Petrographic Analysis of Brecciated Iron Deposit (BID) of Bonai-Keonjhar Iron Ore Belt of Odisha, India

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Abstract: ***Brecciated iron ore deposit (BID) is well demarcated in the majority stretch of bedded type of iron deposits of Bonai-Keonjhar iron ore belt (BK belt). Khandbandh, Thakurani, Banspani are some of the localities where brecciated iron deposits occurs exclusively or along with Banded Iron Formation (BIF). BID lithounit constitutes fragments of hematite, BHJ and shale of different size and shape cemented by mostly iron rich matrix. BID is syngenetically formed by the random arrangement of clasts generated during the time of sedimentation-lithification of iron formation. Clasts are oriented and cemented by hematite matrix in the buffer area where they are produced by breaking down of banded iron formation at its early stage of deposition. Formation of BID may be due to the localized disturbances in depositional environment facilitating concurrent fragmentation of iron formation with sedimentation. In this paper petrographic analysis of BID are carried out megascopically and microscopically supported by X-ray Diffractometer (XRD).***

Keywords: Bonai-Keonjhariron ore belt (BK belt), Brecciated iron ore deposit (BID), Petrography, Odisha

1. Introduction

The Bonai-Keonjhar iron ore belt (BK belt) is known for its rich deposits of high-grade hematitic iron ore, primarily consisting of Banded Iron Formation (BIF). This region also consists of distinct occurrences of brecciated and detrital iron deposits as limited dispositions. Brecciated iron deposits (BID) are well observed in localities like Khandbandh, Thakurani and Banspani which occur either exclusively or along with BIF. Khandbandh area, located on the eastern side of the 'U'-shaped Bonai-Keonjhar synclinorium in the Keonjhar district of Odisha, is predominantly occupied by BID. Mining activities of brecciated iron ores are going on at Khandbandh iron ore mines by TATA STEEL Company.The area comes under the Survey of India Toposheet no.73 G/5 and 73 F/8, lying between the North Latitude 21°55′0″- 22°10′0″and the East Longitude - 85°22′30″- 85°27′30″. The litho-assemblages in this area are mostly un-metamorphosed and devoid of intrusive formations. Brecciated iron deposits are completely consisting of hematite fragments in brecciated forms with lesser amounts of BHJ and shale that vary in shape and size. They are formed syngenetically having the breccias being cemented by contemporaneously supplied hematite matrix. Clasts in BID are randomly settled and lithified with planar or cross-sectional sections observable in various directions. Petrographic analyses of these deposits have been done by both megascopic, microscopic and X-ray Diffractometry (XRD) examinations.

2. Geology

The Khandbandh brecciated iron ore deposit is located in the eastern limb of Bonai-Keonjhar iron ore belt of Keonjhar district of Odisha (**Figure 1**). The Bonai-Keonjhar belt, designated as BIF-III occupies a distinct 'U'-shaped pattern in the western flank of the North Odisha Iron Ore Craton (NOIOC) that rests over the Dhanjori Quartzite [1], [2]. This Precambrian iron ore group (IOG) largely contains BIF in addition to the other volcano-sedimentary rocks forming a significant portion of the Singhbhum–North Orissa Craton of eastern Indian shield [3]. The litho-associations of this area form the youngest Iron Ore Group in the Iron Ore Supergroup (IOSG) of Odisha and named as BIF-III [4], [5], [6]. Various names have been given to this belt such as Barbil Group [7], Koira Group [8] and Khandadhar group [9]. The IOG in addition to BIF also contains other rock units like two generations of shales, tuffs that underlie or are interlayered with BIF. The litho-associations of this area comprise of banded hematite jasper, banded hematite quartz/chert, banded shale, banded manganese formation and ferruginous shale. The brecciated iron deposit occurs as small horizons in discontinuous manner along with hard, massive iron formation. BID consists of predominantly iron oxide minerals hematite along with martite, specularite and silica. The litho-assemblages of this youngest iron ore belt are un-metamorphosed and lack of intrusives.

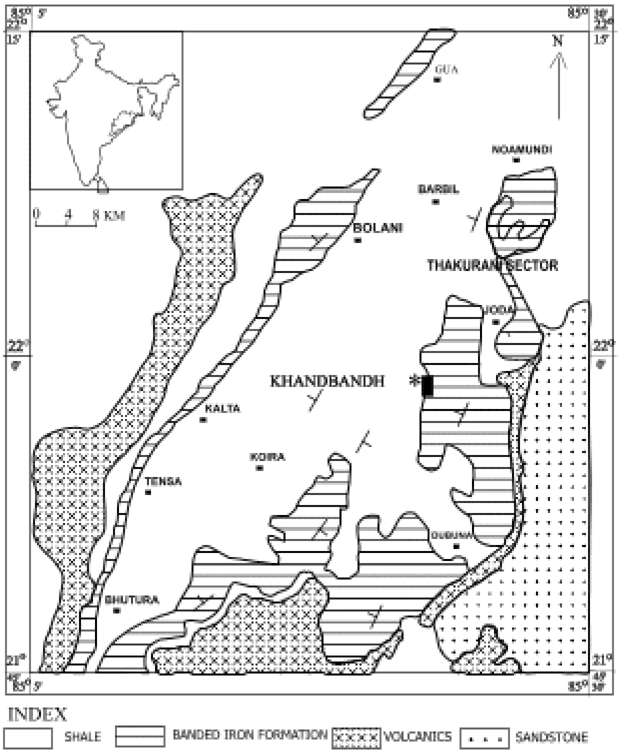


Figure 1: Generalized Geological map of BK belt [10], [11] showing the study area Khandbandh brecciated iron deposit

3. Morphology

The brecciated iron deposit occurs abundantly with limited extensions in Khandbandh area. It consists of pebbles/cobbles of hematite or hard laminated iron ore. At some places cobble to boulder size banded iron formation (BHJ) pieces are cemented to form the brecciated ore bodies. In syngenetically formed brecciated iron deposits cementing material is mostly hematite and clasts are arranged with the planar or cross sectional section in different directions (**Figure 2A** and **Figure 2B**). While in case of transported clasts, the cementing material may be laterite or goethite/hematite. Such type of matrix is also seen in altered brecciated iron deposits (**Figure 2C**). Matrix comprising of clay or silt is not often found in the area. The cementing/matrix material might have been produced and supplied from source ore bodies (bedded) and/or transported clasts. When the clasts are produced from broken down BIF bands and cemented, they are called as intraformational breccias (**Figure 2D**). At few places, shale fragments are present and cemented along with hematitic pebbles to form BID (**Figure 3A**). In some brecciated iron ore, it is also observed that the fragments comprise of BIF, hematite and rounded iron pebbles (**Figure 3B**).

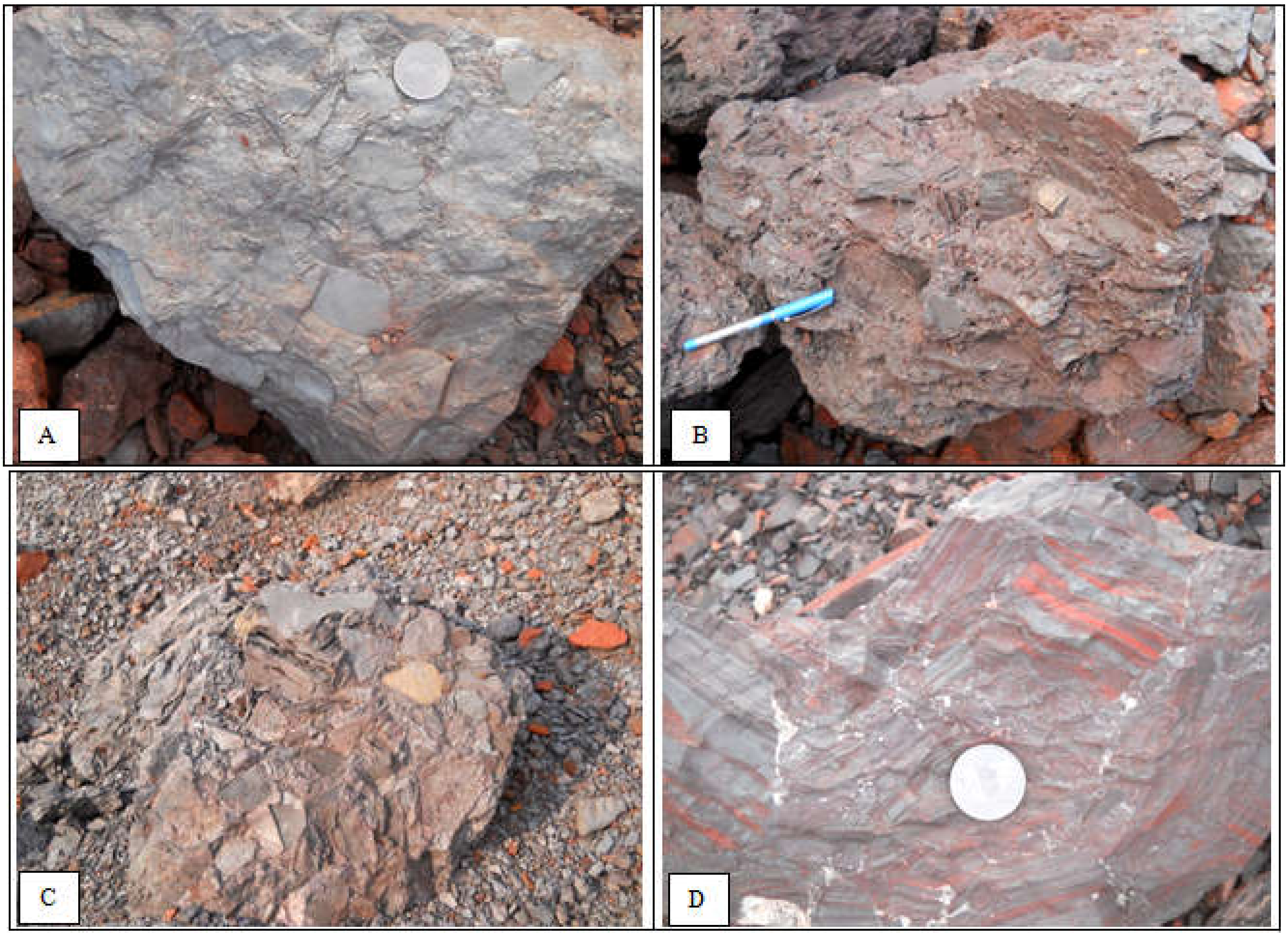


Figure 2: Field photographs of Brecciated type iron ore of Khandbandh area showing

A. Syngenetically formed hematite breccias are bonded by hematite matrix whose planar surface are settled in one direction
B. Hematite breccias in laminated form arrested in the matrix comprising hematite, goethite and silica

C. Hematite clasts of nearly uniform size in iron matrix
D. Intraformational breccias formed by broken BIF bands

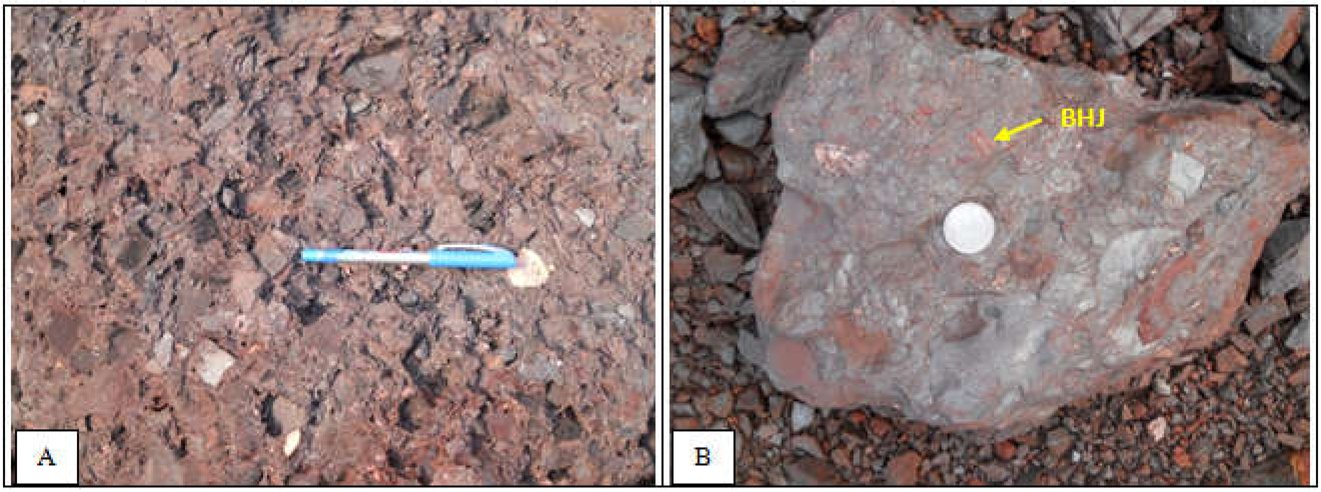
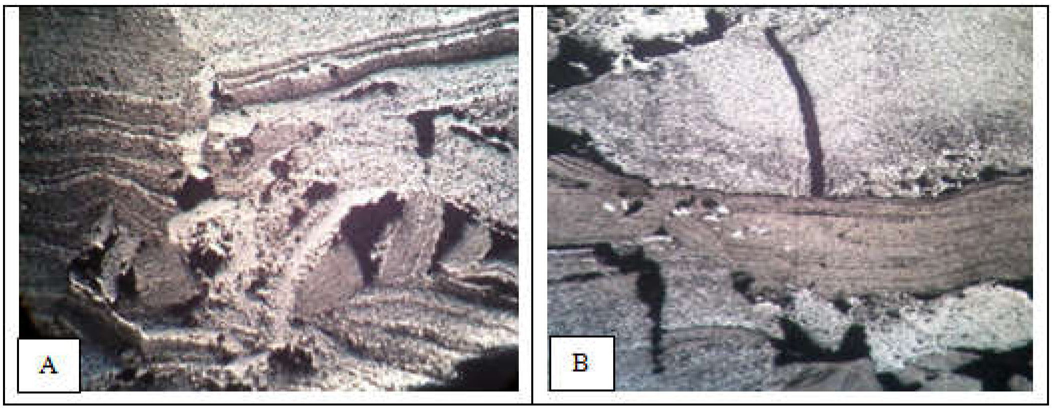


Figure 3: Field Photographs of BID illustrating
A. Shale clasts are cemented along with hematite pebbles
B. Fragments of BIF, hematite and rounded pebbles of hematite embedded in iron matrix

4. Petrography

Micro-morphological characters of a number of polish sections of brecciated iron deposit of the study area were studied for under the optical microscope. Both components, breccia and matrix are found to be hematite. In a network of supply-sedimentation-lithification process of iron material, the layers/bands were broken down to breccias in a disturbed milieu and got cemented by the same iron material while remained floating in the hydro-plastic stage (**Figure 4A**). In some instances bands of hematite as well as BHJ are broken due to load pressure and sagging (**Figure 4b and Figure 4C**). The fragmentation process continues, while the sedimentation process runs (**Figure 4D**). In the later stage they have been undergone recrystallization, martitisation and goethitisation processes to form other minerals. The degree of disturbance and viscosity of hydroplastic base determine the position, orientation and concentration of clasts in BID.

Broken-down hematite fragments of different shapes, sizes, and angularities attain granular status, with intergranular spaces filled with already supplied material like hematite, silica, or their recrystallized altered products (**Figure 5A**). The arrangements and sorting of the clasts in BID are irregular and ill respectively (**Figure 5B**). Mostly the fragments occupy the nearby area where they are degenerated from the bedded or layered masses. Some clasts of folded geometry remain in juxtaposed with non-folded bands attest penecontemponeous non diastrophic features produced simultaneously with sedimentation (**Figure 5C**). Large fragments of banded hematite jasper embedded within the small clasts of hematite indicate differential load/stress bearing capacity between them (**Figure 5D**).



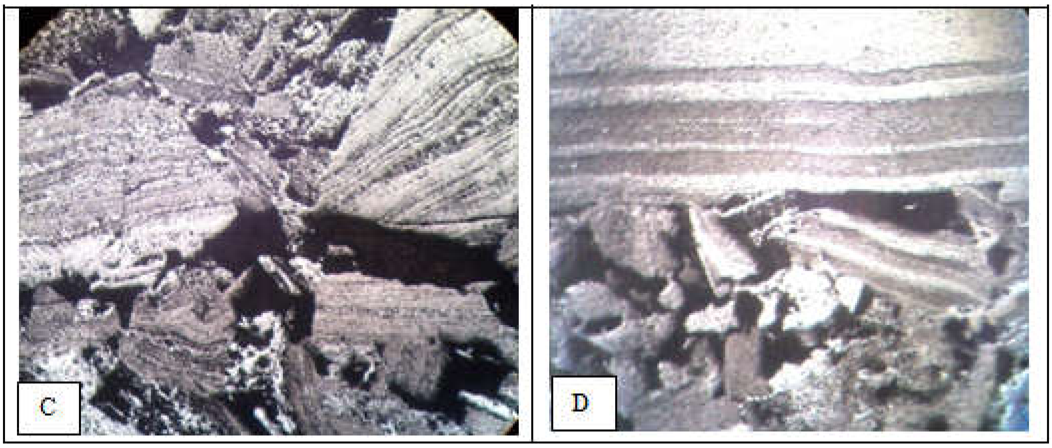


Figure 4: Photomicrographs of brecciated iron ore showing (X 10)

A. Initiation of fragmentation in a disturbed depositional environment
B. Fragmentation of hematite masses by pull apart process due to dehydration
C. BIF bands are collapsed and sagged in the process of producing clasts
D. Simultaneous deposition and fragmentation of BIF clasts

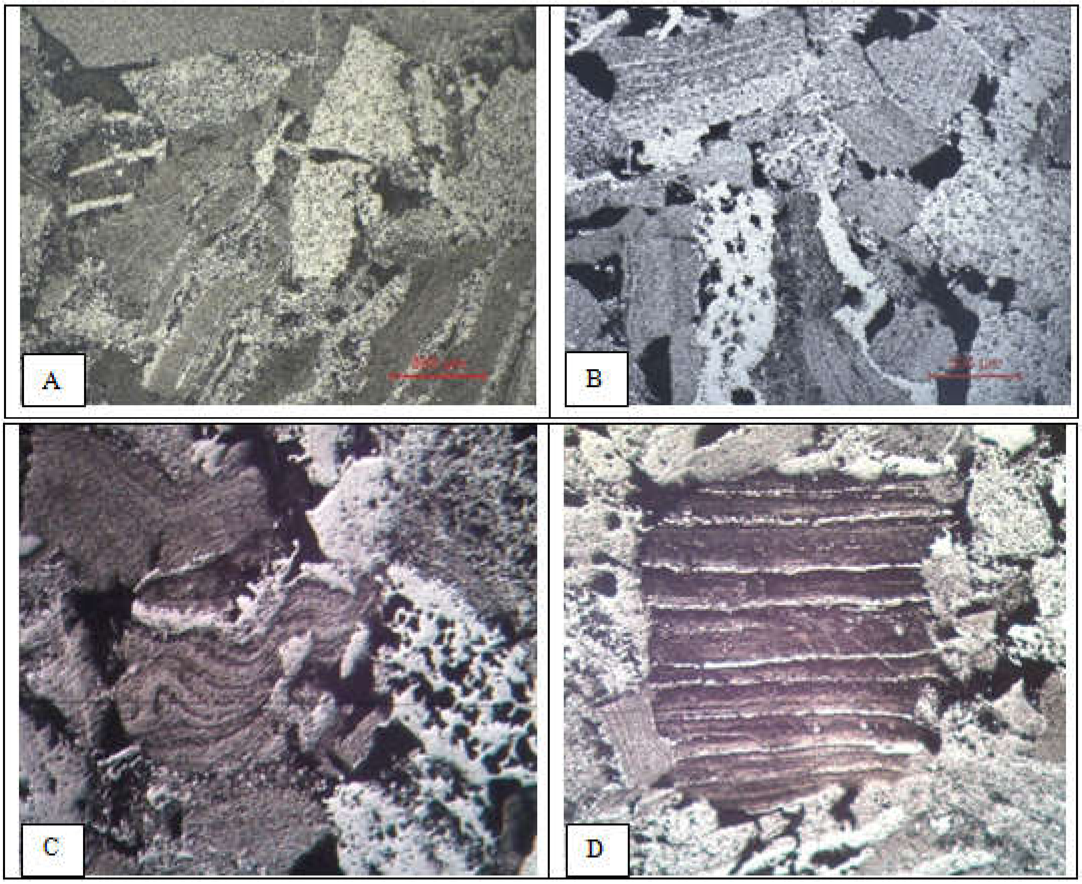


Figure 5: Photomicrographs of brecciated iron ore showing (X10)

A. Hematite fragments take on a granular form with angular shape
B. Hematite fragments of uneven sizes with ill sorting in matrix
C. Folded clasts suggest a non-diastrophic process that occur concurrently with sedimentation
D. A large piece of banded hematite jasper is surrounded by smaller hematite clasts

4.1 X-Ray Diffraction Studies

The X-ray diffraction study (XRD) has been done for identification of various mineral phases. XRD study shows that hematite is the major mineral phase of BID in

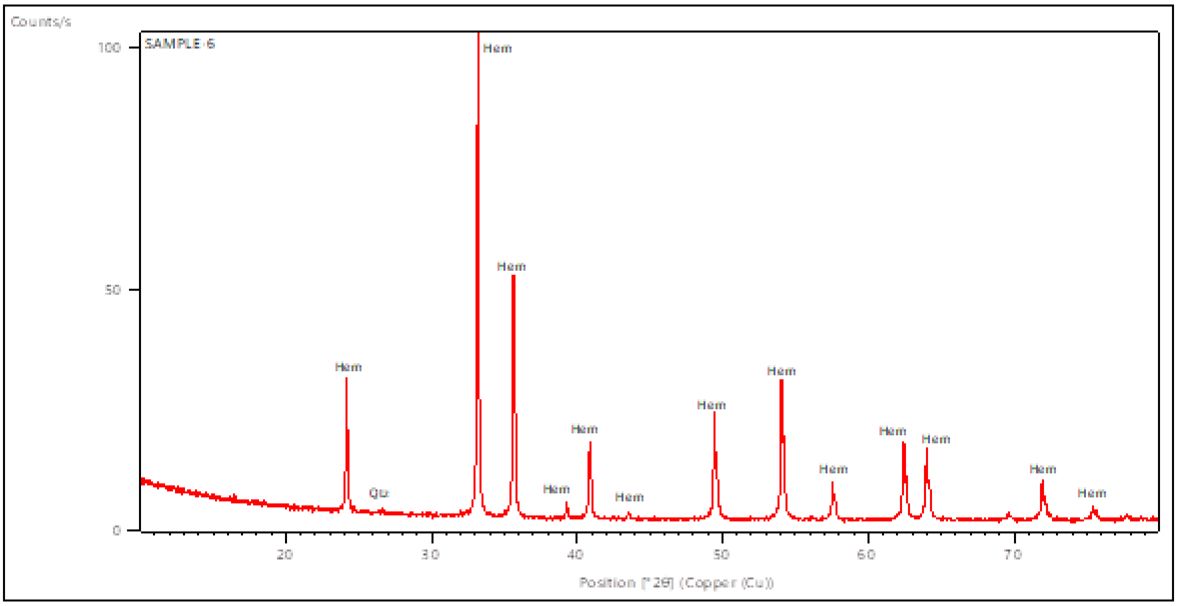


Figure 6: X-Ray Diffraction graph showing different mineral phases present in BID of Khandbandh area

Khandbandh area with quartz as minor mineral **(Figure 6)**. The identified mineral phases of brecciated iron ores in study area is presented in **Table 1.**

Table 1: Mineral Phases in BID

Mineral phases identified	
Major	Hematite
Minor	Quartz

4.2 Modal Analysis

Modal distribution of minerals in the Khandbandh area shows that hematite occurs as a major constituent with a minor amount of quartz, Goethite. Kaolinite and gibbsite contribute very little, occurring in scattered patches. Martite and magnetite are found in traces. The approximate modal distribution of minerals in BID of Khandbandh area is given below in **Table 2**.

Table 2: Modal distribution of minerals in BID of Khandbandh area

Minerals	Approximate (%)
Hematite	90-95
Quartz	3-4
Goethite	1-2
Kaolinite	1-2
Gibbsite	~1
Martite	Traces
Magnetite	Traces

5. Conclusion

The brecciated iron deposit in the Khandbandh area co-exists with banded iron formation and iron ores, which maintains the same stratigraphic level in the eastern limb of the Horseshoe synclinorium. In BID, breccias/clasts are not erosion driven instead they arise from environmental disturbances specific to its depositional site. The simultaneous formation of clasts and sedimentation underlines a cohesive process of accumulation and cementation at the same location, utilizing homogeneous materials. Consequently, the matrix predominantly comprises hematite, same as the embedded fragments. The presence of rounded pebbles of iron and shale within the BID, interposed among the hematite clasts, is indicative of transport from proximate areas. These observations collectively affirm that the formation of brecciated iron ore in this region was a contemporaneous event, without significant variation in the environmental conditions of deposition.

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