INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN: 2278 – 0211 (Online)

Palaeodepth Studyfrom Parts Of Makum Coalfield In The Belt Of Schuppen, North Eastern India

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Abstract:

The study area , a part of the Makum Coalfield is located in the Upper Assam region of north – eastern India. The present study is confined only to the Tikak Parbat Formation of Barail Group and based on the analysis of petro graphic and chemical parameters of samples of coals.

Different methods have been employed to find out the palaeodepth of the base of Tikak Parbat Formation of Barail Group and loss of cover thereafter using existing sedimentary pile from palaeodepth data. It is found that out of Method I, IIA and IIB, data of Method I is close to that of Method IIB. A maximum palaeodepth reached in Tikak Hills area is 2500m, while around Ledo-Tirap Colliery area, it is 2439m which is close to the actual stratigraphic thickness of total sediments had there been no erosion. A loss of cover due to erosion is variable in space and it is approximately 2100m to 2400m in Tirap and Tikak Hill sections respectively.

Key words:*vitrinite reflectance, volatile matter, cover loss, Barail Group, Assam.*

1.Introduction

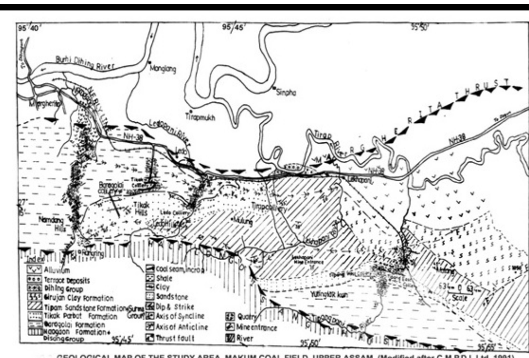
The degree of coalification or metamorphism of a coal can be established by reflectance study (Hoffman and Jenker, 1933; McCartney and Teichmuller, 1972) while proximate chemical analysis can result apparent rank determination. McCartney and Teichmuller (1972) compared the reflectance of vitrinite with other rank parameters like VM, carbon content and Hydrogen / Carbon ratio and found excellent relations for high rank bituminous coal, fair for low rank sub -bituminous and high volatile bituminous coals and rather poor for further lower rank coals.Kisch (1969) pointed out that “maximum depth of burial of sedimentary sequences is notoriously hard to establish. The geological extrapolation involves assumptions about the once superimposed and subsequently removed overburden and about the tectonic development of the area”.Karweil (1956), Huck et al. (1964), Teichmuller et al. (1966) and Bostick (1971) demonstrated convincingly the insignificant role of pressure in the process of coalfication. But the experimental studies simulating coalification indicated that the rate of coalification at a given temperature is enhanced by lowering of pressure. Thermodynamically, the gross reaction in coalification process is governed mainly by temperature and time; the static pressure retards reactions by restricting the removal of reaction products. The published information regarding coal rank and coalification trends in Indian Coal basins and Tertiary Coal basin in particular is very meagre (Chakrabarti and Bardhan 1986; Chandra and Chakrabarti, 1989 ;Mishra and Cook, 1992; Bardhan, 1993, Bardhan and Ghosh ,1999), any attempt to deduce the palaeodepth of burial of sediment pile in a coal basin demands high resolution geological data and better concepts.Taking into considerations the actual difficulty in data acquisition and possible error in extrapolation, the present study is an attempt to derive palaeodepth data pertaining to Makum Coal basin by using petrographic and chemical parameters of coals.

2.Geological Setting

Tectonically, the coalfield areas of Upper Assam and its adjoiningregion occur in the Belt of Schuppen (Evans, 1964) which is a narrow NE-SW trending linear overthrust zone on the Naga-Patkai Range. This belt is delineated on the east by Halflong – Disang thrust and on the west by Naga thrust. The regional structural trend of the exposed coalfield areas in the belt of Schuppen is NE – SW with a subordinate trend from NW – SE to WNW – ESE. Its geological history has a very close link with the regional basin evolution of the Naga – Lushai mobile belt and it was controlled by the plate motion in the eastern continental margin of the Indian plate.The Barail sediments of the Makum Coalfield were presumably deposited in tectonic depressions aligned along a linear mobile belt near to the continental margins. The litho sequence of this coalfield was folded and thrusted due to the effect of several orogenic movements.

The studied coal basin is bounded by the Margherita thrust on the north and the Halflong – Disang thrust on the south (Fig.1).

The Margherita thrust runs along the norhtern periphery of the Makum coalfield and it has brought the older Tertiary rocks in direct contact with the younger Dihings and Alluvium. On the basis of subsurface information it is assumed that the hade of the thrust is due south with an average inclination of 45 degrees and the surface trace of the thrust zone is taken at about 280m to the north of the Tirap colliery. Near Lekhapani, on the sharp turn of the Tirapriver . The Margherita thrust having a general trend NE – SW with hade towards SE truncates the Manabaum line of folding fronting the Mishmi Hills (Ratnam, 1978). The southern margin of the Makum Coalfield is represented by the Halflong – Disang thrust.



GEOLOGICAL MAP OF THE STUDY AREA, MAKUM COAL FIELD, UPPER ASSAM. (Modified after C.M.P.D.I. Ltd. 1991)

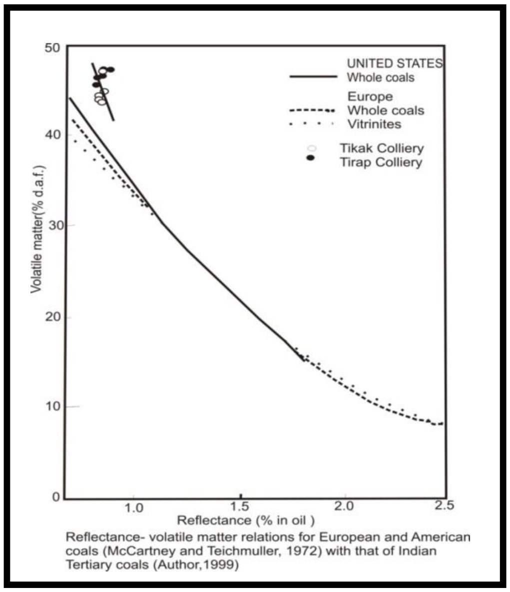
Figure 1

3.Methodology

The author has collected direct evidences or field and laboratory data about (1) reduced level, (2) depth of coal seams (3) volatile matter of coal samples (4) reflectance of vitrinite (5) present geothermal gradient (6) thickness of the formation under study.To reconstruct the geological history of the coal basin under study, the above mentioned assumptions and also geologic age and tectonic events suggested by earlier workers were presumably accepted. Oligocene age 23 m. yrs. (Upper Oligocene) of organic mass (coal) and equilibrated time of 40 m. yrs. (Upper Eocene) in steady thermal state are assumed for deducing the following information: (1) maximum depth of burial/ paleodepth (2) rate of subsidence (3) cover loss/level of erosion.

4.Results

The relation between volatile matter (VM) content of whole coal (Table 26 - 31) versus reflectance of vitrinite was deduced using the diagram (after McCartney &Teichmuller, 1972) as shown in Fig.2.



Reflectance- volatile matter relations for European and American coals (McCartney and Teichmuller, 1972) with that of Indian Tertiary coals (Author,1999)

Figure 2

It indicates a narrow range of value between 43 to 51% and a shift of the line with a steeper slope well above the trend of the United States whole coals. This may suggest the presence of high volatile component in coals (*i.e*. liptiniterich) which actually is the most important characteristic of the Oligocene coals in the study area.Karweil (1975) presented a chart based on mathematical calculations of simplified chemical kinetics for which duration of time and temperature of alteration are responsible. Kisch (1969) plotted a curve after Huck and Karweil (1955) assuming an average geothermal gradient of 40° C/Km from the Upper Carboniferous to the present and a decrease of 2.2% VM/100 m in the fat coal range. Using the master diagram of Huck and Karweil (Fig. 3) the depth and VM values of studied coals are plotted assuming average geothermal gradient of 40° C/Km from the Upper Ecocene to the present age.

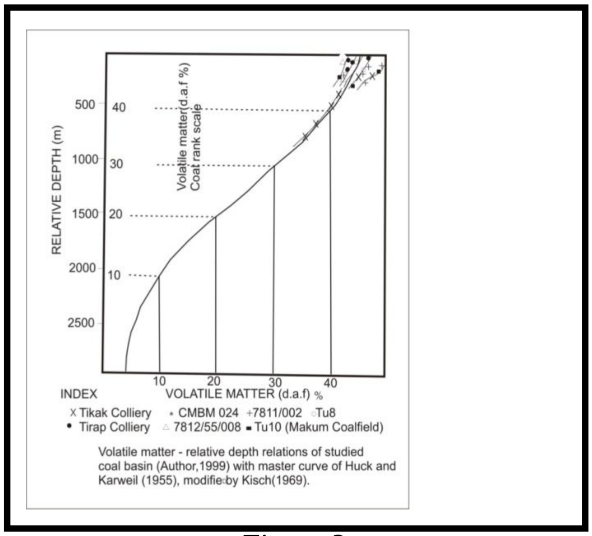


Figure 3

The curves for field sections as well as boreholes show good parallelism with that of the master curve within a range of VM upto 44%. But coals having above 44% VM (dmmf) deviate from the master curve and exhibit a trend below that of the normal burial metamorphism. It is significant enough to note the dual high and low rank character of coals confirms the earlier view (Raja Rao, 1981; Chandra and Chakrabarti, 1989).Since researches related to coal rank and burial metamorphism inTertiary Coal basins in particular is of limited nature (Chandra and Chakrabarti, 1989), the author, therfore, has attempted to justify the validation of data resulted from the present work by plotting the data on McCartney and Teichmuller's VM-reflectance curve (Fig.4.)
and Kisch `s relative depth – VM curve (Fig.5).

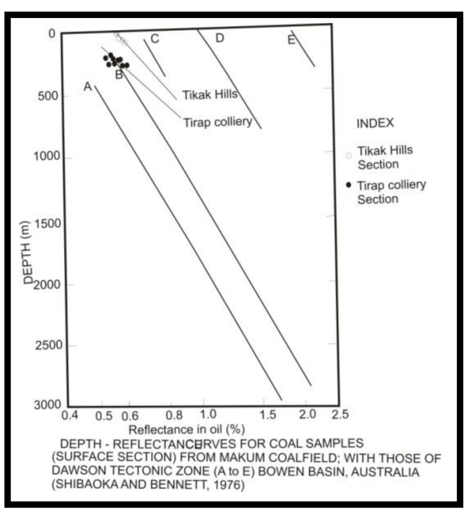


Figure 4

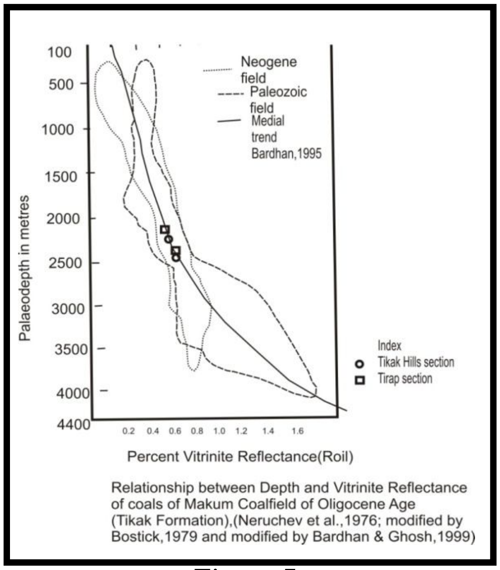


Figure 5

A good similarity is observed which suggests that the trends of burial metamorphism do not deviate much from the normal trend and can be taken into confidence while applying the standard methodologies related to palaeodepth study.Depth – reflectance curves for coal samples from Tirap colliery and Tikak hills sections in the study area are drawn on log – normal scale (after Shibaoka&Benett, 1976) in Fig. 6.

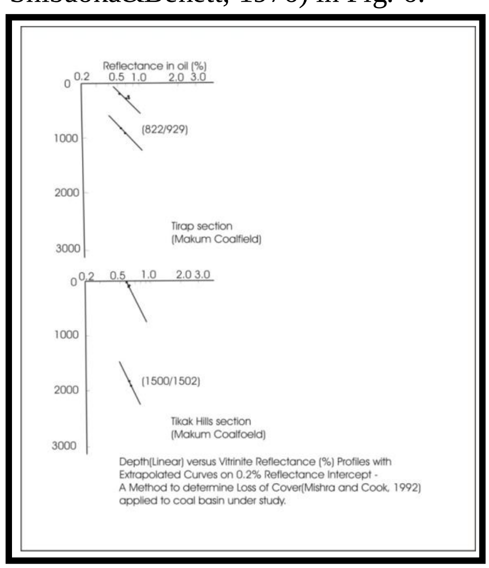


Figure 6

The curves indicate a removal of thick overburden by erosion. Besides, the curves of the study area reveal that there is a shift of the trend line from Tikak Hills section slightly towards higher refelectance side. This is indicative of relatively greater quantity of overburden removal from Tikak hills area to the west.Again the slope of the lines for the two field sections *i.e*. Tirap and Tikak Hills show almost similar trend and this means that they belong to one palaeogeothermal regime.

Most studies related to basin analysis deal with burial depth and petroleum generation in geological formation of Mesozoic and Cenozoic age. In Cenozoic coal basins of north eastern India, burial histories in appropriate time scale is rather least known. For this limitation, the present work has to proceed with initial assumption of soaking time *i.e*. a stable thermal state required to attain a particular maturation level. Many workers have widely accepted the “effective heating time” factor in their time-temperature rank models (Karweil, 1956 ;Lopatin and Bostick, 1973 ; Lopatin, 1976). However, the Russian school led by Neruchev&Parparova (1972), Neruchev et al. (1976) believed that the duration of reaction makes little difference in the level of catagensis after about 1st m. yrs. In Neruchev’s diagram (for the shallow and deeper points) at a given palaeodepth, the vitriniterefectance tends to be greater for the sample of older age. Bostick (1979) admitted that there is incomplete knowledge about the exact catagenetic reaction rate. Hacquebard (1977) also tried to estimate maximum depth of burial for Lower Cretaceous and Early Tertiary sediments from mositure content. This could not be applied here on the ground that the moisture variation in the coals are not significant.

In the present study, two methods i.e. the Method – I of Bostick (1979) (modified from Neruchev et al. 1976) and the Method – II after Mishra and Cook (1992) were employed for determining the palaeodepth of coal samples from Makum Coalfield. Mishra and Cook (1992)presented an excellent work in Jharia coal basin to estimate the loss of cover at the drill site.

4.1.Method – I (After Bostick 1979)

In the present study, the Ro (mean) values determined in the laboratory have been plotted on the diagram of Neruchev et al. (1976) modified by Bostick (1979) at the modified medial line of best fit of 2nd order which passes through 0.2 % Ro at 0.0 metre level (Bardhan, 1994). The correspondingpalaeodepth values for Tikak hills and Tirap colliery sections were determined.The value is directly read from the modified curve and incorporated in Table-1.

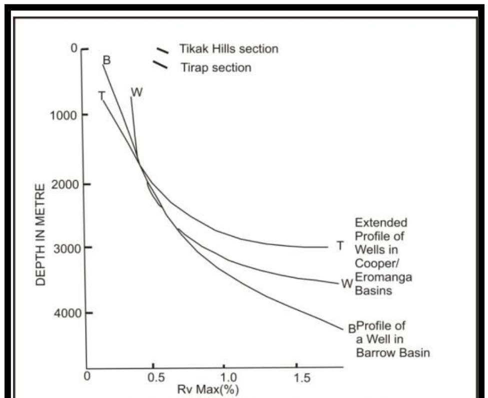
Locality/Coal Field	**Coal Seam**	**Rl. (M)**	**Preset Depth (M)**	**Palaeodeph Method – I (After Bostick, 1979)**	**Cover Loss**	**Method – Ii A**	**Cover Loss Method – Ii B**			**Method – Ii A**	**Palaeodepth Method – Ii B**		
							T Basin	**W Basin**	**B Basin**		**T Basin**	**W Basin**	**B basin**
Tikak Hills section/ Makum coalfield	20 ft.	439.78	26.34	2321	2295	1500	2333	2733	3032	1527	2359	2759	3058
	60 ft	375.0	91.12	2500	2409	1582	2423	2817	3103	1673	2514	2908	3194
Tirap colliery section/ Makum coalfield	20 ft.	139.09	208.20	2179	1971	822	2227	2583	2867	1030	2435	2791	3075
	60 ft	66.07	281.22	2439	2158	929	2333	2683	2950	1210	2614	2964	3231

Table 1:Variation Of Cover Loss/Erosion And Palaeodepth As Determined After Different Workers (In Metres)

If the palaeodepth data is found to be reliable, which the author strongly believes then this simple method can be applied to other Tertiary coal basins. A comparision of the estimated data with postulated stratigraphic thickness is presented in Table 2. The results obtained by this method are found to corroborate partially to the existing geological and geophysical findings.

4.2.Method – Ii (After Mishra And Cook, 1992)

Mishra and Cook (1992) offered two graphical methods to determine loss of cover which in turn if added to the present sediment thickness, then the palaeodepth can be estimated. The first method (Method II A) is a linear extrapolation to determine cover losss from the depth versus reflectance profile plotted on semi log scale (Fig.7).



COMPARISONS OF VITRINITE REFLECTANCE VERSUS DEPTH PROFILES< B(BARROW BASIN< AUSTRALIA) AND PROFILES OF W<T(EROMANGA/COOPER BASINS,AUSTRALIA) - OPTIMISED TRANSPORTED PROFILES

Figure 7

Extrapolation is made back to 0.2% Ro assuming this would be the initial refectance at peat stage or surface reflectance if no cover loss occurred (Middleton, 1982). The profile in Fig.7 has been extrapolated back to 0.2% refelectance intercept. The distance from the present surface to this intersection is considered as the loss of cover at the specific site (field section).

In the second method (Method – IIB), depth versus reflectance profile from the field sections are comparred with Cooper/Euromanga and Barrow basins of Australia in Fig.5.18. A well drilled in Barrow basin (B) through Tertiary and Mesozoic sequence terminating with Jurassic sequence and E, T, W representing the wells from Cooper/ Euromanga basins which were drilled through the Tertiary and Mesozoic to the Perimian have been incorporated. The profile drawn from the present study weretransferrred vertically downwards to the B, T (extended) and W profile. The values read from B, T, W have been systematically incorporated (Table- 3). The T-values of Method – II B are found to be nearly close to the values obtained from Method – I of Bostick (1979).

	BELT OF SCHUPPEN		UPPER ASSAM & NAGA HILLS EVANS (1964)	MAKUM COAL FIELD GENERAL			TIKAK HILLS AREA	LEDO-TIRAP COLLIERY EVANS, 1932	NAMDANG COLLIERY EVANS et al. 1932
	KRISHNA RAO & RAJKUMAR (1987)	RANGA RAO (1983)		Krishnan (1968)	RAJA RAO (1981) MISHRA (1992)	EVANS (1932)			
REPORTE MAXIMUM STRATIGRPHIC THICKNESS	POST BARAILS 5500	---	1800 (DIHINGS) 1800 (NAMSANGS) 1800 (GIRUJANS) 2300 (TIPAM SANDSTONE)	---	± 470 (GIRUJANS) ± 1000 (TIPAM SANDSTONE) 400 (SURMAS)	± 185 (DHING) ± 1040 (NAMSANG) 900 1000 500			
TIKAK PARBAT FORMATION	3625	6100	600	450	609	619		431	500
BARAGOLAI FORMATION			3300	3000	± 2743	+2700		2800	3370
NAGAON FORMATION			2200	2400	± 1525	+1062			
MAXIMUM PALAEODEPT DETERMINED BY THE AUTHOR (UPTOTHEBASE OF TIKAK PARBAT FORMATION)	--	--	--				2500	2439	---

Table 2:Comparative Variation of Stratigraphic Thickness of Total Teritary Sediments from Different Areas under study and Makum Coalfield (Thickness in metres)

5.Conclusion

The present study reveals that the maximum palaeodepth reached in Tikak Hill area is 2500m while it is 2439m in Tirap colliery area. The estimated palaeodepth values are in close to the actual stratigraphic thickness of the total sediments had there been no erosion.A loss of cover due to erosion as determined from the study is approximately 2100m and 2400m in Tirap and Tikak Hill sections respectively.To verify the paleodepth data obtained from the work, a concurrence in observation and estimates is necesssarily required to concede the atempt as an effective and useful work.In the present context, there is no good concurrence between the actual or postulated stratigraphic thickness and estimated palaeodepth values. But if the values as suggested by Raja Rao (1981) in Misra (1992) is considered (i.e 2479 m) for the Makum coal basin, the estimated palaeodepth data (*i.e* 2500 m) is found nearly close to it. It may not be unreasonable to accept the determined palaeodepth data for the studied coal basin due to the fact that the thrusted and folded tectonic block as Makum Coalfield might have subsided differently in relation to adjacent tectonic blocks in the belt of Schuppen. A clear and authentic picture will be evolved only when the tectonic history of the region as a whole and each coal basin in particular in terms of absolute age wilbe available.

6.Acknowledgement

The author is very grateful to Dr. ArabindaGhosh, former Professor, Jadavpur University, Kolkata for his suggestion and help during the research work. The author also thanks Mr. S.N. Changmai, Supdtg. Geologist, Coal India Ltd., Margherita for his help during the field work.

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