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# Co-rich Lithiophorite in Manganese Ores of Bonai-Keonjhar belt, Orissa. Journal of Geological Society of India.

Paper communicated

# Manganese Metallogenesis in Iron Ore Group of rocks, N Orissa, India. Ore Geology Review

Papers presented in Seminar/Symposia

   
   Classification of Manganese ore bodies in parts of Bonai-Keonjhar belt of Orissa and its implications in evaluation of their resource potential

   
   Upgradation potential of low-grade Mn-ores of Bonai-Keonjhar region for sustainable development
NATURE AND DEVELOPMENT OF LATERITOID TYPE MANGANESE ORE BODIES IN THE IRON ORE GROUP OF ROCKS, BONAI - KEONJHAR BELT, ORISSA

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ABSTRACT

Lateritoid type of manganese ore bodies in the Precambrian Iron Ore Group of rocks occur in Bonai-Keonjhar belt, Orissa besides stratiform and stratabound-replacement types of deposits. The ores appear in form of large boulders within lateritised aprons at various depths, often reaching beyond 30 mts from the surface. Overprinting of primary structures, presence of mixed Fe-clasts and Mn-ooliths/pisoliths, mineral species of different generations and wide chemical variation amongst morphological varieties & from boulder to boulder are the characteristic hallmarks of such ore bodies. Features associated with ores occurring in different morphologies, namely: spongy, platy, recemented and massive varieties from a typical profile of Orahari Mn-deposit in Keonjhar district are described. Recemented variety may be further classified into sub-varieties such as canga, agglomerate and mangerete. Common primary Fe-minerals are hematite, martite with relict magnetite. The secondary Fe-Mn phases are goethite, specularite, crytomelane, lithiophorite, chalcofahmite, manganite and pyrolusite.

These are ore bodies of allochthonous nature developed through a number of stages during terrain evolution and lateritisation. Secondary processes such as reworking of pre-existing crust through remobilisation & solution, precipitation & cementation and transport etc are responsible for the development of such lateritoid ore bodies in Bonai-Keonjhar belt.

Key Words: Manganese ore, Iron Ore Group of rocks, Manganese ore deposit, Orahari

INTRODUCTION

Manganese ore bodies of Orissa are confined to three Precambrian stratigraphic horizons viz. Iron Ore Group, Gangpur Group and Khondalite Group. Over 25 MT of manganese ores are reported to occur in Bonai-Keonjhar belt of Iron Ore Group where active mining operations are going on in many areas like Joda, Roida, Kusumdihi, Orahari, Kalimati, Mahuluda, Dubna etc. Barring limited battery grade manganese ore, most of it is used in ferro-manganese production. Compared to the size of the belt, the literature available on the manganese ores of Bonai-Keonjhar belt seems to be limited. Broad geology and geo-economic aspects of this region have been dealt by Spencer (1948), Sen (1951), Ray (1954), Ray (1955), Engineer (1956) and Prasad Rao and Murty (1956). Mukherjee (1966), Basu (1969), Murthy and Ghosh (1971) and Mishra (1994) discussed the classification/mode of occurrence/genesis of some manganese ore deposits of this region. Mineralogical and geochemical studies though reported by Roy (1961, 81), Mohapatra and Bagchi (1961) and Ajmol (1990), are of local significance. Mishra et al (2003) have classified manganese ore...
bodies of this region into three broad categories viz. stratiform, stratabound-replacement and lateritoid types. Though reports on former two types around Noamundi basin have been published by Mohapatra et al (1989) and Dasgupta et al (1999), scanty record is available on characteristics and genesis of lateritoid types of Mn-ore bodies from this belt.
Fig. 2: A view of lateritoid type Mn-ore deposit

(A) Panoramic view of Orahari deposit showing mine benches, (B) An enlarged view of mine surface, note the extent of lateritisation and a thin pebble horizon at depth of 30 mt from the ground surface, (C) The bouldery nature of ore body, (D) An enlarged view of an ovoidal boulder at 20 mt depth
Supergene enrichment processes have generated some of the world’s largest manganese ore deposits (Roy, 1981). For example, the Moanda deposit in Gabon (Leclerc and Weber, 1980), Ukut deposit in Hungary (Szabo and Grasselly, 1980), Nauta deposit of Ghana (Persel and Grandin, 1978), Groote Eylandt in Australia (Pracejus et al, 1988) etc. As no precise report is available on the supergene manganese ores in Iron ore Group of rocks of Orissa, this paper describes the typical profile, ore petrographic (mineralogic-textural) and geochemical characteristics with a view to establishing the genetic development history of lateritoid manganese-ore bodies of Bonai-Keonjhar belt, Orissa.

GEOLOGIC SETTING

The manganese-ore bodies in the Bonai-Keonjhar belt (Jamda-Koira valley) are confined to Upper Shale Formation of Precambrian Iron Ore Group. Based on mode of occurrence, these ore bodies can be classified into three categories: stratiform, stratabound (-replacement) and lateritoid types. The stratiform type shows distinct lamination or banding even on mesoscopic scale. The stratabound type is structure and shear zone-controlled and is often silicaified showing effects of replacement. The lateritoid type occurs as float. Generally each ore body over its effective area is more or less tabular and is capped by a lateritic hat of variable thickness. The manga-
nose ores showing different texture and habit are chemically grouped under high, medium and low-grades. The ores are mostly associated with shale, mainly of kaolinitic composition. The ores, in general, show variable proportion of secondary oxy-hydroxide Mn and Fe-phases, with minor clay minerals.
Fig 5 Microscopic view of Ooliths and Pisoliths A) An oolith of cryptomelane enclosed within secondary cryptomelane matrix, B) An oolith of goethite enclosing elongated patches of clay present within clayey matrix, C) A cluster of Mn-ooliths in different shapes and dimensions, D) A larger pisolith comprising hematite in core uncrushed by cryptomelane E) A large pisolith of cryptomelane showing concentric layering Note, the shrinkage crack cutting across the pisolith, F) Two pisoliths (eye shaped) of cryptomelane welded together by cryptomelane of later generation
Fig 6 Optical micrographs showing different mineral species in lacustrine type ore deposits. A) Iron ore clasts (hematite) enclosed within cryptomelane matrix, B) Enlarge view of laminated iron ore (hematite-bright phase) showing relics of magnetite (<), C) Martite crystals enclosed within clay rich matrix, D) Mosaic grains of lithophorite lining a vug, E) Chalcophanite needles encrusting a vug, F) Tiny specularite grains occurring over cryptomelane base.
Lateritoid Manganese ore bodies

Field characteristics - The manganese ore bodies of lateritoid type have limited depth persistency and mostly of low-grade types. A number of lateritoid manganese deposits viz. Oiahari (OMM Ltd), Dolki, Soyabil (OMC Ltd), Bel pit, Slope pit, Kusum pit (OMDC Ltd) are present in Bonai-Keonjhar belt. Field, ore petrographic and other geochemical characteristics of a typical lateritoid deposit, for example, Oiahari near western limb of horseshoe belt, NW of Korra town (Fig. 1) is described in this paper.

Large-scale lateritisation, often extending beyond 30 m is a common feature of such deposits (Fig 2A). Occasionally, thin sub-horizontal pebble zone (Mn- and Fe-rich) is seen below 30 m (Fig. 2B). When deeper level of mine is opened up, large drifted boulders are seen even below 30 m depth (Fig. 2C). Small boulders are sometimes welded to form large one. Sometimes boulders appear sub-rounded to ovoidal (Fig. 2D). Occasionally, small Mn-rich pockets occur within such low-grade ore bodies.

Ore Morphology vs Mineralogy - The ores from such type of manganese deposits can be grouped broadly into four morphological varieties/types. The mineralogical and textural characteristics of these four types are detailed below.

1. Spongy: Strongly leached, it exhibits porous and cavernous structure. Locally honeycomb structure is seen due to growth of quartz crystals (Fig. 3A). Pyrolusite, lithiophorite and quartz are the major minerals present (Fig. 4) in spongy variety. The lithiophorite occurs as mosaic grains lining some vugs (Fig. 6D). Occasionally, chalcopyrite needles encrusting vug are noted (Fig. 6E).

2. Plate: Cylindrical plates often develop due to strong leaching showing boxwork structure. Presence of cryptomelane, goethite and kaolinite (Fig. 4) is characteristic.

3. A. Recemented-I: This looks like canga. It is composed of clasts of primary iron ore (hard laminated), of size ranging from pebbles to cobbles, that are cemented together by dense Mn-phases (Fig. 3B). The XRD pattern shown in Fig. 4 indicates the major mineral to be hematite.

B. Recemented-II: It is an agglomeration where elongated fragments of primary laminated iron ore and manganese pisoliths are cemented by secondary Mn-phases (Fig. 3C). The major minerals confirmed by XRD include hematite, goethite and cryptomelane (Fig. 4). This sub-variety is termed as agglomeratic variety in a non-genetic sense.

C. Recemented-III: A secondary conglomeratic mass, this may be termed as mangecte. In such case primary Mn-ooliths, in varied shape and size, are cemented together to form mangecte lithounit (Fig. 3D). The major minerals recorded in XRD are pyrolusite and lithiophorite with minor ilrite (Fig. 4).

Recemted ore-III largely constitute primary ooliths and pisoliths. These ooliths and pisoliths are flattened, round to oval shaped closely or partially filled accretionary grains. Ooliths are relatively smaller grains (<2 mm) of single composition, either composed of cryptomelane (Fig. 5A) or goethite (Fig. 5B). Often Mn-ooliths in varied shape and sizes occur in clusters (Fig. 5C). The pisoliths are relatively larger (>2 mm) grains and composed of either layers of cryptomelane/romanechite or hematite core with cryptomelane encrustation (Fig. 5D). The pisolithic grains are concentrically banded and often show transverse/tidal cracks (Fig. 5E). Occasionally, two pisoliths are found welded simulating an eye shaped structure and are further enclosed by cryptomelane of later generation (Fig. 5F).

Texturally, the recemented types under microscope look more or less alike. In recemented - I, laminated martite/hematite minerals are found enclosed within tetravalent manganese oxyhydroxides (Fig. 6A). The primary magnetites are magnetised to...
hematite with remnants of the former (Fig 6B). The primary iron ore invariably show lamination, occurring either as alternately laminated martite shales or martite hematite. Isolated grains of martite are often seen enclosed within clay matrices (Fig 6C). Though cryptomelane occurs as major secondary infillings, it is often oxidised radiating / mosaic / fan shaped pyrolusite crystals, occasionally showing segmented twinning. Thin maganite veins sometimes travers across the ooliths. Manganese imregnation and cementation occur as colloform, concentric and very fine grained masses while secondary Fe-infillings often grow as tiny specularite grains (Fig 6F).

Table - 2

| Trace elements concentration in different morphological varieties/sub-varieties of manganese ores. |
|---|---|---|---|---|---|---|
| Elements | Spongy | Platy | Recemented-I (canga) | Recemented-II (agglomerate) | Recemented-III (mangerelite) | Massive |
| Sb | 0.4 | 0.4 | 0.9 | 1 | 0.3 | 0.9 |
| As | 14.8 | 24.2 | 31.2 | 55 | 15.3 | 15.7 |
| Cs | 0.1 | 0.1 | 0.1 | 10 | 1.1 | 0.2 |
| Cr | 81.9 | 18.2 | 41.4 | 93 | 38.7 | 75.7 |
| Co | 44.4 | 34.33 | 102 | 323 | 347 | 364.4 |
| Cu | 394 | 776 | 37 | 125 | 275 | 237.4 |
| Ga | 74 | 397.5 | 10.3 | 67 | 66.8 | 98.1 |
| Pb | 135.5 | 161.9 | 74.7 | 137 | 36.9 | 45.1 |
| Li | 185.9 | 249.1 | 3 | 12 | 74.6 | 3.9 |
| Mo | 30.3 | 55.6 | 13.9 | 5 | 34.1 | 34.6 |
| Ni | 532 | 530 | 11 | 27 | 269 | 29.1 |
| Nb | 1.6 | 2.1 | 5.9 | 1 | 5.9 | 0.4 |
| Sc | 10.7 | 10.7 | 10.3 | 22 | 8.5 | 2 |
| Sr | 6 | 111 | 33.4 | 159 | 264 | 295.6 |
| V | 37.9 | 31.9 | 65.3 | 56 | 53 | 39.2 |
| Y | 30.1 | 22.2 | 5.1 | 12 | 34.8 | 75.8 |
| Zn | 424 | 1017 | 46.7 | 84 | 332.7 | 164.1 |
| Zr | 6 | 7.9 | 68.6 | 20 | 33.9 | 2 |
4 Massive: It is hard and compact showing massive form. Major minerals recorded are pyrolusite and cryptomelane (Fig 4). The massive ore develops when primary Mn-ores are replaced by dense secondary Mn-phases that overprints primary structure and texture.

GEOCHEMISTRY

The lateritoid manganese deposits are generally of low-grade type. The MnO₂ content between different morphological varieties and from boulder to boulder varies within wide limits and so also Fe₂O₃, Al₂O₃, and SiO₂ (Table - 1). The Mn/Fe ratio in the varieties is thus variable. For instance, in recemented ore varieties a decreasing trend of Mn/Fe from canga (R-I 0 09) to agglomerate (R-II 0 70) to mangcrete (R-III 3 02) is recorded. This supports the mineralogy of the recemented ores - canga consisting solely of Fe-clasts, agglomerate containing both Fe-clasts and Mn-pisoliths and the mangcrete having only Mn-pisoliths. The other morphological varieties show higher Mn/Fe ratios. A higher concentration of P₂O₅ (0 96%), which might have been adsorbed in clay minerals, is recorded in spongy ores (19 3% Al₂O₃ & 20 3% SiO₂). BaO and K₂O show lower concentration values in general (Table - 1).

The distribution of trace elements like Co, Cu, Ni, Zn & Sr show an increasing trend among the recemented types - canga to → agglomerate --> to mangcrete (Table - 2). A higher abundance of Co (0 3%) and Zn (0 1%) is recorded in the platy variety. The Ni is relatively rare except the platy and spongy varieties.

All the morphological varieties are greatly depleted in LREE and HREE excepting platy variety (Table - 3) that shows some appreciable value of Ce (360 ppm). The chondrite normalised REE values do not show any common pattern. The massive, and canga varieties show -ve Ce anomaly while other varieties show +ve Ce anomaly. The normalisation pattern (Fig 7) reveals that HREEs are least fractionated during their deposition particularly the HREEs.

GENESIS

Similar to Nickopol (USSR) and Groote Eylandt (Australia), the manganese ore deposits of Bonai-

<table>
<thead>
<tr>
<th>Elements, ppm</th>
<th>Spongy</th>
<th>Platy</th>
<th>Recemented-I (canga)</th>
<th>Recemented-II (agglomerate)</th>
<th>Recemented-III (mangcrete)</th>
<th>Massive</th>
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<tbody>
<tr>
<td>La</td>
<td>36 3</td>
<td>28 4</td>
<td>24 4</td>
<td>30</td>
<td>28 6</td>
<td>83 7</td>
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<tr>
<td>Ce</td>
<td>142</td>
<td>358 1</td>
<td>41 4</td>
<td>125</td>
<td>159 4</td>
<td>24 9</td>
</tr>
<tr>
<td>Pr</td>
<td>9 8</td>
<td>13 4</td>
<td>6 1</td>
<td>10</td>
<td>8 9</td>
<td>15 4</td>
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<tr>
<td>Nd</td>
<td>35</td>
<td>43 7</td>
<td>19 9</td>
<td>33</td>
<td>30 4</td>
<td>58 1</td>
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<tr>
<td>Sm</td>
<td>9 1</td>
<td>11 1</td>
<td>4 7</td>
<td>9</td>
<td>7 3</td>
<td>14 7</td>
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<tr>
<td>Eu</td>
<td>3 5</td>
<td>4 4</td>
<td>1 1</td>
<td>3</td>
<td>2 7</td>
<td>6</td>
</tr>
<tr>
<td>Gd</td>
<td>13 4</td>
<td>19 3</td>
<td>3 6</td>
<td>7</td>
<td>9 4</td>
<td>26</td>
</tr>
<tr>
<td>Tb</td>
<td>1 5</td>
<td>1 2</td>
<td>0 3</td>
<td>1</td>
<td>1 1</td>
<td>5</td>
</tr>
<tr>
<td>Dy</td>
<td>8 2</td>
<td>2 7</td>
<td>2 5</td>
<td>5</td>
<td>7 9</td>
<td>25</td>
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<tr>
<td>Ho</td>
<td>1 4</td>
<td>1</td>
<td>0 3</td>
<td>1</td>
<td>1 9</td>
<td>8 8</td>
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<td>Er</td>
<td>3 9</td>
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<td>0 7</td>
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<td>Tm</td>
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<td>Yb</td>
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<tr>
<td>Lu</td>
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<td>1</td>
<td>0 6</td>
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</table>
Keonjhar belt of Eastern India were probably deposited in a shallow marine environment and primarily represent manganiferous strata (stratiform) associated with iron-ore shale.

The secondary manganese ores of stratabound-replacement type are gradually evolved in a fresh water environment through resolution and remobilization of Mn-Fe constituents from multiple sources and its reprecipitation in the I O G shales within suitable structural locales (shear zones, weak planes etc.)

However, lateritoid ore bodies owe their mode of origin to widely different environment and secondary processes. In the development of supergene ores of Groote Eylandt Mn-deposit, Australia, Ostwald (1976) and Bolton (1982) considered secondary processes as responsible while Princeps (1986) emphasized on extensive lateritisation. Varentsov (1982) believes that the supergene ores of Groote Eylandt are formed as a result of reworking of pre-existing weathering crust. Princeps et al. (1988) have discussed the transport and precipitation processes in development of supergene Mn-deposits of Groot Eylandt. Before commenting on development of lateritoid Mn-ores of Bonai-Keonjhar belt it would be worth highlighting in brief the following significant observations made on these categories of ore bodies:

1. Deep and large-scale lateritisation often extending beyond 30m depth.
2. Presence of thin sub-horizontal to curvicular pebble zones below 20 m depth indicating old erosional surface.
3. Bouldery nature of ore bodies.
4. Diversified morphology of ores, viz, spongy, platy, recemented, massive varieties.
5. Difference in physical appearance of ore varieties despite their broadly similar mineralogy.
6 Wide compositional variation from boulder to boulder, some being considerably rich in iron

7 Significant difference in chondrite-normalised REE patterns between morphological varieties

Considering the above and inferences drawn thereof, the proposed sequential development stages of lateritoid ore bodies in the belt may be suggested as follows

i Initiation of subsidence of basin consequent to tectonism/folding of IOG rocks in this region

ii Resultant large-scale lateritisation of existing manganese and iron formations

iii Mechanical disintegration and erosion of pre-existing crust i.e. iron and manganese ores from higher horizons

iv Intensive leaching of Mn/Fe bearing rocks/ores

Leaching of manganese into solution, necessary in the formation of supergene manganese deposit is described in detail (leaching at low pH, electrochemical reaction between Fe and Mn, reduction under the influence of bacteria etc) by Pracejus et al (1988) for Groote Eylandt Mn-ores, Australia. Similar processes might have been effective in dissolution of manganese in to solution in the study area. The dominant process for the dissolution of Mn-oxides was probably the redox reaction between divalent iron and tetravalent manganese. However, the entire gamut of dissolution and depositional processes continued for a fairly large duration, over repetitive phases.

The Mn-carrying solution percolates both laterally and vertically slowly through openings in laterites and ores and move on cracks and weak planes

v Precipitation of remobilized Mn/Fe-rich solution followed by cementation of primary Fe-rich clasts and other Mn-ooliths/pisoliths either independently or together depending on their availability.

The Mn-rich solution may precipitate by several processes (Pracejus, et al, 1988) but in the present set-up dehydration and subsequent exudation seems to have influenced the most. Such process was most effective as evidenced by wide spread cementation of ooliths and pisoliths besides the presence of shrinkage cracks etc. During dehydration, shrinkage cracks develop which are often filled with younger massive or needle like Mn-phases.

vi Fragmentation of recemented ores into large boulders followed by their short-distance lateral and vertical transport into adjacent basin during terrain evolution

v Deep burial of manganese / iron-rich boulders beneath thick sub-recent to recent lateritic cover and development of present topography

CONCLUSIONS

Summarising all the characteristic features of lateritoid manganese-ore bodies of Bonai-Koonjar belt of Orissa, the following conclusions may be drawn in support of their formation.

The lateritoid manganese ore bodies are of allochthonous nature.

Such manganese ore bodies are mostly of low-grade type and formed during post lateritisation period of terrain evolution. Secondary processes such as reworking of pre-existing crust, remobilisation & solution, precipitation & cementation and transport etc are responsible for the development and spatial disposition of such type of ore bodies.

The lateritisation/supergene processes may mask the primary ore (pre-existing crust) to a great extent and it becomes difficult to identify primary structures as new morphological varieties develop. Though broad mineralogical composition remains more or less same, some secondary minerals like specularite, mangante, lithiophonte and chalcopyrite appear in newly formed morphological types.
The present day landform is developed due to deep burial of large Mn-/Fe-rich boulders blanketed by thick sub-recent to recent soil/latentic covers.

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Classification of Manganese ore bodies in parts of Bonai-Keonjhar belt of Orissa and its implications in evaluation of their resource potential

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Tabular manganese ore bodies scattered within Jone’s horse-shoe shaped synclorion in Bonai-Keonjhar region of Orissa is well known in the mineral map of India. Different grades of manganese ores are being exploited by various agencies over a few decades. However, deceptive nature of ore bodies and complexity in control of mineralisation greatly confuse the exploration geologists for evaluation of these resources.

In a recent study, the authors have classified Mn-ore bodies of this region into three broad categories such as stratiform, stratabound-replacement and lateritoid types. These ore bodies when mapped together reveal their alignment to both NNE-SSW and ESE-WNW trends. These are the results of two successive phases of deformations, thereby developing a series of doubly plunging antiformal and synformal folded structure. The occasional discontinuity of the ore bodies is releagable to faulting. Mn-ore bands occur in close association with iron ores in the valley region and often encountered below or above iron ore bodies.

In stratiform category of ore bodies, manganese and shale bands, in variable thickness, alternate with each other being of primary syngenetic origin. Such ore bodies (Kusumdih, Maidan etc) generally constitute low to medium grade ores though extend up to a great depth. However, leaching on local-scale may result pockets of powdery ore that may have enriched Mn-values.

The stratabound-replacement types of ore bodies are of epigenetic origin and of intrasratral nature within shale. These are mostly shear controlled ore bodies (Dolki, South-B), extend along a zone of certain width and contain higher oxides of Mn-minerals. Ores exhibit both cavity filled and replacement textures and usually

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consists of medium grade ores. Some of these are partially silicified (Shankar) or highly silicified, appearing like reef quartz (Spencer). Partially silicified zone contains brecciated Mn-ore (low to medium grade). Highly silicified zone is underlain by a fairly continuous high-grade Mn-ore horizon (Dhaba).

The Mn-ore bodies of lateritoid category are of supergene nature, limited depth persistency and mostly of low-grade types. Often large drifted boulders are seen below 50mt depth in Mn-mines (Orahari), which may be rich in iron content. Occasionally, small Mn-rich pockets occur within such low-grade ore bodies to the great relief of mine owners.

Some of the major Mn-ore bodies in whole valley region have been classified into above categories and probable potential of these resources is discussed in the paper.
VISTAS IN GEOLOGICAL RESEARCH

ENVIRONMENTAL MANAGEMENT
FOR
SUSTAINABLE MINERAL DEVELOPMENT

February 2004

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Utkal University, Bhubaneswar
UPGRADATION POTENTIAL OF LOW GRADE MN-ORES OF BONAI-KEONJHAR REGION FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT

High to medium grade ores of Bonai-Keonjhar region, Orissa are getting depleted. Though low-grade ores are abundantly available, these are usually considered as waste thus creating both disposal and environmental problems. For sustainable development of such huge low-marginal grade resources, these need beneficiation to be utilised in ferromanganese industry. The paper reports the upgradation potential of three such low-grade Mn-ores of this area.

Three types of low-grade Mn-ores, viz. siliceous-crystalline/siliceous-amorphous, ferruginous/lateritic and aluminous types were studied to know their susceptibility to Mn-enrichment and utilisation potential. The morphological examination, x-ray diffraction study and magnetic separation study of these types were undertaken. Of these three ore types, siliceous crystalline variety is low in Mn (26%) and Fe (<3%) but gets upgraded to 44-46% Mn with 62 to 67% recovery, and thus can be converted to ferromanganese grade. However, in case of siliceous amorphous/cherty type, the fine microsilica inhibits liberation of Mn-phase and hence though Mn enrichment from 17% to 36% is possible, around 42% of SiO₂ still is left back, thereby restricting its further use. In ferruginous manganese ore type (alumina poor) though Mn content enhances from ~18% Mn in the feed to 24% Mn in the final product with ~57% recovery, it also gets substantially enriched in Fe (20 to 28%). The lateritic Mn-ore containing Mn (18%), Fe (26%), SiO₂ (~13%) and Al₂O₃ (~23%), does not respond to any physical beneficiation technique. In the third type i.e., the aluminous Mn-ore, the alumina content can be reduced by scrubbing/hydrocycloning but when this washed product is subjected to further processing by magnetic separation no encouraging result was obtained.

Thus, only the siliceous type of low-grade Mn-ore, the crystalline variety in particular, of the area is found to be most potential and hence must be processed for better and most cost effective utilisation.