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Manganese mineralization in Archean greenstone belt, Joda–Noamundi sector, Noamundi basin, East Indian Shield

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ABSTRACT

A Mesoarchean greenstone belt (3.5–3.0 Ga) in the western part of the East Indian Shield comprising the Iron Ore Group of the Noamundi basin contains economic resources of both iron and manganese ores in the NNE plunging regional synclinorium. Manganese mineralization in the central and eastern parts of this synclinorium, particularly in Joda–Noamundi sector, has taken place in multiple cycles starting from syngenetic sedimentary and exhalative type through mobilization and remobilization in different stages of tectonism, deformation and hydrothermal activities to latest lateritic or supergene type. A relatively high temperature metamorphic jacobsite–hausmannite–bixbyite–braunite assemblage, low temperature hydrothermal pyrolusite–psilomelane–hollandite assemblage and supergene pyrolusite–manganomelane–groutite–polianite assemblage are present and were formed by recycling of manganese in different stages of mineralization. A detailed structural study of the manganese ore bodies as well as their ore petrographic and mineralogical characteristics with mineral chemistry has revealed systematic mineralization and their relation to deformational phases. Such recycling of manganese and its structural control of mineralization in different phases is unique of its kind in comparison with other Archean manganese deposits in the world.

1. Introduction

Manganese mineralization in association with Banded Iron Formation (BIF) in Archean greenstone Belts is reported from limited occurrences viz. the Rio das Velhas deposit of Brazil (Machado and Carnerio, 1992; Teixeira et al., 1996; Martin et al., 1997), the Barberton greenstone belt of South Africa (De Wit et al., 1980; Anhaeusser and Wilson, 1981), the Yilgarn and Pilbara blocks of Western Australia (Condie, 1981; Hallberg and Glikson, 1981), the Sebakwian–Bulawayan–Shamvaian belt of Zimbabwe (Myers and Kröner, 1994; Windly, 1982), the Superior and Slave provinces of Abitibi belt, Canada (Goodwin, 1973; Dimroth et al., 1982), the Isua Formation of Greenland (Gross, 1986; Schidlowski, 1988, 1993), the Bababudan and Chitradurga belt of South India (Ramakrishnan et al., 1976; Chadwick et al., 1981a,b) and the Iron Ore Group (IOG) of the East Indian Shield (Roy, 1981; Saha, 1994).

The Precambrian rocks of the East Indian Shield (EIS) are distributed in the Chhotanagpur granulite–gneiss terrain in the north, Singhbhum granite–greenstone terrain in the south and Singhbhum orogenic belt between the previously mentioned two terrains (Fig. 1). The Singhbhum granite–greenstone terrain comprises three major greenstone belts viz. the Jamda–Koira belt in the west, the Gorumahisani–Badampahar belt in the east and the Tomka–Daitari belt in the south encircling the centrally located Singhbhum granitic craton. The greenstone rocks stratigraphically belong to the IOG which overlies Singhbhum Granite Type-A (Phase-I & Phase-II) and underlies the Singhbhum Granite Phase-III. Saha et al. (1988) generalized the chronostratigraphic succession as in Table 1. Moorbath and Taylor (1988) later corrected the age of the Older Metamorphic Tonalitic Gneiss (OMTG) as c. 3.52–3.45 Ga.

The Jamda–Koira belt of the Noamundi basin contains more than 130 million tonnes of total manganese ore reserve (Manganese Ore Vision 2020 and Beyond, 2014). According to the Indian Bureau of Mines production report 2010–11 & 2011–12, the average manganese grade is low to medium (~25–35 wt.%).

Manganese mineralization in the Joda–Noamundi sector reveals that recycling of manganese is compatible with the different phases of tectonic deformation, metamorphism, hydrothermal activity and supergene processes. The present paper correlates the manganese mineralization with different phases of tectonism which links the origin and evolution of the Mn-ore deposit through mineralogy, mineral chemistry and structure.

2. Geologic setting

The Joda–Noamundi sector of Kendujhar district, Odisha belongs to the central and eastern parts of the Jamda–Koira greenstone belt of the EIS. Both iron and manganese ores are associated with the Archean IOG which is regionally folded to form the NNE trending Noamundi synclinorium overturned at the eastern part.

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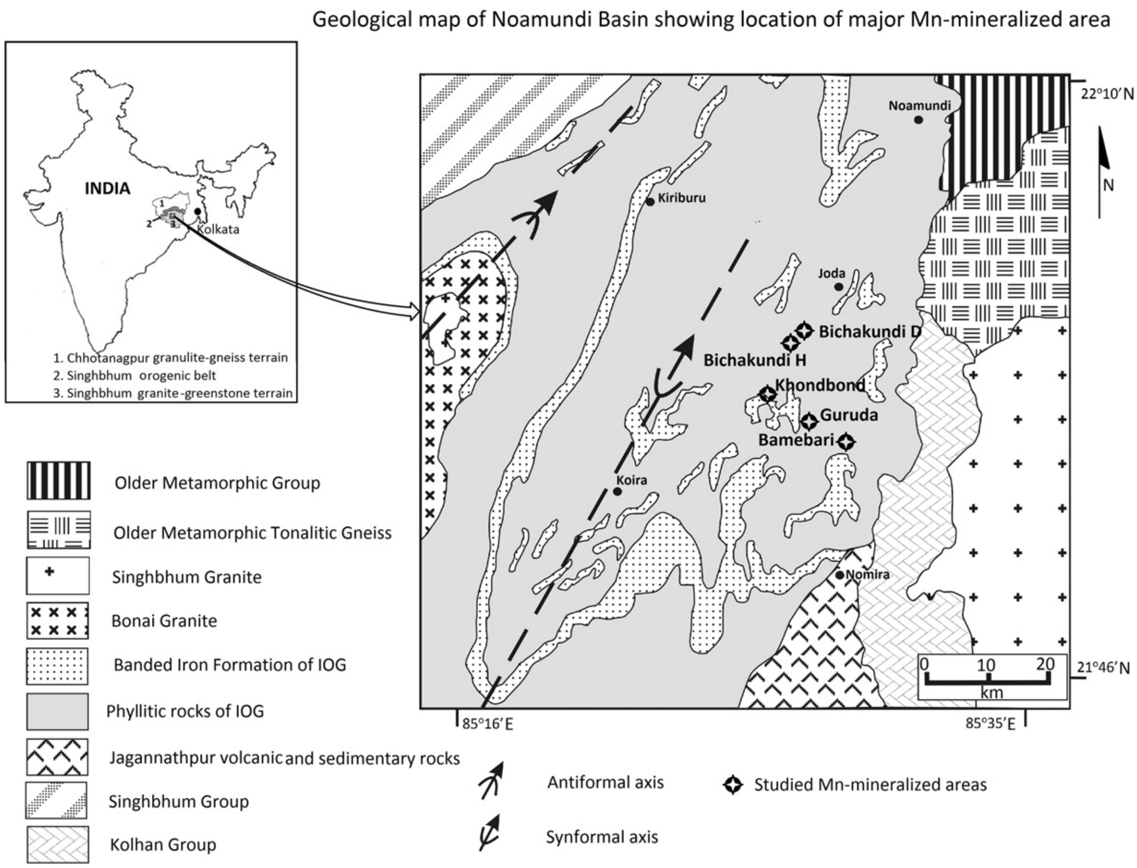

Fig. 1. Geological map of Noamundi basin showing major manganese deposits in Joda–Noamundi sector associated with BIF.

Banerji (1977) stratigraphically characterized iron–manganese mineralization in the Jamda–Koira belt as the Noamundi Group of much younger age (c. 1500–1100 Ma) with the following sequence (ascending order) lower shale (tuffaceous shale–phyllite), banded hematite jasper, upper shale (manganiferous shale, tuff and chert), basic intrusion, grinitic activity. Sarkar and Saha (1962, 1977) described manganese ore bodies intimately associated with unmetamorphosed shales (occasionally tuffaceous) and chert of the Archean IOG. They also considered that manganese mineralization is confined to the topmost upper shale formation in a belt about 80 km long and 25 km wide.

The IOG rocks occupy the major central part forming the Noamundi synclinorium (Fig. 1). The western limb of this synclinorium is more or less continuous but characteristically devoid of any significant manganese mineralization. Iron ore associated with BIF is present in both limbs. The eastern limb is structurally much more disturbed and dissected. It characteristically contains the major manganese ore bodies in the Joda–Noamundi sector.

Table 1
Stratigraphic sequence of the Archean rocks in the Singhbhum granite–greenstone terrain after Saha et al. (1988).

Unconformity		
c. 3.1 Ga	Singhbhum Granite Type-B (Phase III)	
c. 3.3–3.1 Ga	Iron Ore Group	Mafic lava, tuff, acid volcanic, tuffaceous shale, banded hematite jasper and banded hematite quartzite with iron ores, ferruginous chert, local dolomite and quartzite sandstone
Unconformity		
c. 3.3 Ga	Singhbhum Granite Type-A (Phase-I and Phase-II)	
c. 3.4–3.5 Ga	Folding and Metamorphism of OMG and OMTG	
c. 3.775 Ga	Older Metamorphic Tonalitic-Gneiss (OMTG)	
c. 4.0 Ga	Older Metamorphic Group (OMG)	
Basement unknown		

The corresponding anticlinal core in the western part of the Noamundi synclinorium is mainly occupied by the 3.3 Ga Bonai granite (Saha, 1994). The Older Metamorphic Group (OMG), OMTG and Singhbhum Granite occur mainly in the eastern part of the Noamundi basin. The Proterozoic Singhbhum group of rocks in the western part (mainly low grade metamorphosed volcanic and sedimentary rocks), the Kolhan Group (unmetamorphosed sedimentary rocks) and the Jagannathpur–Malangtoli volcanic rocks unconformably overlie the Singhbhum Granite Phase-III. Ghosh et al. (2010) found undeformed basal lava bordering the Noamundi synclinorium and they have studied anisotropy of magnetic susceptibility in the Noamundi basin concluding that two consistent magnetic fabrics correlated with D_1 and D_2 deformation fabrics in the BIF rocks. They also identified two folding phases (earlier F_1 developed during D_1 stage, open to tight, isoclinals and upright to inclined, overturned having axial traces NNW–SSE to NE–SW; and later F_2 developed during D_2 stage with E–W trending axial trace). Beukes et al. (2008), in Noamundi–Kiriburu iron ore area, also observed manganiferous shale overlying the chert breccias and hosting numerous small to moderate sized supergene Mn-ore bodies grading upwards into ferruginous shale which in turn further grades into ore bearing iron formation. Kiriburu is in the western limb and Noamundi is in the eastern limb of the overturned syncline. So, the lithostratigraphy in these two limbs is not expected to remain unchanged.

Due to the lack of proper geochronological data, the absolute age of the three greenstone belts of the IOG is quite uncertain. A relative age can be provided by the fact that the rocks of IOG overlie the Singhbhum Granite Type-A and the younger granites (the Bonai granite in the