

## RECOGNITION OF KARHARBARI FORMATION IN GONDWANA SUCCESSION NEAR RAIGARH AND ITS SIGNIFICANCE ON LOWER GONDWANA STRATIGRAPHY OF MAHANADI BASIN

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### ABSTRACT

Coal seams have been discovered from the light green to grey siltstone and fine grained sandstone of the Talchir Formation of Raigarh area, Madhya Pradesh. Based on the occurrence of coal seams and lithologic features, this coal bearing sequence has now been designated as the Karharbari Formation and a four-tier classification of the Lower Gondwana succession of the Mahanadi Basin is proposed.

### INTRODUCTION

The Lower Gondwana succession in the Kelo river basin near Raigarh forms part of the Gondwana succession of the Mahanadi Basin (also known as Mahanadi valley coal field). The Kelo river basin was earlier mapped by Ball (1875) who recognised Talchir, Barakar and Hingir Formations of the Lower Gondwana succession overlying the Archaean basement rocks. This 3-tier stratigraphic classification of the Lower Gondwana succession of the Mahanadi Basin, including the Kelo river basin, is based mainly on lithologic character and occurrence of coal seams in the Barakar. This classification is still in vogue for the northern part of the Mahanadi Basin (Raja Rao, 1982, 1983) except for designating the Hingir Formation as the Kamthi Formation. However, in the Ib river basin in Orissa, which forms the southern part of Mahanadi Basin, Raja Rao (1982, 1983) proposed a 4-tier classification of the Lower Gondwana succession.

Coal is known, so far, from the medium to coarse-grained sandstone and shale of the Barakar Formation in the northern part of Kelo river basin near Raigarh and from the Karharbari and Barakar Formations of Ib Basin in Orissa adjoining Raigarh.

The southern part of the Kelo river basin near Raigarh, comprising Talchir, Barakar and Kamthi Formations did not show coal seams and hence this area did not receive much attention by the earlier workers.

Recent coal find in the earlier mapped Talchir Formation (Ghosh, 1983 : Geol. Surv. Ind. News V.4, no. 2, July 1983) provides a basis for rethinking on the stratigraphy of the Lower Gondwana Group near Raigarh and its adjoining area. In this paper an attempt has, therefore, been made to present the

geologic setting of the coal-bearing formations and to suggest a revision of the stratigraphy of the Lower Gondwana Group for assisting in coal exploration in the southern part of the Kelo river basin. The tests carried out in the Petrological and Palaeontological Laboratories of the Geological Survey of India, Nagpur and the Coal Survey Laboratory, Bilaspur are gratefully acknowledged.

### GEOLOGIC SETTING

The Kelo river Gondwana basin near Raigarh is possibly the north-westerly continuity of the Ib valley coal field of Orissa and presents a more or less similar stratigraphic and tectonic setting. Coal seams are exposed in the Barakar Formation of the northern part of Kelo river Gondwana basin and the southern part of Kelo river basin near Raigarh remained barren of coal seams.

### STRATIGRAPHY

On the basis of geological mapping in a part of Kelo river Gondwana basin (Fig. 1) the following sequence of formation has been worked out:

FORMATION	NOMENCLATURE	POSSIBLE AGE
Alluvium, gravel, conglomerate, some laterite	Recent Deposit	Recent
Ferruginous sandstone, red shale, discontinuous conglomerate	Kamthi Formation	Permian to Lower Triassic
Current-bedded, felspathic sandstone, carbonaceous shale and coal seams	Barakar Formation	Lower Permian

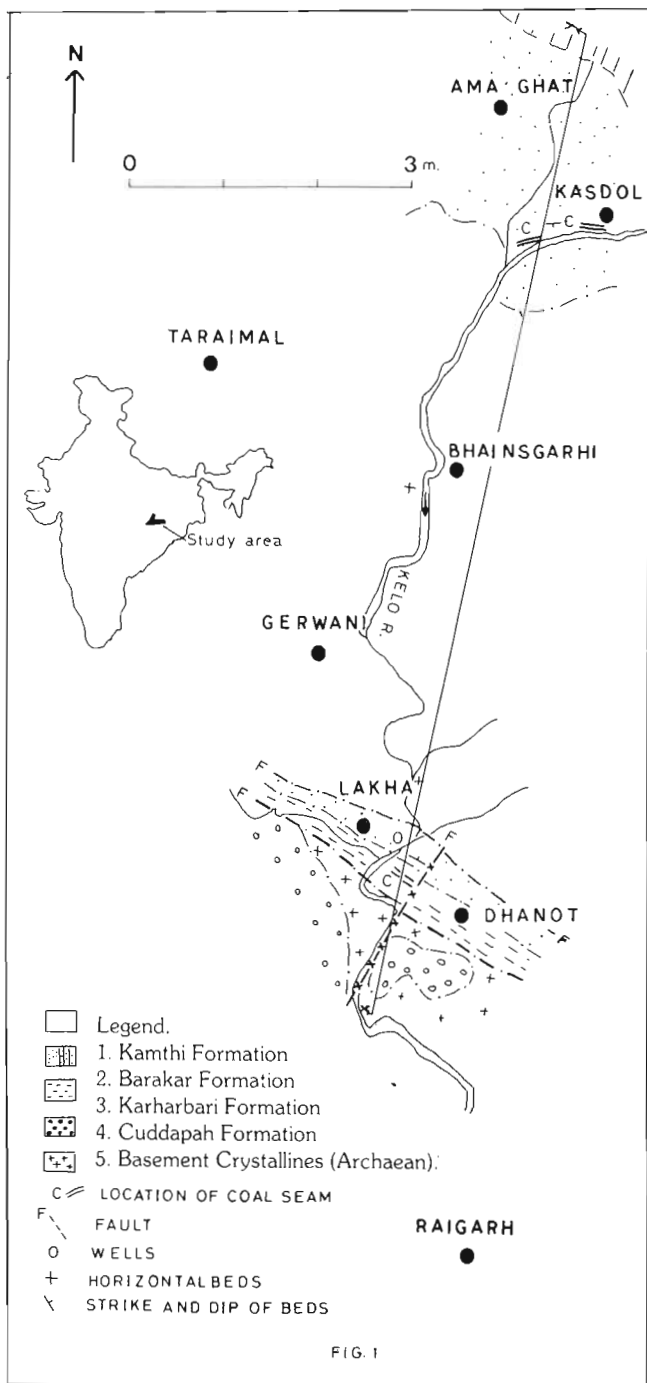


Fig. 1. Geological map of a part of Kelo River Basin, M.P.

Light green to grey siltstone, fine to medium grained sandstone, coal seams	Karharbari Formation	Lower Permian
Pebbly bed, siltstone and conglomerate	Talchir Formation (Concealed)	Upper Carboniferous
	Unconformity	
Quartzite, sandstone and shale	Cuddapah	Proterozoic
	Unconformity	
Granite-gneiss, schist and quartzite		Archaean

#### PRECAMBRIAN BASEMENT ROCKS

The Lower Gondwana sediments rest unconformably over the Precambrian basement, comprising Archaean rocks and along with the Proterozoic Cuddapah rocks at the southern margin of the basin near Raigarh. The Archaean rocks comprise granite-gneiss, chlorite schist (sericitic at many places) and quartzite with quartz and pegmatite veins. The Proterozoic rocks consist of sandstone, shale and quartzite. Some brecciated zones cut across the Precambrian basement rocks at many places along NE-SW, especially at the southern margin of the basin.

#### TALCHIR FORMATION

The Talchir Formation is the lowest lithologic unit of the Kelo river Lower Gondwana succession and is concealed near Raigarh. However, it has been encountered in the exploratory bore holes. It is represented by pebbly and conglomerate beds and siltstone in the drilled length.

#### KARHARBARI FORMATION

The Karharbari Formation consists of light green to grey coloured siltstone, fine-to medium-grained sandstone and coal seams, which have been encountered in the exploratory bore holes. This formation occurs as a strip fringing the southern part of the Kelo river Gondwana basin and rests below the Barakar and overlies the Talchir. This formation was, earlier, mapped as Talchir. However, the coal find and the nature of the rock units bear strong resemblance with the Karharbari Formation of Ib valley in Orissa. Some of the characteristic features of the Karharbari Formation of Kelo river basin and the Ib valley are provided in Table 1.

Table 1. Showing some of the characteristic features of the Karharbari Formations of Kelo river and Ib valley Gondwana basins

KELO RIVER BASIN, M.P.	IB VALLEY, ORISSA
1. Layered sequence of light green to grey siltstone, fine to medium sandstone and thin coal seams varying in thickness from 1.5m to 3.5m	1. Multi-layered sequence of sandstone (fine to medium), shale and thin coal seams, varying in thickness from 1.07m to 3.66m
2. Sandstone, with grains of unaltered feldspar, quartz, clayey and some organic matter.	2. Sandstone, feldspathic with fragments of feldspar and quartz.

Some plant impressions were recorded from the shale-siltstone and the fine-to medium-grained sandstone of the Karharbari Formation. The plant impressions have been identified as *Vertebraria indica* Royle. Apart from this, some carbonised unidentifiable plant remains were also found in this unit. The plant remains were recorded from samples at a depth of about 12-15m and these rock samples showed the presence of quartz grains set in a clayey matrix formed due to weathering of feldspars and some grains of unaltered alkali feldspar, clay pellets and organic matter.

On the basis of these characters, the sequence consisting of light green to grey siltstone, fine-to medium-grained sandstone and coal seams now discovered have been separated from the earlier Talchir Formation and designated as the Karharbari Formation. The thickness of the Karharbari Formation may vary from 45m to 110m.

#### BARAKAR FORMATION

The Barakar Formation occurs in the area as a thin strip at the southern margin of the Kelo river Gondwana basin and a thick pile of Barakar sediment is present in the main basinal portion towards north. The total thickness of Barakar may be around 200m. The sub-arkosic character of the sandstone with calcareous and ferruginous cementation resembles with known Barakar Formation of Mand valley to the west and Ib valley to the east-south-east. In the Kelo river basin, the Barakar Formation consists of cross-bedded sandstone and shale. The sandstone consists of sub-rounded quartz grains and kaolinised feldspar. Some plant impressions, which could not be identified properly because of highly carbonised nature, were recorded from shale and the medium variety of sandstone. Coal exposures were seen towards northern margin of the basin near Kasdol and Amaghat (Fig. 1) where the thickness of coal seam varies from 1.2m to 1.5m. At the southern margin of

the basin, there is no exposure of coal nor any coal seam was encountered in the exploratory bore holes.

#### THE KAMTHI FORMATION

The Kamthi Formation consists of coarse, friable, porous, ferruginous sandstone and some argillaceous bed which rest over the Barakar just north of Dhanote-Lakha. The thickness of Kamthi may be around 50-60m and the lithological character resembles with that of similar formation at Hingir and within Ib valley in Orissa.

#### STRUCTURE

The Lower Gondwana Group of the Kelo river basin represents the south-western extremity of the Upper Mahanadi Valley Coal field, aligned in a NW-SE direction. NE-SW is another prominent lineament direction in the area. These lineament patterns can easily be picked up on the Landsat imageries. The NW-SE lineament along the Archaean-Gondwana boundary near Raigarh, Mand, etc. is possibly due to tectonic truncation. The Hasdo (Korba), Mand, Kelo (Raigarh) and Ib valley Gondwana basins encompass the same structural belt and hence provide almost similar geological and structural setting, delimited by boundary fault at the southern margin of the Gondwana basin.

In the Kelo river basin, the lower Gondwana formations abut against the Cuddapah and Archaean rocks (Figs. 1,2) along faulted contacts, in the vicinity of the southern basinal margin near Lakha and Chiraipani. Another cross fault is seen near Dhanote-Lakha in a NE-SW direction. The Lower Gondwana sediments occur in a broad synclinal structure with a WNW-ESE fold axis near Bhainsgarhi and Taraimal. The beds dip at low angles (2-5 degrees) towards SW in the northern part of the basin and about 10-12 degrees towards NE at southern margin of the basin. Excepting for some evidences of faulting near Raigarh at the southern margin of the basin, the synclinal structure may have undisturbed structural continuity below the Kamthi. This geological setting suggests northern extension of Dhanote-Lakha coal seam and southern extension of Kasdol-Amaghat coal seams. Hence, the area is geologically potential belt for non-coking coal.

A tentative estimate of coal-overburden ratio within a depth of about 30m is 1:3.

#### COAL SEAM

Exploratory bore holes (done by project authorities and suggested on the basis of carbonaceous

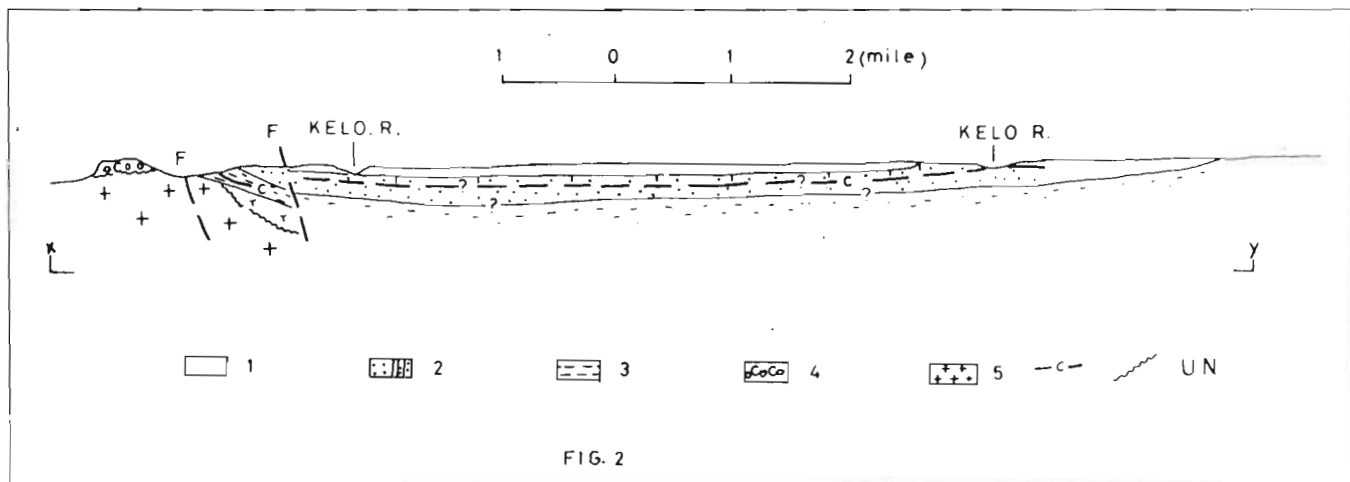


FIG. 2

Fig. 2. Geological section along Kelo River valley.

Legend. 1. Kamthi Formation, 2. Barakar Formation, 3. Karharbari Formation T. Talchir Formation, 4. Cuddapah Formation, 5. Basement Crystallines, 6. Coal seams Un. Unconformity

character of the Karharbari Formation) confirmed the presence of four coal seams in a drilled depth of 171m. The coal seams vary in thickness from 1.5m at 24m depth, 1.8m at a depth of 28m (in a bore hole near Dhanote) and 3m at a depth of 138m, 2.2m at depth 169m (in a bore hole near Lakha) and 3.0m to 3.5m at a depth of 138m and 171m in a bore hole near Chiraipani. Hence, the thickness of coal seams vary from 1.5m to 3.5m. Analysis of coal seams shows that the coal seams contain fixed carbon ranging from 27.6% to 35.8%. The results of coal analysis are tabulated below (Table 2).

Table 2: Analysis of Coal: As analysed basis in %  
—Average

Number of samples	Moisture	Ash	Volatile matter	Fixed carbon
17	4.3 to 9.8	28.9 to 43.0 (in some samples)	22.8 to 25.8	27.6 to 35.8

The coal seams occur about 80-100m above the Talchir contact and as splitting type. These characters are comparable to the Ib valley coal field (Table 3), and suggests that the coal seams of Raigarh area are of Karharbari affinity.

Table 3. Chemical character of Ib seam of Karharbari sequence, Orissa (after Raja Rao, 1982): As analysed in %

Moisture	Ash	Volatile matter	Nature
6.0-7.0	15-22 (sometimes 26.5-27)	21.4-24.2	splitting type

## DISCUSSION

In working out the Lower Gondwana stratigraphy of the region, coal find in the Talchir Formation near Raigarh area suggests three possibilities as under:

- the light green to grey siltstone, fine to medium grained sandstone and coal seams represent the upper part of the Talchir Formation immediately underlying the Barakar Formation, and that the Talchir may also be coal bearing on a regional scale as against recently held view that the Talchir is generally non-coal bearing (except for one occurrence in Orissa with thin seam).
- the light green to grey siltstone, fine to medium grained sandstone and coal seams represent the lower part of the Barakar Formation and this correlation can only be made on the basis of plant impression identified as *Vertebraria indica* rather than on lithologic character.
- the light green to grey siltstone, fine to medium grained sandstone and coal seams represent the Karharbari Formation which can be correlated well with known such occurrences in the adjoining Ib river basin on the basis of lithologic character—multi-layered sequence of siltstone, sandstone and coal seams and the nature of coal seams.

The Kelo river basin near Raigarh has more geological affinity, both litho-stratigraphically and coal character wise, with that of Ib river basin in the southern part of the Mahanadi Basin and hence the coal find in the Talchir Formation near Raigarh is very significant in recognising the Karharbari Formation in the area. The Talchir is more laminated and rhythmic with boulder bed, while the Barakar is more coarse grained with thick coal seams. These characters are lacking in the above unit. The plant impression identified as *Vertebraria indica* is also not an index fossil for precise correlation as it occurs in Talchir, Karharbari, Barakar and Raniganj Formations. Hence, emphasis is given on lithological correlation and analysis of coal samples.

With the recognition of Karharbari Formation having coal seams in the Lower Gondwana succession of the Kelo river basin, which lies below the Barakar Formation, the stratigraphic sequence worked out earlier needs a revision. Earlier a 3-tier classification of the Lower Gondwana succession was proposed by Ball (1875) as Talchir, Barakar and Hingir (= Kamthi) Formations. Later, Raja Rao (1982, 1983) proposed a 3-tier classification for Raigarh and Korba areas and a 4-tier classification for Ib and Hasdo Arand areas which are the southern and northern areas of the Mahanadi Basin. He recognized the Talchir, Barakar and Kamthi Formations in Raigarh and Korba areas, and the Talchir, Karharbari, Barakar and Kamthi Formations for Ib and Hasdo-Arand areas. However, no justification is given for presenting these two separate classifications in the identical geological setting of the Lower Gondwana succession of the Mahanadi Basin. It is suggested here that the non-occurrence of coal seams below the Barakar in the Raigarh area possibly prevented the earlier workers in presenting a four-tier classification here also.

On the basis of geological studies around Korba, Hasdo-Arand, Mand, Raigarh and Ib valley coal field areas, it is seen that the Karharbari Formation, now recognised in Raigarh area, possibly represents a distinct stratigraphic position in the Lower Gondwana succession of the Mahanadi Basin. The geological setting of the Lower Gondwana succession in the Mahanadi Basin is identical in the coal field areas of Hasdo-Arand, Korba, Mand, Raigarh and Ib. The present surficial discontinuous nature of the Lower Gondwana succession along the southern boundary of the Mahanadi Basin is possibly due to tectonic truncation because of Mahanadi Graben Fault. Hence, a 4-tier classification is proposed for Raigarh area and also for the entire Mahanadi Basin. As a result of this proposal, the entire Mahanadi Basin requires assessment with respect to coal occurrences in both the Karharbari and Barakar Formations as per stratigraphic sequence proposed now.

## CONCLUSIONS

Recent coal find in the light green to grey siltstone and fine to medium grained sandstone of the Talchir formation, now designated as the Karharbari formation, suggested a revision of the lower Gondwana succession in the Kelo river basin near Raigarh. A 4-tier classification of the lower Gondwana succession has been proposed for the entire Mahanadi valley on the basis of identical litho-stratigraphic setting and coal character. The Kelo river basin has more geological affinity with that of Ib valley coal field in Orissa.

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