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Research Article

COAL SEAM EVALUATION STUDY USING BORE HOLE DATA IN KARHARBARI FORMATION GIRIDH BASIN JHARKHAND INDIA

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ABSTRACT
Karharbari formation (Permian) is the part of Giridih Coalfield and is the most important one amongst the Hazaribagh group of coalfields of lower Gondwana supergroup. It contains some of the best coking coal of India. Giridih basin is the smaller basin contains Karharbari and Barakar formations occuping about 18 km^2 of the area.
The East Central Railway (ECR) approached CIMFR for the detailed evaluation of ground study and development of the discreet ground stabilisation design for laying railway tracks to run New Broad Gauge, (1987) train load along the proposed layout above the basin.
The basin, being well-formed but very small in size, has certain typical uniqueness that is not generally found in the rest of Giridih basin. In addition, it is also affected by a few local faults. The dip of a coal seam significantly varies here in both, magnitude and direction, from place to place, and the seams plunge as well. Moreover, these seams frequently merge and/or split at many locations. As a result, precise comprehension of the genesis and pattern of formation of this site becomes very difficult.
An attempt has been made in this paper to explain the coal seam pattern and number of coal seam in Karharbari basin, Giridih. This is the part of the work approached by ECR.

Key Words*: Karharbari Formation, Gondwana Supergroup, Barakar Formation, Fault, Plunge and Seams*

INTRODUCTION

Predominantly continental fresh water sediments belonging to the Gondwana supergroup accumulated during late carboniferous to early cretaceous period, are found to occur in a number of isolated basin along several paleo-rift valley in pensular india. The Karharbari coal measures of Giridih basins of Jharkhand, eastern India, comprise an interbedded assemblage of sandstone, shale and coal in variable abundance. The lithofacies composition records a progressive decrease in sandstone and enrichment of shale and coal from Karharbari up to Barakar. The repetitive fining-upward cycles are asymmetrical, i.e. sandstone → shale → coal → sandstone in the case of Karharbari, but symmetrical as sandstone → shale → coal → shale in Barakar. Location Map of Research area is shown in Figure 1.
Giridih coalfield is the type area of Karharbari formation. This is the part of Damodar River valley basin. Our research work is concerned with a part of the Giridih basin which is present in the Northern-most part of the Karharbari formation. The structure of the proposed research area is basin like, strata dip towards the centre and outcrops in both side of the study area. This sub-basin is bounded by two major faults which is present in its northern and western side. Eastern side is bordered by the metamorphic rocks. Average length of the area is 2.5 km and maximum width is 1.14 km., the area surrounded by this sub-basin is approximately 2.85 sq km. By the lithological study of core samples and borehole co- relation, it will be possible to explain the movement of strata/bed through the basin and major disturbances present in this sub-basin.

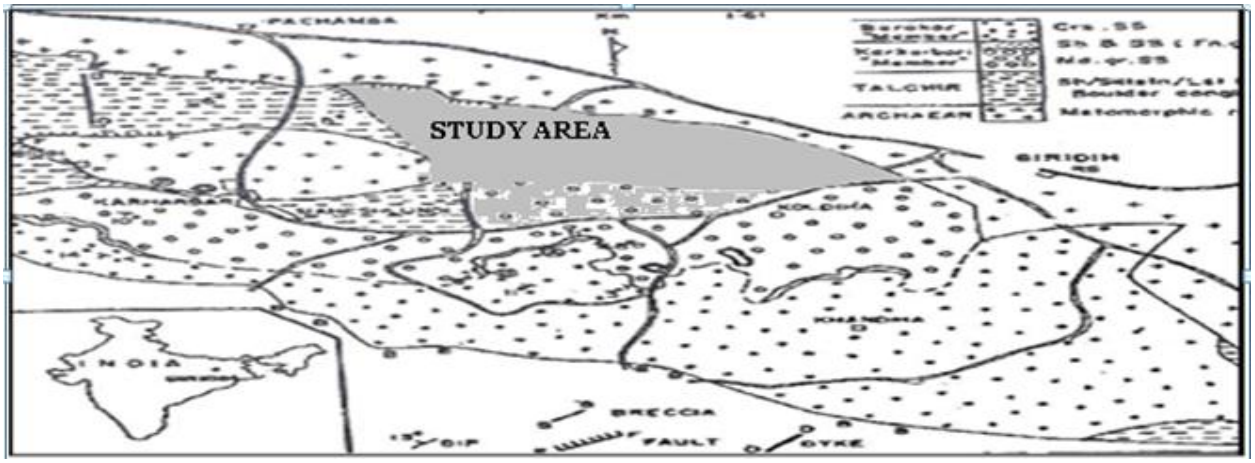

Figure 1: Geological Map of the Girdih Basin (Chandra *et al.*, 2000) Showing Study Area

General Geology of Giridih Basin

Giridih Coalfield is the most important one amongst the Hazaribagh group of coalfields and it contains some of the best coking coal of India. The generalized succession of Giridih Coalfield (Raja Rao, 1987) is given in Table 1.

Table 1: Generalized succession of Giridih Coalfield (Raja Rao, 1987)

Age	Formation	Lithology	Thickness (m)
Lower Cretaceous		Dolerite and lamprophyre intrusive	
Lower Permian	Barakar	Fine to coarse grained sandstone, grey shale, carbonaceous shale and coal seams	165-180
Lower Permian	Karharbari	Medium to coarse grained sandstone with minor shale bands & coal seam	180-210
Upper Carboniferous to Lower Permian	Talchir	Green and buff colour sandstone, needle shale and tillite	15-91
……..Unconformity…….			
Precambrian		Gneisses, Schist and Pegmatite	

The structure of the field is basin-like and is located between two main East–West faults. Strata dip towards the centre of the basin and amount ranges from 6°-35°. Sandstone unit immediately overlying Talchir Formation in Giridih basin was initially recognised as Karharbari on the basis of its fossil content, and the upper sandstone unit devoid of the fossil assemblage was recognised as Barakar (Sengupta *et al.*, 1988). Karharbari and Barakar formations occupy about 18 km^2 of the area and contain productive coal seams.

However, there are differences of opinion about the exact plane of demarcation between Karharbari and Barakar formations in Giridih and also about the nomenclature of Karharbari.

Earlier workers referred Karharbari as a stage while the later workers preferred litho-stratigraphic terminology like formation/member (Sastry *et al.*, 1977). Sengupta *et al.*, (1988) studied the characters of Karharbari and Barakar rocks in Giridih basin with a view to assign appropriate stratigraphic status to them. The authors recognised two units having distinctive petrographic properties. The lower one, consisting of a shale band and quartz wackes of low feldspar content is termed by the authors as

Karharbari. The upper feldspathic quartz wackes constitute the Barakar in Giridih basin. The authors tentatively assign each of these two units as the status of "member".

Major rock types belonging to Lower Gondwana subdivision (Upper Carboniferous) are represented by two stages, viz., Talchir and Karharbari. Talchir stage consists of a boulder bed, needle shale with alternating lenses of silty sandstone, and coarse grits. The boulder bed is un-fossiliferrous as are silty sandstone and coarse grits. But needle shale frequently contains inclusions of carbonaceous material.

Karharbari Stage starts with a conglomerate at the base and consists chiefly of alternating grey arkose, micaceous shale, carbonaceous shale, and coal seams. The arkose are cross-bedded, the cross-bedding being of the type that is usually characteristic of shallow water current. There are five major workable seams in Giridih basin. They are Upper Hill, Upper Bhadua, Lower Bhadua, Upper Karharbari and Lower Karharbari seams,Table 2.

Table 2: Workable Seams in Giridih Basin

Horizon	Coal Seams			Thickness (m)
II	Hill	Upper		0.6-2.4
		Lower	Upper Bhadua	*Not Available*
			Lower Bhadua	0.9-2.1
I	Karharbari	Upper		1.2-3.0
		Lower		3.0-7.3

Each seam is separated from underlying Karharbari seams by 91.5 m barren sandstone. This seam is subdivided into two horizons, the lower horizon contains Lower Bhadua and Upper Bhadua seams, and the upper horizon, called Upper Hill seam. The total thickness of the Hill seam is about 19.8 to 21 m.

Karharbari seams were worked in the past for running locomotives. Lower Karharbari coal seam is of excellent metallurgical coke grade, and varies in thickness from 3.0-7.3 m. Coal from this seam contains low (1.40-1.80%) moisture, 9.0-12.6% ash, 0.5% volatile matters, 0.5% sulphur and 0.01% phosphorous.

MATERIAL AND METHODS

Average length of the area is 2.5 km and maximum width is 1.14 km., the area surrounded by this sub-basin is approximately 2.85 sq km. On this stretch 101 (one hundred one) boreholes have been drilled with the distance of 25m. Boreholes locations are given in Figure 2. Detailed surface survey has been carried out by CIMFR itself. Some of the information's has been also collected from Central Coal Fields (CCL) and ECR office Giridih. By the lithological study of core samples and borehole co- relation, it will be possible to explain the movement of strata/bed through the basin and major disturbances present in this basin.

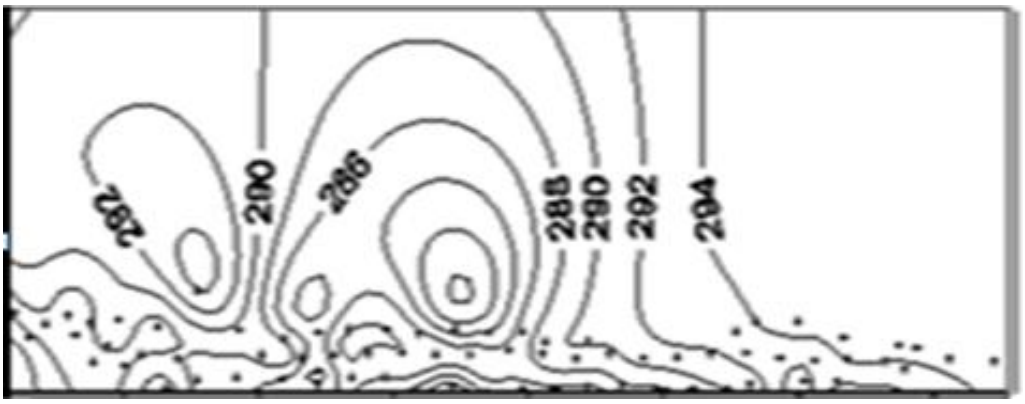

Figure 2: Bore Hole Locations

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Surface Information

So far the site along the proposed track layout is concerned, from the plan of the site, which was provided by the ECR and has been verified by the CCL office in Giridih and CIMFR surface survey, the following informations could be gathered:

The site is on the northern fringe of Giridih Coalfield (known as Karharbari Coalfield as well), bound by Boundary Fault on its north.

On its south there is another fault at its South-West of the site that apparently cuts the site off from the rest and the major part of Giridih Coalfield.

The concerned area mainly stretches along east-west and forms a small part of Giridih Coalfield. The curved outcrops of Karharbari seams occur near both the eastern and western boundaries of the area, curving almost parallel to the proposed railway track alignment, clearly indicates that this area forms a small basin or at the fringe of the main basin of Giridih Coalfield. Being intersected by the Boundary Fault on its north, this isolated formation effectively takes shape of a bowl cut vertically.

CCL officials intimated that during nationalisation of coal mining industry the whole of Giridih Coalfield was handed over to CCL. But they never worked at and around the site of the present study as those mines were largely exhausted, and it was not economically viable to mine the irregularly left-over coal reserve here by regular large or medium scale operation. The plan of this part of the basin was prepared on the basis of whatever little information about those already closed mines was available. The subsurface openings could not be surveyed by CCL due to their inaccessibility. Surface contours are shown in Fig.3.

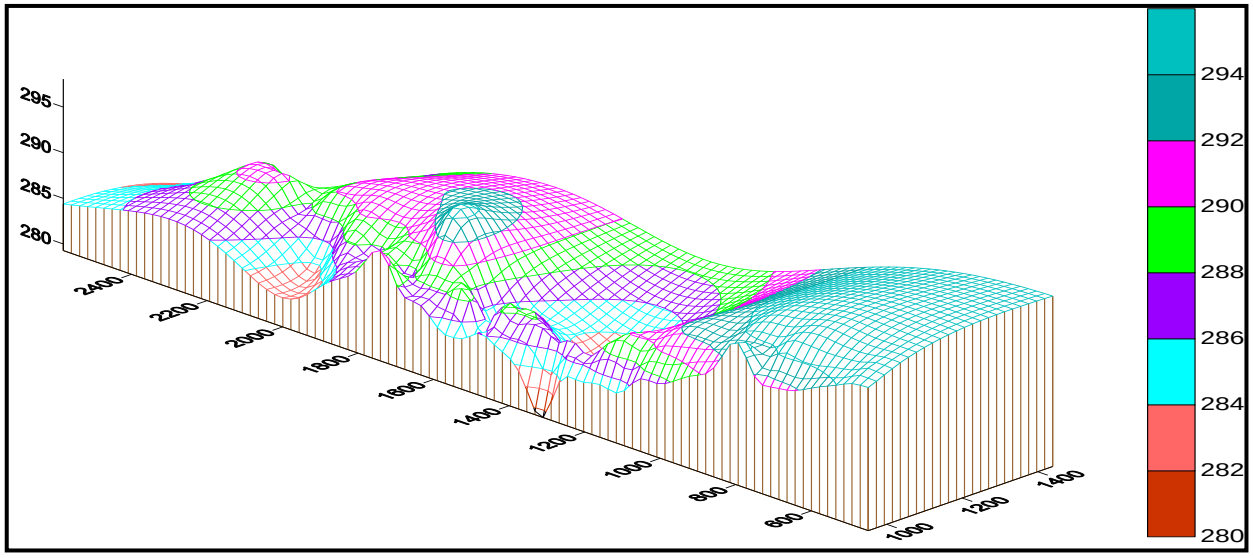

Figure 3: Surface Contour Map of Study Area

Hence, the survey of surface profile was carried out followed by an exhaustive exploration of the site for identification of the mineable horizons in the site, and in the process acquiring information of the status of subsurface openings. As a result total 7006.52 m drillings were conducted in 117 NX size (hole 76 mm Φ, core 54 mm Φ) vertical boreholes of which 101 were coring boreholes (BH-1 to BH-44, BH-44A & BH-45 to BH-100), and 16 were non-coring boreholes ones.

Drilling the Site

The continuous study of drilling parameters and cores from 101 coring boreholes drilled at the project site in the field, followed by analyses of data and information gathered so far, have been presented in this paper. Total 7006.52 m of drilling was conducted in 117 boreholes, over a span of 2.2 km along the centerline of the proposed track layout covering an offset of 10 to 25 m on either side. Of these boreholes, 101 holes [BH-1 to BH-44, BH-44A, and BH-45 to BH-100;] were NX size [hole 3″ (≈ 76.2 mm) Φ; core

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$2^1/_8''$ (≈ 54 mm) Φ] coring ones and their total drilling length is 6667.95 m. Locations of these boreholes are shown in Fig. 1.

The rest 338.57 m of NX size [hole 3″ (≈76.2 mm) Φ] non-core drilling was carried out in 16 test boreholes [TB-01 to TB-16] at selected locations, to study and verify the depths of loose top soil cover and shallow subsurface voids as indicated during core drilling at different locations in the site. The holes were mostly 20 m long barring three which were above 25 m. The first 46 coring boreholes [BH-1 to BH-44, BH-44A & BH-45] were drilled at an interval of around 50 m as close to the centerline of the proposed track layout as practicable, while the rest 55 boreholes were drilled on both sides of the centerline. Locations (latitude & departure) and collar levels (RL) of coring boreholes were precisely determined by surveying using Total Station.

Depth of each borehole was determined by continuous on-the-spot monitoring of its cores obtained, and/or the specific information being searched at that location. Depth of NX coring boreholes varied from 15 m to 151.25 m with an overall average drilling depth of more than 66 m per hole.

Overall core recovery from 101 coring boreholes was 72.64%, which apparently looks to be a little low in general. The value ranged between 27.2% in BH-45 and 87.9% in BH-72. In 6 holes (5.94% cases) core recovery was below 55%, while only in 2 holes (1.98% cases) it was above 85%. However, the reason of 'low' core recovery was due to the presence of thick *top soil* and considerable amount of *void* in boreholes on average, where core recovery was absolutely 0%. In addition, the share of *broken ground* with very poor core recovery was also consequential in many boreholes. Very recently illegal mining in this area is also affecting the top soil cover, especially at and around the outcrops of coal seams.

Interpretation of Drilling Information

There are a number of seams in this area. Seam thickness in this area varies between 0.07 and 7.00 m. While only 2 seats were recognized in BH-32 & BH-35, as many as 14 seams were found in BH-2, and more than 10 seams were identified in BH-1 (12 seams), BH-3 (11 seams), BH-7 (12 seams) and BH-11. Number of seams reduces as one moves eastward i.e. towards Giridih Station. It may be inferred from the above that many of these seams are local that do not extend over the whole stretch of this basin. Most of these seams do not outcrop. At places, a few thin seams merge to form a thicker seam, which again split to form thinner seams. There is no particular order or pattern of merger or splitting of these seams. It is more unclear because of the presence of local seams, most of which originate and die out subsurface.

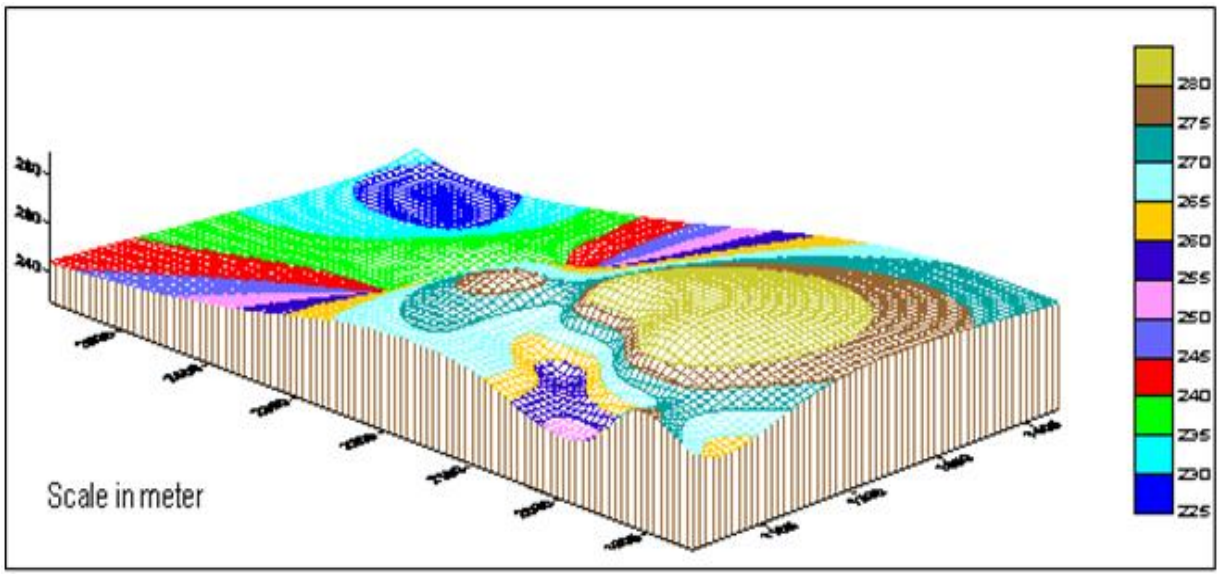

Figure 4(a): Tentative Counter Profile of Upper Karharbari Seam

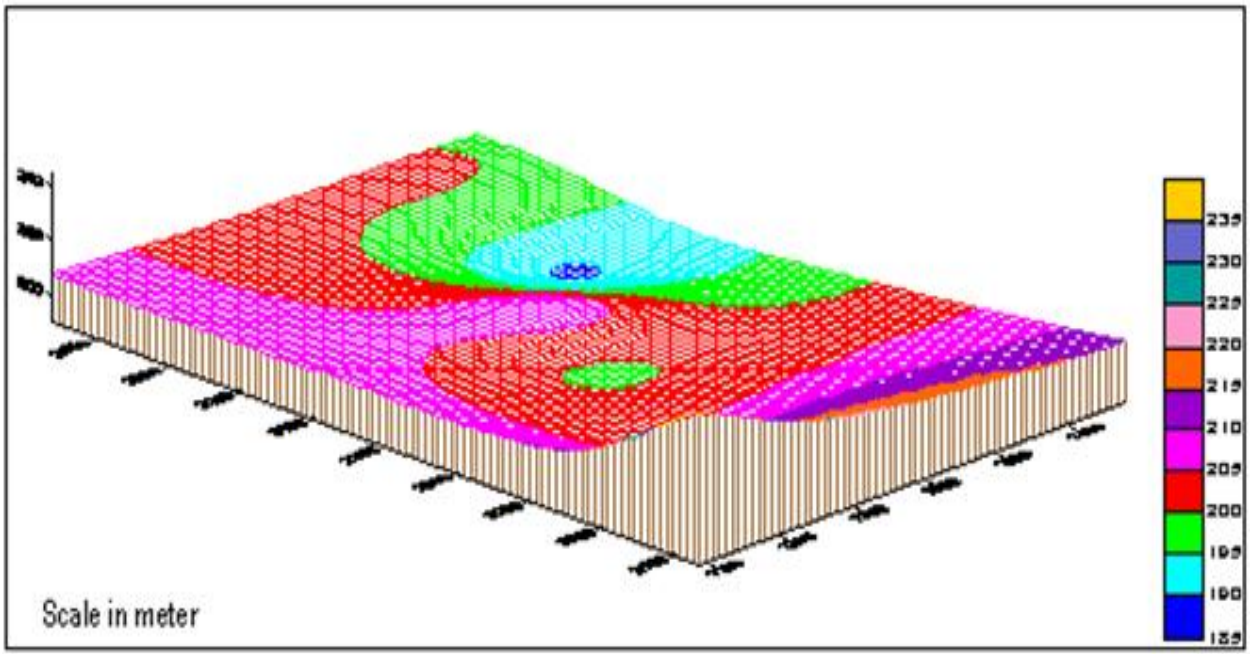

Figure: 4(b): Tentative Contour Profile Map of Middle Karharbari Seam

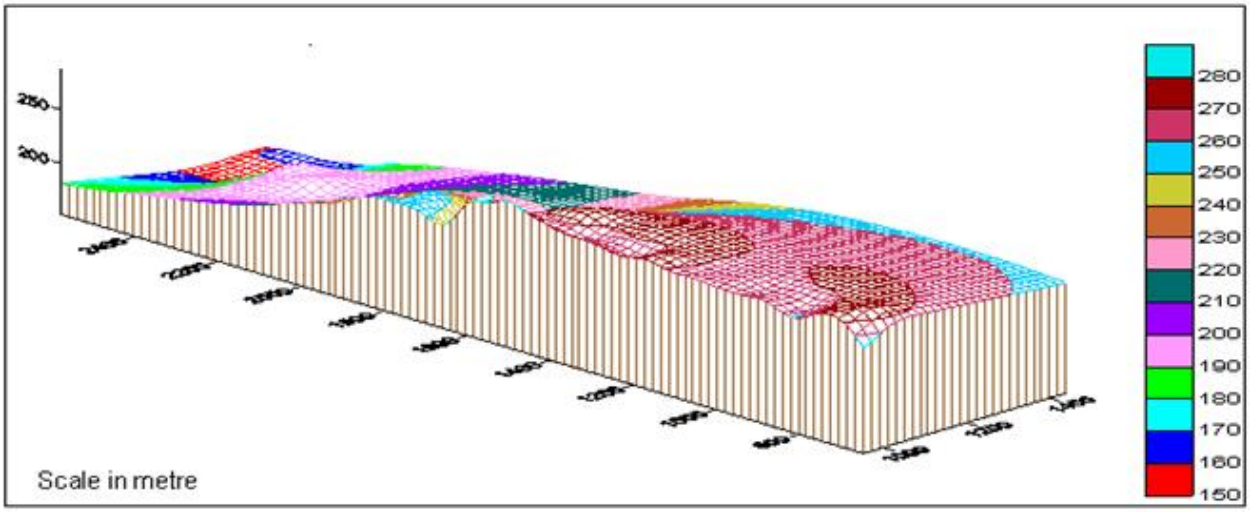

Figure 4(c): Tentative Contour Profile of Lower Karharbari Seam

Depth of coal seams in the western part of the site is more than that in its eastern part. The bottommost coal bearing horizon is at a much greater depth in BH-1 to BH-7 compared to that in the next boreholes towards east (i.e. BH-8 onwards). However, in BH-8 & BH-9 immediately on the east of BH-7, no marked deviation of level is noticed in the top horizons of coal seams. But, as one moves eastward (i.e. towards Giridih Station), in BH-10 onward, the upper coal bearing horizons are found at a higher level. From these observations it may be inferred that a major *(approx. 200m long)* low angle fault may exist between BH-07 & BH-11 with a throw of 28 to 30 m.
The upper seam outcrops between BH-17 and BH-18. This is corroborated from the fact that the seam is

not available in BH-19 onward. Both the top and bottom seam subsided in between BH-35 and BH-38; this is the local depression and indicated as a graven structure. Between BH-40 and BH-41, the bottom lower seam gets uplifted by about 20 m and merges with the top lower seam. This indicates there may be a few local faults in this area that has frequently shifted the horizon of the seams. From BH-44A and BH-45 it is evident that the lower seam outcrops/incrops between these two boreholes and no coal seams exist on further east. No outcrop of this seam could be identified in the field. Coal Seam Profile in Figure 4 a, b and c. However, the tentative profile of Upper, Middle & Lower Karharbari Seams along and around the proposed track layout, as could be established by drilling are pictorially depicted in Figure 4(a, b & c).

CONCLUSION

Lower Permian Karharbari coal measures of Giridih basins of Jharkhand, comprise an interbedded assemblage of sandstone, shale and coal in variable abundance. Karharbari formation starts with a conglomerate *(Talchir Formation)* at the base and consists chiefly of sandstone and in minor amount of micaceous shale & carbonaceous shale. The maturity level of the sediments are low, this indicates that the source is near to the basin. The arkose are cross-bedded, the cross-bedding being of the type that is usually characteristic of shallow water current. This sub-basin is bounded by two major faults which is present in its northern and western side. Eastern side is bordered by the metamorphic rocks. It has been interpreted that Karharbari sediments were deposited in shallow water and based on cross-bedding & sediments were derived from a proximate western source (Rao**,** 1957).

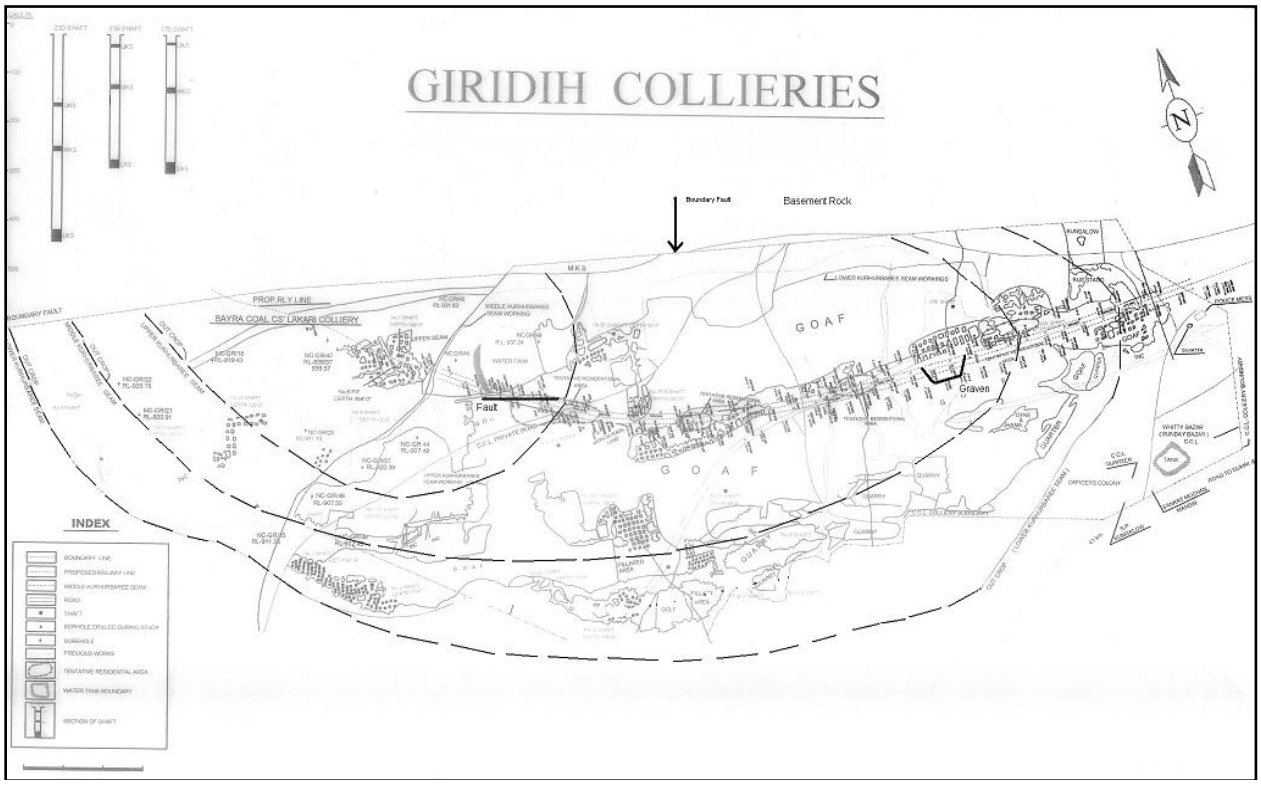

Figure 5: Outcrop/Incrop of Lower, Middle and Upper Karaharbari formations

According to the available geological information (Chandra et al., 2000). There are only two major seams, namely, Upper Karharbari and Lower Karharbari seams in this formation. But with reference to extensive field data and borehole study, it has been interpreted that the Karharbari Formation has three

major seams i.e. Upper Karharbari, Middle Karharbari and Lower Karharbari seams. Showing Outcrops/incrop of Upper, Middle and Lower Karharbari Formation in Fig. 5.

The western part of basin contains thicker seams compare to eastern side, this part of the basin also contain four mineable seams *(local seam)* but after the major fault between BH-7 and BH-11 it merges with lower seam and name as lower Karharbari coal seam. Depth of coal seams in the western part of the site is more than that in its eastern part.

Due to the shape and size of this basin and presence of large number of seams here, some of the seams, both thin and moderately thick ones, outcrop at different locations in this site, while some seams do not outcrop at all but terminates at incrops. A few others outcrop at certain locations but incrop at other places.

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