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Petrographic Characterization and evolution of Eocene Coal from Bapung coalfield, East Jaintia Hills, Meghalaya, North-East India

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Abstract

The Bapung coalfield in the East Jaintia Hills of Meghalaya belongs to the Shella Formation of Jaintia Group and is of Eocene age. Thinly bedded seams of about 1 m thick are vastly exposed in the Bapung area. The present study includes petrographic and geochemical characterization of these coals. This study reveals that the Bapung coals are sub-bituminous 'A' to high volatice bituminous 'C' in rank. These coals are perhydrous in nature with moderately high volatile matter content. The sulphur content is high in these coals having pyrite as the most abundant mineral. Vitrinite is the dominant maceral group constituting nearly 76.5-82.6% of the entire group macerals, while inertinite occurs in subordinate amount and liptinite concentration is insignificant. Facies-critical models used to decipher the paleodepositional environment suggest that anoxic moor condition dominantly prevailed in the paleomire and there was association of peat with brackish water condition which allowed the sulphate reducing bacteria to thrive.

Keywords: Bapung coal, Meghalaya, coal Petrography, geochemistry, depositional environment.

INTRODUCTION

The coal resources of India occur in two main stratigraphic horizons - the Gondwana coals of Permian age and the Tertiary coal resources of Paleogene. Gondwana coals account for over 99% of India's output while the Tertiary coal contributes the rest. The Tertiary coal deposits in the northeastern region of India mainly occur in the States of Assam, Arunachal Pradesh, Meghalaya and Nagaland. The coal-bearing sequences of Meghalaya are deposited over a platform basin having a stable self-conditions especially along the peripheral margins of the Shillong Plateau. Raja Rao (1981) reported three groups of coalfields in Meghalaya located in the Garo Hills, Khasi Hills and Jaintia Hills.

It was Medlicott (1868) who first reported the occurrence of coal in Meghalaya and the subsequent researches were carried out by Bose (1904), Evans (1932), Fox (1934), Gosh (1940 & 1964), Goswami and Das (1965), Chakraborty and Bhattacharyya (1969), Raja Rao (1981), Ahmed and Bharati (1985), Goswamy (1985), Singh (1989), Chandra and Behera (1992), Ahmed and Rahim (1996), and Rajarathnam et al. (1996). Recently, the coalfields of northeastern India have been petrologically studied by several workers and significant contributions have been made by Mishra (1992); Mishra and Ghosh (1996); Singh and Singh (2000 & 2001); Singh et al. (2012c, 2013a). Present study focusses on coals of Bapung coalfield (Fig. 1) which is a minor but important coalfield of Jaintia Hills, Meghalaya. The coal seams occur in the Shells Formation of Eocene age and belong to Jaintia Group. The objective of the present study is to provide comprehensive information of the composition and evolution of Bapung coals from Jaintia Hills of Meghalaya using coal petrography and geochemistry.

Geological Setting

The coal sequences in the Tertiary Assam-Arakan tectono-sedimentary basin occur in two distinct geotectonic provinces: (i) the coal deposits of Garo and Khasi Hills of Meghalaya and Karbi Anglong of Assam deposited over the stable platform areas peripheral to the shield; (ii) the deposits of Upper Assam, Nagaland and Eastern Arunachal Pradesh formed in the peri-cratonic down wraps in a Schuppen zone. Thus, the coal bearing sequences of Jaintia Hills of Meghalaya evolved over platform areas under stable self-conditions. In Meghalaya the sediments associated with coal measures range in age from Upper Cretaceous to Eocene exhibiting lateral and vertical variation in lithofacies. Sedimentation began during the

Upper Cretaceous time when marine transgression took place in the area towards north and inundated the southern block of the Shillong plateau. Though the sedimentation continued throughout the Tertiary period but the sedimentation during the Cretaceous period had a restricted areal extent. The eastern sector is characterized by thick lava flows during Sylhet Trap volcanism of Jurassic period. After cessesion of volcanic activity there was accumulation of thick pile of sediments which progressively decreased towards the Garo hills. It is believed that the sea inundated the present day Jaintia Hills during Eocene period. Probably the Jaintia hills in the east remained a landmass till early Eocene and experienced down sinking during the deposition of the coal-bearing sandstones of Eocene age. Medlicott (1869) was first to provide the stratigraphy of Meghalaya and introduced the names Mahadek, Langpar, Cherra bands and Nummulitic series within Cretaceous-Eocene sediments exposed along the South Shillong Plateau. Subsequently, Evans (1932) provided a comprehensive stratigraphy of the Assam-Arakan Basin and established stratigraphic framework of South Shillong Plateau along with Naga Hills, Barail Range and Surma Valley. While working on the geology of the western part of Garo Hills, Fox (in Heron, 1937) discussed its stratigraphic relationship with the strata exposed in the eastern part of the Shillong Plateau and Ghosh (1940) established the stratigraphic relationship of the lower Tertiary sediments in the Cherrapunji area. The Sylhet Stage of Evans (1932) was subdivided by Wilson and Metre (1953) who introduced several substages with local names. Mathur and Evans (1964), however, felt that ‘Series’, ‘Stages’ and‘ Substages’ appear to be equivalent to ‘Group’, ‘Formation’ and ‘Member’ respectively and therefore proposed another scheme of classification for both the shelf and the geosynclinal part of the Assam-Arakan basin. Chandra et al. (1959) and Chakraborty et al. (1974) mapped the South Shillong Plateau for Oil and Natural Gas Corporation (ONGC). The generalized stratigraphic succession of Meghalaya with subdivision and lithology (after Deshpande et al., 1993) are given in Table 1.

Table 1: Stratigraphic Sequence of Meghalaya (after Deshpande et al., 1993)

<table>
<tr><th colspan="2"></th><th colspan="2">Garo Hills</th><th colspan="2">Khasi and Jaintia Hills</th></tr>
<tr><th>Age</th><th>Group</th><th>Formation</th><th>Member</th><th>Formation</th><th>Member</th></tr>
<tr><td>Recent</td><td></td><td colspan="2">Alluvium</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Pliocene to Pleistocene</td><td>Dihing Group</td><td colspan="2">Dihing Formation</td><td colspan="2"></td></tr>
<tr><td>Dupitila Group</td><td colspan="2">Dupitila Formation</td><td colspan="2">Dupitila Formation</td></tr>
<tr><td rowspan="2">Miocene to Pliocene</td><td>Tipam Group</td><td colspan="2"></td><td colspan="2">Tipam Formation</td></tr>
<tr><td>Surma Group</td><td colspan="2">Undifferentiated</td><td colspan="2">Bokabil Formation Upper Bhuban Formation Middle Bhuban Formation Lower Bhuban Formation</td></tr>
<tr><td>Oligocene</td><td>Barali Group</td><td colspan="2">Undifferentiated</td><td colspan="2">Renji Formation
Jenam Formation
Laisong Formation</td></tr>
<tr><td rowspan="9">Eocene</td><td rowspan="9">Jaintia Group</td><td colspan="2">Kopili Formation</td><td colspan="2">Kopili Formation</td></tr>
<tr><td colspan="2">Sylhet Formation</td><td rowspan="6">Sylhet Formation</td><td>Prang Limestone</td></tr>
<tr><td colspan="2" rowspan="7">Tura Formation</td><td>Nurpuh Limestone</td></tr>
<tr><td>Umlatdoh Limestone</td></tr>
<tr><td>Lungshnong Limestone</td></tr>
<tr><td>Lakadong Limestone</td></tr>
<tr><td>Lakadong Sandstone</td></tr>
<tr><td rowspan="2">Therria Formation</td><td>Upper Sandstone</td></tr>
<tr><td>Lower Sandstone</td></tr>
<tr><td>Palaeocene</td><td>Khasi Group</td><td colspan="2"></td><td colspan="2">Langpar Formation</td></tr>
</table>

Cretaceous		Mahadek Formation	Mahadek Formation
Upper Jurassic to Lower Cretaceous	Sylhet Trap		Sylhet Trap
Precambrian Metamorphic Basement			

Structure and Tectonics

The Shillong Plateau has a horst type structure which got uplifted during the Lower Cretaceous period. Its tectonic evolution is closely related to the outpouring of lava flows (Sylhet Trap) during Upper Jurassic-Lower Cretaceous period. The deposition of coal bearing sequences began in the southern periphery of the plateau during the Palaeocene period under the stable shelf conditions. The coal sequences are sub-horizontal in attitude but further south, near Bangladesh border; the beds are thrown into a major monoclonal flexture, with major dislocation known as Dawki Fault. From Haflong, it runs westwards, towards the boundary of the Surma Valley near Dawki and it is a continuation of the Disang thrust. Evans and Mathur (1964) consider this fault as a tear fault. The movement along this fault is nearly 250 km which separates Sylhet Trap from the Rajmahal Trap of Bihar. Chakraborty (1972) believes that it is a system of up thrust with a differential vertical movement of the basement rocks. The thrust has an east-west trend with northward steep dip which brings gneisses structurally over the Tura sediments. The northern boundary of the Shillong plateau has a thick cover of Brahmaputra alluvium while the eastern margin is characterized by N-S trending graben (Kopili Lineament) which separates it from Karbi Anglong Plateau, and its western boundary is marked by the Bengal Basin separating it from the Chotanagpur Plateau of Bihar.

Materials & Methods

Channel coal samples were collected from all the working/exposed coal seams from Bapung area (Fig. 2). The samples of coal collected were air dried to remove the free moisture. After drying, the required amount of the sample was taken from each sample by coning and quartering method. The portion selected was crushed and passed through 72 mesh (211 micron) sieve for proximate analysis. Polished blocks were prepared from the channel samples selecting hand lumps of coal. In order to prepare polish blocks to study the coal under reflected light, two alternate faces (vertical and horizontal) are selected. The faces were then ground by increasing fine grades of carborundum powder up to 600-grade on a revolving disc in wet condition. The blocks were then polished on a plane glass using alumina suspension. The block was washed with water to remove impurities. The washed surfaces were polished by using energy papers from 004-001 grades. Final polishing was made in a sylvet cloth fitted on a revolving disc. The maceral analysis was carried out on polished blocks under reflected light with oil-immersion lens using a Leitz Microscope. Coal petrography was carriesd out as per ICCP recommendations (1971, 1975, 1998 & 2001). The procedure recommended by Bureau of Indian Standard (BIS 2003, 1974 & 1975) was followed for proximate and ultimate analyses. The vitrinite reflectance measurements were carried out in the KDMI institute, Dehradun using Leitz MPV-2 microscope under oil immersion lens.

RESULTS AND DISCUSSION

Megascopic Characteristics

The Bapung coal is dark grey to black in colour. The coal is hard and compact, but some portion of the seam is soft and friable. The coals break with cubical fracture, but the hard ones break with sub-conchoidal to conchoidal fracture. The coal depicts a dull to glossy lustre and at places thin pyrite bands are also observed. When exposed to sun, most of the coal disintegrates and crumbles into small chips, indicating a high percent of volatile matter in them.

Chemical Attributes

The proximate and ultimate analyses data are summarized in Tables 2 and 3 respectively. The Bapung coals are chemically characterized by a low ash yield (1.1% to 4.2%), low moisture (1.5% to 2.1%) and high volatile matter (40.02% to 45.25%). The ultimate analysis shows that these coals have carbon contents ranging from 74.30% to 79.65% while hydrogen content is moderately high with more than 5wt% in all the samples. The sulphur content is also high and ranges from 3.58% to 5.03%. H/C and O/C atomic ratios have been calculated. The H/C varies frpm 0.84 and 0.94 (mean 0.90) while O/C ranges from 0.07 to 0.13 (mean 0.10). Generally marine influenced coals are rich in sulphur, hydrogen and nitrogen contents and also have a characteristically high volatile matter than other coals (Teichmüller, 1962). This generalization was further substantiated by Price and Shieh (1979) and Chou (1990) who confirmed that this increased proportion of sulfur (usually>1%) comes from seawater. Under such a situation, the hydrogen and nitrogen are retained in the humic materials and finally appear as perhydrous vitrinite (Taylor et al., 1998). This condition could also have been with Bapung coals which have relatively high sulphur and volatile matter contents (Fig. 3) and shows perhydrous nature. Bapung coal in the Van Krevelen diagram (Fig.4) indicates that the coal was derived essentially from continental plants, whose microbial degradation in the basin of deposition was limited due to high sedimentation and rapid burial.

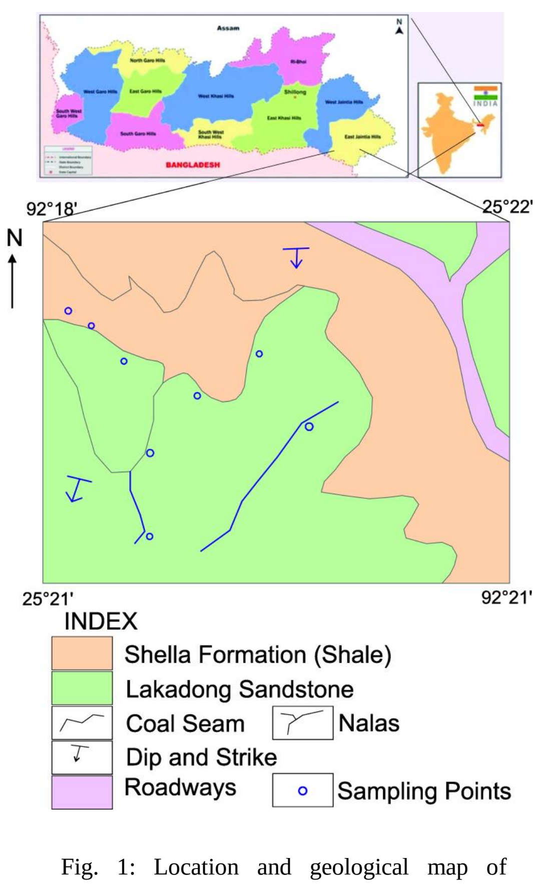

Fig. 1: Location and geological map of Bapung coalfield

Petrographic Composition

The maceral composition of Bapung coals is summarized in Table 4. The representative macerals microphotographs in studied samples are illustrated in Figure 5. The Bapung coals of Meghalaya, in general, are poor in liptinite and inertinite while vitrinite is the most abundant maceral. The vitrinite content ranges from 76.50% to 82.62% (mmf basis). It is dominated by telovitrinite which is mainly represented by collotelinite. It is light grey in colour and shows low to moderate reflectance and occurs as groundmass and coal bands. Liptinite ranges from 1.25% to 3.25% (mmf basis) and it is represented mainly by sporinite and resinite. Sporinite occurs as thread like bodies within vitrinite and it has a low reflectivity than vitrinite. Resinites occur as rounded to oval shaped bodies, in these coals, mostly as inclusions in vitrinite and are almost opaque in reflected light. It includes the plant resin and wax occurring as rodlets in vitrinitic groundmass. Inertinite also occurs in low amounts (8.6% to 18.0%, mmf basis) and it is mainly represented by fusinite, semifusinite, macrinite, inertodetrinite and funginite. Fusinite is characterized by the presence of well-preserved cell structure and higher reflectance. In some cases, cell structure is crushed producing ‘Bogen structure’. Semifusinite is characterized by cell structures less preserved than fusinite and higher reflectivity than the vitrinite. Macrinite occurs as fine particulate matter in the form of lenses. It shows white colour and high reflectance. Inertodetrinite is seen with the cracks and cavities. Funginite occurs as single and multi-chambered body having circular to oval shapes.

Fig. 2: Bapung coal seam during sampling

It represents fungal remains and has variable size, and is characterized by high reflectance.

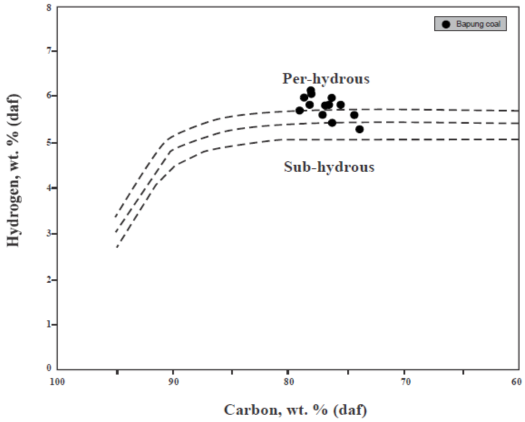

Fig. 3: Simplified Seylers chart with the 'bright coal band' indicated by dashed lines. The sulphur rich Bapungcoals of Meghalaya are at the upper limit of the bright coalband and also in the area of per-hydrous coals.

Mineral matter ranges from 3.1% to 6.3% and is represented mainly by pyrite. It occurs as disseminated grains and specks within vitrinite and as framboidal pyrite bodies. These framboids occur as single or clustered bodies or in the cavities. Argillaceous minerals and carbonates are next in abundance (Table 4).

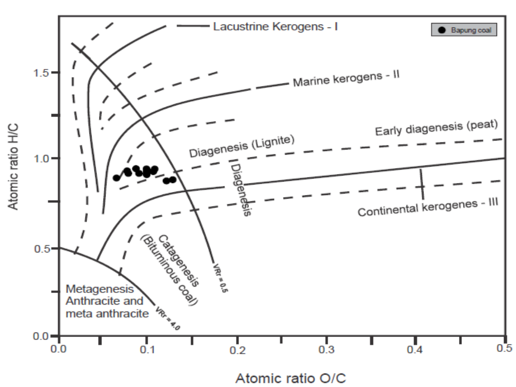

Fig. 4: Position of Bapung coal, Meghalaya in Van Krevelen diagram of H/C versus O/C atomic ratios (after Van Krevelen, 1961)

Reflectance and Thermal Maturation

The thermal maturity of organic matter is related to its chemical changes. A number of parameters are available to assess the maturity like volatile matter, vitrinite reflectance and T_{max} but in the present investigation, vitrinite reflectance was used to know the thermal maturity of Bapung coals. The vitrinite random reflectance (Rr) ranges from 0.57% to 0.67% (avg. 0.62%). The details of reflectance measurements are summarized in Table 4. As per ISO-11760 (2005), Bapung coals are 'medium rank C'/ 'bituminous C' in rank.

Table 2: Results of proximate analysis of Bapung coal in air dried basis (in weight per cent)

Sample No.	Moisture	Ash	Volatile matter	Fixed carbon
1	1.8	1.5	42.15	54.55
2	2.0	1.6	40.25	56.15
3	1.9	2.8	41.20	54.10
4	2.0	1.6	42.30	54.10
5	1.7	2.7	44.70	50.90
6	1.8	2.4	44.25	51.55
7	1.6	1.5	43.70	53.20
8	1.8	2.4	40.10	55.70
9	1.5	2.2	42.75	53.55
10	1.7	4.2	44.10	50.00
11	2.0	2.4	40.25	55.35
12	1.9	3.4	42.35	52.35
13	1.6	1.1	44.20	53.10
14	1.5	1.6	42.23	54.67
15	1.7	1.5	40.02	56.78
16	1.5	1.7	40.02	56.78
17	1.7	2.2	42.32	53.78
18	1.6	2.1	42.02	54.28
19	1.7	2.5	43.67	52.13
20	2.1	2.7	45.25	49.95
21	1.8	2.5	43.07	52.63
22	1.6	3.7	44.25	50.45
23	1.9	3.1	42.02	52.98
24	1.5	3.2	42.87	52.43
Average	1.7	2.4	42.50	53.39
Maximum	2.1	4.2	45.25	56.78
Minimum	1.5	1.1	40.02	49.95

Evolution of Bapung Coal

Teichmüller (1962) believed that the coals formed under marine conditions are generally rich in sulphur, hydrogen and nitrogen contents and are also characterized by relatively high volatile matter. This fact has also been substantiated by Price and Shieh (1979) and Chou (1990) who demonstrated that increasing sulfur proportion (usually> l%) of such coals comes from sea water. Taylor et al. (1998) have shown that hydrogen and nitrogen are retained in the humic materials and are reflected consequently as perhydrous vitrinite. Similar conditions were also recorded in the nearby coal seams of Nagaland (Singh et al., 2012) and could also be applicable with coals which have relatively high sulphur content and volatile matter as in Bapung coals. Bapung coal in the Van Krevelen diagram (Fig. 4) indicates that the coal was derived mainly from continental plants, whose microbial degradation in the basin of deposition was controlled by sedimentation and rapid burial. However, the marine influence cannot be ruled out as few plots also show some deviation from pure continental route (Fig.4).

Table 3: Elemental composition of coal in dry mineral matter free basis

Sample No.	Carbon (wt. %)	Hydrogen (wt. %)	Nitrogen (wt. %)	Total sulphur	Oxygen (wt. %)	H/C	O/C
1	77.06	5.83	2.66	4.11	10.34	0.08	0.14
2	74.30	5.32	2.82	4.25	13.31	0.07	0.19
3	79.15	5.69	2.95	4.45	7.76	0.07	0.11
8	78.32	6.15	1.76	4.40	9.37	0.08	0.14
9	76.58	5.37	2.20	3.58	12.27	0.07	0.17
10	78.13	6.11	1.92	5.02	8.82	0.08	0.13
11	79.65	5.95	1.39	4.69	8.32	0.07	0.12
12	76.63	5.90	2.23	4.71	10.53	0.08	0.15
13	76.85	5.74	2.80	4.38	10.23	0.07	0.14
17	74.68	5.86	1.99	4.20	13.27	0.08	0.19
18	75.74	5.81	2.67	4.27	11.51	0.08	0.16
19	78.47	5.81	2.84	3.37	9.51	0.07	0.13
24	76.39	5.77	2.35	4.97	10.52	0.08	0.15
Average	77.07	5.79	2.35	4.31	10.48	0.08	0.15
Maximum	79.65	6.15	2.95	5.03	13.31	0.08	0.19
Minimum	74.30	5.32	1.39	3.58	7.76	0.07	0.11

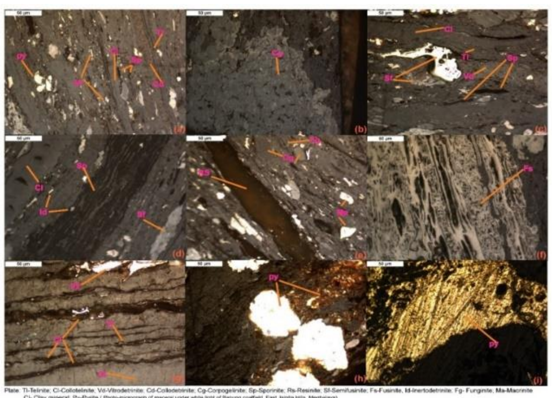

Fig. 5: Representative macerals microphotographs observed in Bapung coal samples

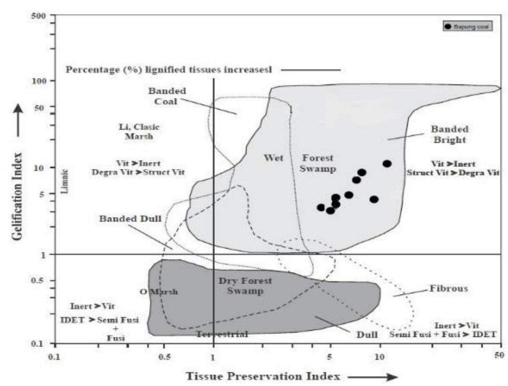

Fig. 6: Coal facies deciphered from gelification index (GI) and the tissue preservation index (TPI) in relation to depositional setting and type of mire for Bapung coal (after Diessel, 1986 and modified by Kalkreuth et al., 199) [Li = limited influx; O marsh = open marsh; Vit = vitrinite; Inert = inertinite; Semifus = semifusinite; Fus = fusinite; Idet = inertodetrinite; Struct = structured; Deg = degraded

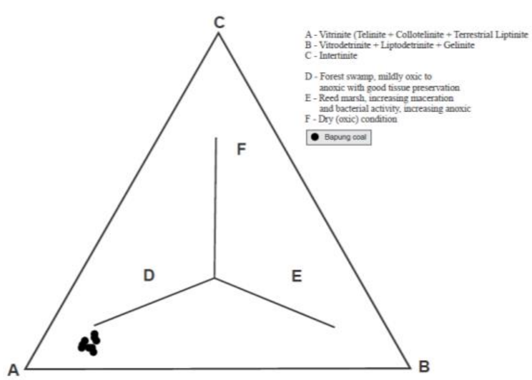

Fig. 7: Ternary diagram illustrating facies-critical maceral association in Bapung coal, Meghalaya and suggested peat environments (modified from Mukhopadhyay, 1986)

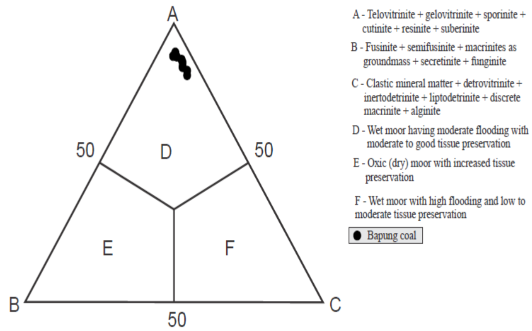

Fig. 8: Depositional condition of Bapung coal, Meghalaya based on maceral and mineral matter content (modified from Singh et al., 2012a)

Teichmüller (1982) believed that 'coal facies' depend on the paleoenvironmental conditions under which the precursor peats accumulate. Thus, plants are sensitive and react to the changes in the environmental conditions and therefore, petrographic study provides a precise tool for the facies study (Teichmüller and Teichmüller, 1982). Moreover, several researchers have related the petrographic components of coal with the paleoecological setting (Cohen and Spackman. 1972; Cohen et al., 1987; Grady et. al., 1993; Singh and Singh, 1996; Hawke et al., 1999; Shearer and Clarkson. 1998; Styan and Bustin. 1983; Singh et al., 2003, 2010a &b, 2012 a, b & c, 2013a &b, 2014, 2016, 2017a, b, c &d; Naik et al., 2016; Rajak et al., 2018 (in press)). For this purpose, different maceral indices have been used. Initially gelification index (GI) and tissue preservation index (TPI) were introduced by Diessel (1986) to characterize the depositional environments of Australian Gondwana coals. However, some scientists raised critical comments against the usage of such indices especially for Tertiary coals and lignites (Lamberson et al., 1991; Crosdale. 1993; Dehmer. 1995; Scott. 2002; Moore and Shearer. 2003; Amijaya and Littke. 2005). Modifications were subsequently made in the indices by some researchers to make it applicable for other coals (Calder et al., 1991). Kalkreuth et al. (1991) and Petersen (1993) further modified these indices and used them for low rank coals. For Bapung coals of Meghalaya, the modified

Table 4: Maceral composition with mineral matter content (in Vol %), random vitrinite reflectance, gelification index (GI) and tissue preservation index (TPI) of Bapung coal samples

Sample No.	CC1 (Vol %)	CC2 (Vol %)	CC3 (Vol %)	CC4 (Vol %)	CC5 (Vol %)	CC6 (Vol %)	CC7 (Vol %)	CC8 (Vol %)	CC9 (Vol %)
Telinite	0.0	0.1	0.3	0.7	0.5	0.0	0.4	0.3	0.8
Collotelinite	78.2	76.2	77.5	75.2	76.0	81.5	73.5	80.2	79.5
Gelinite	1.1	0.1	1.1	0.0	0.5	0.0	2.1	0.0	0.0
Corpogelinite	0.1	1.8	0.7	0.5	1.6	<1	0.2	0.1	1.3
Collodetrinite	2.3	<1	0.5	0.2	0.1	1.7	0.1	2.1	<1
Vitrodetrinite	<1	1.1	<1	0.7	0.2	0.6	0.2	0.5	0.2
Total Vitrinite	81.7	78.2	80.1	77.3	78.5	82.6	76.5	82.2	81.8
Sporinite	2.23	1.12	1.94	1.07	0.68	1.46	1.88	1.4	0.75
Resinite	1.02	0.4	1.01	0.2	0.6	0.7	0.1	0.3	0.5
Cutinite	0.0	<1	0.0	0.0	<1	<1	0.0	0.0	<1
Total Liptinite	3.25	1.52	2.95	1.27	1.28	2.16	1.98	1.70	1.25
Fusinite	1.1	1.2	1.0	0.9	0.2	0.1	0.8	3.0	0.3
Semifusinite	1.0	0.4	1.1	0.4	1.5	0.8	2.0	1.0	1.0
Macrinite	6.2	12.8	9.2	16.5	14.5	10.2	15.0	9.0	12.1
Inertodetrinite	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.0	0.2
Sclerotinite	0.1	0.2	0.0	0.1	0.3	0.0	0.1	0.0	0.1
Total Inertinite	8.6	14.7	11.4	18.0	16.4	11.1	18.0	13.0	13.7
Mineral Matter	6.3	5.5	5.6	3.3	4.2	4.0	3.4	3.2	3.1
%VRr	0.66	0.62	0.58	0.67	0.59	0.61	0.65	0.63	0.57
TPI	12.54	5.98	8.55	4.61	5.36	8.07	4.93	9.35	6.57
GI	9.5	5.3	7.0	4.2	4.8	7.4	4.2	6.3	5.9

indices were calculated using following formulae:

GI = Vitrinite/Inertinite

TPI = (Telinite + collotelinite + Fusinite + Semifusinite)/(Collodetrinite + macrinite + inertodetrinite)

Bapung coals are characterized by moderate GI and TPI values. A moderate GI indicates a continuous presence of water cover in the basin during Bapung coal formation. The facies model shows that these coals evolved mainly from wet forest (Fig. 6). Presence of high telovitrinite content in these coals also reveals this fact because this maceral subgroup is derived from partially gelified woody tissue and indicates wood producing plants as well as biochemical gelification. Marchioni and Kalkreuth (1991) relate the biochemical gelification to high moisture condition. Further, Diessel (1982) believe that brighter components of coal are formed under wet conditions. The present study is also in agreement with the earlier work (Mishra and Ghosh, 1996; Singh et al., 2012c, 2013a) who demonstrated that the coals of NE India evolved under wet forest swamps in marshy environments. Mishra (1992) has revealed through palynological records that during Palaeocene and Oligocene periods there was growth of green forest vegetation under humid tropical conditions in India. Lack of forest fire could have been the reason for low inertinite content in these coals. To understand the peat forming environment, a petrography based ternary model given by Mukhopadhyay (1986, Fig. 7) was taken into account. The samples of Bapung coals are located close to ‘A’ corner of the plot which is dominated by telovitrinite (telinite and collotelinite) and terrestrial liptinite indicating forest swamp having more anoxic environment with good tissue preservation. This is further confirmed in a recent model proposed by Singh et al. (2012a) which is based on maceral composition and clastic mineral matter content. The amount of clastic minerals directly relates to the water cover in the basin and the plots of Bapung coal indicate that this coal evolved under wet moor condition having moderate flooding with moderate to good tissue preservation (Fig.8). This is also in agreement with the GI and TPI values (Diessel, 1986; Kalkreuth et al., 1991; Petersen, 1993).

Moreover, Bapung coals are enriched in sulphur (3.58-5.03%; mean 4.31 wt %) and elevated pyrite content is commonly seen under microscope indicating the association of peat with brackish water condition. This type of association has been reported by several workers (Bustin and Lowe, 1987; Casagrande, 1987). Dasgupta and Biswas (2000) reported the prevalence of hallow brackish water condition during the formation of Barail Formation. This has been further substantiated by the studies on modem peats formed under marine influence (Querol et al., 1989; Phillips et al., 1994).

CONCLUSION

Petrographic and geochemical investigations were conducted on the samples of Bapung coals from Meghalaya. The results reveal that these coals are ‘medium rank C’/‘bituminous C’ in rank. They are dominantly rich in vitrinite (76.5% to 82.6% on mmf basis) with low contents of liptinite and suboderdinate/moderate inertinite. Moderate GI and TPI values are indicative of a wet forest origin for these coals. The petrography based ternary facies model further supports this contention and infer the formation of Bapung coal formation under high water cover in the paleomire with good tissue preservation. Moreover, association of peat with marine sediments appeat yo have elevated sulfur content in these coals.

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