating deposits represents the NKB close Jharkhand town. Any parts where the interaction between iron ore and banded iron formation protolith is well exposed have been exposed recently by mining activity in the NKB. The key purpose of this paper is to reflect on and interpret the essence of BIF mineralization and its petrography in terms of BIF genesis or ore genesis.

MATERIAL AND METHODS

The field and laboratory methods to be adopted in the Research paper of shall be as follows:

1. **Literature survey**: Consulting of available literature on the study area and on similar deposits/occurrences world over.
2. **Field work**: Includes large scale detailed geological mapping, collection of representative samples and demarcation of mineralized zones.
3. **Laboratory work**: Thin section of the representative samples have been studied under both reflected and transmitted light and mineral composition has been determined by EPMA. The data obtained are presented in the following chapters and have been used to infer the evolution of Banded iron formation the process involved in the deposition of BIF. Major elements were determined by XRF and trace elements and rare earth elements were determined by ICP-MS.

GEOLOGICAL SETTING:

Singhbhum- Odisha- Iron-Ore Craton [8-11] or Singhbhum Odisha Craton consists of Iron ore Group, which were deposited over Older Metamorphic Group (OMG).They occur in three basins along eastern, western and southern perimeters of Singhbhum granitoid batholithic complex, known as Singhbhum-Keonjhar or Jamada-Koira Basin, Gurumahisani-Badampahar Basin and Daitari-Palalahara Basin respectively[6&7]. The western Singhbhum-Keonjhar or Jamada –Koira Basin extends over a strike length of 60-70 km in NNE-SSW direction from Chakradharpur to Malangtoli.The Iron Formations and associated rocks are found in horse shaped, gently plunging sharply bent synclinorium known as Noamundi- Koira Basin.

It is therefore fair to date the BIF rocks of the NKB to the Early Proterozoic Period instead of the Middle Proterozoic Age. Centered on their mode of origin, the BIF of the Basin was graded into three big units.

Tuff, Tuffaceous Shale (Phyllite) is a lower volcanogenic facies devoid of any iron or Manganese deposits, which occurs peripherally to the Basin and is poorly exposed in the eastern part of the Basin, where its thickness does not reach 30 to 50 metres.

Banded Hematite Jasper (BHJ) consists of the overlying transitional chemogenic facies 300 to 400 metres thick. The upper facies are described in the shapes of layers and isolated lenses by mangniferous Shale, Chert, Dolomite and Tuff, classified as Upper Shale, some associated with chert and few with dolomite beds.

NATURE OF IRON ORE MINERALIZATION AND ORE TYPE

Economically significant iron ore deposits in India are hosted by prominent BIF successions Proterozoic and Archean greenstone belt with major iron ore district located in the state of Chhattisgarh, Jharkhand, Odisha, Goa and Karnataka. In different district the BIF host rock is referred to as Banded hematite quartzite (BHQ), Banded Hematite Jasper (BHJ) or Banded Magnetite Quartzite (BMQ), Fig. 1 & 2. This terminology is rooted in the strongly supergene altered appearance of the BIF in outcrop. The consistency of the weathered BIF ranges from friable to very hard , but it is always composed of mesobands rich in microplaty hematite- martite alternating with microcrystalline quartz (Chert) mesobands (the terms micro,meso and macrobands are applied in this contribution. Variable proportion of remnant magnetite, siderite and pyrite are also present. In India based on Fe content, Indian ore are classified as high grade with >65%wt % Fe, medium grade with 62-65% wt %Fe and Low grade with <62wt%Fe. Crushed and classified ores with particle size <10 mm and >6 mm are generally referred to as lumpy ore and ores with particle sizes <6mm are considered fines .The classification of ores on a megascopic scale varies from mine to mine but is usually based on hardness and degree of in duration (friability-hardness);the ores are typically categorized using termed as hard ,friable, soft powdery and Blue dust .

Mineralogy of the BIF is represented by hematite of different types (euhedral, anhedral,cryptoplaty and microplaty), martite (after magnetite),goethite ,magnetite and pyrite (Fig.4)Considering mineralogy and physical attributes like hardness, porosity and friability, the BIF of Thakurani iron ore Noamundi village and Jhillingburu Gua iron ore can be grouped in to four fundamental types Soft lateritic ores, hard massive or laminated ores ,Friable powdery ores ,Blue dust ores. Lateritic ores, known as soft ores or SBIF are the product of laterization of primary ores and hence their composition varies widely depending upon the nature of primary ore and degree of laterization. They are usually vesicular or porous and observed capping over ore bodies. The steel grey colored hard massive , sometimes finally laminated ores found below lateritic ore are characterized by their compact and homogeneous nature. Flacky friable ores are brown to grey in color and varies in characteristic from laminated ,biscuty,flacky to friable ,powdery in nature .powdery ores are fine in nature and often closely associated with blue dust, ferruginous and shaly materials..Blue dust occur as fine, steel grey colored powder with a few flaky ore pieces and generally found below hard massive ores in associated with BHQ .It occurs in limited extent at deeper levels of the mineralized zones. BHJ consisting of laminations of fine grained hematite and jasper vary in thickness from mere parting to a few centimeters. High grade hard hematite ores are dominantly composed of different generations of hematite, mainly microplaty (5to 30 um) and cryptoplaty (<5 um) with subordinate martite and magnetite, and are massive or laminated. Massive hard hematite ores essentially consist of martite and variable amount of micro platy hematite. Loss of laminated habit of iron formation protolith in this ore is due to fabric destructive replacement of silica by iron oxides. Laminations in the hard hematite ore, where preserved, are due to developed of alternating mosaic of microplaty hematite of different dimensions and the replacement of early silica by iron oxide phase was not fabric-destructive .Magnetite, where present occurs as patches within equant martite and pyrite grains Flacky ore contains thick flakes (few mm to cm) of massive ore in a matrix of microplaty hematite.

Fig 1 & 2 BHQ exposures in Bai hill mining area in Gua mines, M/s SAIL Blue dust with well maintained banding of the precursor banded iron formation. Blue dust zone grades laterally to unaltered banded iron formation, and shows a typical brittle folding due to sagging of beds in the Eastern BIF bearing Basin.

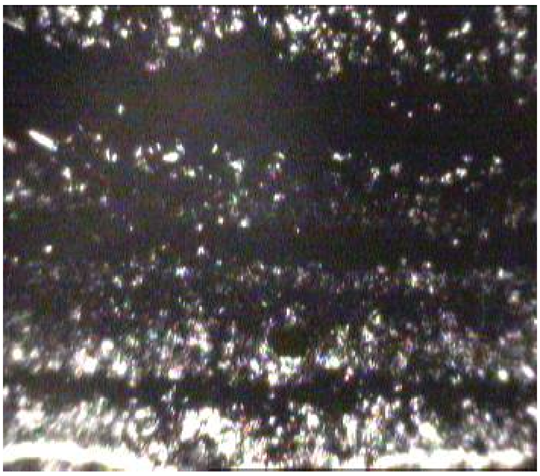

Fig. 3 Photograph showing Goethite

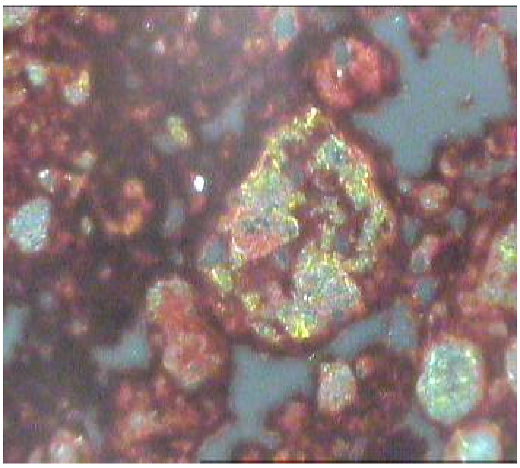

Fig.4 Photograph show Band mineral magnetite

RESULT AND DISCUSSION

Mineralogy study suggests that magnetite was the principle iron oxide mineral now a relict phase whose depositional history is preserved in BHJ, where it remain in the form of martite .The platy hematite is mainly the product of martite. The different types of iron ores are intricately related with the BHJ. Cherty Banded Iron Formation (Hard laminated Ore) and Shaly Banded Iron Formation (Soft laminated ore) are resultant of desilicification process through the action of hydrothermal fluids .Removal of silica from BIF and successive precipitation of iron by hydrothermal fluids of meteoric origin in the formation of martite-goethite ore. Cherty Banded Iron Formation (CBIF) has been formed in the second steps of supergene processes, where the deep burialupgrades the hydrous iron oxides to hematite. Shaly Banded Iron Formation (SBIF) and biscuit ore were formed where precipitation of iron was partial or absent in this case, the leached out space remains with time and the ore becomes very fragile in between the laminae. Blue dust has been formed owing to circulating waters, which leached away the silica from protore. The precense of martite in massive ore along with their gradational contact of with BHJ suggests its syngenetic origin with BHJ.

The Noamundi-Koira Basin BIF, deposited in horseshoe shaped synclinorium, is of great economic importance as of very high grade and it contains Fe more than 60 wt%. The trace and rare earth elements geochemistry of banded iron-formations of the Noamundi-Koira Basin BIF deposits belongs to Singhbhum-Odisha Craton shows that they are detritus-free chemical precipitates. The BIFs are composed of two major types of ore deposits of different origin, that is of paleoproterozoic hydrothermal origin and soft ores related to recent weathering along a lateritized Cretaceous-Cenozoic land surface (soft ore). Chartey Banded iron Formation is formed as volcanic exhalatives and hydrothermal replacement of BIF protolith, not only through leaching of silica but possibly also through introduction of iron by hydrothermal fluids of meteoric origin. Soft saprolitic iron ores formed as a product of lateritic weathering processes in Cretaceous-Cenozoic times [6,7,11,12].

The Noamundi-Koira Basin BIF contains higher concentrations of transition elements such as V, Ni, Cr , Zn, Co, and Cu and lower concentrations of incompatible elements Rb, Nb, Th, Ga and Cs . Zr is the most abundant whereas U shows the least values. These show that the Fe was derived from the mafic sources. The lower values of U compared to Th in BIF samples are due to their Eh and pH conditions. The lower concentration of Ni and Cr as compared to paleo and Neoarchean concentration in Cr vs. Ni plot shows that the deposition of the Noamundi-Koira Basin BIF was taken place during the Proterozoic time. The Eu/Eu* vs. Gd/Yb plot also shows deposition of BIF during Proterozoic time.

SUMMARY AND CONCLUSION

The Noamundi-Koira Basin BIF's overall field and petrographic features strongly suggest that the mineralization was hydrothermal in origin. The hydrothermal ores were later partially altered using near-surface supergene / weathering processes. The formation and subsequent martitization of early magnetite-rich ore, as well as the subsequent production of microplaty hematite-rich ore by silica substitution, suggest that the iron-rich mineralizing fluid was initially limited, warm, and alkaline in nature, before gradually becoming oxidizing with cooling.

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