INTERNATIONAL JOURNAL OF RESEARCH CULTURE SOCIETY
Monthly Peer-Reviewed, Refereed, Indexed Journal
Volume - 8, Issue - 6, June - 2024

ISSN(O): 2456-6683
[Impact Factor: 7.148]

DOIs:10.2017/IJRCS/202406011 --:-- Research Paper / Article / Review

Comprehensive Evaluation of Paleo Environment Using Advanced Petrographic Techniques for Coals of Raham Block of North Karanpura Coalfield Jharkhand, India

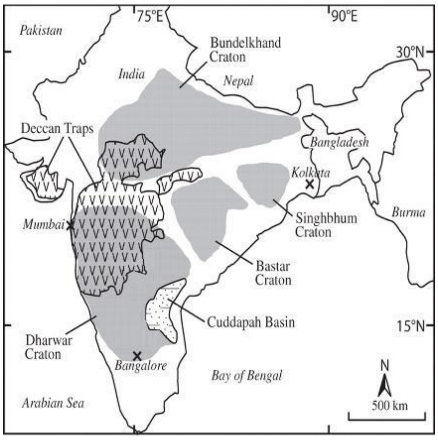
Anup Kumar Sinha[1*], Bacha Ram Jha[2], Chanchal Lakra[3]
[1*] Research Scholar, University Department of Geology, Ranchi University Ranchi
[2] Ex-Associate Professor, University Department of Geology, Ranchi University Ranchi
[3]Assistant Professor, University Department of Geology, Ranchi University Ranchi
Email - [1]*aashvi007anup@gmail.com

Abstract: *Petrographic analysis has been a strong tool for studying coal. Its utilization involves coal rank determination, coal characterization and prediction of paleo environment.[1] Coal seams occur in the peninsular Gondwana basins of India in the lower Gondwana sequence (Damuda Group) where the Karharbari formation is located at the base, the Barakar formation at the middle and the Raniganj formation on the top. Study area Raham block is located on the North – Western part North Karanpura Coalfield and bounded by Latitudes 23°47'38'' N and 23°50'22'' N & Longitudes 84°57'38'' E and 85°02'02'' E. The petrographic analysis of the coal samples determine the composition and its association, nature and behaviour of coal that suggests two genetically evolved groups – which are dominant groups on ternary diagram and two – axis logarithmic graphs irrespective of the seams position in space and time i.e. Trimacerite, rich in inertinite group macerals "Fuso – Vitric group" and Trimacerite, rich in vitrinite and Liptinite macerals "Vitro – Fusic group".[2] The association of siderite mineral with vitrinite indicates fresh water condition during their formations confirms sudden flooding. Hence, the paleo environment existed during coal formation in Raham block was oxic dry mire with sudden flooding condition.*

Key Words: *Petrographic, Barakar, Macerals, Raham block, North Karanpura Coalfield*

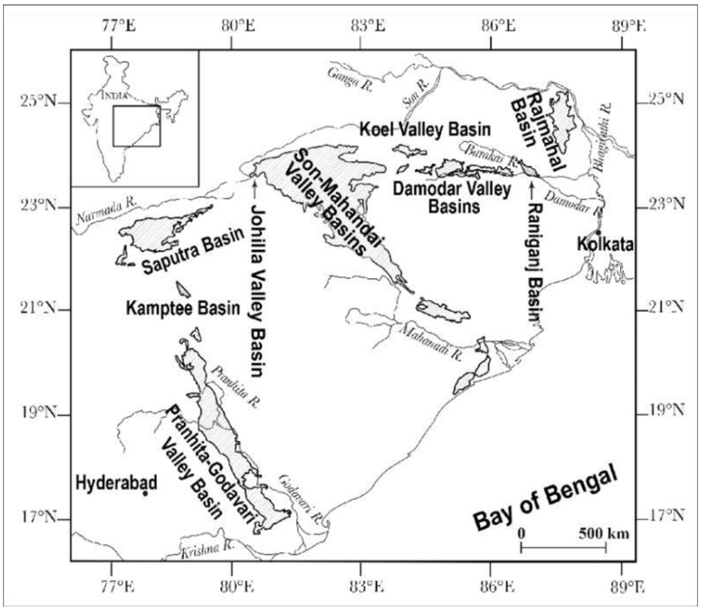
1. INTRODUCTION :

The Gondwana basins are deposited between different Precambrian blocks of Peninsular India. (Map No 1) Their complete absence in the cratonic interior indicates a strong influence of such tectonically weak zones in the Gondwana basins development. During the last phase of Carboniferous the basins were initially developed or at the beginning of Permian within which Talchir sediments were deposited having a much larger extent than the present day basin boundaries and it continued as such during early part of early Permian.



Map No.1: Map showing Precambrian cratonic blocks of Peninsular India

Occurrences of coal seams in the peninsular Gondwana basins of India is more or less confined in the lower Gondwana sequence (Damuda Group) and occur in the Karharbari formation at the base, the Barakar formation at the middle and the Raniganj formation on the top. (Map No 2)



Map No.2: A geological map showing major Gondwana basins of peninsular India

Coal petrography is one of the basic tools to understand the genesis and evolutionary path of coal. They provide basis for the interpretation of paleo geography and paleo climate of the peat forming basins. The development of coal facies in the Raham block of North Karanpura basins has been discussed on the basis of quantitative relationships along with the macerals and mineral matters.

The interaction of water level, water flow, humidity level, pH-value and redox potential are responsible for condition in the peat formation of the vegetal matters, if the basin of deposition is shallow and there are highly oxidative conditions with prolonged exposure of peat to the atmosphere, the peat contains of high amount of inertinite macerals.

2. Regional Geology :

The Karanpura Basin is divided into North Karanpura Basin and South Karanpura Basin. It lies between Auranga Basin in the West and Ramgarh and Bokaro Basin in the East. The Karanpura Coalfields of the Karanpura Basin that is situated about 60 km North – West of Ranchi and 20 km South – West of Hazaribagh and forms a part of Ranchi, Hazaribagh and Palamu districts of Jharkhand State. The Karanpura Coalfield is bounded between Latitudes 23^{o} 37' 16" North to 23^{o} 58' 05" North and Longitudes 84^{o} 45' 00" East to 85^{o} 28' 44" East and is covered under Survey of India Topo sheet No’s. 73 A/9, 73 A/10, 73 A/13, 73 A/14, 73 E/1, 73 E/2, 73 E/5, 73 E/6. The area in North – South direction extends for about 38 km and East – West direction for about 75 km covering an area of about 2280 sq. km. in Damodar River Basin. The study area Raham Block of North Karanpura Coalfield is located in Damodar River Basin. The coalfield is well known for its substantial resources of mainly power grade coal of Barakar, Karharbari and Talchir formation.

A general geological succession of the Gondwana rocks in the North Karanpura Coalfield was reported by Geological Survey of India earlier. (Table No.1) The Mahadeva formation of Upper Gondwana Group the thickness ranges from 61m to 165m with sedimentation of 104 m. While in Panchet, Raniganj, Barren Measures, Barakar, Karharbari and Talchir Formation of Lower Gondwana the thickness ranges from 2 m to 457 m with highest sedimentation can be observed in Barakar Formation with 312 m and lowest sedimentation in Karharbari Formation with 72 m.

Table No.1: General geological succession of Gondwana rocks (reported by GSI, 1987)

Group	Formation	Thickness (m)	Sedimentation (m)
Upper Gondwana	Mahadeva	061 to 165	104

--Unconformity---

Lower Gondwana	Panchet	050 to 225	175
	Raniganj	155 to 432	227
	Barren Measures	180 to 457	227
	Barakar	145 to 457	312
	Karharbari	003 to 075	72
	Talchir	002 to 130	128
----------Unconformity----------			
Precambrian			

3. Location and Geology of Raham Block :

Raham block is located on the North – Western part North Karanpura Coalfield, where strata dips towards South. The geologic features are in continuity with the adjoining area. It is situated in Tandwa sub – division of Chatra district of Jharkhand state. The area is encompassed in Survey of India Topo – sheet No. 73 A / 13 (RF 1:50,000) in West and 73 E / 1 in East and bounded by Latitudes 23°47'38" N and 23°50'22" N & Longitudes 84°57'38" E and 85°02'02" E. Raham block is spread over an area of 16.09 sq. km. It is bounded in North by Magadh block, Gonda block in West, Naiparam block in East and Peto block in the South.

The Barakar formation, Barren measure formation and Raniganj formation of lower Gondwana series occur in the block in the chronological order of younger above older. The Barakar and Barren measure formation occupy major portion of the Raham block. They display an overall Homoclinal structure with regional North West – South east strike of beds and gently dip (usually varying between 8° and 10°) towards the South and gently warping and swinging of altitude of beds. All faults re assumed as normal gravity fault with about 60° to 70° dip in the absence of any definite evidence. The estimated throw of the fault may be the cumulative of one or more faults. Four faults are interpreted to be present in the Raham block.

4. Materials and Methods :

More than one hundred samples were taken but only selected seven samples were taken for Petrographic analysis. The coal samples of Raham Block received from half reserve by the courtesy of Central Institute of Mining and Fuel Research, Ranchi Jharkhand and selected samples were tested for Petrographic Study by using Petrographic Microscope[3] – LEICA DM 4500P by the courtesy of Central Mine Planning and Design Institute, Ranchi and the data was acquired by the analysis are tabulated in Table No 2.

Coal samples from the central part the Raham Block were selected for special test as representation samples. (Table 2)

Table 2: Representative samples and their maceral composition

Description					Maceral Composition %			Visible Mineral Matter
Bore Hole No	Depth (m)	Thick (m)	Seam	Sample Detail	Vitrinite	Liptinite	Inertinite	
SPNR 8	338.07	1.88	IV	P1(A9)	31.8	8.2	37.0	23.0
	343.20	6.49	III	P2(A10)	22.7	11.4	30.7	35.2
	378.30	1.97	II (T)	P3(A11)	18.6	11.4	48.6	21.4
	380.27	2.20	II (B)	P4(A12)	20.2	8.1	44.1	27.6
	383.62	2.89	I (T)	P5(A13)	18.6	8.5	43.2	29.7
	393.35	6.90	I (M)	P6(A14)	21.8	10.6	32.8	34.8
	411.30	5.13	I (B)	P7(A15)	30.9	10.9	37.6	20.6

The samples P1 to P9 were analyzed using Advanced Research Microscope Leica DM 4500 P (for White and Fluorescent light) and with MSP 200 Photo – multiplier used for Reflectance study.

The table no 2, represents the Maceral composition where Vitrinite percentage ranges from 18.6 to 31.8, Liptinite percentage ranges from 8.1 to 11.4, Inertinite percentage ranges from 30.7 to 48.6 and Visible Mineral Matter

ISSN(O): 2456-6683
[Impact Factor: 7.148]

percentage ranges from 20.6 to 35.2. The table no 2, infers that Seam I and Seam IV shows good Vitrinite percentage whereas middle Seams i.e. Seam II and Seam III have lesser value.

The Reflectance study of the selected samples was also done[4] and the data acquired are given in Table No 3 and Fig No 1.

Table 3: Representative samples and their maceral composition (VMMF)

Description					Maceral Composition % (VMMF)			
Bore Hole No	**Depth (m)**	**Thick (m)**	**Seam**	**Sample Detail**	**Vitrinite**	**Liptinite**	**Inertinite**	**Reflectance R %**
SPNR 8	338.07	1.88	IV	R1(A9)	41.3	10.6	48.1	0.68
	343.20	6.49	III	R2(A10)	35.0	17.6	47.4	0.68
	378.30	1.97	II (T)	R3(A11)	24.0	14.5	61.5	0.97
	380.27	2.20	II (B)	R4(A12)	26.9	11.3	61.8	0.92
	383.62	2.89	I (T)	R5(A13)	26.5	12.1	61.4	0.67
	393.35	6.90	I (M)	R6(A14)	33.4	16.3	50.3	0.68
	411.30	5.13	I (B)	R7(A15)	38.9	13.7	47.4	0.70

The Vitrinite, Liptinite, Inertinite, Visible Mineral Matter, Visible Mineral Matter Free and Random Vitrinite Reflectance analysis is carried out as per Indian Standard 9127 (Part 2, 2014; Part 3, 2003 and Part 5, 2010)[5].

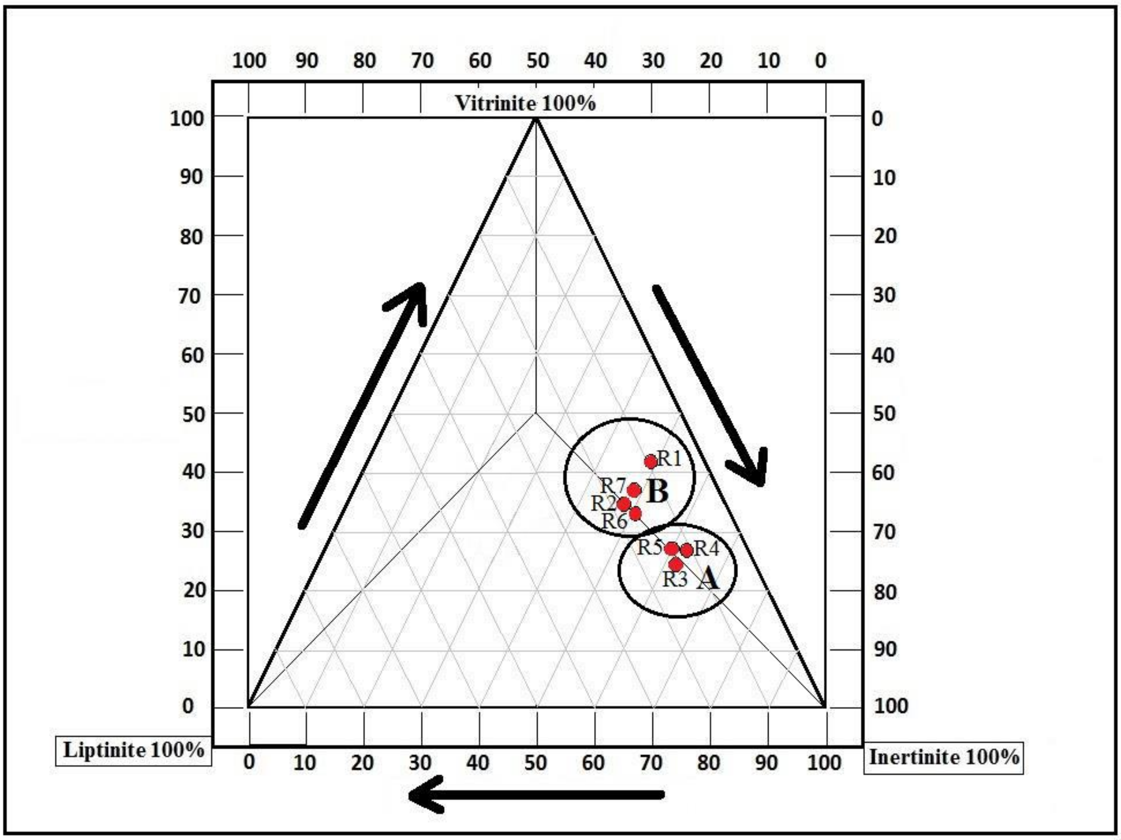


Fig 1: Relation between Vitrinite, Liptinite and Inertinite (mineral matter free basis)

5. Results and Discussion :

After detailed study of coal macerals and its quantitative distribution in different coal samples have been plotted on ternary two axis logarithmic graph to decipher the possible genetic coal types. In ternary diagram every axis represents 100% vitrinite, Exinite and Inertinite.[6, 7]

ISSN(O): 2456-6683
[Impact Factor: 7.148]

The macerals composition pattern on mineral matter free basis along with the ternary and two axes logarithmic graph reflects mainly two genetic groups and position of coal seams in space and time. From the above study, the coal seams of Raham Block can be concluded as two genetic types (or, in other words, petrographic facies).[8, 9]

A) Trimacerite, rich in inertinite group macerals over vitrinite and Exinite (Liptinite) "Fuso – Vitric". This group lies between 70% to 80% on inertinite axis, 20% to 30% on vitrinite axis. It is characterized by richness in inertinite group of macerals. Thus it can be safely concluded that it represents Trimacerite inertinite dominant composite coal types.

B) Trimacerite, rich in vitrinite and Exinite (Liptinite) group macerals over inertinite group macerals "Vitro – Fusic". This association lies between 55% to 70% on vitrinite axis and 30% to 45% on inertinite axis. Thus, this type is predominated by vitrinite plus Liptinite group over inertinite.

Microphotographs of Coal

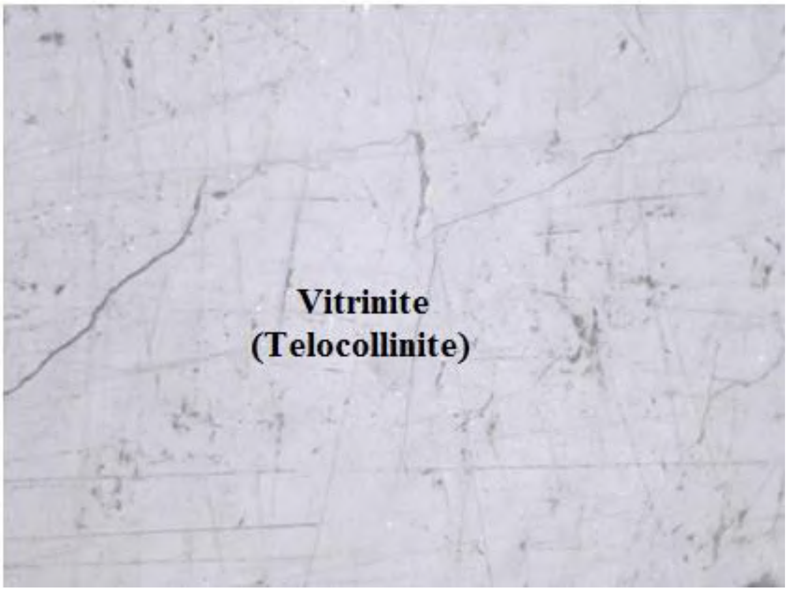


Plate 1: Showing Maceral Group–Vitrinite, Maceral–Collinite, Sub Maceral – Telocollinite (Vitrinite A)

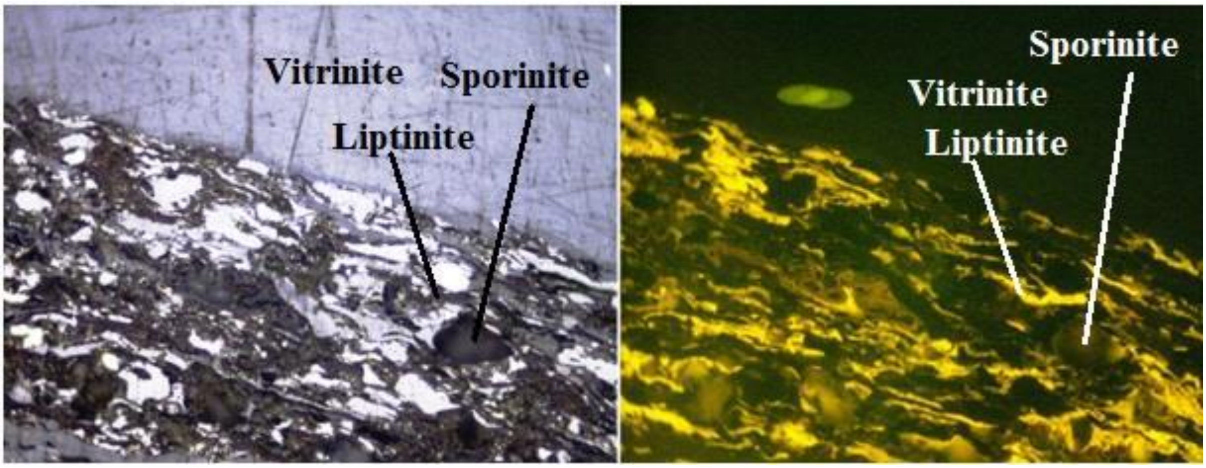


Plate 2: Showing Maceral Group–Liptinite (Exinite), Sub Maceral – Sporinite

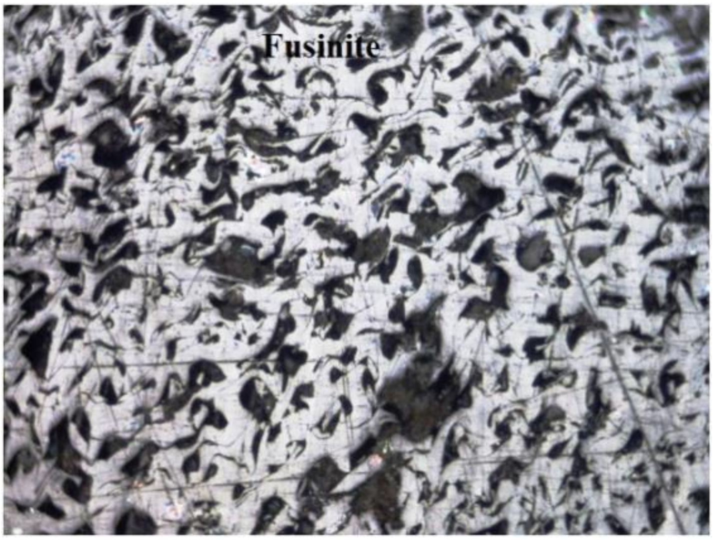


Plate 3: Showing Maceral Group – Inertinite (Fusinite)

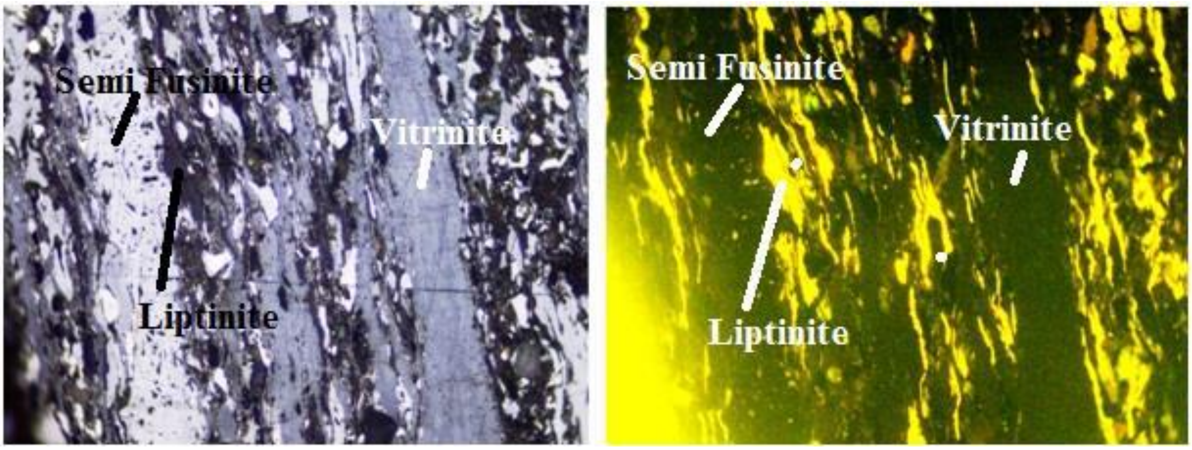


Plate 4: Showing Maceral Group–Vitrinite, Liptinite and Inertinite (Semi Fusinite)

6. Environment of deposition of Raham Block coal :

After the detailed study of macerals, an attempt is made to interpret about the depositional conditions of the coals of Raham Block, North Karanpura coalfield as there is no detailed account available on the formation of Raham Block coals of North Karanpura basin, which is one of the most important Gondwana basins in our country.

The petrographic composition and its association, nature and behaviour of coal suggests two genetically evolved groups – which are dominant group on ternary and two – axis logarithmic graphs irrespective of the seams position in space and time. (Fig 1)

A) Trimacerite, rich in inertinite group macerals “Fuso – Vitric group”
B) Trimacerite, rich in vitrinite and Liptinite macerals “Vitro – Fusic group”

The petrographic characteristics depends on the conditions operating in the swamps as well as in source area during the formation viz. Water level, subsidence of swamps, pH level, redox potential is responsible for such type of condition in peat formation of the vegetal matter.

Trimacerite group coal type predominates with inertinite group of macerals over vitrinite and Liptinite i.e. “Fuso – Vitric”, (A of Fig. 1), suggests a progressive increase in humification process in coal swamps resulting into coal seams rich in vitrinite group of macerals. However, the process of fusinization which acted upon peat bog due to periodical exposure of vegetal matter to atmosphere during transportation of peat to coal swamp resulted in partial rotting of organic matter due to the fluctuation in water level. This led these coals to have the inertinite group of macerals.

Further, Trimacerite coal type predominated with vitrinite and Liptinite group maceral over inertinite i.e. "Vitro – Fusic", (B of Fig 1) suggests a more progressive rate of vitrinization in swamps. The peat after the transportation to the site of deposition was covered by water. The anaerobic conditions which prevailed during that time i.e. low pH value and redox potential led these coal seams to be rich in vitrinite. However, the presence of inertinite macerals is due to oxidative phase in peat bog before its deposition in the coal swamp.

These observations also corroborated with the findings of different authors.

Author has also tried to develop another depositional model of Raham block on the basis of macerals and mineral matter. Importance was given to mineral matter because in the coal, it is directly related to the influx of surface water in the swamps. The plots of petrographic composition of Raham Block coals in the model (Fig 2) shows that a major part of coal has been formed under "oxic dry mire and sudden flooding condition". In this model, Raham block coals originate from forest swamps under oxic dry mire and sudden flooding conditions and the process of vitrinization begins to dominate over fusinization and fusinization begins to over vitrinization.[10, 11]

These observations were also corroborated with the findings of Goodarzi and Singh.[12] This work is also interpreted by a number of workers like Diesel, Misra and cook, Misra, [13] Chandra & Verma, Rudra and Singh and Singh, [14, 15] they also suggests that Gondwana coals are formed under alternate wet and dry environment conditions and were deposited in dry and wet forest swamps.

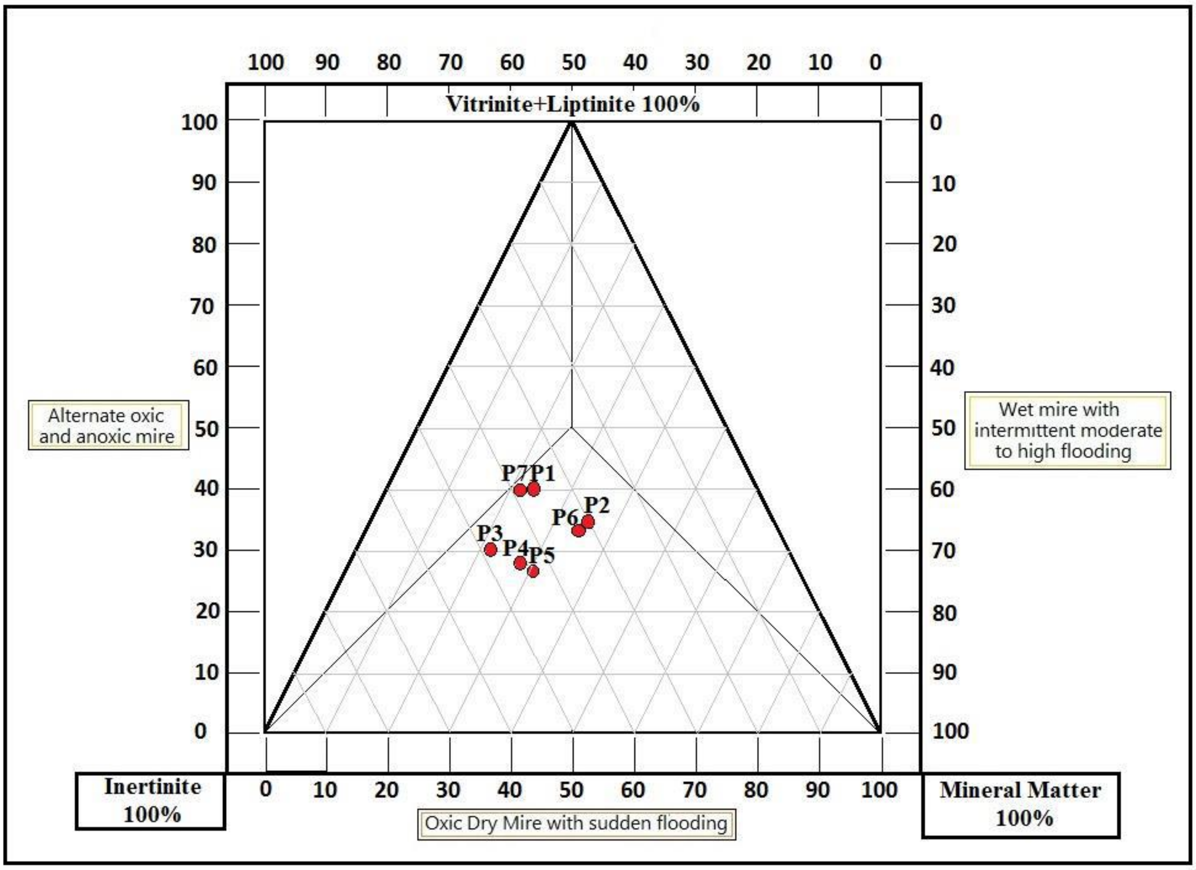


Fig.2: Ternary diagram of borehole samples drawn between Vitrinite + Liptinite, Inertinite and Mineral Matter for interpretation of depositional conditions of coal (after Singh & Singh, 1996), prepared by A.K.Sinha

Thus, it can reasonably be presumed that Raham Block coal seams investigated here were deposited in the typical structural set up with conditions conducive in swamps and rich vegetal matter. The Raham Block shows that area is structurally very complex and because of folding and too much faulting on both side of it there are two synclinal basins in northern and southern part of the block that is highly disturbed in comparison to central region.

The variation in maceral assemblage in these coal seams reflects fluctuation in environmental conditions under which humification of organic matter proceeded in bio-chemical stage.

The paleogeographic conditions seem to have played an important role in the formation of coal, which were mainly influenced by fluctuating hydrological conditions in the basins. Formation of inertinite contents was mainly due to the variation in the water level and exposure during transportation of peat to the coal swamps.

Absence of ash beds, richness of mineral matter content, close association of vitrinite, Liptinite and inertinite & Inertodetrinite macerals support the possibility of peat exposure to atmosphere rather than role of forest fire. The association of siderite mineral with vitrinite indicates fresh water conditions during their formations.

Thus, the above evidences suggest that the unstable conditions under typical structural set up were responsible for the depositions of these coal seams. These observations are corroborated with findings of Navale[16] and Dutta[17] for the formation of Barakar coals in Damodar Valley Coalfields.

7. Interpretation of Ternary diagram :

The ternary diagram has been plotted against Vitrinite + Liptinite (100%), Inertinite (100%) and Mineral matter (100%) at three corners of the Ternary diagram. The petrographic analysis data acquired were plotted to predict the paleo environmental condition of Raham block, an attempt made by author after Singh & Singh (1996). It had been observed that the selected sample data were plotted in Ternary diagram model and found that most of the samples fall indicating that Raham block coals had oxic dry mire and sudden flooding condition. Due to such condition the vegetal matter that had been in basin during dry condition were influenced by sudden flooding distributing the mass and Raham block experienced faulting due to distribution of mass load of sedimentation, tectonic disturbance and mass balancing. The data acquired was used for prediction of paleo – environment depositional condition of coal of Raham block.[18, 19]

Absence of ash beds, richness of mineral matter content and close association of vitrinite, Liptinite and inertinite & Inertodetrinite macerals support the possibility of peat exposure to atmosphere rather than role of forest fire confirms oxic dry mire. The association of siderite mineral with vitrinite maceral indicates fresh water condition during their formations confirms sudden flooding. Hence, the paleo environment existed during coal formation in Raham block was oxic dry mire with sudden flooding condition.

REFERENCES:

1. International Committee for Coal Petrology (1963). Int. Handbook of Coal Petrology.
2. International Committee for Coal Petrology (1971). Handbook, second edition – supplement to International committee for coal petrology (1975). Handbook, second edition – supplement to 1st – 1976. Indian standards institution 1976: Classification of India coals, in 1st Doc. Cdc 14 (68, 49) E.
3. IS: 9127 (Part III) – 2002, Indian Standard, Methods for the Petrographic analysis of Bituminous coal and anthracite, Part III (Methods of determining Maceral group and Composition)
4. Navale, G. K. B. (1984) Lower Gondwana Coals of India paleobotany, petrology and Genesis. Symp. Gond. Coals, Com. Surv. Geol. Portugal., v.70(2), pp.245-256.
5. Bustin, R. M., Cameron, A. R., Grieve, D.A. and Kalkreuth, W. D., (1963) Coal petrology and its principle methods and applications. Geol. Soc., Can. short course notes, Victoria., pp-273.
6. Stopes, M. C., (1919) On the four fisible ingredients in banded bituminous coal. Proc. R. Soc., v.90, pp. 470-487.
7. Stach, E., Mackousky, M. TH. Teichmullar, M., Taylor, G. H. Chandra, D. And Teichmullar, R., (1982).) Stach's Textbook of Coal Petrology, 3rd Edn., Gabruder. Borntraeger. Berlin. Stuttgart., pp.535.
8. Seyler, C.A., 1929. The microscopic examination of coal - D.S.I.F., Fuel, Res., Phy. and Chern. Surv. National coal Resource, No. 16, H.M.S.O.: London: 67 pp.
9. Smyth, M., (1984) Coal microlithotypes related to sedimentary environments in the copper Basin, Australia. Spce. (1966) Publ. Int. Asso. Sed., v.7, pp.333-347.
10. Hacquebard, P. A and Donaldson, J. R. (1969) Carboniferous coal deposition associated with Flood Plain and linmic environments in Nova Scotia. In Apples, E. C. and Hopkins, M. E. (Ed), Environment of coal deposition., Geol. Soc. Of America. Spec. Paper. v.114, pp. 143-191.
11. Singh, B. D. (1995) Lower Gondwana (Permian) Coals of Peninsular India: Environment of Deposition related to organic petrographic types. Proc. India. Natn. Sci. Acad., v.61A(4), pp.371-394.

12. Misra, B. K. and Singh, B. D. (1990). The Lower Permian coal seam from Singrauli coalfield (M.P.), India. Petrochemical nature, rank, age and sedimentation. Int. Jour. of Coal Geol.,v.14, pp. 309-342.
13. Misra, H.K., T.K. Chandra, and R. Verma, (1990), Petrology of some Permian coals of India: Int. Jour. Coal. Geol., v 16/1-3, pp 47-71.
14. Singh, M.P. and Singh, P.K. (1996) Petrographic Characterisation and evolution of the Permian Coal deposits of the Rajmahal Basin, Bihar, India. Intl. Jour. Coal. Geol., v.29, pp.93-118.
15. Singh, M.P. and Singh, P.K. (1996) Petrographic Characterisation and evolution of the Permian Coal deposits of the Rajmahal Basin, Bihar, India. Intl. Jour. Coal. Geol., v.29, pp.93-118.
16. Navale G. K. B. (1979) Depositional environment of Lower Gondwana coals of India. In B. Laskar and C. S. Raja Rao (Edn IVth). Int. Gond. Symp. India, (1977) pp.248-264.
17. Dutta, N. R., De, Ajay. Kumar and Chakrabarti, S. K. (1979) Environmental interpretation of Gondwana Coal Measures in Peninsular India and B. Laskar and Raja Rao 4th (Eds). Int. Gond. Symp. India, 1977., pp. 255-264
18. Sinha. A. K., and Jha. B. R., Assessment of Paleo – environment conditions of deposition of coals of Raham Block of North Karanpura Coalfield, Chatra District, Jharkhand, India, Rujost Vol. 5&6, No. 1&2, 2020-2021.,pp. 87-92
19. Sinha. A. K., and Jha. B. R., Correlation of Petrographic and Proximate analysis data of coals of Raham Block, North Karanpura Coalfield, Chatra District, Jharkhand, India , Rujost, Vol. 7, No.1, 2022., pp. 127-132