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Structural Implications and Mineralization of Iron Ore around Pur-Banera, District Bhilwara, Rajasthan (India)

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Abstract

The Pur-Banera Belt, located in the Bhilwara District (Rajasthan), is one of the most prominent iron ore deposits that form a part of the Bhilwara Supergroup. The Belt is trending in NE-SW direction. The major litho-units of the area are Conglomerate, Garnetiferous Mica-schist, Calc-schist, Amphibolite, Calc-gneiss, Calc-silicate marble, Banded Iron Formation [includes Banded Hematite Quartzite (BHQ), Banded Magnetite Quartzite (BMQ)], and Carbonate Rocks with associated sulfide mineralization.

The structural relationships of the Pur-Banera supracrustal rocks, (i.e quartzo-feldspathic gneisses, banded iron formation, carbonates, amphibolite, garnetiferous mica schist,) are associated with rare mafic and granitic intrusions, but with several generations of granite pegmatites. Strike of the rocks varies from N25^{0}E-S25^{0}W to N55^{0}E-S55^{0}W and dip varies from 65^0 to 80^0 towards the SE. The bedding plane (S_0), is prominent in the iron formation and calc gneiss therefore it is defined by compositional banding. Foliation plane (S_1) is prominent in garnetiferous mica-schist and calc-schist within the study area. Asymmetrical S, M and Z type of drag folding, which is present in outcrops of Bedded Iron Formation (BIF), forming a Syncline Structure, especially in Tiranga Formation where the average thickness of the hematite and magnetite quartzite zone has been observed to be between 3 m to 10 m, but apparent thickness of the zone goes up to 60 m at the three peaks, due to repeated drag folding of the individual hematite & magnetite quartzite band at the synclinal closure. However, they are highly jointed and fractured also. Moreover in other blocks, thickness of the ore zone varies from 10 m to 40 m.

The Pur-Banera Belt is mostly composed of meta-sedimentary, metamorphosed dolomite, and small number of igneous rocks. However, iron ore deposit was originally a sedimentary exhalative deposit before experiencing a metamorphic event.

On the basis of geology, structures, mineralization textures, and field assignments author shows that, the banded iron ore occurs with quartzite and other meta-sedimentary sequences that indicate metamorphism took place after the completion of sedimentary rock.

I. INTRODUCTION

Bhilwara is a small town in the Mewar region of Rajasthan, India. The district covers an area of 10,455 sq. km. It is bounded by North latitudes 25^{0}01' to 25^{0}58' and East longitudes 74^{0}01' to 75^{0}28'. It is surrounded by other districts i.e. on the north by Ajmer District, on the east by Bundi District, on the south by Chittaurgarh District, and on the west by Rajsamand District.

The total length of Pur-Banera Belt is about 30 km, of which study area is restricted to 14.2 km only. It is bounded by four corners (i.e. Point A: 25^{0}27'53" North latitude 74^{0}37'32" East longitude Point B: 25^{0}27'49" North latitude 74^{0}41'48" East longitude Point C: 25^{0}22'10" North latitude 74^{0}36'26" East longitude and Point D: 25^{0}22'10" North latitude 74^{0}31'46" East longitude) and it is diagonally spread towards NE-SW and covers a total geographical area of 79.5 Sq. Km (Fig. 1) which fall under toposheet number 45K/11.

The iron ore deposit belongs to the Tiranga Formation, of Pur-Banera Group. It is part of the Bhilwara Supergroup. The entire area has undergone medium grade metamorphism. The major lithology is designated around the study area which is parallel to each other and affected by metamorphism.

The rocks, which are exposed around the study area are deformed and metamorphosed, belongs to Pur-Banera Group. In the study area, the major litho-units are conglomerate, quartzite, metapelites, quartzo-feldspathic gneisses amphibolite, calc-gneisses, and banded hematite-magnetite quartzite. The beds of conglomerate with quartzite form the base of Pur-Banera Group.

According to planar data and structural analysis, it is inferred that, the structure found in that area is a plunging synform with inclined geometry.

II. GEOLOGY

Geologically, the region is considered to be a part of Bhilwara Supergroup of Archean to Lower Proterozoic in age. The Pre-Aravalli's in Rajasthan, hitherto known as the Banded Gneissic Complex, however, it has been re-grouped by Geological Survey of India into Bhilwara Supergroup. It forms the oldest stratigraphic horizons, due to which the entire geological succession of rocks inside Rajasthan had developed. On the basis of techno-environmental setting, magmatic events, lithological homogeneity, and order of superimposition, the rocks of Bhilwara Supergroup have been classified into Sandmata Complex, Mangalwar Complex, and Hindoli Group. However, Sawar Group, Pur-Banera Group, Rajpura-Dariba Group, Jahazpur Group, and Ranthambore Group have been considered to be of Lower Proterozoic in age (Prasad et al. 1997).

The study area belongs to the Mangalwar Complex and Pur-Banera Group of the Bhilwara Supergroup. The rocks found in Suwana Formation, of Mangalwar Complex, are the basement rocks of the study area (Fig. 1). It comprises amphibolite (granitised), mica schist with amphibolites, calc-silicate rocks, and quartzite. The Potla Formation is underlain by the rocks of Suwana Formation, of Mangalwar Complex. It comprises an amphibolite and garnetiferous mica schist.

The Pur Formation overlain by the rocks of the Pansal Formation of Pur-Banera Group. It comprises conglomerate, quartzite, and quartzo-feldspathic granite gneisses. The Pansal Formation is underlain by the rocks of Pur Formation and overlain by the rocks of the Rewara Formation. It comprises conglomerate, quartzite, and marble. The Rewara Formation is overlain by the rocks of the Tiranga Formation. It comprises calc-schist, calc-gneiss, calc-silicate marble, mica schist, and amphibolitic schist. The Tiranga Formation is overlain by the rocks of Samodi Formation. It comprises sulphide bearing banded hematite quartzite and banded magnetite quartzite. The Samodi Formation is underlain by the rocks of Tiranga Formation and overlain by the alluvium soil (Recent). It comprises mica schist, marble interband, quartzite, and amphibolite dyke (intrusive) and it is overlain by the alluvium/soil.

The sulphide bearing banded magnetite quartzite and banded hematite quartzite occurring in the central range of Pur-Banera Group, which had been previously described in the Tiranga Formation. It is underlain by the Rewara Formation and overlain by the Samodi Formation of Bhilwara Supergroup. This hematite/magnetite quartzite and carbonate rocks inter-bedded with biotite garnet schist, calc schist, and calc gneiss rocks. The banded hematite/magnetite quartzite has two individual bands detached by separations of biotite-sericite-schist which are folded. The two prominent bands representing a line of asymmetrical fold forming a chain of hillocks, which are exposed from Tiranga in the south to Dhulkhera in the north and Suras in the south to Dhulkhera in the north and also from Jipiya in the south to Devpura in the north direction. Iron ore (hematite and magnetite) is exposed as a thick bed in the various ancient working pits whose thickness ranges from 10 m to 40 m. It is black to brownish red in color and much consolidated at some places.

III. BHILWARA TECTONIC SYSTEM

The Bhilwara Supergroup (BSG) is essentially Archaean in age, which is evident from ca. 3.5 Ga age of some mafic inclusions within BSG (Mac Dougal et al., 1983) and from age of the intrusive granites (2.9 Ga, Untala and Gingla granitoids; Chaudhary et al., 1984). These basement rocks, in general record imprints of at least four phases of deformations (Naha, 1983; Srivastava et al., 1995).

The episodes of deformations of Bhilwara Supergroup on the basis of their position in stratigraphy, mutual relationship and orientation, have been designated as BD_1, BD_2, BD_3 and BD_4 episodes. The folds, lineation's and planar tectonic anisotropy corresponding to these four episodes have been designated as BF_1, $B\beta_l$, BS_1; BF_2, $B\beta_2$, BS_2; BF_3, $B\beta_3$, BS_3 and BF_4, $B\beta_4$ and BS_4 respectively.

The tectonic system of Pur-Banera Belt of Bhilwara district are described on the basis of geological succession of rocks, mutual relationship, orientation, techno environmental setting, and magmatic events in the area.

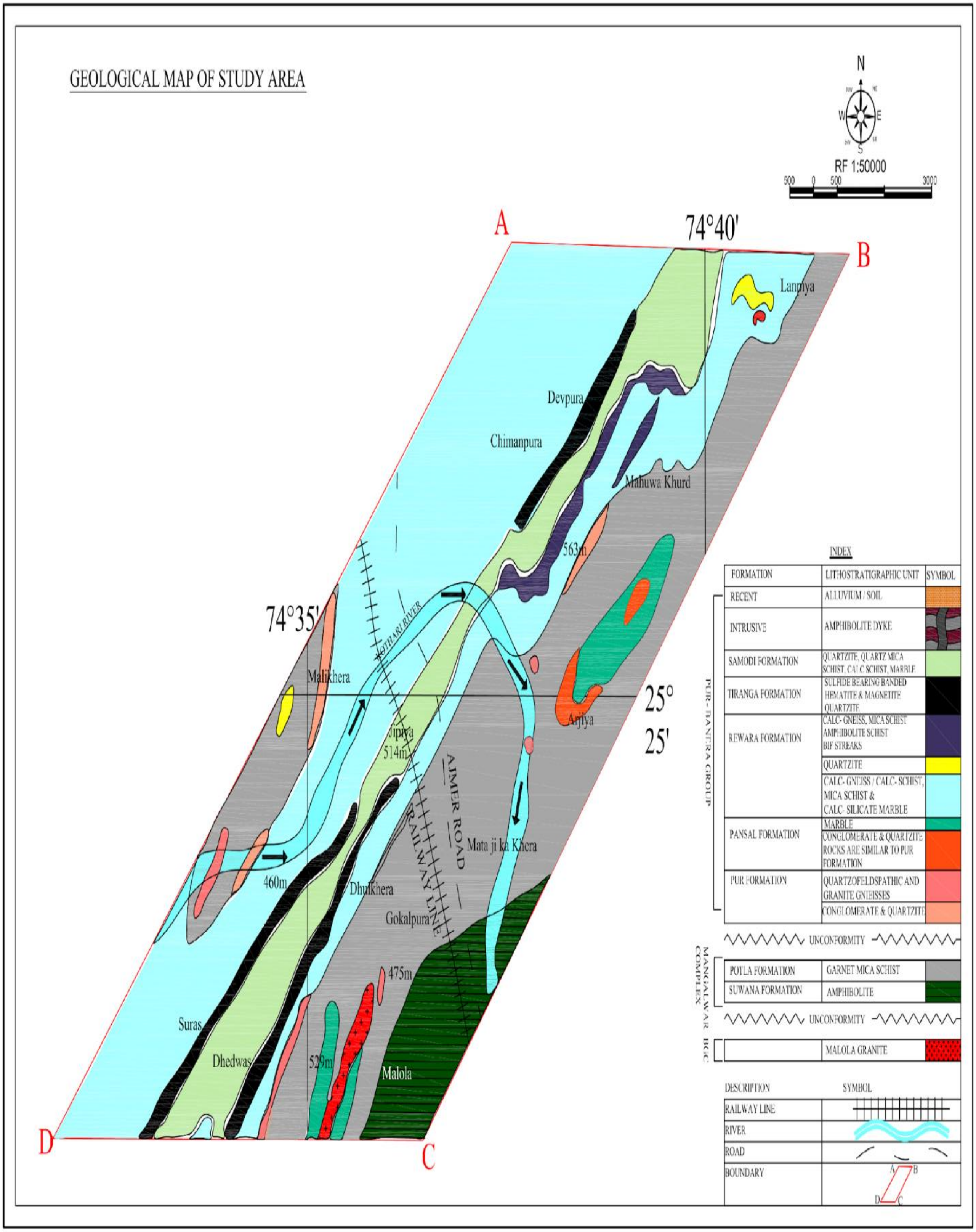


Fig. 1 Geological Map of Study Area

Tiranga Synform

Mahajan (1965) and Dhara (1976) have mapped a major synformal closure manifested by the magnetite quartzite (sulphide-bearing) at Tiranga Hill. The synform is traceable from 2 km SW of Pur to 1 km east of Suras. The axial trace of the synform trends from NE-SW direction, over a distance of about 10 km from the hill .1728 to east direction of Suras. The outer arc of the synform is defined by the Pur quartzite and the inner arc by the magnetite quartzite. The synform is tight, with the limbs following a general NE-SW trend which dip sub vertically (80^0-85^0) towards NW and SE. The fold exhibits progressive increase in the tightness from the outer arc towards the inner arc. Mahajan (op. cit.) has marked a number of dextral drags on the eastern limb and sinistral drags on the western limb of the Tiranga Hill Synform. The folds show steep plunge of 65^0-70^0 towards NNE. The axial-plane schistosity trends NNE-SSW and dips 65^0-70^0 towards WSW. These folds, in the regional tectonic sequence, have been referred to BF_2.

The BF_2 folds are present in the rocks of the Bhilwara Supergroup on micro-, meso- and macro-scales and show wide-spatial distribution. These folds are moderate to steeply inclined open folds with low amplitude to wavelength ratio. The orthogonal thickness of these folds remains nearly constant. Associated with the BF_2, folds, parasitic folds as asymmetrical drags on the limbs and symmetrical drags in the hinge zone of the larger wavelength structures, have been observed at places.

The Tiranga Synform is separated from Lakshmipura Synform, on the east, by a complementary antiform designated as the Pur Antiform. Its axial trace extends from Pur to SW of Bhilkhera in NE-SW direction over a distance of 15 km.

Balyakhera Antiform

To the west of Tiranga Synform a complementary antiform has been mapped by Dhara (op. cit.) with axial trace extending from Balyakhera to 1 km east of Suras, roughly following a NE-SW trend over a distance of 10 km. The antiform is steeply plunging and upright with fold axis plunging 75^0-80^0 towards ENE and axial plane dipping 85^0 towards SE. The inner arc of the fold is defined by the Pur quartzite and the outer arc by the magnetite quartzite which is present as discontinuous bands. The closure is defined by the calc-silicate rocks and marble horizon occurring between the Pur quartzite and magnetite quartzite bands in the hinge zone, which is traceable upto east of Surawas. The Balyakhera Antiform is overturned to the NE.

IV. LITHOLOGY AND SMALL SCALE STRUCTURES IN THE STUDY AREA

The total length of Pur-Banera Belt is around 30 km, of which study area is restricted to 14.2 km (Fig. 1). It is compositionally diverse, being composed of conglomerates, quartzites, garnetiferous mica-schists, para-gneisses, amphibolites, banded iron formations, calc-silicate rock, and dolomitic marbles (Gupta et al., 1997), with rare mafic and granitic intrusions but with several generations of granite pegmatites. Recent researchers (e.g., Hazarika et al., 2013; Ozha et al., 2016) have identified Proterozoic (1.81 Ga) metamorphic events in this Belt, using a petro-chronological approach. However, structural data which are crucial in understanding the tectonic deformation history are lacking in most studies. The integration of structural data provides significant insights on the Meso-archaean to Neo-proterozoic crustal growth and reworking of this relatively little known but important part of the Aravalli Craton.

Field Relationships and Outcrop Structures

The structural relationships of the Pur-Banera supracrustal rocks and associated intrusive and basement rocks are summarized below (Figs. 1 to 4).

1. Quartzo-Feldspathic Gneisses

Low-lying outcrops consists of grey color, quartzo-feldspathic gneisses trending from NE-SW direction are well-identified in nearby villages like Pansal, Jipiya and Suras, which are typically form strong bonds with metapelitic rocks (Fig. 1). These well-built layering explores gneisses with unequal felsic (quartzo-feldspathic) and mafic (biotite rich) flakes (Fig. 2a). Moreover, they are having lateral permanency and similar size of the orchestras more than 10 m and consequently the existence of relict kyanite recommend a sedimentary protolithic of the gneisses. The first design of para-gneisses is of intercalated sandstone and shale flakes, and original metamorphism is related to local migmatisation (Fig. 2f).

Joseph D' Sauza et al., (2019) select the main layering in the para-gneisses as S_0 foliation which have subsequently tightly folded i.e. deformation phase D_1 (Fig. 2b), to form the north east – south west trending, tight to isoclinal F_1 folds (Fig. 2c). However, because of the tightness of F_1 folds, the subsequent S_1 axial planar fabric is concerned with unevenly equivalent to the gneissosity. Resulting D_2 distortion on S_0//S_1 compound foliation has produced open, reclined and perpendicular folds with shear fold axes plunging greater than (>) 80° east course (Fig. 2d). In the refolding of F_1 fold axes superimposition of F_2 folds on large standing F_1 folds produced and developed doubly plunging F_1 folds (Figs. 2c and 4b). Angled F_1-F_2 superimposition caused in type-I and type-II combination of the interruption designs of Ramsay (1967). Expected the moderately smooth nature of gneissic outcrops, in some places only refolded F_1 fold axes are seen, as compared to this on the gneissosity the F_2 folds procedure wide-ranging warps. The F_2 folds, be indebted to their lengthier wavelengths, and having emerged a spaced axial planar cleavage (S_2) in the east-west (approx) trending. Asymmetrical folds related to unevenly north-south trending dextral shears on the gneissosity, define in the gneisses the prior phase of distortion/deformation D_3 (Fig. 2e–g).

The D_3 deformation has produced in moderately plunging less than < 50°, F_3 folds, and S_3 axial planar fabric (Fig. 4c). Migmatisation in the gneisses has produced the formation of comparatively capable leucosomes that has been ptygmatically gathered attracted in apprised isoclinal F_1 folds. And superimposition of new (younger) F_3 folds has produced within the development of a type-III meddling pattern (Fig. 2f). The gneisses are intruded by numerous peers of muscovite manner pegmatites, co-folded within the gneissosity and also happening along with the F_3 shears (Fig. 2a and 2g).

Insufficient cliffs of granite gneiss also occur amid the supracrustals, along the length of the River Kothari and towards the west direction of village Mandal (Fig. 1). The granite gneisses show similar deformation patterns to those of quartzo-feldspathic gneisses. Irregular bands destined by K-feldspar–quartz–biotite groups explain the primary foliation (S_0) in granite gneisses (Fig. 2h). The tight to isoclinal folds (F_1), S_0 foliation has recognized S_1 axial planar fabric, at that time it overlaid by complete bare open folds to build a spread out S_2 foliation (Fig. 2i). The granite gneisses, containing microcline, are compositionally altered from the quartzo-feldspathic gneisses, with the addition of microcline. In total, the ductile presentation of both quartz and feldspar reveals distortion under high quality (T ≥ 550 °C) circumstances (Gower and Simpson, 1992).

2. Carbonates, Banded Iron Formations (BIF), and Amphibolite's

The central part of the Pur-Banera sequence is predominantly composed of carbonates, BIF and amphibolite. However, because of the banded appearance of the carbonates, they have additionally been referenced to as calc-gneisses (Heron, 1953; Gupta et al., 1997). The development of primary foliation (S_0) in calc-gneisses is all around characterized through alternating mafic rich (hornblende > biotite > plagioclase) and calcite rich layers, which can be from a couple of centimeters to a couple of meters thick (Fig. 3a). Outcrops show an ordinary edge and wrinkle scene as a result of differential suffering of calcite and silicate rich layer (Fig. 3b). The calc-gneisses plausible initially formed as sediments, with chemical precipitation of the carbonate layers, alternating with deposition of mafic-well off detrital sediments derived from comparable mafic sources. Moreover, in spite of the fact that calc-gneisses emerge at some phase in the Pur-Banera Belt, they are extraordinarily safeguarded inside the southwest areas of Jipiya and Lapiya villages (Fig. 1).

The joint effect of layer width and competency on distortion directly is all around situated in those calc-gneisses, with denser layers demonstrating folds with predominant wavelength and lower amplitude than more slender layers (centimeter-scale) (Fig. 3b–d). Competence contrast between alternate layers (S_0) is too responsible for the expansion of ptygmatic folds within distorted compositional (Fig. 3b) layers. The following F_1 folds are trending in the north east – south west with fold axis plunging modestly (30–40°) closer to southwest direction (Figs. 3b and 4d). Wide-open folds on S_1 foliation depict the hole out S_2 axial planar fabric with moderate to steeply plunging 50–70° F_2 (Fig. 3c) fold axis. The steep dipping (>75°), trending towards north of north-west to south of south-east, inclining shear fabric characterize S_3 foliation in the calc-gneisses (Figs. 3d and 4e). Tectonic fabrics are best observed in the calc-gneisses (S_1, S_2, and S_3) are the same with the S_1, S_2 and S_3 foliation plans decided inside the quartzo-feldspathic gneisses (Fig. 4).

At some areas, capable flakes in the calc-gneisses display boudinage at outcrop scale, and the similarly known on a local scale in the arrangement of the lengthened and intermittent outcrop plan of the Banded Iron Formation (Joseph et. al, 2019) (Fig. 1), which are by and large connected with calc-gneisses. The Banded Iron Formation comprises magnetite rich and quartz-rich layers. Outcrop scale S-, Z- and M− molded folding of Banded Iron Formation layering has set up tight to isoclinal folds with parasitic lopsided folds having fold tomahawks plunging steeply (>70°) towards south-west (Fig. 3e).

Amphibolites, molded by the changeability old enough mafic interferences (dykes and sills) are believed to be concordant inside the gneissosity of calc-gneisses at Jipiya, and also structure more outcrops in the northern segment of the Pur-Banera Belt close Lapiya, Chamanpura, and Meja. An uncommon minor dykes and sills of un-metamorphosed dolerite additionally infringe to the Pur-Banera meta-sedimentary request, close to Malola and the Five hundred sixty-three (563) meters (Fig. 1) hill.

3. Garnetiferous Mica Schists

GMS (Fig. 3f, g) found in the Pur-Banera Belt is frequently associated with amphibolites, dolomitic marbles, and quartzites (1997, Gupta et al.). These mica schists are composed of garnet, biotite, kyanite, muscovite, plagioclase, and quartz by minor quantities of K-feldspar. The most primitive fabric (S_1) in the mica schists is designated by a shape-favored arrangement of chlorite, muscovite, and biotite ounces sideways with recrystallized quartz sums (Fig. 3f). Therefore, resulting bending has formed an infiltrator S_2 foliation in the schist's whose mean course nearby the quartzo-feldspathic gneisses is north-north east to south-south west trending and steeply (>80°) south-east (Fig. 4f) dipping. Tight, centimeter-scale crenulations on S_2 foliation, with very much assembled axial planar material (S_3), are experiential along with the east and west limits of the belt (Fig. 3g). The resulting S_3 foliation is north-north west to south-south east trending with F_3 folds falling steeply (>60°) while in transit towards the south (Fig. 4f). The crenulations are overlaid on the prior quartzo-feldspathic and mica spaces that portray the all-inclusive foliation in the schists, acknowledged on both outcrop and microscopic scales (Fig. 3g). Moreover, the differential width of these quartzo-feldspathic and mica regions controls the wavelength of the crenulations, with denser spaces beginning, bigger wavelength crenulations.

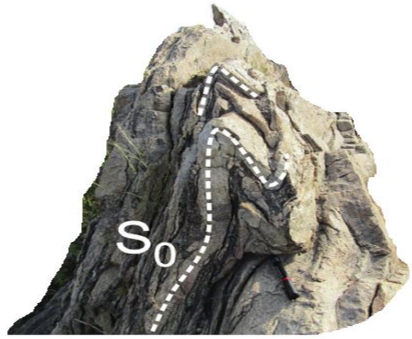
4. Basement Granite

A north east–south west trending form of light grayish color, medium-grained, well foliated granite extends for 6 km from south south west of Pansal to north north east of Malola (Fig. 1). We term this the Malola Granite as its outcrops, with moderate relief, are greatest rationed here. The partners of the rock granite with the close by litho-units are secured by soil spread. Though, seeing the apparent nonappearance of dykes, veins, or stringers of the granite into the close by rocks, just as an absence of any undeniable warm impacts, we believe this granite to be the local underground space to the Pur-Banera supracrustals.

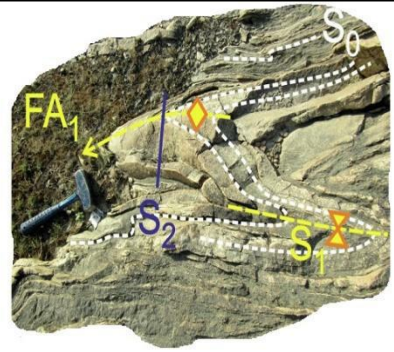
The Malola Granite is made of quartz, alkali feldspar, biotite, diopside, plagioclase, and actinolite, with subordinate zoisite and calcite, and addition zircon and titanite. Three arrangements of foliation are present in the Malola Granite. Joseph D' Sauza et al., (2019) assigns the underlying unmistakable inescapable foliation existing all through the granite as S_1 (Fig. 3h and 4g). This S_1 foliation has stayed then disfigured by north north east to south south west heading thickness that has caused in the advancement of ~east-west heading slanting open folds and divided S_2 foliation (Fig. 3i). In high-strain zones along with the west course connection of the granite with amphibolite, the S_2 foliation creates penetrative and springs a mylonitic appeal to the granite. Mesoscopic S-C fabrics (S_3) in the granite assign a dextral feeling of shear. In contrast to the Malola Granite, granites somewhere else in the Pur-Banera Belt (e.g., at Lapiya) are poorly foliated and may connote signify newer/younger intrusions.

In the Bhilwara region the planer and the linear structures of short account are mapped in Fig. 4 where (a) for marking out several fabrics (S_0–S_3) different signs are used and lineation's (F_1–F_3) made details in the quartzo-feldspathic gneisses and linked supracrustal lithologies. However, reports of foliation and lineation (b–c) stereographic irregular data taken for quartzo-feldspathic gneisses as well as (d–e) calc-gneisses, (f) garnetiferous mica schists, and (g) the Malola Granite. (b) Poles to folded S_0 foliation (n = 71) are shown forming two profile planes indicative of a doubly plunging fold geometry, with corresponding mean girdle and north east–south west direction trending, the quartzo-feldspathic gneisses having a tendency axial planer fabric S_1 (n= 7). (c) Poles to widely folded S_1 foliation (n = 26) with north west–south east trending, having a tendency mean girdle of S_1 is shown. The north-south direction concerned with S_3 foliation designates i.e. n = 3 within the quartzo-feldspathic gneisses with moderately plunging F_3 fold axis i.e. n = 5 plotting in the direction of north east. (d) Poles to S_0 foliation i.e. n = 40 in calc gneisses over direction west north west – east north east striking and north north east, dipping lies of a girdle. The axial planar fabric $S_{1,}$ i.e. n = 8 unevenly focused on north-north east –

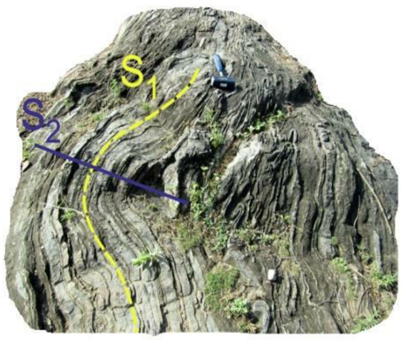
a) Gneisses, by and large safeguarded as low-alleviation outcrops, with pegmatites and quartz veins intruded along the gneissosity.



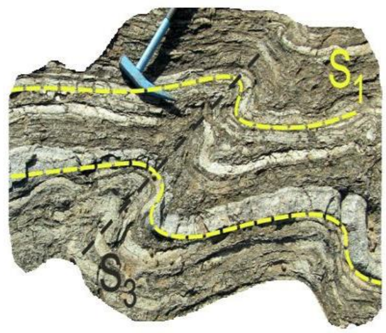
b) Area and plan perspective on plunging and refolded axes of the tight to isoclinal F_1 folds. Note the gently plunging nature of this F_1 folds.



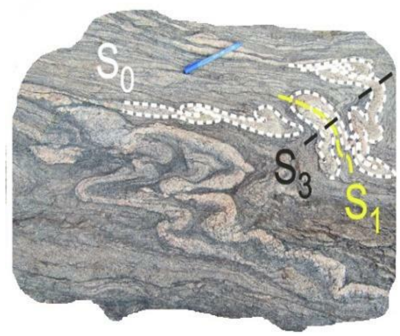
(C) Segment and plane sight of plunging and refolded axes of the tight to isoclinal F_1 folds. Note: the gently plunging nature of the F_1 folds.



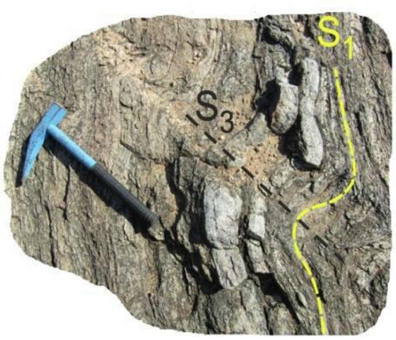
(d) Strategy view of the extensive F_2 open folds in the gneisses, with (e)



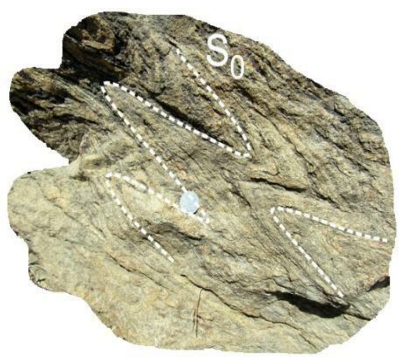
(e) The youngest (newest) asymmetrical shears defining the S_3 foliation in gneisses.



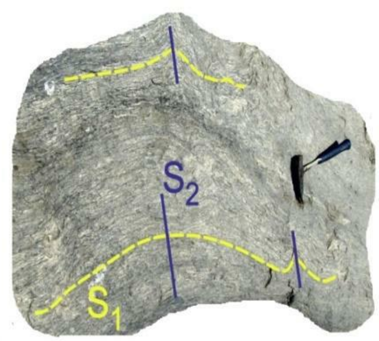
(f) Stigmatically folded leucosomes presentation superimposition of F_3 folds on prior F_1 folds that creates a type-III interference design.



(g) Plan view of pegmatite intrusions alongside the S_3 shear planes in the quartzo-feldspathic gneisses



(h) Granite gneisses display similar tightly folded gneissic layering (section view)

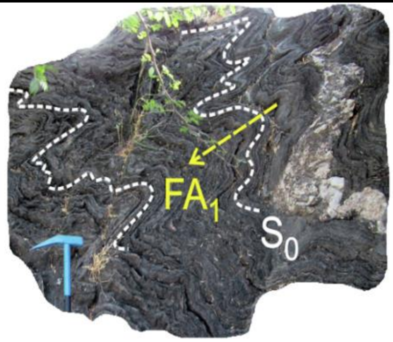


(i) wide-ranging F_2 folds (plan view) alongside local dextral shearing

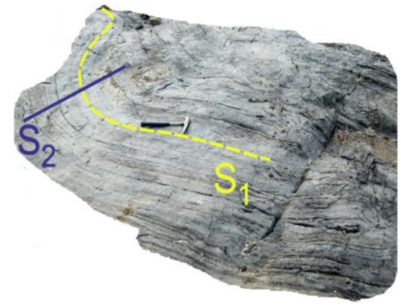
Source: - Joseph D'Souza et al.

Fig. 2 Photographs showing different stages of deformation in the (a–f) quartzo-feldspathic gneisses, and (h–i) granite gneisses.

(a) Dense primary banding in the calc-gneisses (S_0) in a excavation face near Lapiya

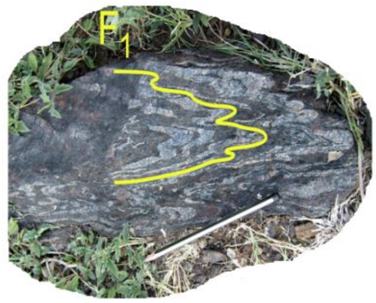


(b) Tight-isoclinal folds on calc-silicate bands with well-developed S_1 axial planar fabric

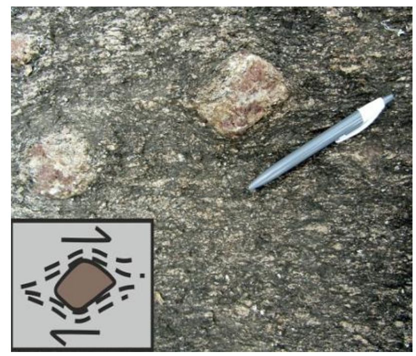


(c) The comprehensive folds on penetrative S_1 foliation crop spaced S_2 foliation

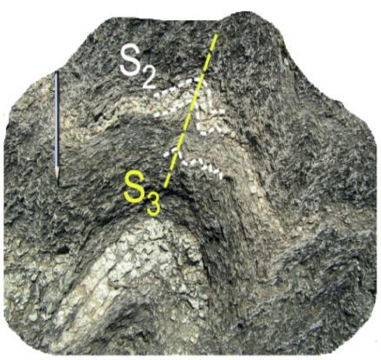
(d) small-scale shears with dextral sense of shear demarcate the S_3 foliation in calc-gneisses



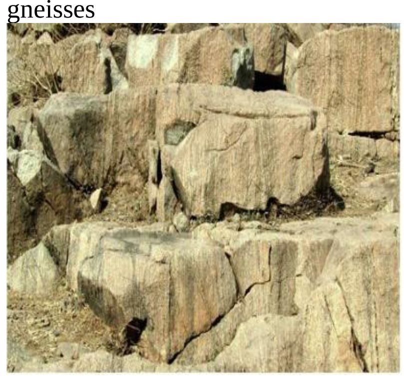
(e) Strategy opinion of the tightly folded magnetite-rich and quartz-rich bands surrounded by BIF forming the tall ridges nearby village Jipiya. These steeply plunging and tight–isoclinal F_1 folds in BIF are equal to those in the gneisses



(f) Garnet-kyanite schists comprising large garnet porphyroblasts in the supracrustal order. Note that pervasive matrix foliation characteristically warping nearby garnet porphyroblasts, representative pre-tectonic association between porphyroblast and matrix



(g) Segment view of schistose rocks presenting tight crenulations on primary foliation (S_2) with well-built axial planar fabric (S_3).The capability contrast among the schistose and felsic layers has caused in mutable fold amplitude and wavelength

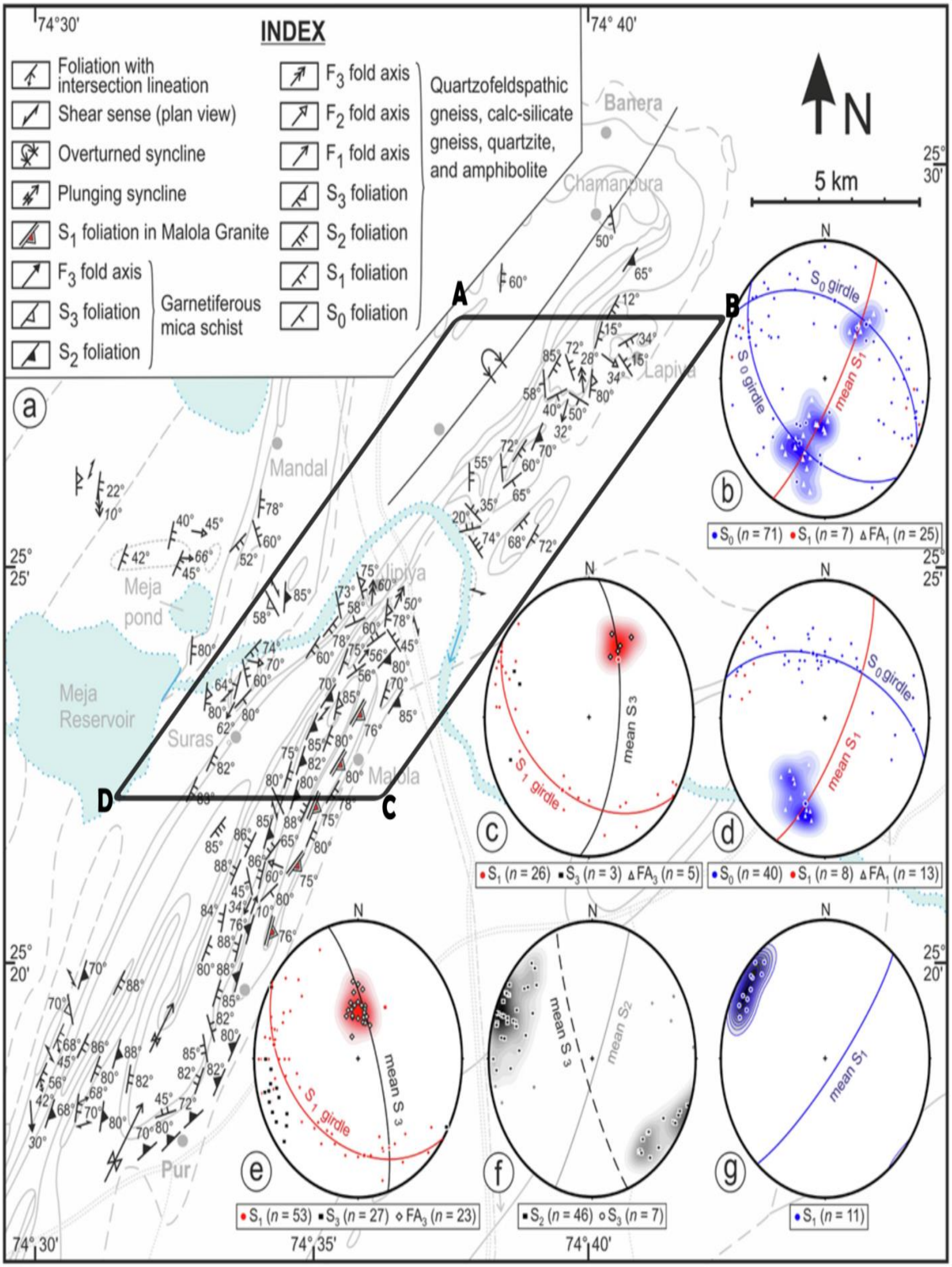


(h) Overall appearance of well-foliated Malola Granite, which procedures the basement for the supra crystals

(i) Close by developed open folds in the granite equal to the F_2 folds in the quartzo-feldspathic gneisses revealing of coeval deformation

(Source: - Joseph D'Souza et al.)

Fig. 3 Field relationships of various litho-units within the Pur-Banera supracrustal belt (a-i).



(Source: - Joseph D'Souza et al.)

Fig. 4 Planer and the linear structures of Pur-Banera Belt

Fig. 4 planer and the linear structures of Pur-Banera Belt of Bhilwara region south south west direction with folds F_1 i.e. n= 13 plunging gently towards south south west direction. (e) Poles to widely folded S_1 fabric ends i.e. n = 53 through girdle along the north west – south east direction. The mean orientation of S_3 foliation i.e. n = 27 is made throughout by north north west, south south east striking plane surface. The axis of F_3 folds i.e. n= 23 equivalent to asymmetrical folds. (f) Ends coming into existence throughout S_2 foliation i.e. n= 46 in garnet-mica schists. The proper adjustment is known throughout the north north east - south south west direction with axial planar crenulation fabric (n = 7) formed by north north west -south south east trending, having a tendency plane. (g) The coming into existence everywhere S_1 fabric identified in the Malola Granite with mean adjustment in the direction of north east – south west. The projections were prepared using the Stereonet 10.1.6 program of Richard Allmendinger.

V. MINIRALIZATION OF IRON ORE AT PUR-BANERA AREA

Iron ore has been reported from many geological environments viz. igneous, metamorphic and sedimentary rocks. Various occurrences of iron ore can be classified on the basis of types of deposits into:
(l) Magmatic deposit, (2) Sedimentary deposit, (3) Volcanogenic-Hydrothermal deposit, (4) Volcano-Sedimentary deposit

***(l) Magmatic Deposit*: -** An ore deposit formed by magmatic segregation, generally in mafic rocks and layered intrusions, as crystals of metallic oxides or from an immiscible sulphide liquid. Synonyms of magmatic deposits are magmatic injection deposit and magmatic segregation.

***(2) Sedimentary Deposit:* -** Sedimentary exhalative deposits (Sedex deposits) are ore deposit which is interpreted to have been formed by the release of ore-bearing hydrothermal fluids into a water reservoir (usually the ocean), resulting in the precipitation of stratiform ore.

***(3) Volcanogenic Hydrothermal deposit*: -** Volcanogenic massive sulfide ore deposits, also known as VMS ore deposits, are a type of metal sulphide ore deposit, mainly copper-zinc which are associated with and created by volcanic-associated hydrothermal events in submarine environments. The term hydrothermal mineral deposit is defined as any concentration of metallic minerals formed by the precipitation of solids from hot mineral-laden water (hydrothermal solution). However, the solutions are thought to arise in most cases from the action of deeply circulating water heated by magma.

***(4) Volcano-Sedimentary deposit:* -** Volcanogenic Sedimentary Deposits. They are deposited in layers of rock consisting of lavas, ash, and strata of siliceous rocks alternating with normal marine deposits.

According to the researchers, the volcanic nature of the period during which the Archaean iron formation was accumulated has also been recognised. The oldest iron formation like those of Isua, probably was deposited in a submarine exhalative environment (Appel, 1980).

A controlling factor probably has the composition of ocean water during the Archaean. The pH and oxidation potential were significantly different from that of later years. The oceans of that period were major reservoirs of both iron and silica their source was mainly volcanogenic and partly terrestrial. Even cosmic origin is envisaged.

Gross (1965) concludes that hydrothermal effusive processes are the principal sources of metal constituents in stratified iron formation and those modern metalliferous sediments and crusts formed in the sea bed are progenitors of older sedimentary formations preserved in the geological record (Simonsen, 1985).

The character of the Late Archaean-Early Proterozoic atmosphere is also one of the important aspects to be taken, not only considering the origin of iron formation the atmosphere at that time was different from the present day atmosphere and is believed to have been rich in carbon dioxide and nitrogen and deficient in oxygen it was possible for the ferrous form of iron to occur in solution in warm sea water. Vast quantities of iron could does get stored in the ocean and lakes of that periods. Photo dissociation of water vapour no doubt produced oxygen but that was very much limited.

It was only when life first appeared on the scene; photosynthetic release of bulk of the oxygen became possible. The released oxygen combined with the dissolved iron in the oceans and precipitated it giving rise to iron rich bands. When once the dissolved iron was used up there was no further precipitation of iron (Cloud, 1973).

These are the aspect of banded iron formation, on which no final opinion has been possible despite years of study in so many countries. The bulk of the BIF was deposited between 3.0 to 2.0 billion years ago. No single mode of origin for all the BIF can be thought of. It is conceded that the larger and more widespread deposits are of sedimentary origin.

According to the author in study area, the occurrence of banded hematite quartzite (BHQ) and banded magnetite quartzite (BMQ) has following characteristic:

The iron ore mineralization is found in banded form, around Pur- Banera area in which hematite is the main iron ore mineral. Moreover, it is associated with quartz, garnet and interlayered with biotite-sericite schist. The average thickness of iron ore bands varies from 10 m to 40 m except where it gets repeated by folding and it is steel black in color.

The banded hematite quartzite and banded magnetite quartzite occurring in banded form and showing sedimentary structure like bedding and flame structure. Banded iron ore occurs with quartzite and other meta-sedimentary sequence that indicating metamorphism took place after sedimentary deposit. Therefore, it can be concluded that the iron ore, in present area of investigation belongs to metamorphosed sedimentary type deposits.

VI. CONCLUSION

The authors use structural analysis of the greatly deformed Pur-Banera supracrustal meta-sedimentary series and its Granite Basement to decipher the crustal evolution of the Bhilwara region of south-central Rajasthan, a key part of the Aravalli Craton of northwestern India.

The Pur-Banera supracrustals, comprising quartzo-feldspathic paragneisses, calc-gneisses and marbles, quartzites and banded iron formation, amphibolites, and garnetiferous schists, preserve structural evidence for three strong events of compressive deformation and shearing. We suggest a tectonic model for the Pur-Banera Belt in which chemogenic sediments are intensely folded along with pelitic and psammitic sediments and isolated basement highs. Intense crustal shortening associated with basin closure and development of tight to isoclinal folds has resulted in steeply dipping litho-units.

In the Pur-Banera Belt, the banded iron formation are sedimentary rocks containing more than 42% iron composed predominantly of thickly bedded iron minerals and silica (as quartz). The average thickness of iron ore bands varies from 10 m to 40 m except where it gets repeated by folding, it occurs exclusively in Precambrian rocks, and the entire area has undergone medium grade metamorphism.

On the basis of geology, structures, and field assignments author shows that firstly in that area there were sedimentary rocks, and then due to metamorphism the rocks deposited into metasedimentry deposits. These metasedimentry deposits are formed through the deposition and solidification of sediments then, the rock was buried underneath subsequent rock and was subjected to high pressures and temperatures, causing to rock recrystallize.

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