Research Article

Petrographic and Chemical studies of Tertiary Lignite of Ratnagiri Coast of Maharashtra, INDIA

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Abstract Tertiary Lignite of western Maharashtra is trapped in basalt and laterite and at places between laterite. These deposits are 50mts above MSL and 500mts away from sea coast. Lignite of Ratnagiri are studied petrographicaly, chemically and with SEM studies for their genesis, depositional environment and quality. The microlithotypes of lignite are recognized on the basis of shape and nature of maceral. The properties of the coal are mainly dependent on the relative abundance and the degree of mixing of maceral. From the study it has been observed that huminite maceral is present in abundance (72 to 90%), followed by irrtertinite and exinite which is very rare to absent. Lignite of Jaigarh is close to peat with high ash, low carbon and calorific value, more mineral matter. While lignite of Golap-Pawas area have distinct maceral content, high carbon and sulphur, low ash and mineral matter with high calorific value. Pyrite nodules concentration indicate reduced environment of deposition. Present study indicates lignite is deposited in estuarine to marine environment.
Key words: Ash Huminite, Irrtertinite, Lignite,Maceral, Tertiary,Volatile matter.

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INTRODUCTION

Available literature on the Indian coal is related to coal petrography, coal chemistry, coal classification and coal reserves. Plenty of work has been done on coal, however, little attempt has been made on lignite. Petrographic, palaeontlogical and stratigraphic studies of Indian coal have been attempted by Chandra (1975), Chaudhari (1979), Ghosh *et al.* (1987), Chatterjee *et al.* (1988), Singh *et al.* (1993). The petrochemical studies have been carried out by Ahmecl (1969). An approach to the nomenclature and classification of Indian lignite have been carried out by Sen et. al (1969), Navale (1973,a and b), Pareek (1962, 1971, 1980, 1981). Lignite, occurring in Kerala and Neyveli beds has been studied by Chatterjee *et al.*, (1968) Sen *et al.* (1975). In this paper, various studies of maceral contents, proximate and ultimate analysis of Tertiary lignite occurring around Ratnagiri have been presented.

Study area

The study area is a coastal belt of about 80km.in length which lies between Jaigarh creek in the north (Lat. 17^0 10' N and Long. 73^0 25' E) to Pavas creek in the south (Lat. 16^0 50' N and Long. 73° 10' E) with average width of 15km.This area lies in survey of India toposheet no.47 G/3, G/7, G/8 and H/5 covering 70sq.Km.(Fig 1) The area is composed of Deccan basalts, which are invariably capped by laterite and in subordinate amount of bauxite. The Tertiary sediments are found to be sandwiched between the laterite, while in some sections, they overly directly on the basaltic lava flows.The microfossil bearing tertiary sediments are 50-60mts above sea level and 500mts from sea.

Geology of the area

Lignite is mainly occurring in association with carbonaceous shale. It is soft, loose, brown to brown-yellow and black in colour. Lignite is mostly of fragmental aggregates of various plant material, The detailed examination of the sections observed in open wells indicate, lignite thickness is ranging from 0.30 to 1.60 m.(Fig 2) The lignite exposed around Golap has maximum thickness of about, one meter which is sandwiched between grayish blue to black colored carbonaceous shale. These carbonaceous beds and lignite layers contain pyritic nodules ranging from microscopic to prominent one. The larger nodules found in this area have 3.5 cm. length and 2 cm. thickness. The percentage of nodules is more in the lignite beds exposed in the well sections around Golap - Pavas area. The lignite in Golap - Pavas area is more soft, loose and dark black in colour and gives strong sulphurous odour. It consists of woody matter along with fossil plants and distinct leaf impressions.

MATERIAL AND METHOD

Systematic sampling was done by using grid method (Fig. No.3 and 4), from the two major areas one from Golap - Pavas and the other around Ratnagiri town. Fifteen representative samples were selected then crushed and passed through 18 mesh B.S.S. sieves. About 6-7 grams of sieved samples were placed in the metal mould to form a 0.5 cm. thick layer. Then epoxy resin and hardener mixture (5:1) was poured into the mould over coal particles. A paper strip with sample reference was also placed in the liquid resin .Air bubbles formed on the upper mould (liquid) surface were removed by gentle pricking of bubbles with a needle point. Due to high porosity, lignite moulds develop large number of air bubbles on the upper mould (liquid) surface. Bubble free resin embedded samples were left to cure for three hours. Hardened resin pellet was extruded from the metal moulds by pressing a plunger through the upper particle free end of the cast. The released particulate pellet was taken for grinding. Coal face of the pellet was made into a smooth surface by grinding it on rotating metal lap with abrasive carborundum powders of 250 and 400 mesh. Then successive grinding was followed by finer carborundum powder of 600 mesh. To avoid contamination of abrasive powders, three separate laps were used for coarse, medium and fine grinding. Following each stage of grinding, the sample was thoroughly washed before placing it in the next grinder. About 8 - 10 minutes were sufficient to obtain a smooth surface at each stage of grinding. To avoid fragmentation of the edge during polishing and consequent risk to damage to the prepared surface, pellet edge was ground off at the initial stage of coarse grinding. Several stages of polishing after grinding were required. The first coarse polish was done by hand on glass plate, using 1000 mesh carborundum powder. About ten minutes of polishing was sufficient. Next stage of polishing was carried out on high speed lap fitted with polishing cloth. Alumina with grade 1, 2 and 3 were used separately to give medium, fine and very fine polish, respectively. Alumina polishing slurry was used by mixing 30 ml. of water added to 10 ml. of polishing alumina. At each stage, four to five minutes of polishing was adequate. Sample was thoroughly washed after each stage of polishing and placed in ultrasonic bath for one minute. At the end of last polishing step, the sample was air dried and kept in desiccators.

OBSERVATION AND DISCUSSION

The maceral analyses were carried out on polished pellet. The observations were carried out on Leitz microscope, with the help of a point counter in oil immersion lens and maceral analyses were done following the procedure laid down by the International Committee for coal petrology (1957). The micro lithotypes of lignite can be recognized on the basis of shape and nature of maceral of coal. Different parameters are used to distinguish different individual maceral. The properties of the coal are mainly dependent on the relative abundance and the degree of mixing of maceral. In present study, it has been observed that huminite maceral is present in abundance (72 to 90%), followed by irrtertinite and exinite which is very rare to absent in the samples. In microscopic studies, lignite is brown colored containing cellulose and mineral matter. The detailed observations of all the fifteen representative samples show that the organic compounds in the lignite are in the first stage of collification. Microscopic observations of maceral are as follows.

Huminite Group

Humotelinite, Humodetrinite and humocollinite are the main microconstituents of Huminite, observed in the lignite samples. The bark and wood tissues are important organic constituents of humotelinite. These tissues are seen with thick walled cells. The cells are dark and compressed due to huminisation. Thick walled cells are elongated or rectangular in shape with indistinct lamella. Resin filled cells are rare. The cells contain large quantity of fragmental and fine granular matter. All huminite maceral are occurring as grey-white groundmass. Humitolinite is differentiated on the basis of its intact cell walls of tissues or individual cells preserved in humic state. A typical huminite is observed in the lignite samples collected from Golap area (Photo 1). Textinite and ulminite are sub-lithotypes of humotellinite represented in the lignite samples. The textinite is identified on the basis of variable size and shape of cells. It is seen that the textinite maceral is with cell lumen open and also filled in with dark mineral matter (Photo 2). It has also been observed that in tissues, the cell walls are deformed and are broken (Photo 3). However, the form of the cell is retained as it is. This deformation is due to the process of coalification and diagenetic changes during sedimentation. The textinite is dark grey in colour with weak brownish internal reflection.

Texto - Ulminite

Texto-Ulminite is present in very few samples. It is represented by closed cell lumane and are with weakly visible cell wall structure present within the tissues.These are present in the well sections of Ratnagiri area. It has been observed that cell lumens are entirely obliterated(Photo 4) . It is identified on the basis of cell structure,.

Humodetrinite

It is represented in few of the samples, which is characterised by a formless, porous huminitic matter. It has finest humic fragments generally less than 10µ in size which is loosely packed ground mass with spongy texture. It is more or less dark grey in colour with weak reflectivity. Attrinite and densinite are the subtypes of humodetrinite, in which densinite shows grayish colour with moderate reflectivity and attrinite is showing dark grey colour with weak reflectivity (Photo 5).

Humocollinite

This maceral sub-group is also present in all the samples. It consists mainly of amorphous humic gel i.e. Gelinite. It is homogeneous in appearance and occurring in cavities of slits, pores and cell lumens. It is precauser of cellinite or gelcollinite. The gelinite is the maceral composed of humic gel with no definite form. It occurs as infilling material and acquires the shape of the structure. The other type of humocollinite observed is carpohuminite which is spherical, elliptical, rod or plate like shape. The surface is smooth, porous or pitted. It exhibits grey to light grey colour. These are circular to elliptical in shape with rounded margin and variable reflectivity within the huminite range (Photo 6).

Exinite and intertinite are rarely seen in the samples studied. Exinite maceral are the waxy resinous part of plants such as spores, cuticles and wood resines. To study such rare maceral in lignite, thin sections of coal are useful (Sen, 1975S). The exinite includes sporinite which shows spherical shape with yellowish brown colour in thin sections.While, cutinite forms long thin stringers with highly crenulated margins (Photo 10).Intertinite group is highly altered and degraded plant material, which has highest reflectance. In thin sections, it is white to grey in colour.

SEM Studies

The quantification of mineral matter has been carried out by using the petrological microscope. However, the examination of mineral matter from the superficial pore fillings, cavity fillings, superficial mountings and blanketing during the course of grinding and polishing of coal does not give clear picture of quantitative and qualitative data of the occurrence and distribution of mineral matter in the lignite, and therefore, SEM studies of lignite sample have been carried out to obtain the micro details. Different lithotypes were selected from the lignite samples and chips of approximately one cm. size were separated. To remove the superficial dust, the samples were washed with alcohol. The washed chips were then mounted on aluminum stubs using silver paste as sticking media. After coating the chips by silver in vacuum coating machine, examination was carried out under a high performance scanning electron microscope (PSEM 500).Four samples of lignite were examined at M.A.C.S. laboratory, Pune. The various surface microstructures were recorded and photographed. The identification of mineral matter as well as micro structural features has been done visually. It has been observed that in all four samples, clay mineral matter is found to be dominated with disseminated pyrites and clay variety is of kaolinate and montmorillonate. Kaolinite is identified by a typical book stack like structure (Photo 7) while, montmorilonite is identified by typical honey-comb structure (Photo 8).Clay matter also occurs as filled cavities of tissue cells of lignite, it is present in the form of superficial mounting and superficial cavity filling and intergrowth (Photo 9).It has also been seen that the moderately dull variety of coal appears as the compact and granular mass in the lignite samples.

Mineral Matter

It has also been observed that these maceral contain major amount of mineral matter as an impurity. The total amount of mineral matter ranges from 25 to 65% in the samples studied. The samples from Golap - Pavas area consists of less percentage (26.5%) of mineral matter as compared to the northern part of the area investigated. The common mineral impurities in the samples are clay, pyrite and few grains of quartz. Clay minerals are scattered in some polished sections of lignite and also occur as fine inclusions impregnated in the maceral. It also occurs as partial or complete infilling of plant cell cavities in huminite. The polished sections and SEM studies show that, the clays are most abundant mineral matter in all the samples. Clay minerals are irregularly distributed as inclusions, lenses, microclots and regular bands. These inclusive minerals are of very small in size, approximately less than 10 µ Photo 2). The clay minerals present in the samples appear to be dark grayish in colour and they are kaolinite and montmorillonite type. The clay minerals are of syngenetic origin. They have been transported and introduced by water during the sedimentation process. Detrital grains of quartz and anatase minerals are also associated with lignite, which is observed in thin section of lignite of well No. 83, in the area around Jaigarh. Pyrite is second prominent mineral matter present in lignite. It occurs in the nodular form with varying size between few mm to 3.5 cm. Pyrite nodules have been observed in the lignite sample in the scattered form. They are with cavities at the centre. The nodular pyrite after polishing shows brass yellow colour with high reflectivity.

Chemical Analysis

In order to classify lignite various factors, like the proximate analysis and ultimate analysis have been carried out at Mineral Exploration Corporation Ltd., Nagpur for the representative samples from the selected localities. Selection of these samples has been done on the basis of their morphological characters like colour, hardness, lustre, odour, and by keeping reasonable distance between the samples of the well sections. The data of proximate analysis and ultimate analysis of lignite coal has been presented in Table 1 a and b. From this analysis it is seen that all the nine samples of lignite contain high percentage of ash on comparing them with the Neyveli lignites. The percentage of ash is considerably low, i.e. 26.25% observed in sample No. 8, obtained from village Vaingane. It is situated in the western periphery of the Tertiary deposits. While, maximum 66.5% of ash has been observed in sample No. 82, collected from the Jaigarh area, situated in the north of the area investigated. It is interesting to note that the representative sections from the village Adiwade in the west, from where sample No. 76 has been collected gives 42.9% of ash, while, from village Mirazole, in the east, from where sample No. 67 has been collected gives 53.6% of ash which is situated in the northern part of the area around Ratnagiri. On the basis of the percentage of ash in the sample, it can be inferred that there is reduction in ash percentage in the western side. This could probably be due to the organic material, that have been transported faster for a longer distance, whereas the mineral matter have been settled near the source along with the organic matter, which is present at comparatively shallower depth in the eastern periphery of this area. Similarly the percentage of ash in the samples, selected along the section, from village Kashop in the west, from where sample No. 1 has been collected, shows 26.35% of ash, while, a sample No. 18 collected from Madalevatar in the east, shows 44.6% of ash. On the basis of the ash percentage observed along these sections, it can be said that the ash percentage is considerably more in the samples, collected from the eastern border of the area, while, percentage of ash decreases towards west. This observation gives the similar conclusion, drawn on the basis of the ash percentage, of the samples collected in the section described earlier. From the Table 1.a, it can be seen that, wherever the percentage of ash is more, there is relative decrease in percentage of fixed carbon and in the same sample; there is relative decrease in the sulphur percentage. On the basis of the percentage of ash samples containing more percentage of fixed carbon, could be comparatively of better quality. Samples of Golap- pawas area show less percentage of ash i.e. 26.25%, where, there is a relative increase in the percentage of fixed carbon, i.e. 38,25 %. The sample No. 82 collected front extreme north of the area, from Jaigarh shows 65.5 % of ash with only 9.02 % of fixed carbon with 23.2% sulphur. The sulphur percentage has been observed in all the samples except sample Nos. 58 and 67. From these observations, it can be concluded that, wherever, the percentage of sulphur is more,which gives strong sulphurous odour. Out of nine samples, the samples collected front Ratnagiri area (Sample No. 58 and 67) and Jaigarh (Sample No. 82) give more ash percentage and less fixed carbon, which is low quality lignite and therefore ultimate analysis of sulphur percent and calorific values are not determined. From the Table No. 1 b, it can be seen that the carbon percentage varies between 67.8 % to 78.8 % and is very close to the carbon present in the lignite standards, which is 72.95%, pointed out by Clarke (1924).

Table 1a: Proximate analysis of lignite coal in percentage

Sample No.	Moisture	Ash	V.M.	F.C.	Calorific value	Sulphur in %
1	3.8	26.35	36.15	33.8	2895	25.50
8	8.1	26.25	27.45	38.25	2937	17.00
18	8.6	44.6	25.3	21.5	1690	19.70
23	6.8	43.75	26.35	23.1	1732	21.40
53	7.2	44.6	16.5	31.7	1525	18.30
58	7.4	62.5	19.8	7.6	N.D.	N.D.
67	8.4	53.6	21.7	16.3	N.D.	N.D.
76	7.2	42.9	27.5	22.4	1725	19.70
82	4.3	65.5	20.4	9.02	N.D.	23.20

V.M.-Volatile matter, F.C. = Fixed Carbon, N.D.= Not Determine

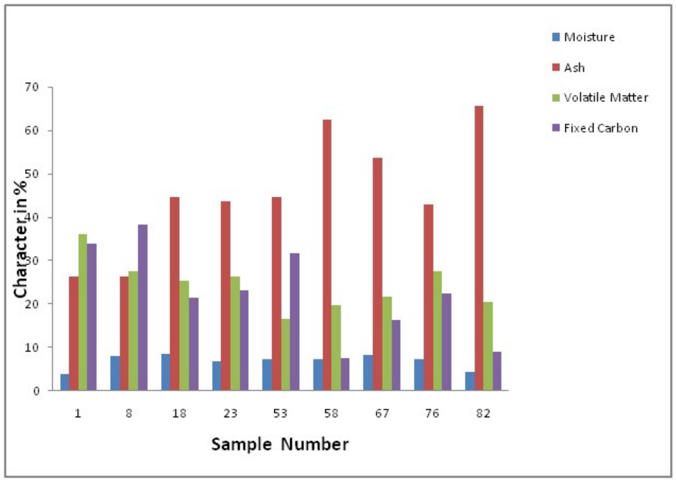


Table 1b: Ultimate analysis of lignite in percentage

Sample no.	C	H	N	O
1	74.2	5.1	0.8	19.9
8	78.8	4.7	1.2	13.3
53	69.6	5.3	0.6	24.5
76	67.5	5.1	6.7	26.7

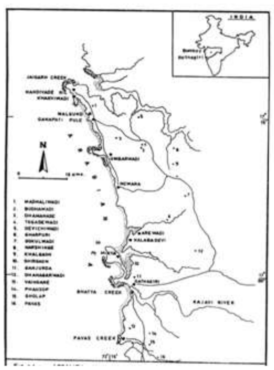


Figure 1

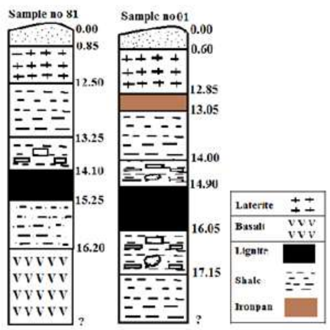


Figure 2

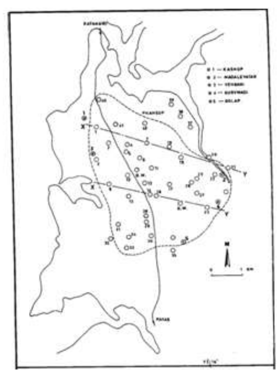


Figure 3

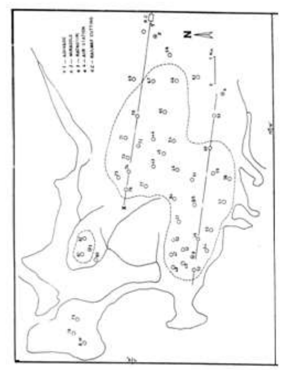
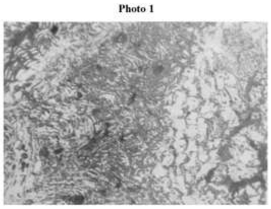


Figure 4

Photo 1



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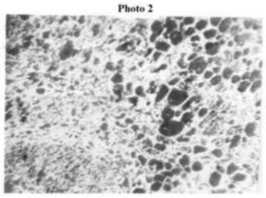

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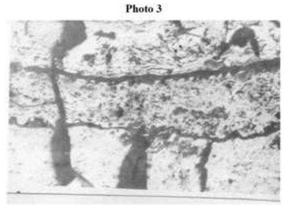

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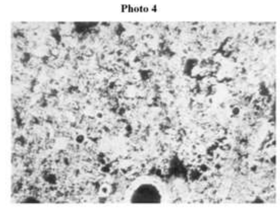

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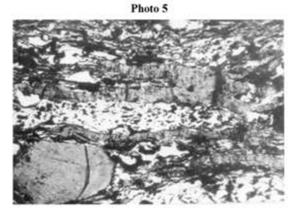

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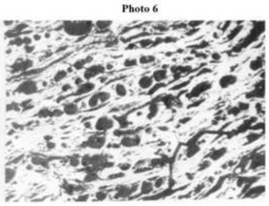

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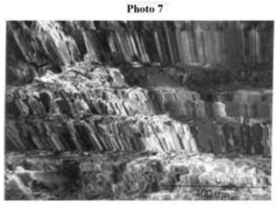

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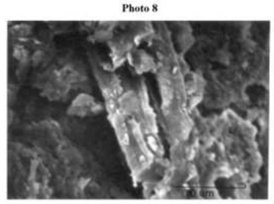

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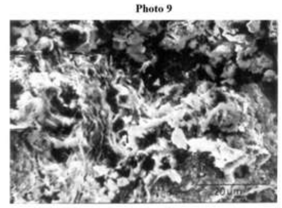

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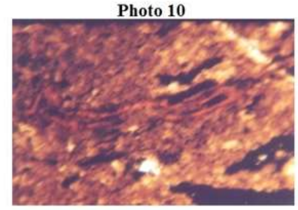

CONCLUSION

In Tertiary sediments lignite constitutes a major litho unit, which is sandwiched between the carbonaceous shale and deposited in estuarine and marine environments. In the present case, the lignite deposits have been formed from the vegetation, which have been existed ages ago in the areas very close to the coast. This could be formed, first by submergence in the body of stagnant water. The cellulose derived from the plant material might have been subjected to decky. Though peat is the product of bacterial action on the plant material, it is further transferred in to lignite with more carbonification. Comparing the samples of various localities, the sample collected from Jaigarh area situated in the north shows very similar properties of that of the peat. It is interesting to note that the sample collected in the southern direction of the area, shows comparatively high percentage of carbon, indicating the favorable conditions for the collification process. From the values of ash percentage, fixed carbon and carbon in the samples collected in the E - W direction, it is seen that values of the ash percentage is decreasing towards west. While, there is a gradual increase in the fixed carbon and carbon percentage. On the basis of these observations, it can be said that the collification process is comparatively more intense in the south - western part of the area. The high percentage of sulphur, i.e. pyrite nodule, present in the samples mainly in the western part of the area, indicates reduced environment, under which they have been formed. Considering the thickness of the lignite beds in the well sections, it is observed that the thickness of lignite coal is more in the western part of the area, which goes on gradually decreasing in the eastern direction. As is evident from the proximate and ultimate analysis, petrographic studies and morphological characters of the lignite coal, it can be said that this lignite coal have been deposited in transitional environment, where influence of estuarine and marine environments prevailed.

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