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Evaluation of coal bed methane potential of Tertiary coals of Nagaland

Abstract

The study evaluates Coal Bed Methane (CBM) potential of coals of Tikak Parbat Formation, Barail Group (Oligocene) from Mon and Mokokchung district of Nagaland. Proximate analysis, vitrinite reflectance (Vro) studies and scanning electron microscopy (SEM) analysis have been performed on outcrop coal samples to know coal rank, maturity and fracture morphology, apertures and secondary mineralization. Results show that the coals are lignite to sub bituminous rank with well developed exo-genetic cleats, fracture networks and immature for thermogenic gas generation.

Introduction

Nagaland is endowed with rich potential wealth of natural resources. Of these, coal deposits spread in Mon, Mokokchung, Tuensang, Wokha and Dimapur districts of Nagaland which are lying untapped CBM potential. The total coal reserves in this State are estimated at about 315 million tons (Source Ministry of coal, 2014). Nagaland carries 21% tertiary coal reserves of North-Eastern India. The coal deposits are hosted in Barail Group occur along Schuppen belt adjoining the Assam plains (Fig. 1). Coal bed methane potential of these coals are unknown and virtually no data present.

Geological setting

Coal deposits of Nagaland occur in the belt of Schuppen which is a 20 to 30 km wide NE-SW trending linear overthrust zone on the Naga-Patkai Range. The stratigraphy of Oligocene sequence of belt of Schuppen is given in Table-1. The coal bearing Barail Group can be subdivided into Naogaon, Baragolai and Tikak Parbat Formation in ascending order. Naogaon Fromation consists of thin bedded sandstone with alternation of shale and streaks of coal. Baragolai formation is madeup of inter bedded sandstones and alternating sequence of shales, carbonaceous shales, coals and thin sandstone beds. The Tikak Parbat Formation consists of thick coal seams in the basal part followed by interbedded sequence of carbonaceous shale, sandy shale and thin sandstones. The coal deposits extend over an area of 3370 sq km, whereas the exposed coal deposits in the various fields hardly covers 260 sq km (CMRL report, 1982).

Fig.1. Geological and tectonic map of North Eastern India (after Mathur & Evans, 1964)

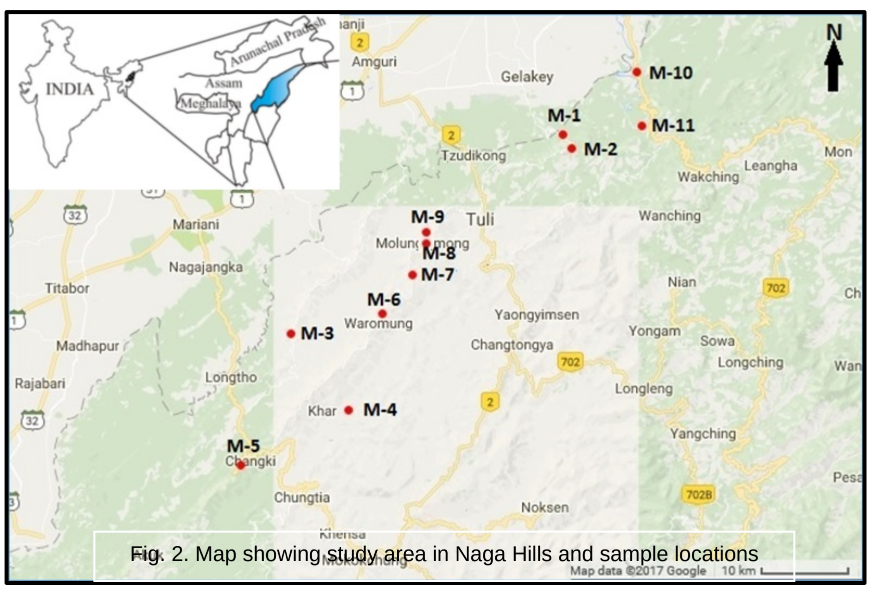


Fig. 2. Map showing study area in Naga Hills and sample locations

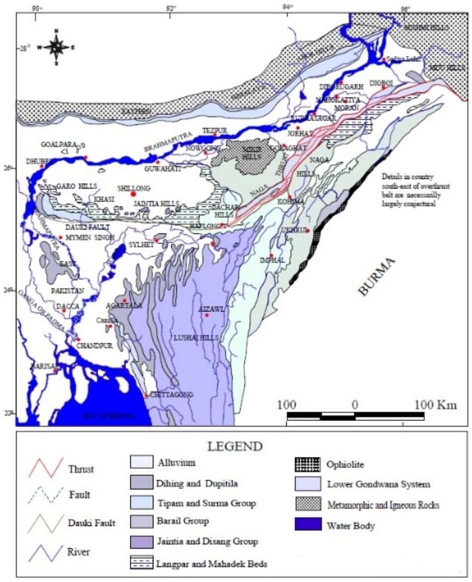


Table-1: The stratigraphy Oligocene sequence of belt of Schuppen.

Age	Group	Formation	Description
Oligocene	Barail	**Tikak Parbat**	Coal & carb shale interbeded sequence at lower part and interbedded sandy mudstone, shales and thin coal seams in upper part
		Baragolai	Lower part is Interbedded shale, sandy shale, thin sandstones and coal. Upper part is predominantly sandy sequence with thin interbeds of sandy shales
		Naogaon	Lower part is thinly bedded sandstone and shale overlain by massive sandstone

Materials and methods

A total of 11 coal samples were collected from outcrops at the banks of streams, springs and rivers spread across the Tikak Parbat Formation from Mon and Mokokchung district of Nagaland. Sample details are given in Table-2 and plotted on map (Fig. 2)

Table-2: Coal samples location details and descriptions

Sl.	Location	Sample No.	Sample Details
1	Anakiyimsen	M-1	Dull brown to black, moderately hard, compact and non banded, resinous luster, non cleated, appears more like matrix rich lignite.
2	Aonokphu	M-2	Jet black, moderately dull to moderately bright, hard and compact, non banded, cleats moderately developed.
3	Lakhuni	M-3	Dull black, moderately hard, non banded, no cleat development, secondary mineralization observed along bedding surface, coal thinly laminated. Mostly crushed.
4	Khar	M-4	Jet black, moderately dull to moderately bright, hard and compact, non banded, cleats moderately developed.
5	Changki	M-5	Dull brown to black, moderately hard, compact, non banded, dull coal
6	Waromung	M-6	Dull black, moderately hard, non banded, no cleat development, secondary mineralization observed along bedding surface, coal thinly laminated, vitrain band thickness 1-3mm. Mostly crushed.
7	Yimjenkimong	M-7	Dull black, moderately hard, non banded, no cleat development, secondary

			mineralization observed along bedding surface, coal thinly laminated. Mostly crushed.
8	Moulungkimong	M-8	Dull black, moderately hard, non banded, no cleat development, secondary mineralization observed along bedding surface, coal thinly laminated, vitrain band thickness 1-3mm.
9		M-9	Dull moderately hard, massive face cleats observed. Coal is rich in sulphur as exhibited by greenish yellow color.
10	Borjan	M-10	Moderately bright to bright coal, hard, compact, non banded and vitrain and clarain rich. Face cleat moderately developed, secondary mineralization apparent, bright coal
11	Kongan	M-11	Moderately bright to bright coal, hard, compact, non banded and vitrain and clarain rich. Face cleat moderately developed, secondary mineralization apparent, bright coal.

Proximate analysis

Proximate analysis of total 11 coal samples was carried out using standard ASTM methods to determine moisture, ash and Volatile matter (VM) contents (Table 2). From the study it was seen that Moisture content varies from 2.30 to 7.21%, Ash content range from 2.78 to 27.92% and Volatile matter range was 36.32 to 49.58% and 47.30-55.58% on daf basis. The results show coal rank falling within lignite to sub bituminous range.

Table-3: Proximate analysis data of coal samples

Sl.	**Sample No.**	**Proximate Data**					
		As received basis				(DAF Basis)	
		Moist %	**Ash %**	**V.M. %**	**FC %**	**VM %**	**FC %**
1	M-1	**5.16**	**5.06**	46.13	43.65	**51.38**	**48.62**
2	M-2	**3.89**	**7.97**	48.99	39.15	**55.58**	**44.42**
3	M-3	**5.98**	**2.78**	47.36	43.88	**51.91**	**48.09**
4	M-4	**6.21**	**4.15**	45.13	44.51	**50.35**	**49.65**
5	M-5	**2.30**	**5.24**	43.73	48.73	**47.30**	**52.70**
6	M-6	**5.16**	**5.06**	46.13	43.65	**51.38**	**48.62**
7	M-7	**7.21**	**8.55**	43.74	40.5	**51.92**	**48.08**
8	M-8	**4.03**	**3.42**	49.58	42.97	**53.57**	**46.43**
9	M-9	**5.32**	**27.92**	36.32	30.44	**54.40**	**45.60**
10	M-10	**4.23**	**8.25**	47.25	40.27	**53.99**	**46.01**
11	M-11	**4.30**	**13.41**	43.95	38.34	**53.41**	**46.59**

Vro Studies

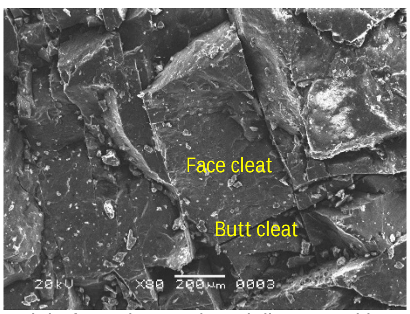
In order to assess the maturity, Vro studies were carried out on 9 outcrop samples and have been given in Table-4. From the studies, it was found that the Vro ranges from 0.416-0.504 and coal is immature in nature.

Table-4: VRo data of selected coal samples

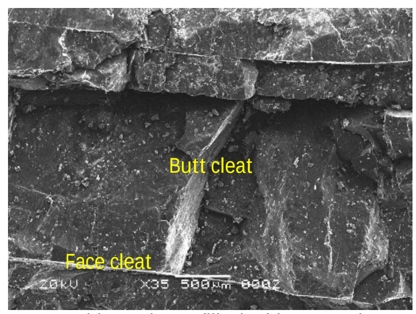
SNo	Sample No.	VRo Range	Average VRo
1	M-1	0.448-0.553	0.496
2	M-2	0.445-0.539	0.496
3	M-4	0.445-0.582	0.504
4	M-6	0.425-0.541	0.479
5	M-7	0.379-0.487	0.429
6	M-8	0.347-0.494	0.416
7	M-9	0.418-0.588	0.486
8	M-10	0.357-0.612	0.475
9	M-11	0.447-0.561	0.492

Cleat characterization studies

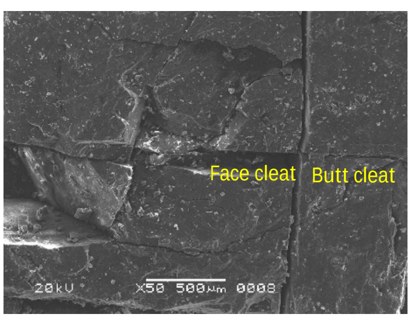
To assess cleat character at micro level, SEM studies were carried out on coal samples (Fig. 3a-f). The coal samples M1, M-5, M-7, M-9 and M-11 seem to have developed rudimentary cleats which were later destroyed. In samples M-3 & M-6 vitrain rich bands are reduced to a grit or powder consistency. The samples M-2 (Fig. 3a-b), M-4 (Fig. 3c-d) and M-8 (Fig. 3e) from Aonokphu, Khar and Molungkimong respectively showed well developed face cleats and moderate to poorly developed butt cleats. While the sample M-10 (Fig. 3f) from Borjan showed poorly developed face cleats with no development of butt cleats. Thus from SEM studies it can be inferred that there is a good development of Face and Butt cleats in Aonokphu, Khar and fractures in Molungkimong.



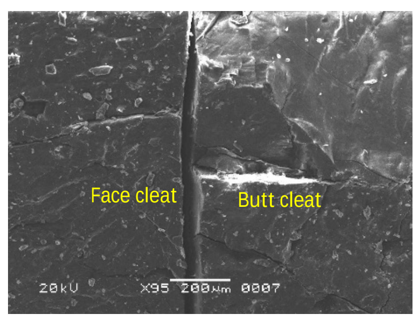
a) M2:Tight face cleat and partially opened butt cleat



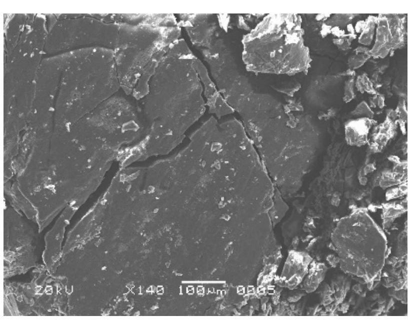
b) M2:Face and butt cleats filled with secondary minerals

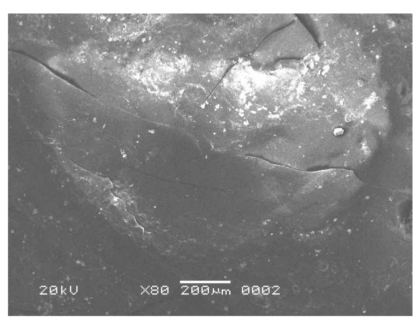


c) M4:Well developed face and butt cleats with open aperture



d) M4:Closer view of face cleat with open aperture





e) M8:Fractures on coal surface

f) M9: No cleat development and haphazardly oriented fractures

Fig. 3. SEM photographs showing cleat characters at micro level

Discussion

The Tertiary coal seams and layers associated with Barail Group in Schuppen belt are inconsistent in nature with regard to their thicknesses, strike lengths, depth persistence, compositions, structural set-up, etc. Moreover, they are disturbed by compressional tectonics i.e. folding and thrust faulting. Coal seams pinch and swell erratically, sometimes lost by pinching even within a very short distance. Their persistence along strike and dip is unpredictable due to complex deformation of Schuppen Belt. Coals are highly jointed, fragmented and powdery nature due to tectonic disturbances.

There is a strong relationship between coal rank, moisture content, cleat development and cleat spacing (Law, 1993). With increasing coal rank, cleat spacing and moisture content decreases & degree of cleating increases. In contradictory to this, well-developed cleats and fracture networks are observed in low rank lignite and bituminous coals from Nagaland. Based on the SEM studies of coal samples, it is observed that well developed cleats and fracture networks in lignite and sub-bituminous coals are exogenetic in nature and nothing to do with coalification process. The exogenetic cleats and fractures are tectonic in origin and they are not necessarily perpendicular to bedding and their geometries are controlled by regional stress fields. In contrast to endogenetic cleats (formed due to shrinkage of coal caused by loss of water and volatile matter during progressive coal maturation) exogenitic cleats may form under compression and therefore tend to generate powdered coal. The powdered and crushed nature of the coal could damage permeability.

Proximate analysis of the coal samples collected from outcrop indicates volatile matter ranges from 47.30 to 55.58% (daf basis). The rank of coal is in the range of lignite to sub bituminous. Thermogenic methane generation commenced when volatile matter dropped below about 37.8% on a daf basis, corresponding to a rank of high volatile bituminous coal. The volume of thermogenic methane generated from a coal can be derived by using an empirical equation developed by Meisner (1984). The equation is as follows.

$$V_{C1} = -325.6 \log \mathrm{VM\ daf} 0.378$$

Based on this equation, any coal having VM>37.8% should generate no methane at all. However, there are case studies where lignite to sub bituminous rank coals contain good quantity of methane such as Powder River Basin, US. (Flores, 2004). This type of low rank coals generally contain biogenic methane with good reservoir permeability in shallow depth. But in absence of gas samples, chemical and isotopic data, the generation potential could not be determined. Since, the Nagaland coals are immature to generate thermogenic methane and any commercial accumulation of CBM is likely to be sourced from biogenic origin.

Conclusions

A total of 11 no. coal samples from outcrops of Tikak Parbat Formation, Barail Group (Oligocene) from Mon and Mokokchung district of Nagaland were analyzed and studied.

i. Proximate analysis data indicated that the coals from Belt of Schuppen are in the rank of lignite to sub bituminous range.
ii. Based on the SEM studies of coal samples it is observed that well developed cleats and fracture networks in lignite and sub-bituminous coals are exogenetic cleats in nature and nothing to do with coalification process.
iii. The Average vitrinite reflectance coals varies from 0.416-0.504% indicate that the coals are immature to generate thermogenic methane.

iv. Nagaland coals are immature to generate thermogenic methane and any commercial accumulation of CBM is likely to be sourced from biogenic origin.

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