RESEARCH PAPER | Geology | Volume : 3 | Issue : 6 | June 2013 | ISSN - 2249-555X

Study of the Maceral Composition and Coal Facies of the Oligocene Coals in Makum Coalfield, Upper Assam, India

KEYWORDS: maceral composition, coal facies, depositional environments, Makum coalfield.

Dr. Ranjan Kumar Sarmah

Associate Professor, Department of Applied Geology, Dibrugarh University, Dibrugarh-786004, ' Assam, India

ABSTRACT *The study area, a selected part of the Makum Coalfield is located in the Upper Assam of North Eastern India. The present study is confined only to "Coal Measures" i.e. the Baragolai and Tikak Parbat Formations of Barail Group (Oligocene) and based on the analysis of coals collected from both the Formations.*

Megascopically, the coals are bright, non-banded, pulverizing and soft in nature. Maceral analysis shows that Vitrinite, Exinite and Inertinite group occur in respective order of abundance with variable proportion of mineral matter and shale. The characteristics of maceral groups suggest that the bark and woody tissues of plant deposited in a slowly subsiding wet-swamp basin in a higher ground water table condition. The coal facies analysis indicates that the coals of both Baragolai and Tikak Parbat Formations belong to a limited, clastic marsh to wet forest swamp of limno- telmatic condition which is typical characteristics of lower delta plain environment.

1. INTRODUCTION:

The Makum Coalfield in Upper Assam, India, forms an integral part of the Naga-Lushai mobile belt of Tertiary sedimentary rocks. The study area covers a selected portion of the Makum Coalfield of about 75 sq.km. stretching between Namdang colliery ($95^{0}40^{/}$: $27^{0}16^{/}$) to the southwest and Tipong colliery (95^{0} $42^{/}$: $27^{0}17^{/}$) to the south east in the Tinsukia district, Assam, India. And it is bounded by Latitudes ($27^{0}15^{/}$:$27^{0}20^{/}$) and Longitudes ($95^{0}40^{/}$-$95^{0}52^{/}30^{//}$) and included in the Survey of India toposheets No. 83M/11 and 83M/15.

During recent years geological exploration and mining for coal in this areas have established an inferred reserve of over 235 million tonnes of ungrades, high sulphur coals to a depth of 300 meter from the surface (Raja Rao, 1981; Prasad and Verma, 1982). The Oligocence Coal Measures of Barail Group houses five regionally persistent coal seams namely 60 ft., 7 ft., 20 ft., and 8 ft. which are being extensively worked in different coal mines by the North Eastern Coalfields (N.E.C.F.), a subsidiary of Coal India Limited.

The objective of this paper is to present petrographic data on Makum Coals and to relate the findings to understand the maceral composition, depositional environments of coals.

2. GEOLOGICAL SETTING:

The Makum Coalfield (Fig.1) is disposed as detached, isolated tectonic blocks in the Belt of Schuppen (Evans, 1964). Some of the type sections and typical sections of the Tertiary rock sequence of the geosynclinal facies are also located in this coal basin. These sedimentary rocks are folded and thrusted under the impact of several orogenic movements. The coal basin is demarcated by the Margherita thrust on the north and the Halfong-Disang thrust on the south. A generalized stratigraphic succession in the coalfield areas of Upper Assam is presented in Table-1.

The coal bearing Barail Group (Oligocene) rests conformably over the thick (3000m.) flysch sediments of Disang Group (Eocene) in this area. The subflysch Barail sediments were presumably deposited in a tectonic depression aligned along a linear mobile belt near to the Upper Assam Shelf corresponding to the miogeosyncline. In the Makum coalfield area, the rocks of Barail Group is subdivided into Naogoan, Baragolai and Tikak Parbat Formations in order of superposition. Naogaon Formation comprises of hard, thin bedded grey sandstones with interbeds of shales and sandy shales. This formation is succeeded by the Coal Measures of Mallet (1867) include Baragolai Formation for the lower part of Tikak Parbat Formation for the upper section.

3. METHODOLOGY:

Representative coal samples from 60 ft., 7 ft., 20 ft., and thin seams of Tikak Parbt Formation and some thin coal seams of Baragolai Formation were collected from different collieries in the Makum Coalfield and analysed by petrological methods. Petrographic studies including maceral analysis and fluorescence of macerals were made on polished coal pellets following the recommendations of ICCP (1971) and IS 9127 (Part III), (IS 1992) and using a Leitz orthoplan microscope in oil media with 32 x or 50 x objectives and 10 x or 8 x oculars. For fluorescence mode, high pressure mercury vapour lamp was used.

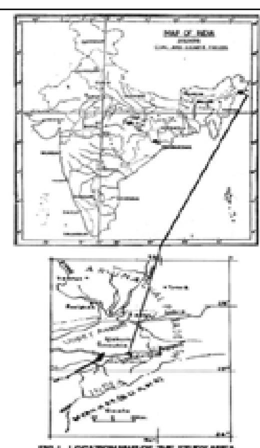


FIG.1. LOCATION MAP OF THE STUDY AREA

TABLE- 1: Lithostratigraphic Succession in the Makum Coal field, Upper Assam (modified by Sarmah, 1999)

AGE	GROUP	FORMATION	LITHOLOGY
Recent Pleis-tocene		Alluvium and high-level terraces	Sands, Clays, Siltstones, Gravel beds etc.
-----------------------	----------------	----Unconform-ity----------	------------------------

Volume : 3 | Issue : 6 | June 2013 | ISSN - 2249-555X

Pliocene	DIGHIN	-	Alternating pebble beds; coarse bluish green to grey feld-spathic, ferruginous sandstones and grayish to brownish clays.
----------------	----------------------	--- Unconform-ity-------------------- Girujan Clay	--- Variegated clay, silty clay, bluish green and grey sandstone (+470-990m: thick-ness).
Miocene	TIMPAM	Tipam Sandstone	Coarse, gritty and massie, bluish green to grey feldspathic and micaceous sandstone, varie-gated clay, sandy clay, shale, coal streaks and silicified woods. (+1000m: thickness).
	SURMA (?)	Not subdivided	Grits, thin con-glomerate beds, brown, fine grained sandstone, sandy clays and shales. (approximately 400 m: thickness).
- - - -	-----------------------------	--- Unconform-ity------------------	--
		Tikak Parbat	Upper Assam Unit: Massive to well bedded, yellowish white to light grey, medium to fine grained sandstone interbedded with sandy shale, grey shale, siltstone, light grey calystone, mudstone, carbo-naceous shale and several coal seams. Lower Argillaceous Unit: Alternations of siltstone, mudstone, shale, carbonaceous shale, claystone and thick workable coal seams. Occasion-ally laminated shaly sandstone, sandy shale and sandy clay. (600m : thick-ness)
Oligocene	BARAIL	Baragolai	Well bedded or at places massive, hard, grayish, mica-ceous or ferruginous shaly sandstones alternating with bluish grey, green-ish yellow clays, shales sandy shale, siltstone, calcareous mudstone, carbona-ceous shale and thin coal seams (3300 m: thickness)
Eo-cene	DISANG	Naogaon (occurs on the southern part of the coalfield, separated by the Halflong-Disang Thrust)	Hard, compact and flaggy dark grey, fine grained Sand-stone and interbeds of grey splintery shales (2200m: thickness) Dark grey splintery shale with interbeds of dark greey and fine grained sand-stone (over 3000m: thickness)

4. COAL PETROGRAPHY:

4.1Megascopic character:

The coals of the study area are light, bright and non-banded in appearance. They are pulverulent, soft and break with sub con choidal to conchoidal fracture with greasy lustre. The streak of the coals varies from black to pale brown. Specks and patches of pyrite and other sulphides occur in the bright and semi-bright coals. Pyrite concretions are abundant in the 20 feet coal seam. Occasionally thin bands or lenticles of fusain may be present but not easily perceptible. Coals of the Tikak Parbat Formation show white incrustations of car-bonates along the cleats. However, the Baragolai coals are semi-bright to dull in appearance and are occasionally im-pregnated with bitumen like substances (oily smear surface).

4.2Microscopic character:

The petrographic study shows that the coals of the study area are composed of varying proportions of group macerals i.e. vitrinite, exinite and inertinite along with mineral matter and shale or clay. The details of the morphology and optical char-acteristics of the macerals in coals are described below:

(a) Vitrinite:

The vitrinite content in the coal samples varies from 92.69% to 65.47% and in general a trend of slight decrease in vitrinite percentage from older to younger coal seam and also across the individual seam has been observed. Structureless vitrinite forms thick to thin bands in alternation with or without teli-nitic structure (Fig.2 C). The grey level increases from from desmocollinite to Vitrinite A or telocollinite. Some of the vit-rinites show weak fluorescence characteristics (raddish brown to brown), particularly those filled with resins or gels. Some oval or rounded desmocollinite bodies with low reflectivity are associated with clarite.

In the colas of the Baragolai Formation, smear films on some vitrinites are observed . Vitrodetrinite occur at places in abun-dance when the thin clay layers and cuticles are enclosing it.

(b) Exinite:

Amongst exinite group, sporinite and resinite are the abun-dant macerals. Sporinite both miospores and megaspores are common in the coals (Fig.2 A) under fluorescence mode, sexinal part fluoresces with relatively brighter yellow colour than theat in the nexial part bordering streaky slit or thread like lumen (Fig.2 B). Some sporangia are also noted (Fig.2 A). Occasionally densely packed layers of flornite are observed (Fig.2 D & E). Thin walled, untoothed tenuicutinites are also recorded (Fig.3C). Cuticles with some secmdary resins of su-berinite type are noted. Suberinite is usually common in 60 feet coal seam than that of 20 feet seam.

Resinites occurs in various shapes and sizes as isolated ellipti-cal bodies or oval shaped inclusions in Vitrinite A and fillings in cell lumens. Resinites are dark grey to pale brown in nor-mal reflected light but display variable fluorescence intensity and colour from pale yellow to pale brown (Fig.3A). A few doubtful alginate bodies (Pila-type, Ghosh, 1981) with strong yellow fluorescence are observed (Fig.3A). Exudatinite the secondary resin in sporadic in distribution. It occurs as cracks or fissure fillings and something oozing out from florinite along minor cracks (Fig.3C).

Almost all the exinite macerals show variable intensity in yel-low fluorescence colour. The exinite varies laterally along coal seams from 22.02% to 0.62%.

(c) Inertinite:

Semifusinite and selerotinite are most common internite marcerals in the coals. Interodeterinite and micrinite occur in minor amounts. The interinite content in the coal samples does not show any significant variation along the saem and with depth. Semifusinite shows higher reflectance than vitrin-ite and occurs as isolated smaller lenticular bodies and also as transitional degraded product of vitrinit. Fungal sclerotia

Volume : 3 | Issue : 6 | June 2013 | ISSN - 2249-555X

bodies are commonly associated with Vitrinite A and Vitrinite B, showing single chamber or multichambers (Fig.2C). Micro fragments of sclerotia, fungal spores occur in small amounts. Micrinite represents smaller intertinites which are sporadically seen in vitrinites.

d) Mineral Matter:
In the Makum coals, sulphide minerals occur as organic and inorganic forms of sulphur. Pyrite, the major inorganic sulphide occurs as tiny isolated grains in vitrinite and also as fillings in cell lumens of sclerotia. Fine granular or spheroidal frambroid clusters of pyrite occur in Vitrinite B (Fig.3D). Epigenetic pyrite occurs in cleats and fissures,. Spheroidal concretions of siderite (reddish yellow in colour) occur in association with Vitrinite B or in clay/shaly matter. Calcite is recorded as impregnations in vitrinite, particularly in the coals of the Baragolai Formation. In the Baragolai coals, dark grey to brown irregular patches of clay minerals are recognized. Sometimes clay minerals formed thin layers around Vitrinite B. In the coals of Tikak Parbat Formation, clay occurs as irregnlarly scattered patches of non-fluorescing type.

The maceral analysis reveals that vitrinite, exinite and intertinite group of macerals occur in respective order of abundance with variable proportions of mineral matter and shale. Vitrinite content of the coals laterally and across the seams is over 80%. Mineral matter, particularly pyrite content definitely increases towards the younger seams. The Baragolai coals, however, show sufficiently high mineral matter content.

From the petrographic characteristics of the coals, it appears that the bark and woody tissues of plant deposited in a slowly subsiding wet swampy basin in a higher ground water table conditions in which tissue structure were less preserved in a fondo-toxic environment with microbial decay.

5. COAL FACIES ANALYSIS:
Various coal properties carry palaeoenvironmental signatures. A number of facies diagrams have been developed by different workers in the past to decipher the coal forming palaeoenvironment based on the quantitative relationships among the tissue and non-tissue derived components in coals (Teichmuller, 1950, 1962; Diessel, 1982, 1986; Smyth and Mastalertz, 1991; Kalkreuth et al., 1991; Lamberson et al., 1991). In the present study, the approaches referred by the above mentioned workers have been critically used to interpret the palaeoenvironment condition. .

A ternary diagram (after Kalkreuth et al., 1969) with apices A, B, C, to evaluate palaeoground water level condition and depositional environments from swamp to open lake has been considered where A= Vitrinite A + Semifusinite + Fusinite, B = Vitrinite B + Macrinite, C = Mineral matter + Exinite + Inertodetrinite + Sclerotinite. A-B-C triangular plots in Fig. 4 indicate that the ground water level is low inase of Baragolai coals, whereas it is moderately high in theyyounger Tikak Parbat coals. A persistent ground water condition is envisaged from least scatter of data.

T-D-F diagrams of Diessel (1982) have been considered (Fig.5) in the synthesis of palaeodepositional environment. Diagnostic macerals are grouped to represent a facies triangle with apices as follows: T= Vitrinite A + Vitrinite B, F =Fusinite + Semifusinite + Sclerotinite, D= Inertodetrinite + Exinite + Macrinite. T-D-F diagram indicates that a persistent wet forest woor of telmatic facies flourished in the avea from the older Baragolai time to younger Tikak Parbat coal deposition in peat-swamps.

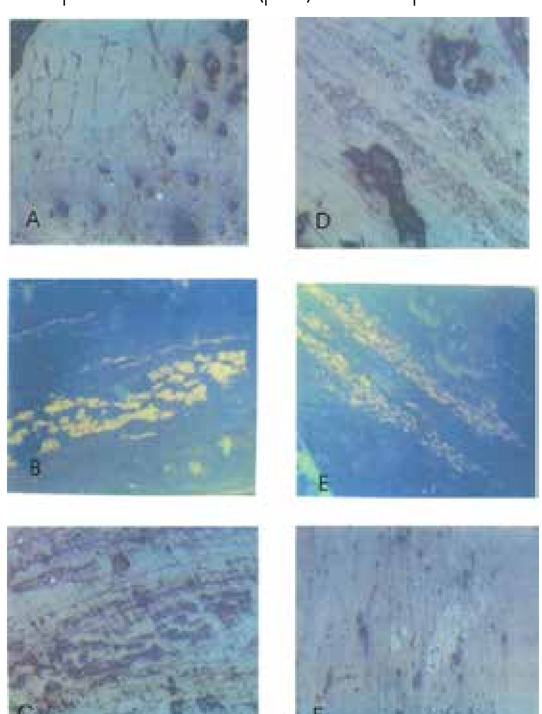
Following Smyth and Mastalerz (1991), the plots in the triangular diagram (Fig.6) points to a fluvio-deltaic model which shows resemblance with North Carnarvon basin in the western Australia. Low to high amount of liptinite and high vitrinite in these coals are characteristics which according to Smyth and Mastalerz (op.cit) is common in fluvio-deltaic environment.

Diesel (1982, 1986) developed a diagram illustrating variation in two petrographic indices, the Gelification Index (G.I.) and the Tissue Preservation Index (T.P.I). G.I. contrasts the partially and completely gelified macerals with those that are ungelified and lavgely reflects the degree of dryness or wetness of the peat environment. T.P.I is affected by the duration of severity of humification of the maceral precursors. Diessel's diagram was later modified by Kalkreuth et al, (1991) who used log-log scale instead of semilog scale to accommodate a large T.P.I value within the diagram. Diessel's original proposition of T.P.I/G.I was again modified by Lamberson et. Al. (1991) to include pseudovitrinite and defined the indices as, T.P.I = (Telinite + Telocollinite + Seifusinite A + Semifusinite B + Fusinite)/C Vitro-detrinite + Desmocollinite = Inerodetrinite + Macrinite); G.I. = Vitrinite + Macrinite)/ (Total Inertinite).

In both the definitions, influence of exinite was not given adequate attention possibly due to its low abundance in the studied fields. Following the modified T.P.I. and G.I. (Lamaberson et al. 1991; Bardhan, 1995; Sengupta, 1997), the petrographic indices were calculated and plotted in the diagram (Fig.7). Study of the binary diagrams shows that the coal seams of both Baragolai and Tikak parbat formation belongs to limited influx, clastic marsh to forest swamp of limno-telmatic condition. From Diesel's diagram, a lower delta plain environment is evident. A slow burial from limited influx, clastic march to wet forest swamp in the area is possibly one of the vital factors to increase considerably the T.P.I value. In the peat marches, vegetal matter had undergone extensive microbial degradation in anaerobic conditions to pull G.I. around 50.

Conclusion:
The maceral analysis of the Makum Coals exhibits some qualitative as well as quantitative differences from others.

The coal facies analysis indicates that the coals seams of both Baragolai and Tikak Parbat Formations belong to a limited influx, clastic marsh to forest swamp of limno-telmatic condition which is typical characteristics of lower elta plain environment prevailed under wet (peat) land set-up.



(All photomicrographs are taken on polished surfaces under oil immersion, x 320).

Volume : 3 | Issue : 6 | June 2013 | ISSN - 2249-555X

Fig.2A. Sporangia and thin-walled cutinite under normal reflected light.

Fig.2 B. Same field as in fig.2 a under fluorescence mode.
Fig.2 C. Telinite with cell structures under normal reflected light.

Fig.2D. Florinite of conspicuous nature, under normal reflected light.

Fig.2E. same field as in fig.3 a. under fluorescence mode.
Fig.2F. Sclerotia bodies in virtrinite under normal reflected light.

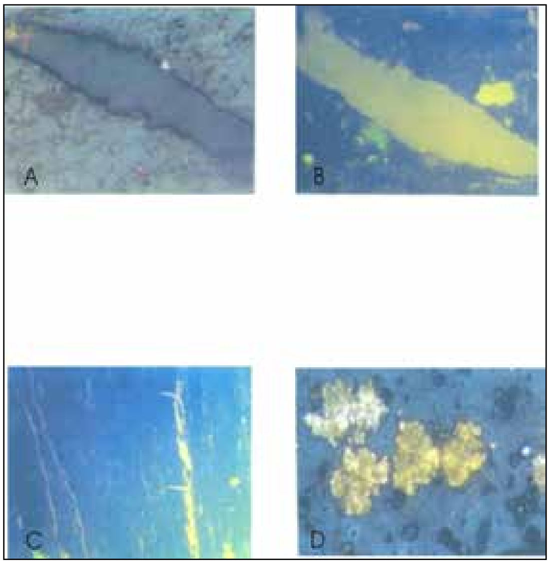


Fig 3A. A small Pila type algae with a big resin body under normal reflected light.

Fig.3B Same field as in fig. a . under florescence mode.

Fig.3C. Exsudatinities expelled from florinite and thin-walled cutinite, under fluorescent light.

Fig.3D. Frambroidal pyrite in vitrinite groundmass, under normal reflected light.

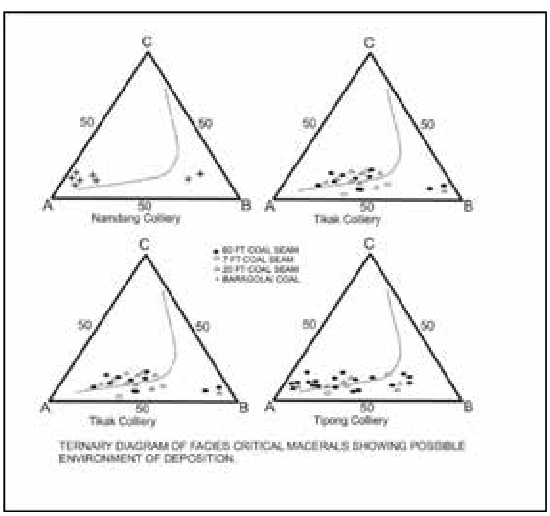


Fig.4

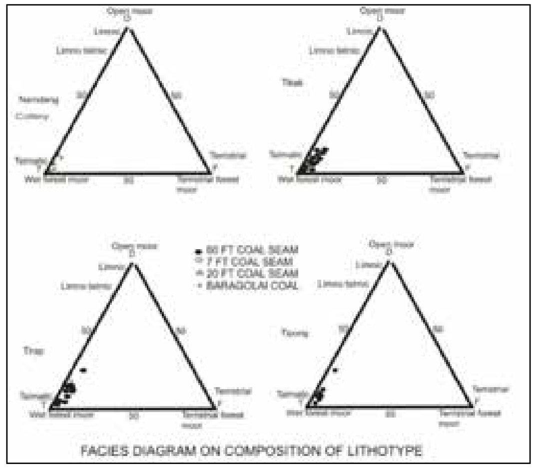


Fig.5

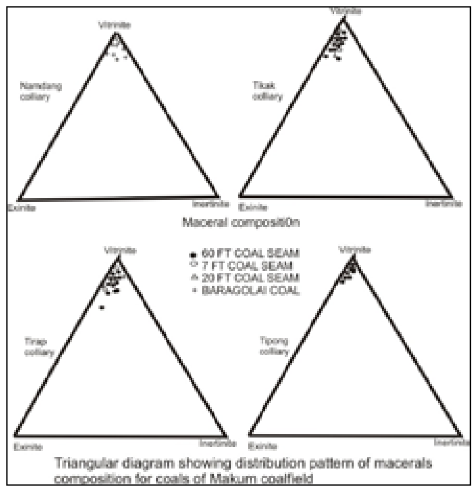


Fig.6

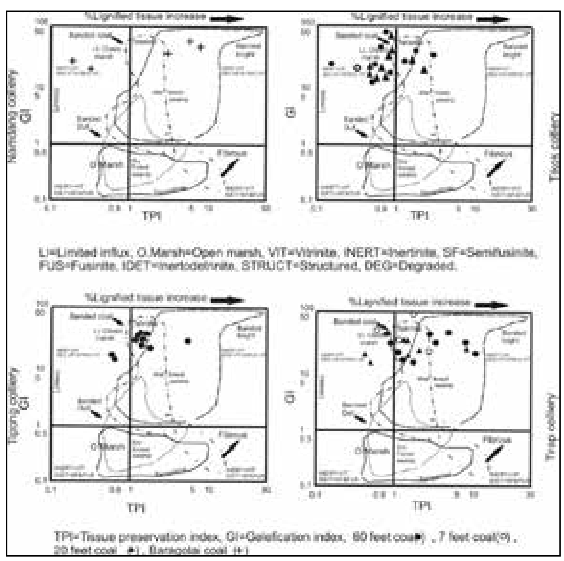


Fig.7

Volume : 3 | Issue : 6 | June 2013 | ISSN - 2249-555X

REFERENCE Bardhan, B. (1995)- In Ph.D Thesis of Sarmah, R.K. (1999), Dibrugarh University, Assam. | Diessel, C.F.K. (1982). An appraisal of coal facies based on maceral characteristics. Aust. Coal. Geol. 4(2), pp. 474-484. | Diessel, C.F.K. (1986). The correlation between coal facies and depsitional environments. Advances in the study of the Sydney Basin. Proc. 20th Sym. Univ. New Castle pp. 19-22. | Ghosh Arabinda (1981). Biostratigraphy and some anomalous petrological properties of Chupevita coal, Rajmahal coalfield, Bihar Evolutionary Botany & Biostratigraphy Symp. A.K. Ghosh Comm. Vol., pp. 323-330. | ICCP (1971). International handbook of Coal petrology. Suppl. 2nd ed. Cent. Natl. Res. Sci. Paris. | IS 9127 (1992)- Bureau of Indian Standards, New Delhi, part II & Part III. | Kalkreuth, W.D, Marchioni, D.L., Calder, J.H., Lamberson, M.N. Naylor, R.D. and Paul, J. (1991). The relationship between coal petrography and depositional environments from selected coal basins in Canada. Int. Jour. Coal. Geol. 19, pp 21-76. | Lamberson, M.N., Bustin, R.M., kalkreuth, W.D. (1991) Lithotype (maceral) composition and variation as correlated with palaeo-wetland environments, Gates Formation, northeastern British Colombia, Canna, Int. Jour. Coal. Geol. 18, pp. 87-124. | Prasad, B.R. and Verma, A.K. (1982). Geology, reserve and general quality parameters of coals from Northeastern India. Coal India Ltd, N.E.C.F., Assam. (Internal Report) pp. 1-5. | Raja Rao C.S. (1981). (Ed.) Coalfields of India. Bull. Series A. No. 45, V.I- Coalfields of North Eastern India, G.S.I. pp. 5-14. | Sarmah, R.K. (1999). Petro-palynological and Sedimento logical study of coal and associated sediments from a part of Makum coalfield, Upper Assam. Ph.D Thesis, Dibrugarh University, Assam. | Sengupta, S. (1997). Maturation study and Geothermics from differential Coalification trend in two adjacent sub-basin of Sohagpur Coalfield, M.P, India. Ph.D thesis, Jadavpur University, Kolkata. | Smyth, M and Mastalerz, M. (1991). Organic petrological composition of Triassic source rocks and their clastic depositional environment in some Australian Sedimentary basins. Inter. Jour. Coal Geol. 18, pp. 165-186. | Teichmuller, M. (1950). Zum petrographischem Aufbau and Werdegang der Weichbraunkohle Geol. Jahrb 64. pp. 429-488. | Teichmuller, M. (1962). Die Genese der Kohle. 4th long. Stratigr. Geol. Carbonifere (Heerlen, 1985). C.R. pp. 679-