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# Precambrian Evolution and the Deformation Style in the Great Boundary Fault Zone around Chittorgarh, Rajasthan

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*Abstract:* **The Precambrian crust of the Aravalli Mountain range mainly comprises several Proterozoic fold belts underlain and determined by rocks of Archaean age like schist- gneiss- granitic rocks. The remobilization which takes place partly during the Proterozoic orogenesis includes a heterogenous assemblage of biotite gneiss, amphibolite, aluminous paragneiss, quartzite and marble formed during the period 3.5-2.5 Ga. The Banded Gneissic Complex (BGC) having more extensive occurrences in the region is regarded as the oldest supracrustals succession representing some of the primitive sediments composed of unweathered igneous debris overlying the Bundelkhand gneiss. The Aravalli rocks have been subjected to two phases of folding. The Vindhyan rocks occur south of the Aravallis with a faulted contact i.e., Great Boundary Fault, and also with unconformable contact at places. Several evidences have conferred that the fault originated as a thrust and brittle ductile deformation such as en-echelon quartz veins were observed.**

*Index Terms:* **Aravalli Mountain, BGC, Bundelkhand, Precambrian, Proterozoic Supracrustals**

## I. INTRODUCTION

The pioneering work of Heron (1953), Gupta (1934) and Gupta & Mukherjee (1938) give us a basic framework of the Precambrian Stratigraphy of Rajasthan. The BGC denotes the oldest forms of rocks which form the basement for all the younger metasedimentary rocks of the Aravalli- Raialo and Delhi Groups. Multiple deformations have been reported in all the Precambrian rocks of Rajasthan for the last three decades but Aravallis and Banded Gneissic Complex show similarity in all their structural aspects. In Southern Rajasthan Aravalli Groups is overlain by Banded Gneissic Complex with a contact of the conglomerate horizon. According to Gupta (1934) and Heron (1936), they considered Banded Gneissic Complex and Bundelkhand Gneiss as a basement for overlying metasediments. Later Bundelkhand Gneiss was renamed as Berach Granite because of the difference in their petrographic property of the granites of Chittorgarh and Bundelkhand. The Berach Granite (Bundelkhand Gneiss of Gupta 1934; Gupta & Mukherjee 1938; Heron 1935) was thought to be the basement for younger sediments of Chittorgarh area. Prasad (1982) reviewed the geology of Chittorgarh and inferred the following succession-

| | | |
|---|---|---|
| | Acid Intrusive | |
| | Basic Intrusive | |
| | Berach Granite and Gneiss | |
| | Dungla migmatites and para amphibolites | |
| | Bari Sadri and Hera Quartzite | |
| ----------Unconformity---------- | | |
| Chittorgarh Group | Bhadesar shale | Slate, quartzite, limestone & dolomite |
| | Putholi Shale | Shale, siltstone and quartzite |

The main objective of this review paper is to evaluate tectonic setting related to fault zone, to indicate the controversy about the stratigraphic position of various units of the basement rocks with the above younger sequence and also the geology of the area.

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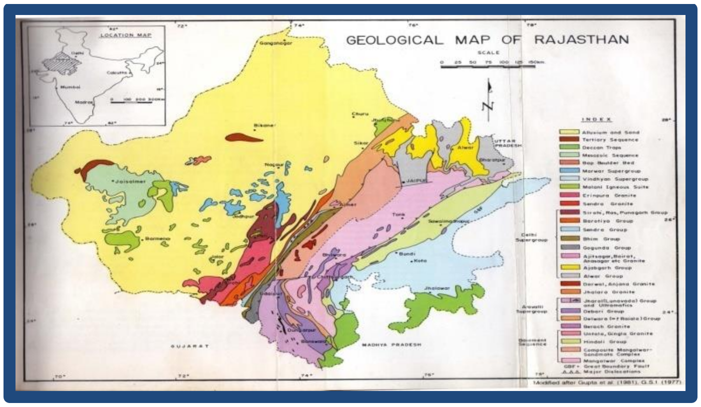


Fig 1: Geological Map of Rajasthan (GSI), 1977

## II. GEOLOGY OF THE PRECAMBRAIN TERRAIN

The Banded Gneissic Complex (BGC) has more extensive occurrences in the region and is regarded as the oldest supracrustals succession representing some of the primitive sediments composed of igneous debris which are unweathered overlying the Bundelkhand gneiss. The characteristic banding in the BGC was interpreted as due to the subplanting of the oldest granitic materials into the original schist. Crookshank and his colleagues (cf. Naha and Halyburton, 1974) interpreted the conglomerate pebbles which Heron (1953) considered an evidenced of pronounced erosional unconformity between the Aravalli system and the BGC, as tectonic inclusions formed by intense isoclinals folding and stretching of competent quartzite bands embedded in incompetent mica schist. The most remarkable feature of the revised geological map of Gupta et.al (1980) is the inclusion of extensive outcrops described as the Aravalli system and the Raialo series by Gupta (1934) and Heron (1953) as the Archaean basement named the Bhilwara Supergroup .

Soni et. al., 1987, observed that the Proterozoic Vindhyan basin of Indian Shield is a non-linear large sedimentary basin that covers thick underground sedimentary succession. The undeformed Middle Proterozoic sediments forming the Vindhyan Supergroup occur in a large arcuate basin in the northern region of the Indian shield. Basement rocks (Pre-Aravalli) i.e the Bhadesar formation and Berach Granite are overlain by Vindhyan rocks with unconformity in it. The Bhadesar formation mostly consists of quartzite, dolomitic limestone, shale, slate. According to Crawford (1968), Berach Granite has been dated as 2585 my old, Lower Vindhyan rests unconformably on Bhilwara Supergroup and at certain places, this Group is overlain by Khairmalia Andesite, Khardeola Conglomerate or Bhagwanpura Conglomerate. Vindhyan sedimentaries are found further east of Chittorgarh which is separated by Great Boundary fault and it mainly comprises of conglomerate, shales, sandstones, limestones, and porcellanite. Deccan Traps are mainly exposed in the southern part which is basaltic; some intrusive bodies of dolerite have been identified in Gangrar and Bari Sadri also. While moving eastwards, the Hindoli Group is found trending northeast-southwest in the north and more northwest-southeast with the south. Berach Granite is found all along with the Hindoli group of rocks that intrude on the sediments of the area. Vindhyan basin of Rajasthan is a dome and basin-like structure (Ramsay 1985) and is characterized by peribasinal deformation where the central part exhibits little or no deformation (Iqbaluddin and Mughni 1976, Iqbaluddin et. al, 1978; Srivastava and Iqbaluddin,1981). Topographically, the Chittorgarh area is characterized by undulating features with mostly Aravalli Hill Range and these hills are scattered all over the area and the area has a regional slope from north to south. Chittorgarh district mainly comprises of rocks of Bhilwara Supergroup, Vindhyan Supergroup, and Deccan Traps.

The complete section of the Great Boundary Fault is exposed in abundance around Chittorgarh area. The Great Boundary Fault is an imbricate zone that comprises a series of steeply dipping reverse faults and intervening slices of sheared rocks in the Precambrian terrane of northwestern India (Sinha-Roy et al., 1995) and the nature of the fault rocks within the Great Boundary Fault Zone is highly variable.

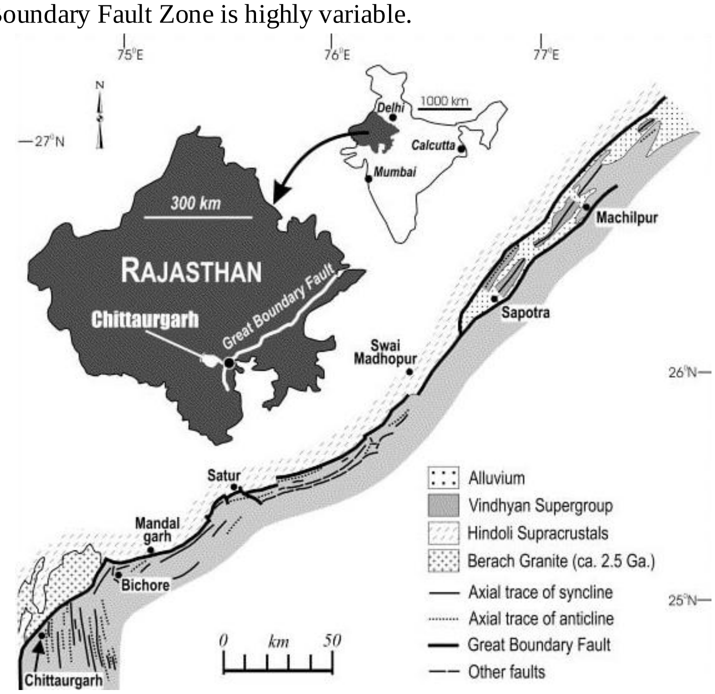


Fig 2: Geological setting of the Great Boundary fault (GBF) compiled from Banerjee and Singh, 1981; Prasad, 1984; Tiwari, 1995.

Table 1: Stratigraphic succession of Vindhyan Supergroup (DMG report, April 17, 2018)

| Age | Super group | Group | Lithology | Extrusive | Intrusive |
|---|---|---|---|---|---|
| Upper Cretaceous to Palaeocene | - | - | - | Deccan Trap (Basalt) | - |
| Upper Proterozoic | Vindhyan Supergroup | Bhander Group i) Upper ii) Lower Kaimur Group Khorip Group Lasarawan Group Sand Group | Shales, Sand-Stone, Conglomerate Porcellanite | - | - |
| | | Satola Group Great | Boundary | Fault | |
| Bhilwara Geological Cycle (>250 m.y.) | Bhilwara Super group | Ranthambhor Quartzite, Group | Shale and slates | - | Pegmatites Quartz vein |
| Pre-Aravalli | PurBanera Group | Calc-schist, calc- gneiss, dolomitic marble, quartzite and garnet-mica schist | - | - | |
| | | | | | Dolerite sills and dykes |
| | (A)Hindoli Group | (A)Shale, Slates Phyllites, metagreywackes, limestone, dolomitic marble | | | Berach Granite |
| | (B) Mangalwar Complex | (B) Migmatites, gneiss, Feldspathic mica schist, garnet mica schist, impure marble and para amphibolite | | | |

## III. HISTORY OF GREAT BOUNDARY FAULT

The Great Boundary fault which marks the northern and western boundary of Vindhyan basin act as an important and major plane of weakness originating before the Vindhyan sedimentation. It is a pre-Vindhyan grain which got mainly reactivated during the sedimentation and deformation of the Vindhyan sediments, (Iqbaluddin et al. 1978). Morphologically it is a normal gravity fault which occurs at the margin of the basin along which gradual sinking of the basin floor took place. The present reverse geometry of this fault with thrusting at places in which the pre-Aravalli basement rocks are brought in juxtaposition with the Vindhyan sediments indicates reactivation of this lineament simultaneously resulting with sedimentation and deformation of the Vindhyan sediments. Since it has affected the youngest of Vindhyan formation it is post-Vindhyan in age (Choudhari et.al 2004). The Gangrar and Hamirgarh region consists of ridges which are mainly governed by patterns of mega structures in the area. The eastern limit of Vindhyan basin is near Sasaram in Bihar and the western limit is close to Chittorgarh in Rajasthan. The rocks are mostly unmetamorphosed and undisturbed to moderately disturb with low angle of dips. The study area consists of three critical sections of the fault around Chittorgarh, where the Vindhyan sedimentary rocks occurring on the footwall side show well-developed fault zones and fault-related deformation zone, and the Berach granite (ca. 2500 Ma), occurring on the hanging wall side, does not bear any significant imprints of the fault-related deformation.

Chronological Evolution and Age of Great Boundary Fault

| **Author** | **Opinion** |
|---|---|
| Medlicott (1868) | A feature of very ancient data. |
| Fermor (1930) | A Pre- Vindhyan fault that reactivated during and Vindhyan sedimentation. |
| Heron (1953) | Evolved with the uplift of Aravalli range in Mesozoic era (205-65Ma). |
| Pascoe (1959) | Evolved as a result of earth movements, which give rise to folding in Aravalli Group and Delhi Group of rocks (ca. 2000-1450 Ma). |
| Iqbaluddin et.al (1978) | Initiated as a normal fault along a pre Vindhyan grain and acquired a reverse geometry during Vindhyan sedimentation due to folding of fault plane in Paleozoic Era(570Ma). |
| Banerjee & Sinha (1981) | A zone of tectonic weakness that existed since Aravalli period (ca. 2000Ma) developed during and after the deposition of Vindhyan sediments. |
| Prasad (1981,1984) | A pre-Vindhyan fault, which marks a lineament after fundamental grain comprising zone of fractures. Active since the end of Vindhyan sedimentation. |
| Sinha- Roy et.al (1981) | Caused by impingement of Bundelkhand massif with Vindhyan cover rocks. This impingement is a result of crustal deformation in Indian plate after collision with Asian plate (ca. 60 Ma). |
| Sinha Roy et.al (1995) | GBF is an imbricate zone comprising a series of steeply dipping reverse faults and slides of sheared rocks. |
| Verma (1996) | A pre- Vindhyan fault that initiated as a normal fault 2500 Ma and acquired reverse geometry during Delhi orogeny 1400 Ma. |
| Chaudhari and Guha (2004) | A post Vindhyan fault that originates as thrust in brittle ductile regime and reactivated as a normal fault. |

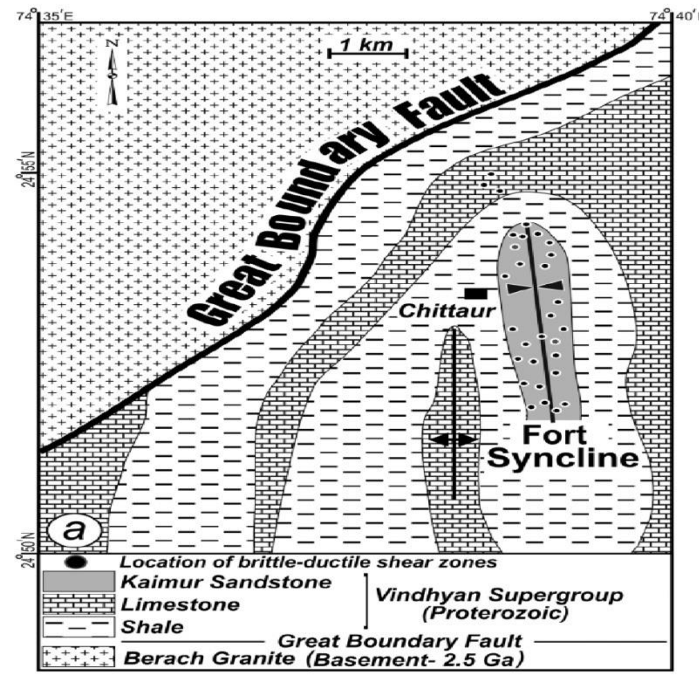


Fig 3: Geological map of the area around Chittaurgarh (lithological boundaries after Prasad, 1984).

According to Prasad (1984), in the western part of the area, the Vindhyan Supergroup is divisible into seven groups – the Satola , Sand, Lasrawan, Khorip, Kaimur, Rewa and Bhander. The metasedimentary rocks of the Bhilwara supergroup, Berach granite, and Bhadesar quartzite occur adjacent to Middle Proterozoic rocks in the west of the Lower Vindhyan. The northwestern part of the Vindhyan basin is indicated by a fault which extends from Chittorgarh in south to Machilpur in north which strike in NE – SE direction and having strike length of about 400 km. The Northwestern margin of Vindhyan Basin is characterized by a major fault extending from Chittorgarh in South to Machilpur in North, having a strike length of about 400 km trending roughly in NE-SE direction. The Berach granite is grey to pink in colour, mafic rich, foliated near shears, occurring in the eastern part of the area, where it forms the basement for Hindoli supracrustals. On the eastern flank of the Hindoli basin, the Mangalwar represented by felsic volcanic and associated pyroclastics were intruded by Berach granite and form the basement for the Hindoli supracrustals. The tectonic evolutionary history of the Great Boundary Fault mainly give evidence of an early event of ductile shearing and the late events of successive reactivation by brittle faulting. (Srivastava, D. C. and Sahay, A., 2003) and these ductile shear zones were typically formed in the local domains of the sedimentary rocks of Lower Vindhyan .The Vindhyan Basin as a whole is characterized by peribasinal deformation where there is a mild deformation in the central part (Iqbaluddin and Mughni, 1976; Iqbaluddin, et al., 1978; Iqbaluddin, 1979) and the folds are developed in the central part which are open to gentle and exhibit progressive tightening towards basin margin. The Khairmalia Andesite which forms the basal stage of lower Vindhyan in Chittorgarh area (Prasad, 1976) have given an age of 1250 M.a. (Crawford and Compston, 1970). The metasedimentary groups of the Precambrian were supposed to be separated from each other by angular unconformities. Gupta 1934; Gupta & Mukherjee 1938; Heron 1953 said that the Berach Granite (Bundelkhand Gneiss of Gupta 1934) represent the basement for younger metasediments. The unconformable relationship between BGC and Aravalli and between Aravalli and Delhi was considered to be of regional extent whereas the unconformity between the younger groups of Aravalli and Raialo is considered to be of local extent. Phurcalite, which is a are secondary calcium phosphate mineral from Putholi area, Chittorgarh through examination of X-ray powder diffraction indicates that it compares very well with the X-ray diffraction profile of phurcalite from Germany described by Deliens and Piret (I978). The basement and the Vindhyan sediments which occur on the hanging wall side of the fault have been folded into large-scale plunging folds which trend parallel to the GBF.

Fig 4: Field photograph showing Great Boundary Fault area, in Chittorgarh.

The Berach Granite constitutes a mineral assemblage of sodic plagioclase, potash feldspar, quartz and some minor ferromagnesian minerals like hornblende, biotite and epidote etc. A few centimetre to 3 m thick pockets of palaeosol has developed on 2585 Ma old Berach granite along the unconformity that separates the Aravalli Supergroup (2500 - 2000 Ma) from the former. Besides, a typical concentration of U, Th, Y and Zr has also been noted. Broad subdivision of the Vindhyan Supergroup as proposed by Auden (1933):

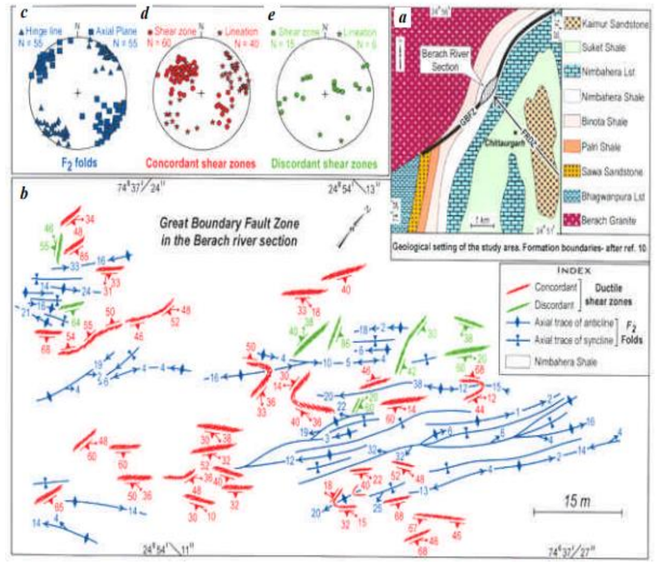


Fig 5: ***a***. Geological Setting of the Great Boundary Fault Zone (GBFZ) and the fault- related deformation zone (FRDZ) around Chittaurgarh area. ***b***. Strutural map of the GBFZ. Orientation of mylonite foliation and stretching lineation in concordant and discondant ductile shear zones shown in red and green respectively. Axial trace and plunge of $F_2$ folds are shown in blue. ***c-e.*** Lower hemisphere, equal area projections for poles; $F_2$ axial planes and hinge lines concordant shear zones and stretching lineations, and discordant shear zones and stretching lineations (Srivastava & Sahay, 2005).

| | After Auden (1933) | Modified |
|---|---|---|
| Upper Vindhyan | Bhander Series | Bhander Group |
| | Rewa Series | Rewa Group |
| | Kaimur Series | Kaimur Group |
| ----------Unconformity---------- | | |
| Lower Vindhyan | Semri Series | Semri Group |

CONCLUSION

In this part of the study area, the Basement rocks (Pre-Aravalli) and Berach Granite are overlain by Vindhyan rocks with unconformity in it and that the Proterozoic Vindhyan basin of Indian Shield is a non linear large sedimentary basin which covers thick underground sedimentary succession. Various assemblages of biotite gneiss, amphibolite, aluminous paragneiss, quartzite and marble occur in the basement which was partly remobilized during the Proterozoic orogenesis. Vindhyan basin of Rajasthan is a dome and basin like structure and is characterized by peribasinal deformation where the central part exhibits little or no deformation. On the eastern side are the high rising ridges quartzites and on its western side, there are thin bands of limestone with some associated metasediments of clay, slate, carbonates. An important dislocation zone in the south-eastern Rajasthan, striking NE-SW as a tectonic lineament, the Great Boundary Fault (GBF), which originated as a thrust in a brittle-ductile/Ductile regime. The GBFZ in Berach River is characteristically controlled by folds of open to gentle and upright F2 folds that plunges towards NE and /or SW. Ductile shear zones and the other major characteristic structure of the GBFZ in the Berach river section, occur a metre-scale lensoid or tabular zones that consist of progressive mylonite foliations and stretching lineation, and cut sharply through the Nimbahera shale. Presence of some closed spaced GBF parallel joints, near GBF also proves that it is subjected to a late tensile stress.

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