Nanometer Thick Microplaty Hematite in Indian Iron Ores: Its Implication on Washing

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ABSTRACT: Occurrence of nanometer to submicron thick microplaty hematite in the iron ore of eastern India is reported for the first time. High grade soft laminated ore and biscuity ore contain randomly oriented microplaty hematite along porous lamellae and pseudo-foliation planes. These microplaty hematites have a thickness of 70 nm to 500 nm or more. The thicker ones also show cleavage planes within, indicating the possibility of generating nanometer thick flakes. These microplaty hematites bridge the lamellae/laminae and interlamellar zones providing strength to the ore. On gentle tapping or by scrubbing with water, the ore breaks to fragments and fines of free microplaty hematite. On washing, the microplaty hematite grains get liberated and washed out to fine fraction of -150 μm. It results in the fines of higher grade and low alumina in comparison to the associated lumps. It carries importance in the washing circuits using such ore types as feed.

1. INTRODUCTION

It is a well known fact that magnetite, martite/hematite, goethite constitute the ore component and associated quartz, kaoline and gibbsite constitute the gangue component in the iron ore. These limited numbers of ore minerals occur in wide range of association and texture, characteristic to the complex geological and geochemical history of the ore deposit (Morris, 1985; Morris, 1986; Morris, 1987; Morris,1993; Li et al., 1993; Webb et al.., 2002; Clout, 2003; Pires, 2003; Beukes et al., 2003). The present work reports the discovery of nanometer to sub micron thick microplaty hematite for the first time in the ore of eastern India, its association and behaviour in the washing.

2. IRON ORE IN EASTERN INDIA

Iron ore deposit of Bonai-Keonjhar-Singhbhum area is one of the important source for the iron industries in eastern India. It belongs to the Ironore Group in the Singhbhum craton of Precambrian age (Krishnan, 1954; Chakraborty and Majumdar, 1984 and references therein). The ores are broadly classified as massive ore, biscuity ore, hard laminated ore, soft laminated ore, lateritic ore, powdery ore, blue dust etc. based on their physical attributes. The deposit is indicated as supergene modified hydrothermal type with friable saprolitic ore derived from a precursor 'hydrothermally altered iron ore formation', successively enriched by supergene activity and subsequently altered to the present state (Beukes et al., 2003). They are comprised of dense martite, microplaty hematite, vitreous goethite, colloform goethite and closely associated gangue minerals such as quartz, kaolinite and gibbsite.

3. METHODOLOGY

The high grade iron ores from Singhbhum-Keonjhar belt were selected based on their megascopic features and physical attributes. The laminated ore was observed at various magnification by zoom stereo microscope, polarization microscope and some fragments by Table top microscope TM1000, Hitachi make. Table top microscope provided back scattered electron image at very high magnification up to 10000X. The image was studied by QWIN image analysis system, Leica make, and the dimension of the microplaty hematite was measured. The ROM sample was subjected to size analysis and washing.

4. OBSERVATION

4.1 Mineralogy

Majority of the high grade ores contain dense martite, microplaty hematite and their altered variant goethite. The low grade ore is dominantly of colloform goethite associated with kaolinite, gibbsite, detrital quartz and goethitic nuggets. Amongst the ores of high grade, there exists is a spectrum of transitional ore types between massive ore, hard laminated ore, soft laminated ore, biscuity ore and powdery ore and altered with varied degree of porosity and development of microplaty hematite. The microscopic observations show that the laminae donot carry sedimentary characteristics but are the zones of varied degree of microporosity. Microporous zones are comprised of randomly oriented microplaty hematite of various dimension with intergranular pore spaces of micron size (Figure 1). As the microporosity and pore size increases, the zone appear as weak pseudo-foliation plane along which the ore cleaves. These foliations exhibit neither any compositional difference nor mineralogical difference nor any structural features of preferred grain orientation, and hence are cited as pseudo foliations. Along the grain boundary and surface of these microplaty hematites, a later generation microplaty hematite has grown randomly through intergranular pore space and bridged the coarser grains (Figures 2 & 3). These later generation microplaty hematites are of nanometer thick ranging from 70 nm to 120 nm and as high as 500 nm and more. The lateral dimension was found to be 1-3 μm (Figure 3). The submicron thick microplaty hematites also exhibit cleavage and may be potential precursor of such nanometer thick hematites. On gentle tapping of air dried samples, these minerals escape out as powdery grains.

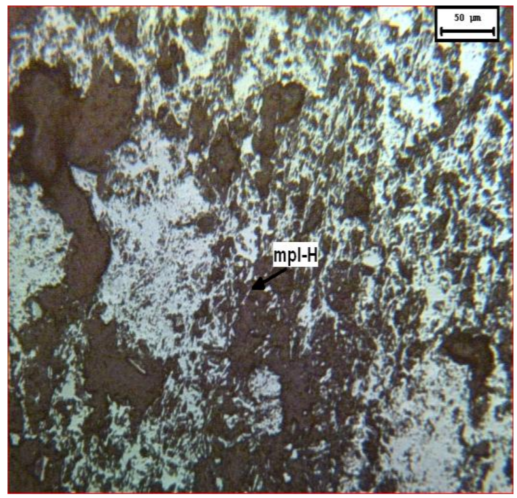

Fig. 1: Microplaty hematite (mpl-H) in high grade soft laminated ore with pores and voids (dark grey colour) under reflected microscope. The network of these micron sized grains provides a support to the porous ore structure. The length of scale is 50 μm.

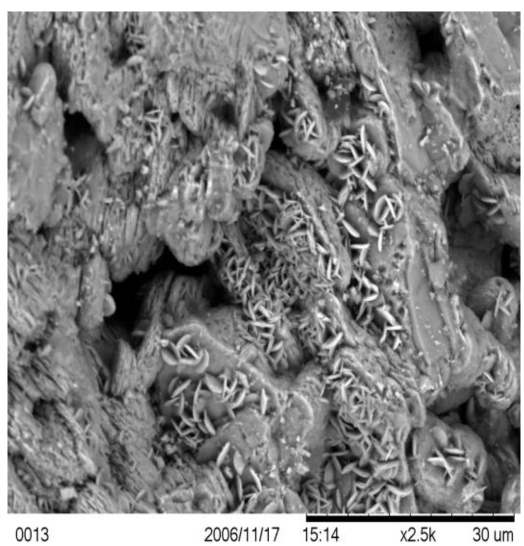

Fig. 2: Nanometer thick microplaty hematites (later generation) grown over the microplaty

hematite of earlier generation along the pore space as observed under electron microscope at 2500X magnification. Length of scale is 30 μm.

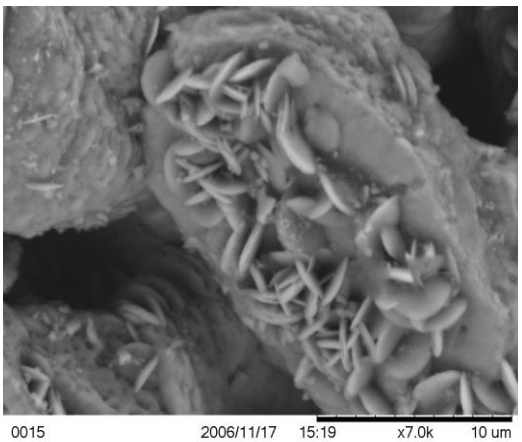

Fig. 3: Nanometer thick microplaty hematites of dimension ~3 μm under electron microscope at 7000X magnification. These minerals crystallize over the surface of larger microplaty hematite (~20 μm) . Length of scale is 10 μm.

4.2 Study on Washing

The high grade biscuity ore is more fragile than the soft laminated ore and often generates powder on drying. The size distribution shows that biscuity ore contains about 19 wt% and 13 wt% of grains in the size class '-74+44 μm' and '- 44 μm' respectively. The grains in these size classes are dominantly of microplaty hematite. It is expected that washing would remove these minerals to a finer size fraction. The study of washed products from high grade ROM soft laminated ore and high grade ROM biscuity ore shows that there is a significant release of hematite in the finer fractions (e.g., in the size class smaller than 150 μm). It is also corroborated by low silica and alumina content (both 0.7 wt%) in finer size fractions in comparison to that in larger size fractions.

5. DISCUSSION

The nanometer thick microplaty hematite of the eastern India is comparable in the mode of occurrence with the nanometer sized nanoplaty hematite in the Australian iron ore, as reported by Trudu etal (2004). The latter is comparatively of smaller size, higher toughness and is different in colour. The microplaty hematites of 1-3 μm size and 70-120 nm thickness as observed in this study is much smaller than the lower limit of size (150 μm) usually considered in mineral processing. Even the sub-micron thick grains may also break down to nanometer thick grains by cleaving along the cleavage when subjected to gentle tapping or minor stress like hydrostatic stress in mineral processing. Washing of such ores would release these nano and submicron sized mineral as ultrafines or slimes. This is also reflected in the washed products of high grade biscuity ore (Rath et al 2006). The -150 μm fraction is rich in iron and low in alumina and silica in comparison to the lump fraction.

6. CONCLUSION

The high grade iron ore from the eastern India contain nanometer thick microplaty hematite, which is reported for the first time. Its mode of occurrence, texture and grain size may have a negative implication in the washing circuit of mineral processing. The ores associated with this component should be given special attention to in the process circuit.

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