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Imprints of great boundary fault (GBF) on Vindhyan Supergroup in Motipur-Malikhera area, Bhilwara district, Rajasthan

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Abstract

Great Boundary Fault (GBF) demarcates the western and north-western margin of Vindhyan basin. Its evolution is complex and has been treated mostly as basinal margin fault for Vindhyan. Structural deformation pattern from Motipur - Malikhera area along the contact of pre-Vindhyan and Vindhyan Supergroup signifies the presence of fault related deformation or damage zone with circulation of fluids through the inter-connected sets of fracture. This has led to ferruginisation or silica venation along the fracture sets. The latest reactivation of the GBF is in form of reverse faulting with the last stage of deformation represented by the displacement along wrench faults.

Keywords: Fault damage zone, great boundary fault, Malikhera, reverse fault, Vindhyan supergroup, wrench fault

1. Introduction

Great Boundary Fault (or GBF) demarcates the north-western and western margin of the Vindhyan basin; over 400 km trending in NE-SW direction. It juxtaposes the pre-Vindhyan and Vindhyan Supergroup; wherein the pre-Vindhyan consists of Hindoli Group, Berach Granite and Jahazpur Group [1]. The Vindhyan Supergroup is generally considered to be undeformed strata of siliciclastic - carbonate - argillaceous sequence in the Son valley and Chambal sector but in Rajasthan sector the sedimentary has been variably deformed due to the GBF. Such deformational structures have been elucidated from Chittaurgarh and Sawai Madhopur area [2, 3] but other areas have not been studied in details so far. The present study focuses on the imprints of the deformation by GBF on the Vindhyan from Motipur-Malikhera area, Bhilwara district, Rajasthan which is about 50 km NE from Chittaurgarh area.

2. Geological setting

The study area (Figure 1a-b) falls in the south-eastern part of Rajasthan and comprises NNE-SSW trending long-linear ridges of Vindhyan Supergroup which abates locally in the north against the peneplained Hindoli Group. The Jahazpur Group and Berach Granite are exposed to the west of the ridge in small hillocks and mounds. Hindoli Group is composed of slate with thin quartzite lenses. Berach Granite is coarse grained with abundant quartz, grey feldspar and minor biotite marked by ferruginisation and kaolinisation. Jahazpur Group consists of shale with interbedded orthoquartzite which manifest planar lamination and cross-stratification. Vindhyan Supergroup consists of shale-sandstone sequence of Chittaurgarh Fort, Jhiri and Taragarh Formation. Chittaurgarh Fort Formation is dominantly arenaceous and composed of mostly quartz along with subordinate heavies exhibiting planar to trough cross-stratification. Jhiri Formation is argillaceous dominated by red shale with interbedded thin lenses of siltstone. The Taragarh Formation is arenaceous as Chittaurgarh Fort but is massive lacking sedimentary structure except for presence of thin lamination.

3. Imprints of GBF in study area

Study area lacks direct evidence of fault zone such as gouge or mylonite but the contact of pre-Vindhyan and Vindhyan has been subjected to fracturing, venation with slickenfibers, change in dip of bedding along with folding and wrench faulting (Figure 2a-f).

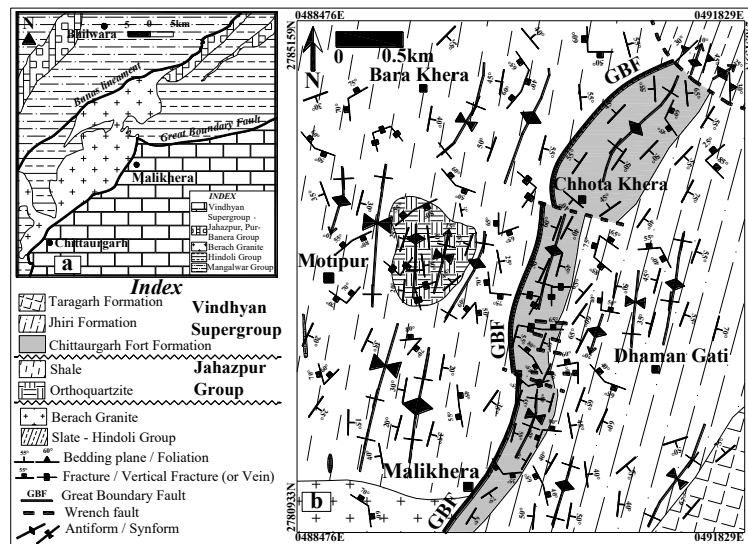


Fig 1: Geological map of (a) south-eastern part of Rajasthan (after Sinha-Roy *et al.*, 1998) and (b) Motipur - Malikhera area, Bhilwara district, Rajasthan

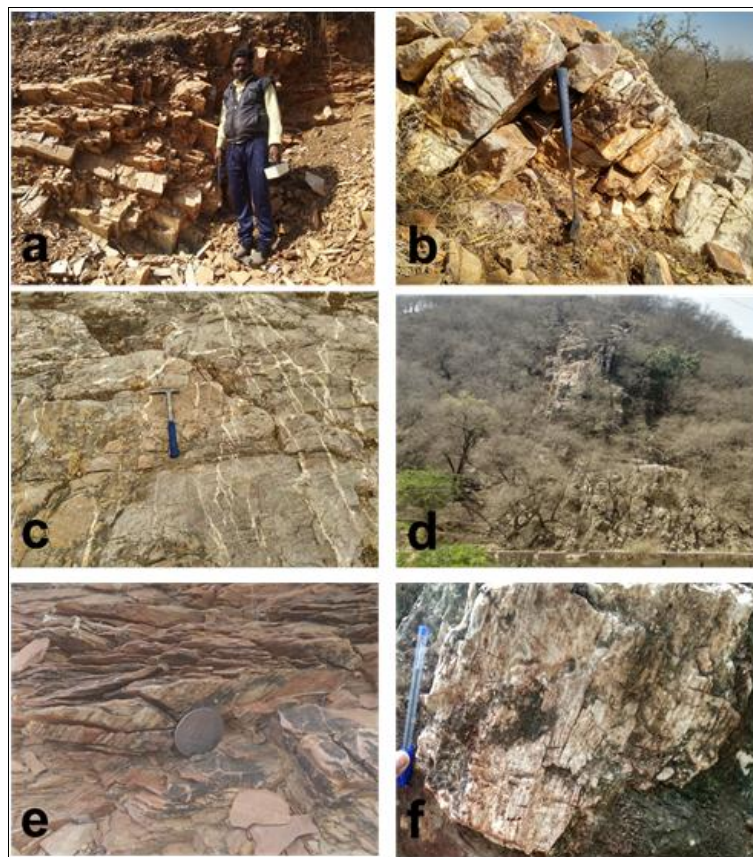


Fig 2: Field photographs of (a) fracture sets; (b) ferruginisation along fracture; (c) silica veins; (d) sub-vertical bedding in Chittaurgarh Fort sandstone; (e) slickenlines and (f) slickenfibers

Conjugate sets of fractures and veins are prominent striking in NE-SW and NW-SE (Figure 3a) direction. Fracture (and vein) density (number of fractures per 1 sq m; Figure 3b) have been measured across the pre-Vindhyan and Vindhyan contact along E-W indicate that the contact has been traversed by 8-12 per sq m over 100m width which decreases to 3-4 per sq m on either direction away from the contact. Ferruginisation and silica veins are common; their intensity has been measured along with the density. It reveals that nearly 20-40% of fractures are ferruginised and the other 20-40% are sealed with silica veins proximal to contact which decreases to <20% away it. Few of the NE-

SW fracture and veins manifest slickenline and slickenfiber with general down-dip movement restricted to few centimeters.

Geochemical study through X-Ray Fluorescence (Table 1) shows presence of Cu (av., 85ppm), Pb (av., 87ppm) and Zn (av., 150ppm) within the ferruginised and silica veined samples (n=16) along the contact in contrast to samples away from the contact (n=18) with Cu (av., 14ppm), Pb (av., 6ppm) and Zn (av., 34ppm).

Bedding has been steepened along the contact in respect to the beds away from it on either E or W direction. Steepening is mostly prominent in Vindhyan rather than in

Jahazpur Group with the sandstone attending sub-vertical dip adjacent to the contact (Figure 3c). Numerous meso-scale gentle to open folds are prevalent in Jahazpur Group and Vindhyan Supergroup which are of non-plunging to gently plunging nature with steeply inclined to upright axial plane striking parallel to the contact in NE-SW or NNE-SSW trend (Figure 3d-e). These folds cease to exist after 1-2 km from the contact.

Wrench faulting displaces the contact along WNW-ESE and has leads to local abutment of Vindhyan with juxtaposition of Hindoli Group in the NE portion. The WNW-ESE striking fracture set (Figure 3f) is prominent in proximity of these faults. Additionally, small-scale fault related asymmetric folds have been observed at terminal portions of these faults with horizontal fold axis and inclined axial plane striking along NNE-SSW.

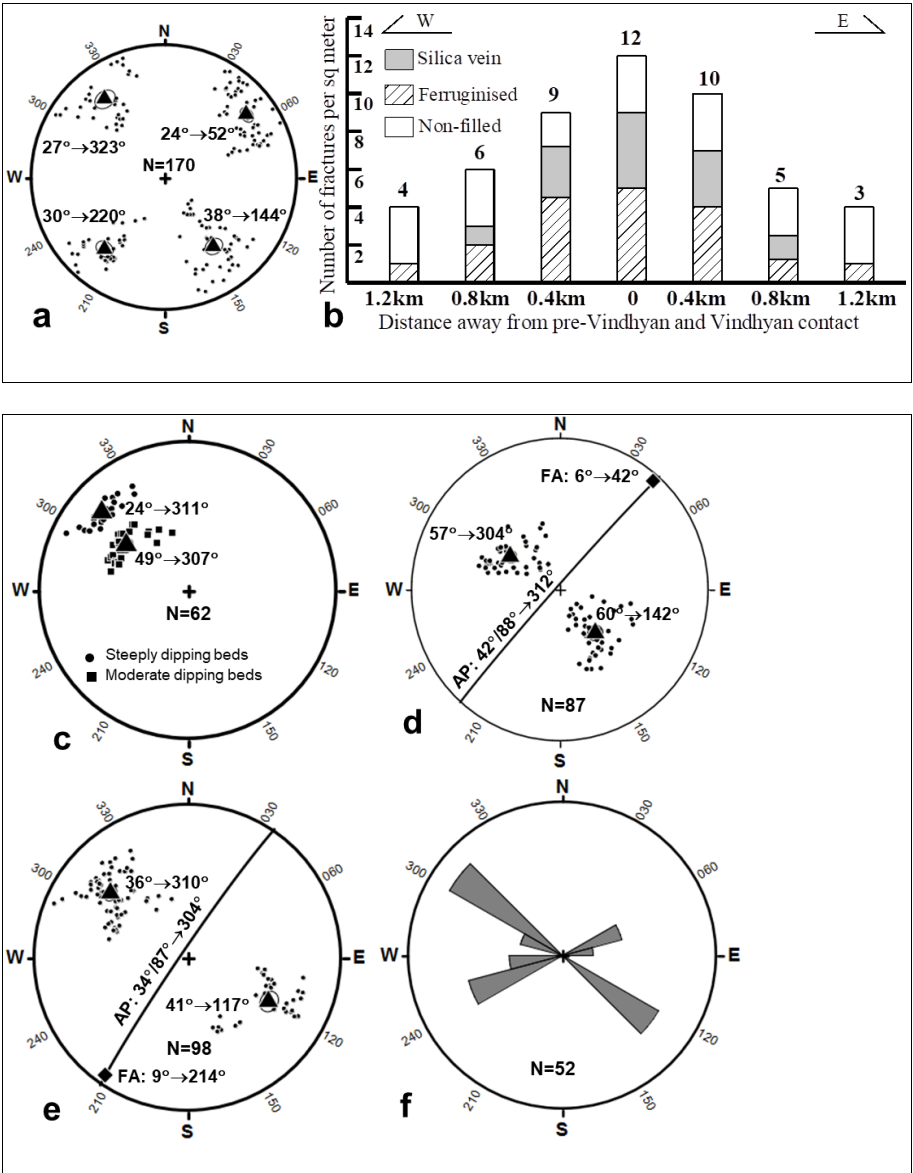


Fig 3: (a) stereoplot of poles of fracture sets; (b) histogram showing the number of fractures per sq. m. and proportion of it either ferruginised or sealed with silica vein; stereoplots of (c) poles of SE dipping beds in vindhyan showing a steeply dipping and moderately dipping sets; (d) poles of limbs, fold axis and axial plane of small-scale folds in Jahazpur Group; (e) poles of limbs, fold axis and axial plane of small-scale folds in Vindhyan Supergroup and (f) rose plot of fracture in proximity of wrench fault

Table 1: Geochemical values of Cu, Pb and Zn in ppm

Proximal to the contact of pre-Vindhyan and Vindhyan				
Sample	Cu	Pb	Zn	Lithology
X/1	60	28	78	Jahazpur group
X/2	243	20	91	
X/3	28	8	128	
X/4	212	479	40	
X/5	127	307	32	
X/6	116	253	30	
X/7	105	16	59	
X/8	85	42	27	
X/9	13	41	14	

X/10	89	21	594	Vindhyan supergroup
X/11	75	12	544	
X/12	51	8	224	
X/13	35	23	434	
X/14	100	17	61	
X/15	12	72	22	
X/16	13	40	26	
Minimum	12	8	14	
Maximum	243	479	594	
Average (n-16)	85	87	150	
Away from the contact of pre-Vindhyan and Vindhyan				
Sample	Cu	Pb	Zn	Lithology
X/17	18	14	51	Jahazpur group
X/18	18	8	76	
X/19	31	10	87	
X/20	20	11	65	
X/21	12	5	40	
X/22	22	<5	30	
X/23	7	<5	32	Vindhyan supergroup
X/24	<5	<5	36	
X/25	18	10	69	
X/26	20	14	72	
X/27	10	<5	14	
X/28	9	<5	11	
X/29	11	<5	12	
X/30	12	<5	16	
X/31	10	<5	21	
X/32	6	<5	12	
X/33	8	<5	12	
X/34	8	<5	15	
Minimum	<5	<5	11	*Average is calculated by considering <5ppm as 2.5ppm
Maximum	31	14	87	
Average (n-18)	14*	6*	34	

4. Conclusion

The pre-Vindhyan and Vindhyan contact is marked by a narrow zone of systematic fracture sets associated with ferruginisation and silica veins. This indicates that it has suffered brittle-scale deformation due to shearing advent by movement along GBF and circulation of hydrothermal solution through the inter-connected secondary voids. The hydrotherms fixate Cu, Pb and Zn within the slivered and fracture zone along the contact. Small-scale slickenline and slickenfiber indicate incremental movement along the fault plane associated with block adjustment during the fault propagation. Asymmetric steepening of the beds along the adjoining contact pronounced in Vindhyan coupled with numerous small-scale folds is indicative of dragging and associated fault related fold due to the movement of GBF. Wrench fault have been the product of variable rate of propagation and displacement of the fault which have been re-activated later displacing the contact as well as main fault zone.

A fault zone comprises of two parts; a core with characteristic gouge and cataclasite development and the other part is the damage zone with fracturing and venation. Thus, the deformational signatures along the contact of pre-Vindhyan and Vindhyan from study area are indicative of part of fault related deformation or fault damage zone. This means that the core zone could be possibly present in the sub-surface with transition from brittle regime to a brittle-ductile regime. Further, as drag folds and other associated meso-scale fault related folds are profound in the study area; it indicates that the latest major re-activation of GBF is in form of a reverse fault as has been reported from Chittaurgarh sector ^[1]. Low-T hydrothermal solution en-

circulate through the fracture system causing the iron oxide bleaching along with fixation of Cu, Pb and Zn. Initial wrenching may be resulting from non-uniform propagation of fault tip line as in case for most large-scale faults ^[4]. Later, these wrench fault are re-activated causing the displacement of the major fault zone representing the last stage of deformation.

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