BEARING OF HEAVY MINERAL STUDIES ON THE POSITION OF THE KARHARBARI BEDS IN THE DALTONGANJ COALFIELD, BIHAR

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ABSTRACT—The present study has revealed a close similarity between the heavy mineral assemblages of the Talchir and Karharbari sediments, indicating a common provenance for both. This evidence, if considered in the light of the results of the fabric analysis of these sediments made earlier by the authors, strongly suggests that the grouping of the Karharbari beds with the Talchir series instead of the Damuda series is more appropriate.

INTRODUCTION

A heavy mineral study of the Gondwana sediments from the Daltonganj coalfield has been undertaken by the authors to supplement their earlier study of the apposition fabric in the same area (Srivastava & Israili 1963). The results of the fabric investigation proved to be interesting in as much as they strongly suggested a close relationship between the Talchir & Karharbari sediments which were found to possess the same fabric pattern and the same direction of sediment transport, indicating a common source area for both. It was suggested that in view of such and other similarities the Karharbaris could be grouped with the underlying Talchirs instead of the overlying Barakars.

It was further thought that if the Talchirs and Karharbaris had more or less the same source area and were deposited by the same pattern of palaeo-currents as indicated by the fabric study, this fact should be reflected in the nature of their respective heavy mineral residues.

In the present study heavy minerals have been extracted from the matrix of the boulder bed as well as from sandstones of the Talchir and Karharbari stages and an attempt has been made to compare the results with the already existing data from other coalfields of eastern India.

CLASSIFICATION OF GONDWANA SEDIMENTS

According to Hughes (1870), only the rocks of the Talchir and Damuda (Barakar) series are present in this field and cover an area of about 200 sq. miles. However, the so-called Barakars of this coalfield were assigned, on palaeobotanical grounds, to the Karharbari stage by Feistmantel (1883) who, following Blanford (1878), grouped these rocks with the Talchir series, forming its topmost horizon. This scheme of classification was followed in later years by Latouche (1891), Oldham (1893), G. de P. Cotter (1917), Simpson and Ball (1922) and Wadia (1953). On the other hand Saise (1894), for startigraphical reasons, preferred to place the Karharbaris at the base of the overlying Damuda series. Among the supporters of this classificatory scheme are Gee (1932), Fox (1934), Pascoe (1959) and Krishnan (1960).

In common with all the other Gondwana coalfields of India the Talchir series starts with a basal boulder bed considered to be of glacial origin. Recent fabric studies by the authors (Srivastava and Israili, 1963) confirm this view of their origin. The boulder bed consists of an unsorted accummulation of coarse debris set in an abundant fine-grained graywacke-like matrix. It is succeeded by sandstones of variable grain size which contain subordinate intercalations of green splintery shales. The rocks of Karharbari stage consist essentially of a sequence of coarse grained sandstones, carbonaceous shales and occasional intercalations of coal seams.

HEAVY MINERALS

Samples containing about 20 to 25 gms. of the very fine sand fraction (1/8 mm. to 1/16 mm.) of the matrix of the boulder bed and 50 to 200 gms. of the same grade from the Talchir and Karharbari sandstones, obtained earlier during the mechanical analysis of these sediments, were digested in 1 N hydrochiclro acid to remove the coating of iron oxide around the grains. The samples were then dried and weighed.

The heavies were separated from these samples according to the technique suggested by Krumbein and Pettijohn (1938, pp. 343-344, Fig. 153) using acetylene tetrabromide (Sq. Gr. 2·94 at 33°C) as the separating liquid. The heavy mineral crop so obtained was washed with carbon tetrachloride and dried. A small sample containing about 1000 grams of the heavies was then obtained by using the simple technique suggested by Hutton (1950, p. 693) and mounted permanently in Canada balsam.

For the identification of the opaques a small portion of the heavy residue was mounted in sealing wax, polished and studied under the ore microscope.

TABLE 1

Weight Percentage of Heavy Minerals in the 1/8—1/16 mm. grade in the Gondwana Sediments of Daltonganj Coalfield, Bihar

TALCHIR STAGE

	Talchir Boulder Bed						Talchir Sandstones			
Sample No.	RK1T	RK2T	Dr10T	Dr11T	Dr12T	Average	SK4T	SK9T	SK11T	Average
Weight Percentage	8·98	11·54	9·71	5·45	5·22	8·18	2·9	0·29	0·35	1·18

KARHARBARI STAGE

Sample No.	SK14B	SK25B	SK32B	Ka13B	Ka16B	Ja12B	Ja2B	Ja18B	Average
Weight Percentage	4·23	2·5	2·17	0·87	1·30	0·16	0·61	0·19	1·50

The percentage by weight of the total heavies present in the matrix of the boulder bed and Talchir and the Karharbari sandstones show some interesting trends. Table 1 shows the weight percentage of the heavy minerals in the very fine sand fraction of the different samples. The total quantity of the heavy minerals in the matrix of the boulder bed varies from 5·22% to 11·54% by weight of the sample with an average of 8·18%. The Talchir sandstones contain a much smaller concentration of heavy minerals, the quantity varying from 0·29% to 2·9% by weight with an average of 1·18%. There is again a slight increase in the total quantity of the heavies in the Karharbari sediments varying from 0·16% to 4·23% with an average of 1·5% by weight.

In the present study 200 grains per slide were counted and the frequencies determined according to the scale devised by Evans & others (1933). Table 2 shows the distribution of the heavy minerals frequencies in the various groups of the Gondwana rocks. Text figure 1 shows the average frequency of the heavies in Talchir and Karharbari sediments.

TABLE 2

Heavy Minerals of Talchir and Karharbari rocks, Daltonganj Coalfield, Bihar

	Matrix of the Boulder-bed					Talchir Sandstone			Karharbari Sandstone					
Heavy Minerals	RK1T	RK2T	Dr10T	Dr11T	Dr12T	SK4T	SK9T	SK11T	SK14B	SK32B	Ka16B	Ja12B	Ja2B	Ja18B
Garnet	8−	8−	8−	7+	7+	7	6+	7	8	6+	6	5	5	2
Tourmaline	3	4	4	4	3	3	4	2	4	5+	5	3	4	5
Zircon	4	4	1	5	2	5	6−	6+	3	5	5	4	4	2
Pistacite	3	3	3	2	4	4	3	2	1	1	1	2	2	1
Zoisite	2	2	—	3	6−	5	5	4	3	—	—	3	2	—
Rutile	2	—	4	—	3	—	1	1*	2	2	3	1	3	2
Actinolite-Tremolite	5	3	5	5	5	2	2	—	—	—	1	—	1*	—
Magnetite & Ilmenite	4	4	5	5	5	5	5	5	5	6	7−	7+	7	8
Titanite	1*	—	—	1	3	—	—	—	—	—	—	—	2	—
Monazite	—	2	1	—	3	—	1	—	—	—	—	—	—	—
Alterites	4	3	1	4	3	7−	5	2	5	6	6—	3	5	2

MINERALOGY

Actinolite-Tremolite

Actinolite and tremolite occur in all samples of the matrix of the boulder bed and range upto the lower Talchir sandstones but are almost entirely absent from upper Talchir and Karharbari sandstones. Only one grain of tremolite has been observed from the lower Karharbari horizon. Actinolite is light bluish-green in colour and occurs as short prismatic crystals with distinct cleavage showing feeble pleochroism. Tremolite grains are colourless and occur as fibrous crystals. The grains of both these minerals are distinctly etched specially those from the Talchir and Karharbari sandstones.

Epidotes (Pistacite, Clinozoisite and Zoisite)

Pistacite occurs in almost all the horizons but is fairly common in the boulder bed and also in the lower portion of the Talchir sandstones. It is yellowish-green in colour with subangular to rounded grains and exhibits a "compass needle" interference figure under convergent light. The other two varieties, viz., zoisite and clinozoisite are colourless and occur as angular to subrounded grains, and show "ultra blue" anomalous birefringence colours. The zoisite grains are more common and distinguished from clinozoisite by the smaller optic axial angle.

Tourmaline

Five varieties of tourmaline have been recognized on the basis of colour, namely, brown, blue, green, yellow and pink. The bluish grains are usually subangular to subrounded while other varieties are prismatic and euhedral. The green and brown varieties occur characteristically in the boulder bed while the yellow and blue varieties are common in the Talchir sandstones. In the Karharbaris probably all the types are equally common. The grains are pleochroic and some of them show authigenic overgrowths in optical continuity with the detrital grains.

Garnet

Three varieties based on colour are distinguishable, namely, brown, pink, and colourless. The brown variety is common in the boulder bed, and the colourless in the Talchir sandstones while the Karharbaris are characterized by the pink variety. The Talchir garnets are angular, sharply chipped and show conchoidal fractures while the garnets of the Karharbari beds show pronounced etching effects.

Zircon

Colourless, greyish green and pink zircons are common in all the horizons. The grains show a great variation in shape and roundness. The zircons in the boulder bed and Talchir sandstones are clear and free from inclusions while those in the Karharbaris show numerous inclusions.

Rutile

Although rutile occurs in all the horizons, it is concentrated mostly in the Talchir and Karharbari stages. The grains are elongate or oval in shape and are deep yellow to reddish brown in colour.

Titanite

It occurs essentially in the Talchir boulder bed and is rare in the upper horizons. The grains are pale yellow in colour and are subangular to subrounded and show a marked conchoidal fracture. Grains turn blue as the extinction position is reached and are biaxial positive.

Monazite

This mineral occurs exclusively in the boulder bed. The grains are yellowish in colour and exhibit a well rounded oval form. Biaxial positive with a small 2V.

Magnetite & Ilmenite

The grains are irregularly shaped, shiny black in colour and are difficult to recognize under transmitted light.

Under reflected light magnetite appears grey in colour with a distinct brownish tint while ilmenite is of brownish grey colour.

DISCUSSION

The position of the Karharbari stage in the classification of the Gondwana sediments of India was variously fixed in the past on palaeobotanical and stratigraphic grounds and no serious attention was paid to the textural and compositional characters of the sediments. Blanford (1878), taking into consideration the close floral affinities between the Talchirs and Karharbari rocks, for the first time advocated the separation of the Karharbari beds from the Damuda series and suggested instead their grouping with the Talchir series. Saise (1894), however, found that such a regrouping was not supported by adequate evidence and suggested thier placement back to the base of the Damuda series below the Barakar stage.

The present study, however, has brought out some evidence which, when viewed from the point of view of the sedimentological history of the Daltonganj basin, is of importance and throws some light on the question of the stratigraphic position of the Karharbari stage at least in this coalfield.

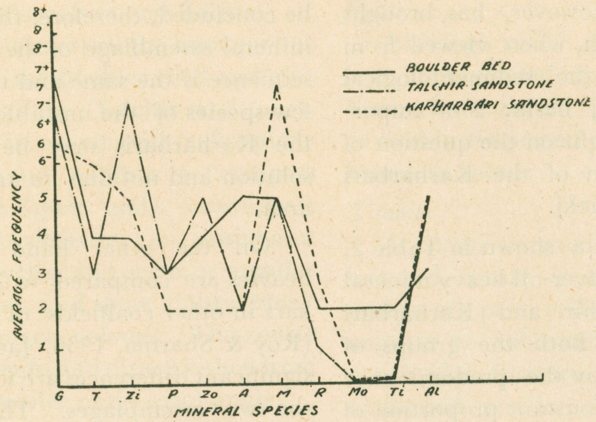
The heavy mineral data shown in Table 2, clearly indicates that the over-all heavy mineral assemblage of the Talchir and Karharbari sediments is the same. Both the groups of rocks are characterised by the predominance of garnet and an almost constant proportion of tourmaline, zircon, pistacite, zoisite, rutile and magnetite and ilmenite. However, it is true that some minerals like actinolite-tremolite, titanite and monazite are almost exclusively present in the Talchirs and are rare or absent in the Karharbaris. Such differences are not very significant because all the minerals exclusively present in the Talchirs, are unstable and show a progressive dilution even within the Talchir strata itself from the base upwards. As a matter of fact such minerals are concentrated only in the matrix of the boulder bed. Their absence or relative impoverishment in the higher strata probably reflects the simultaneous changes in physical and climatical conditions of deposition.

The glacial climate prevailing at the time of deposition of the boulder bed was probably capable of preserving these unstable heavy minerals in much the same manner as fresh undecomposed felspars are preserved in glacial sediments due to repaid erosion, peculiar mode of glacial transport and quick burial under conditions of inhibited chemical activity. But with the close of the glacial period and the advent of warmer climate, chemical activity increased resulting in the progressive dilution by intrastratal solution of the more unstable heavy minerals. The etched garnet, tourmaline and zircon in the Karharbaris and actinolite and tremolite in the Talchir sandstones probably bear testimony to this fact. It may be concluded, therefore, that the overall heavy mineral assemblage of the Talchir-Karharbari sequence is the same and that the absence of a few species of the unstable heavy minerals in the Karharbaris may be due to intrastratal solution and not due to any shift in the source area.

On the other hand if the Karharbari heavies are compared with those of the Barakars in other coalfields of the neighbourhood (Roy & Sharma, 1936, Jacob & others, 1958), significant differences are found to exist between the two assemblages. The data given by the above authors makes it abundantly clear that the heavy mineral assemblage of the lower Barakars is characterised by the absence or insignificant presence of garnet, large quantities of tourmaline and an increase in the amount of rutile and zircon.

Although no Barakar rocks are exposed within the limits of this coalfield, the above comparison clearly shows that the Karharbari and Barakar rocks do possess different heavy mineral suits and consequently different source areas. It may well be that there exists a significant sedimentological break between the Karharbaris and Barakars but in absence of any fabric and other palaeocurrent data on the Barakar rocks, this statement is only suggestive.

The close similarity between the Talchir and Karharbari sediments of this coalfield is further collaborated by the fabric investigations made earlier by the authors (Srivastava & Israili, 1963). The results obtained indicate that the overall pattern of the palaeocurrents and consequently the palaeoslope during the deposition of the Talchir and Karharbari sediments was the same and that there appears to be no great break in the sedimentation history of the basin after the deposition of the Talchir sediments. It is very probable that the Karharbari sediments are in fact an upward continuation of the Talchir sedimentation though under somewhat different physical



TEXT FIG. I AVERAGE FREQUENCY OF HEAVY MINERALS IN THE GONDWANA SEDIMENTS, DALTONGANJ COALFIELD BIHAR

G = GARNET : T = TOURMALINE : Zi = ZIRCON : P = PISTACITE
Zo = ZOISITE : R = RUTILE : A = ACTINOLITE : M = MAGNETITE AND ILMENITE : Mo = MONOZITE : Ti = TITANITE : Al = ALTERITE

and climatical conditions.

In view of the striking fabric and heavy mineral similarities between the Talchir and Karharbari sediments coupled with equally striking differences in the heavy mineral suits of the latter group of rocks and the Barakars, it may be more appropriate to place the Karharbaris of the Daltonganj coalfield at the top of the Talchir series rather than in the Damuda series at the base of the Barakar stage. This conclusion, based purely on sedimentological considerations, is in full agreement with that reached earlier by Blanford (1878) who was greatly impressed by the close affinities between the flora of the Karharbaris and that of the Talchirs.

REFERENCES

Blanford, W. T. 1878, The Karharbari stage, flora, horizon. *Rec. Geol. Surv. Ind.*, Vol. XI, p. 145.

Cotter, G. de P. 1917, A Revised classification of the Gondwana system. *Rec. Geol. Surv. Ind.*, Vol. XLVIII, Pt. I, p. 23.

Evans, P., R. J. Hayman, & M. A. Majeed, 1933, The graphical representation of heavy mineral analyses. *Proc. World Petrol. Cong.*, London, pp. 251-256.

Feistmantel, O. 1883, Palaeontological notes from the Daltonganj and Hutar coalfields in Chota Nagpur. *Rec. Geol. Surv. Ind.*, Vol. XVI, Pt. 4, p. 175.

Fox, C. S. 1934, The Lower Gondwana coalfields of India. *Mem. Geol. Surv. Ind.*, Vol. LIX, p. 13.

Gee, E. R. 1932, The Geology of coal resources of the Raniganj coalfield. *Mem. Geol. Surv. Ind.*, Vol. LXI, p. 21.

Hughes, T. W. H. 1870, The Daltonganj coalfield. *Mem. Geol. Surv. Ind.*, Vol. VIII, Pt. 2, pp. 325-346.

Hutton, C. O. 1950, Studies of heavy detrital minerals. *Bull. Geol. Soc. Amer.*, Vol. 61, pp. 635-716.

Jacob, K., S. K. Ramaswamy, S. R. A. Rizvi, & A. Krishnamurthy 1958 Sedimentological studies in parts of Jharia and East Bokaro coalfields. *Proc. Nat. Inst. Sci. Ind.*, Vol. 24, A, No. 6.

Krishnan, M. S. 1960, *Geology of India and Burma.* Third Edition, Madras.

Krumbein W. C. & F. J. Pettijohn 1938, *Manual of Sedimentary Petrography.* Appleton-Century-Crofts, Inc., New York.

Latouche, T. D. L. 1891, Boring exploration in the Daltonganj coalfield, Palamow. *Rec. Geol. Surv. Ind.*, Vol. XXIV, Pt. 3, pp. 141-153.

Oldham, R. D. 1893, *A Manual of the Geology of India*, Calcutta.

Pascoe, E. H. 1959, *A Manual of the Geology of India*, Vol. II Third Edition. Calcutta. pp. 946-947.

Roy, S. K. & N. L. Sharma 1936, A description of heavy minerals of the Jharia coal-measures. *Quart. Jour. Geol. Min. Met. Soc. Ind.*, Vol. VIII, No. 2.

Saise, W. 1894, The Giridih coalfield. *Rec. Geol. Surv. Ind.*, Vol. 27, pp. 86-100.

Simpson, R. R. & V. Ball 1922, The coalfields of India. *Mem. Geol. Surv. Ind.*, Vol. XII, Pt. I., p. 3.

Srivastava, V. K. & S. H. Israili 1963, A note on the dimensional fabric of Gondwana sediments in the Daltonganj Coalfield, Bihar, *Sci. & Cult.* Vol. 29

Wadia, D. N. 1935, *Geology of India*, London.