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Study Of Maturation Trend And Utilization Characteristics Of The Oligocene Coals In Makum Coalfield, North Eastern India

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Abstract:

The Makum Coalfield is located in the Tinsukia district of Assam, India. The coal measure sequence of Barail Group(Oligocene) contains the thick, workable coal seams and the present study is based on field and petro-chemical data of coals.Maturity of sediments shows a vertical increasing trend with depth indicating the role of burial tectonism and dynamic folding. Time temperature index values for the coal basin are strongly indicative of oil generation and occurrence of oil with API gravity less than 400. The study indicates that the coals have attained high volatile Bituminous C to A stage. The Makum coals are classified mostly as per-vitrinous coals and only a few as meta-vitrinous coal types. Seyler's classification places the coals of the study area in per-hydrous type but the younger seams show sub-hydrous character.. Correlation between volatile matter and H/C ratio does not show any distinct trend from younger to older coal seams; however, high volatile matter content in the coal seams is evident. Evaluation of coal quality and utilization of the coals have been attempted.

Key words: *vitrinite reflectance, TTI, coal rank, utilization, Makum coalfield, Assam.*

1.Introduction

It has long been established that chemical composition of coals particularly volatile matter(VM) content decreases with depth in stratigraphic successions (i.e. Hilt's Law). Initially the maturity trends in coals was studied based solely on chemical parameters like loss of moisture, VM and hydrogen or fuel ratio, which are found inadequate to explain the causes of variation in coal properties during coalification process. Teichmuller (1950) made use of vitrinite reflectance in coalification studies that supplements some inadequacy in chemical variables and also eradicated anomalies resulting from oxidation. Later studies revealed the dominant role of sedimentary burial (depth) with temperature required for organic metamorphism. The significant studies made by Karweil (1956); Bostick (1971, 1974), Hood et al. (1975), Robert (1988), affirmed the role of temperature and time required for burial metamorphism or organic matter. The rank of organic matter was determined using vitrinite reflectance, whereas for low rank coals coalorific value was used and volatile matter for high rank coals. Lopatin (1971) developed an index of maturity called Time-Temperature Index (TTI) to quantity the thermal maturity of organic matter in sediments. This method finds considerable use in petroleum exploration (Waples, 1980; Cohen, 1981). With appropriate kerogen, if the TTI value falls with within the threshold zone: 15 to 160 for oil generation, ~1000 for oil preservation, ~ 1500 for wet gas preservation and ~ 6500 for dry gas preservation, the predication made by Lopatin was found to be true in real situation. Considering these findings the present study has been carried out using field as well as laboratory data on coal samples to understand the coalification trend and utilization character of coals of Barail Group.

2.Geological Set-Up

Geologically the Makum Coalfield forms an integral part of imbricately thrusted zone known as the belt of Schuppen (Fig.1). The coalfield area represents a well defined asymmetrical syncline plunging towards north-east. It is reffered as 'Namdang Syncline' which gradually widens out to the east. This syncline is bounded on the north by Margherita thrust and on the south by Halflong-Disang thrust.The northern limb of the syncline is again folded into anticlines and synclines. The coal bearing Barail Group of rocks are disposed as isolated, interlocking thrust slices. A Lithostratigraphic succession as developed in the Makum Coalfield is presented below: (Table-1).

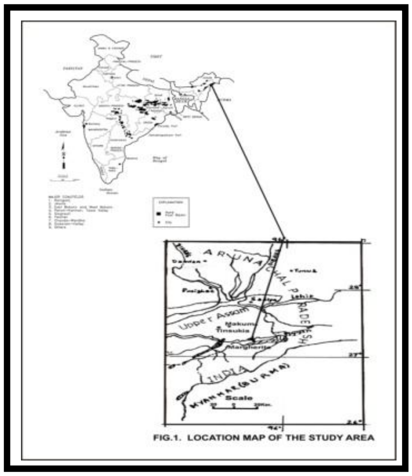

Figure 1

AGE	GROUP	FORMATION	LITHOLOGY
Recent – Pleistocene		Alluvium and high – level terraces	Sands, Clays, Siltstones, Gravel beds etc.
		—Unconformity—	
Pliocene	DIHING		Alternative pebble beds; coarse bluish green to grey feldspathic, ferruginous sandstones and greyish to brownish clays.
		—Unconformity—	
Miocene	TIPAM	Girujan Clay	Variegated clay, silty clay, bluish green and grey sandstone (+ 470m – 990m: thickness).
		Tipam Sandstone	Coarse, gritty and massive, bluish green to grey feldspathic and micaceous sandstone, variegated clay, sandy clay, shale, coal streaks and silicified woods. (+ 1000 m: thickness).
	SURMA (?)	Not subdivided	Grits, thin conglomerate beds, brown, fine grained sandstone, sandy clays and shales. (approximately 400 m: thickness).
		—Unconformity—	
Oligocene	BARAIL	Tikak Parbat	Upper Arenaceous Unit: Massive to well bedded, yellowish white to light grey, medium to fine grained sandstone interbedded with sandy shale, grey shale, siltstone, light grey claystone, mudstone, carbonaceous shale and several coal seams. Lower Argillaceous Unit: Alternations of siltstone, mudstone, shale, carbonaceous shale, claystone and thick workable coal seams. Occasionally laminated shaly sandstone, sandy shale and sandy clay. (600 m: thickness)
		Baragolai	Well bedded or at places massive, hard, greyish, micaceous or ferruginous shaly sandstones alternating with bluish grey, greenish yellow clays, shale, sandy shale, siltstone, calcareous mudstone, carbonaceous shale and thin coal seams (3300 m : thickness)
		Naogaon (occurs on the southern part of the coalfield, separated by the Halflong – Disang Thrust)	Hard, compact and flaggy dark grey, fine grained Sandstone and interbeds of grey splintery shales (2200 m: thickness)
Eocene	DISANG		Dark grey splintery shale with interbeds of dark grey and fine grained sandstone (over 3000 m: thickness)

Table 1 : Lithostratigraphic Succession In The Makum Coal Field,Upper Assam(Sarmah, 1999).

3.Methodology

Representative coal samples from 60 ft., 7 ft., 20 ft., and thin seams of TikakParbt Formation and some thin coal seams of Baragolai Formation were collected from different collieries in the Makum Coalfield and analysed by chemical methods.The analytical results of the coals of the present study together with the published data on quality in the technical reports (from 1956-1991) of CFRI laboratory, Jorhat, Assam are used to assess the coals.Petrographic studies were made on polished coal pellets following the recommendations of ICCP (1971) and IS 9127 (Part III), (IS 1992) and using a Leitzorthoplan microscope in oil media with 32 x or 50 x objectives and 10 x or 8 x oculars. For reflectance measurement stabilized monochoromatic sodium light with blue filter having 544 nm wavelength was imparted on the sample and the values were recorded from photo voltmeter calibrated against standard (normal glass with Ro 1.24%) and Leucosapphire (Ro 0.59%).

4.Results

Applying Lopatin's method and measured values of vitrinite reflectance (Ro), a graph as been drawn which uniquely fits in the diagram by Waples (Fig. 2) where reaction rate was assumed to be doubled with every 10 degree rise in temperature. TTI values for the coal basin are strongly indicative of oil generation (TTI; 10 to 15) and occurrencec of oil with API gravity less than 400. This corroborates the works of Navale and Misra (1980); Kamaraju&Rao (1991); Srivastava et al (1993), wherein it was observed that (i) the regional trend of thermal maturity of the Barail Group falls within the oil- window and an overall increase in maturity towards cast of Naga thrust in the Belt of Schuppen (ii) the Upper Assam Coals show the degree of maturity corresponding to the zone of oil generation. A catagenetic stage of maturation for the Barail sediments of Upper Assam is inferred (Goswami, 1983, 1985). Saikia and Dutta (1979) have considered the Oligocene organic mudstones and shales of Upper Assam as the probable source rocks for high wax Oils in sands associated with coal-carbonaceous sediments. In the study area, the Baragolai sequence shows numerous oil shows and once a producing area of crude oil (Mathur& Evans, 1964) and hence the areas have viable potential for petroleum generation. To understand the maturity trends in the Oligocene coals, the depth (present day) versus vitrinite reflectance (Ro) diagram is drawn (Fig 3) and this relationship has concurrence with those observed in Tertiary coals of northeastern India (Chandra, 1965). Also the study reveals that a linear relationship between depth and reflectance value does exist but not a steady rank variation. Parallel but shifting of trend lines towards higher Ro values in younger coals indicates multiple phases of sinking at rapid rates but deeper burial lead to higher maturity trend for younger seams. It can be stated that maturity of sediments show a vertical trend from younger to older coal seams and hence, the role of burial tectonism and dynamic folding is apparent.

5.Coal Quality And Utilization

Precise utilization of coal in the user industry requires proper evaluation of coal quality. The physical and chemical changes undergone during coalification process constitute the basis for the assessment of coal quality. Many schemes for classification of coals used in commercial or scientific purposes are based on rank and utilization parameters. The rank of coal is expressed in terms of physical, chemical and optical characteristics of coal. McCartney and Teichmuller (1972) suggested the use of reflectance of vitrinite as a criterion of classification of coal besides other rank parameters. The measured reflectance values are presented in reflectograms. (Fig 4). Mean maximum vitrinite reflectance values of coals from the study area range from 0.51% to 0.69%. It indicates that the coals have attained high volatile Bituminous C stage (McCartney and Teichmuller, 1972; Stach et al., 1982). Following the scheme suggested by Sen and Sen (1970), the Makum coals are classified mostly as per-vitrinous coals and only a few as meta-vitrinous coal types. Scrutiny of the published proximate and ultimate analysis data and data from the present study indicates that the Makum coals correspond to high volatile Bituminous C to A stage. Carbon, hydrogen and oxygen contents are important in most scientific classification schemes. Fig. 5 shows correlation between carbon and hydrogen content in the coal samples studied. It is observed that the coals of the study area cluster mostly in per-hydrous type (Chandra et al. 1984) following Seyler's classification. Some of the coal samples from younger seams (5ft. and 8 ft.) plot below the coal band as sub-hydrous type. Binary plots of Carbon versus oxygen exhibit a linear trend and congruent relationship (Fig.6) and the values of carbon scatter within a narrow range. The atomic H/C vs O/C diagram was considered to understand the course of the processes operating during coalification of coal (Van Krevelen, 1950). The binary relation of H/C vs C for the studied coals (Fig.7) indicate that the values are clustered within the dehydration track with carbon percent between 83.5 to 89.0. Correlation between volatile matter (VM) and H/C ratio does not show any distinct trend from younger to older coal seams (Fig 8). Scatter of VM in coal within 43% to 48% range indicates high volatile matter content in the coal seams. On close examination of available chemical analysis data, the coal of the study area can be categorized as high sulphur (1.1-9.41%), low ash, per hydrous, per-vitrinous, high volatile (41.0-56.1% VM) bitumimous coal. It shows low softening temperature, high swelling index (4-7 ½), and high calorific value (6035-9187) Kcal/Kg on d.m.m.f basis) and hard grove grind ability index of 59 (Raja Rao, 1981; Prasad and Verma, 1982). On low temperature carbonization at 6000C, the coal yields 156 to 191 litres per tonne of tar and this yield is the highest for Indian coals and the tar can be processed to give a wide range of basic chemicals, oil and preservatives. These coals can be utilized be blends in steel-industry (highly caking index: 16-32) particularly some selected portions of 60 feet coal seam (Prasad and Verma, 1982). Pilot plant tests and commercial coking test carried out by Central Fuel Research Institute, Dhanbad during 1964-67 confirmed this possibility for making metallurgical coke. 6000C, the coal yields 156 to 191 litres per tonne of tar and this yield is the highest for Indian coals and the tar can be processed to give a wide range of basic chemicals, oil and preservatives. These coals can be utilized as blends in steel-industry (highly caking index: 16-32) particularly some selected portions of 60 feet coal seam (Prasad and Verma, 1982). Pilot plant tests and commercial coking test carried out by Central Fuel Research Institute, Dhanbad during 1964-67 confirmed this possibility for making metallurgical coke. High sulphurMakum coals are ideally suited for hydrogenation and the syncrude produced from these coals shows similarities with identical fraction of crude oil from Naharkatiya Oilfield, Assam (Raja Rao, 1981). Recently, Oil India Limited, Duliajan in collaboration with a U.S. based company has established co-processing pilot plant to produce syncrude by using high sulphur coals with some suitable fraction of petroleum end products. Moreover, if the high sulphur content in the coals can be reduced considerably by some ways and means the demand for this coal may increase manifolds. Desulphurization of the 60ft. coal seam from Baragolai colliery in the Makum coalfield by physical methods and also by bacterial means has been tried with some success on laboratory scale test (Roy, 1964; Chandra, 1980). All these efforts may open up new possibilities for proper commercial utilization of high sulphur Makum coals in near future.

6.Conclusions

Maturation study is strongly indicative of oil generation (TTI value ranges: 10 to 15) and occurrence of oil with API gravity less than 40 degree. This entails the position of Oligocene coals under “Oil window” which is commercially highly viable. Maturity of sediments shows a vertical increasing trend with depth indicating the role of burial tectonism and dynamic folding. The studies related to coal quality and utilization characteristics of the Makum coals add a special direction and the data now available may be regarded valuable. There is necessity of finding new areas of utilization for the high sulphur, high volatile, low ash Tertiary coals of India.

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