ISSN 0376-5561
Geophytology 46(2): 113-120
November 2016

Petrographic analysis and depositional environment of the coal seams from Ashtona area of Yeotmal District, Maharashtra

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Manuscript received: 8 July 2016
Accepted for publication: 4 October 2016

ABSTRACT

Petrographic analysis *vis á vis* maceral composition and vitrinite reflectance study of Seam I and the underlying Seam II encountered in borehole No. AK-8 from Ashtona area, Yeotmal District, Wardha Valley Coalfield affirm that the coal of Seam I contain vitric as well as mixed type of configuration whereas, Seam II is predominated by vitric coal. The random vitrinite reflectance (R_o mean%) measurements however, suggests that the rank of coal in both the (I & II) seams vary between sub-bituminous C to B stages. The facies model based upon maceral constitution and mineral matter content advocates the static prevalence of wet moor with intermittent high floodings during the deposition of both I and II seams with a shift from alternate oxic to anoxic conditions for a short spell. The coal of Seam III is shaly in nature.

Key-words: Coal maceral, Reflectance, Wardha Valley, Ashtona, Yeotmal District, Maharashtra.

INTRODUCTION

The coal deposits of the Wardha Valley play a significant role in fulfilling the needs as energy resource for various industries as well as the power sector of Maharashtra State. Therefore, emphasis has been given to understand the constitutional properties of the sub-surface coal deposits of the Wardha Valley to ascertain their best utility. The present study has been taken up to gather data regarding the maceral composition and rank of the two coal seams (I & II) recently encountered from a bore-hole No. AK-8, drilled in the vicinity of Ashtona Village of Yeotmal District, Maharashtra.

We have substantial information concerning the geological aspects of the Gondwana sequence in Wardha Valley Coalfield, however, we still strive hard to gather information regarding petrographic characteristics of coal deposits in the valley. Anand Prakash & Khare (1974) petrographically analyzed coal from open cast mines, underground mines and sub-surface seams of Wardha Valley Coalfield. Similarly, Pareek & Pande (1971), covered the Majri, Ghugus, Rayatwari, Lalpeth, Ballarpur and Sasti areas, while Sarate (2000) petrographically analyzed the coals from Kondha and Nanduri areas and Sarate (2001 & 2005) studied the coals of Durgapur and Telwasa mines, respectively. Sarate (2009) carried out petrographic study of coals from Junad open cast mine.

The recent sub-surface coal explorations have lead to the discovery of coal seam extensions from several new areas in the valley, which needs to be evaluated on petrographic grounds to ascertain their quality.

GENERAL GEOLOGY

Wardha Valley Coalfield covers approximately 4150 sq. km areas of the Gondwana deposits covering major parts of Chandrapur and a small projection in Yeotmal districts of Maharashtra. The Gondwana rocks are marked between 19°30' and 20°27'N latitude and 78°50' and 79°45'E longitude, (Raja Rao 1982).

Wardha Basin displays a broad anticline feature which plunges towards NNW. Continuity as well as similarity in the lithology as well as stratigraphy exists in the Gondwana sequence laid down in the north-western portion of Wardha and Godavari Valley coalfields. Existence of coal in Wardha Valley dates back to 1831 in the form of outcrops noticed at Wardha River bank near Kumbhari Village (19°57' : 79°06') in Chandrapur District, Fox (1934). Blanford (1868) and Hughes (1877) were also the pioneers who provided the geological details of the Wardha Valley Coalfields. Similarly, Raja Rao (1982) has compiled the information regarding geological, geophysical and the tectonic events of the coal bearing Gondwana deposits of Wardha Valley.

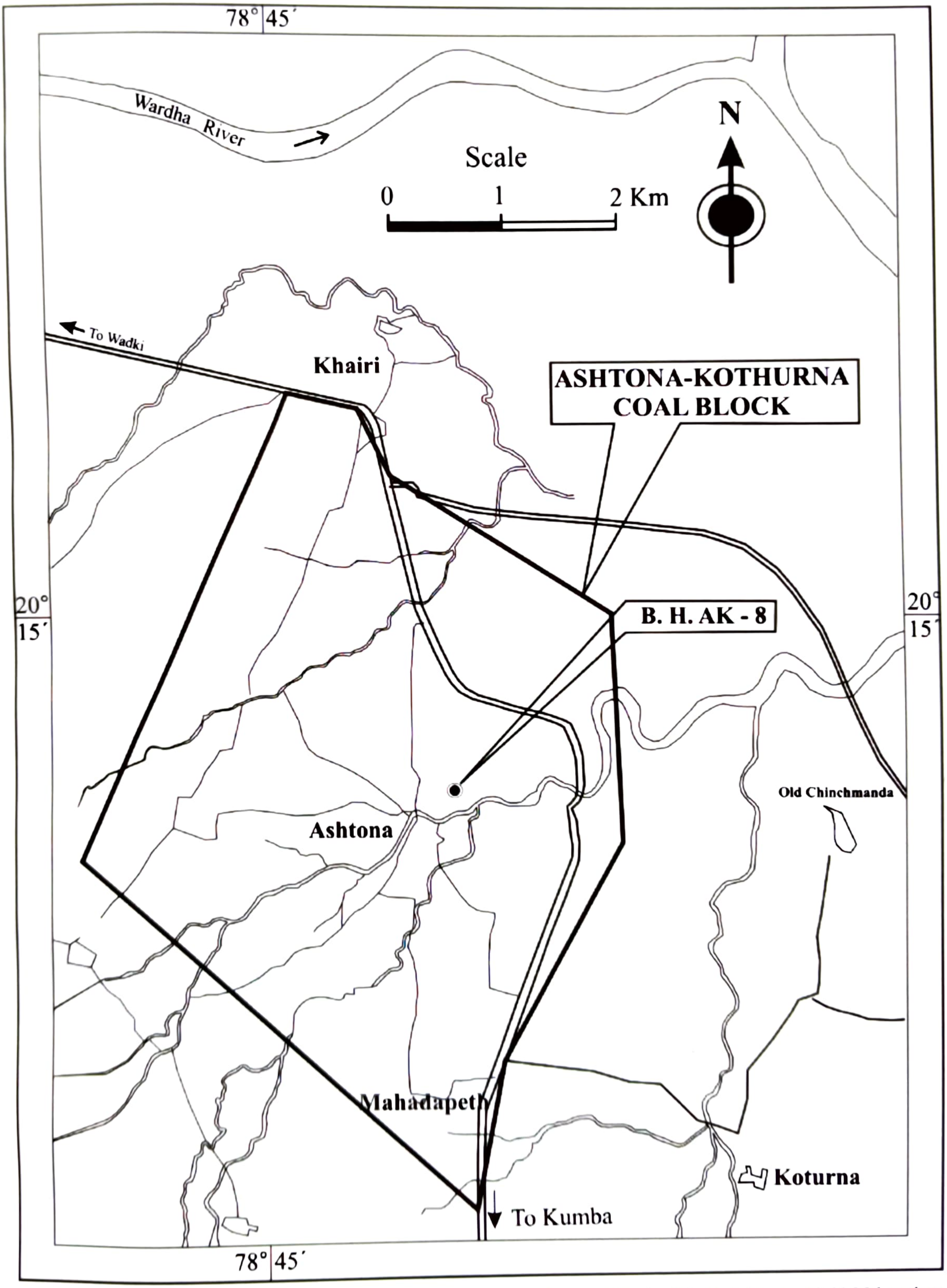
Lower Gondwana sediments in the study area have been deposited unconformably over the Vindhyan rocks, which are characterized by the presence of dolomite with blackish grey colour, interbedded with fine-grained, dark-grey or blackish, hard and compact limestones, besides, thin shale partings displaying veins of calcite and silica. Talchir Formation represents the oldest member of the Lower Gondwana sequence deposited over the Vindhyans, which mainly includes, pebble and cobbles of limestone, shale, quartz and jasper cemented in quartoze matrix that is soft and friable. The succeeding sequence is characterized by needle shales showing greenish grey to olive green tint, followed by a sandstone unit. The overlying Barakar Formation is deposited in the form of a stripe with width of nearly 1 km and length measuring about 11 km. This strata mainly includes fawn, yellowish and white coloured, medium-grained sandstones containing sub-angular rounded grains of quartzite, dispersed in the felspathic matrix besides, the intervening shale bands and well developed coal seams. The uncomfomably overlying sediments belong to Kamthi Formation, which cover an area of approximately 24 km length, however in the north-east, it exists in the form of small patches. The top of Kamthi Formation contain sandstone unit which is quartzitic and calcareous in nature and displays dark-brown, brick-red or fawn to yellowish colour, interstratified with clay and purple-red to brick-red shale bands. Towards the basal part, the sandstone becomes coarser with white colour and ferruginous nature. The uncomfomably overlying sequence deposited in the northern part of the basin is designated as Lameta Formation, which occupies an infra-trappean position and comprises brick-red, sandy clays intercalated with limestone and sandstone units, along with some fossil remains (Table 1).

Table 1: General geological succession in Yeotmal District, Wardha Valley Coalfield, Maharashtra (after Deshmukh, S. S., GSI, Maharashtra Circle).

Group/ Formation	Stratigraphic Unit	Age
	Alluvium and conglomerate	Recent.
	Deccan Basalts	Cretaceous-Eocene.
Lameta Formation	Lameta beds	Cretaceous.
	--------Erosional Unconformity------	
Gondwana	Kamthi shales and sandstones. Barakar sandstones Talchir shales	Upper Carboniferous to Permian
	--------Erosional Unconformity------	
Vindhyan	Dolomites limestones and shales	
Penganga Beds (Pakhals)	Dolomitic limestones, red brown and purple shales.	Pre-Cambrian

MATERIAL AND METHODS

Coal samples representing the topmost I and its underlying II and III seams have been collected from bore-hole No. AK-8, through the courtesy of the Directorate of Geology and Mining Government of Maharashtra, to undertake the petrographic analysis. The present bore-hole is located at a distance of approximately 0.50-0.75 km NE of Ashtona Village which is under the jurisdiction of Ralegaon Tehsil of Yeotmal District, Maharashtra. Ashtona Village is situated nearly 8-9 km south-east of Wadki, which can also be approached via Khairi Village. The distance between Wadki and Hinganghat is nearly 38 km whereas, Nagpur is 77 km away from Hinganghat (Text Figure 1, Table 2).

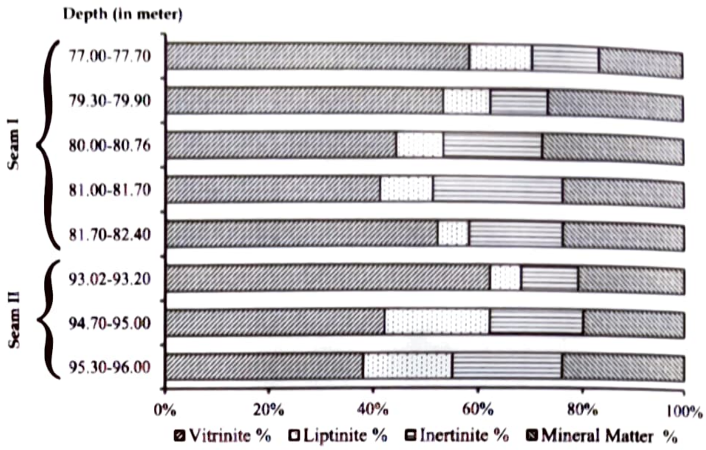


Text Figure 1. Map showing location of borehole No. AK-8, Ashtona area, Yeotmal District, Wardha Valley Coalfield, Maharashtra (after DGM, Nagpur).

Table 2 : The coal seam samples collected from borehole No. AK-8, representing Ashtona area, Yeotmal District, Maharashtra.

Sr. No.	Pellet No.	Depth (in meter)	Coal Seam	Lithology
1.	AK – 8/1	76.00-76.30	I Seam	Coal
2.	AK – 8/2	77.00-77.70	I Seam	Coal
3.	AK – 8/3	79.30-79.90	I Seam	Coal
4.	AK – 8/4	80.00-80.76	I Seam	Coal
5.	AK – 8/5	81.00-81.70	I Seam	Coal
6.	AK – 8/6	81.70-82.40	I Seam	Coal
7.	AK – 8/7	93.02-93.20	II Seam	Coal
8.	AK – 8/8	94.70-95.00	II Seam	Coal
9.	AK – 8/9	95.30-96.00	II Seam	Coal
10.	AK – 8/10	168.00-168.30	III Seam	Coal

The collected coal samples from bore-hole No. AK-8 were cautiously crushed to obtain particles of size range 1-2 mm to be used for pellet preparation. Nearly 15-20 gm of the crushed sample was utilized for pellet preparation. The crushed sample was placed into plastic moulds, thinly coated with the releasing agent. A mixture of hardener and resin in the ratio 1:5 is poured in the moulds and the coal particles were properly blended and allowed to harden for 24 hours at room temperature. Thereafter, hardened pellets were



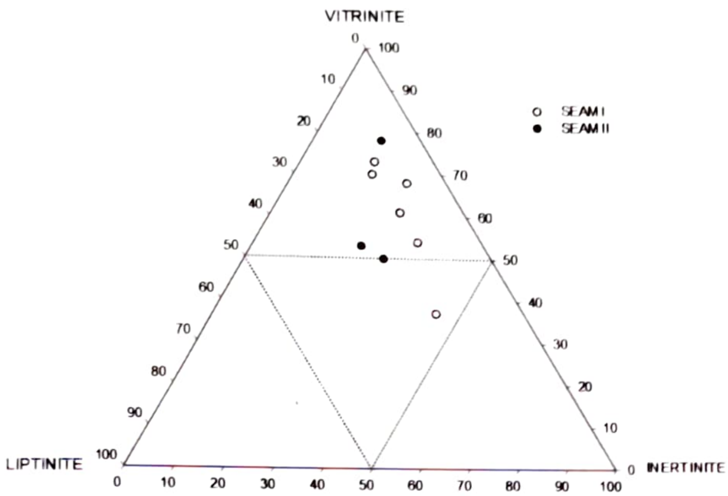
Text Figure 2. Maceral constitution of the coal seams intersected in borehole No. AK-8, Ashtona area, Wardha Valley Coalfield, Maharashtra.

removed from the moulds, grounded and polished on silicon cloth by using different grades of polishing alumina, following the recommendations of ICCP (1971, 1975,1998 and 2001) and Stach et al. (1982). The maceral and reflectance study was carried out on Leica DM 4500P microscope, whereas, for random vitrinite reflectance analysis (R_o mean %) Microscopephotometry System (PMT III) and MSP 200 software were used. Quantitative maceral study has been done by computerized point counter and through 2.35 version of Petroglite Software. Similarly, for microphotography Software tool Leica applications suit (LAS) has been utilized.

Table 3. Maceral constitution and reflectance analysis of the coal seams intersected in borehole No. AK-8, Ashtona area, Wardha Valley Coalfield, Maharashtra.

Sr. No.	Pellet No.	Depth (in meter)	Coal Seam	Vitrinite (%)	Liptinite (%)	Inertinite (%)	Mineral Matter (%)	Reflectance (R_o mean %)
1.	AK-8/1	76.00-76.30	I Seam	27 (37)	13 (18)	33 (45)	27	0.38
2.	AK-8/2	77.00-77.70	I Seam	58 (70)	12 (14)	13 (16)	17	0.38
3.	AK-8/3	79.30-79.90	I Seam	53 (73)	09 (12)	11 (15)	27	0.41
4.	AK-8/4	80.00-80.76	I Seam	44 (61)	09 (13)	19 (26)	28	0.48
5.	AK-8/5	81.00-81.70	I Seam	41 (54)	10 (13)	25 (33)	24	0.39
6.	AK-8/6	81.70-82.40	I Seam	52 (68)	06 (08)	18 (24)	24	0.38
7.	AK-8/7	93.02-93.20	II Seam	62 (78)	06 (08)	11 (14)	21	0.45
8.	AK-8/8	94.70-95.00	II Seam	42 (53)	20 (25)	18 (22)	20	0.42
9.	AK-8/9	95.30-96.00	II Seam	38 (50)	17 (22)	21 (28)	24	0.39
10.	AK-8/10	168.00-168.30	III Seam	13	07	23	57	--

Note : The values stated in brackets indicate mineral matter free (m.m.f.) percentage.



Text Figure 3. Ternary diagram showing maceral constitution and reflectance analysis of the coal seams intersected in borehole No. AK-8, Ashtona area, Wardha Valley Coalfield, Maharashtra.

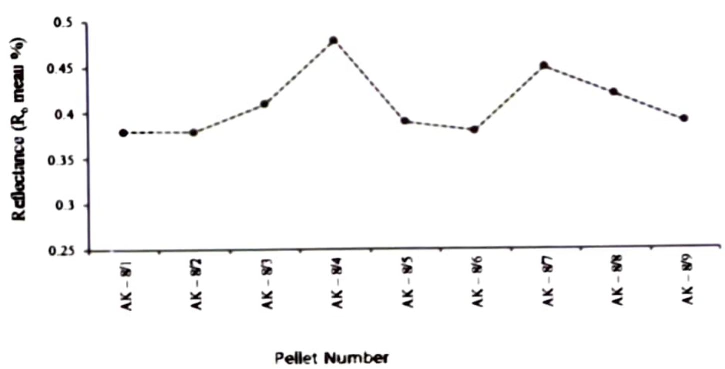
DESCRIPTION OF MACERALS

The entire Seam II and the middle and bottom parts of Seam I are predominated by the vitrinite group of macerals, particularly the collotelinite (Plate 1, Figs. 1-5) type is commonly noticed in the form of thick and thin bands with colour variation from light grey to dark grey, their cell lumens are infilled with argillaceous mineral matter. Telinite contains well preserved cellular structures. Vitrodetrinite, gelinite and corpogelinite maceral types were also recorded from these coals, though in low frequencies. Sporinite shares bulk of the liptinite group of macerals, which display thread like appearance with linear or random distribution pattern, both the thick and thin walled spores are observed with dark grey colouration, the former is observed more commonly. They exist with an intimate association of the collinite, vitro-detrinite and fusinite fractions. Thin walled tenu-cutinites are noticed in plenty whereas, the thick walled crassi-cutinites have scanty distribution (Plate 1, Figs. 6-7) and generally they display dark grey shade. Similarly, dark grey coloured isolated resin bodies with round or oval shape have also been found embedded in the vitrinitic and lepto-detrinite fractions with wide range of variation in their shape and size. Intact as well as broken megaspores (Plate 1, Fig. 8) are also found in these coals even if their frequency is low. They are easily distinguished due to large size, display dark grey to black colour with distinct lumen and beautiful ornamentation. Dominant association of inertinite group of macerals is recorded from the upper part of Seam I, which includes large as well as small bands of fusinite and semifusinite with varied cellular organization, caused by compression effect. The pyrofusinite have higher reflectivity, distinct cellular preservation and yellowish colouration whereas, degradofusinites show lower reflectivity, white colour and ill-preserved cellular organization (Plate 1, Figs. 9-12), the intercellular spaces are mostly occupied by mineral matter contents. Semifusinite also displays cellular disintegration and has reflectivity lower than the fusinite and displays white to light grey colour. Transitional stages from vitrinite to semifusinite have also been documented during the microscopic study. Micrinites and macrinites with white or yellow colour exist as structure-less, small amorphous bodies with considerable variation in size and shape, mostly recorded from inertodetrinite fractions, besides funginite and secretinite (Plate 1, Figs. 13-15). Mineral matter in these coals have generally been recorded as carbonates, sulphides (pyrite granules as well as framboids) and clay from the intercellular spaces as well as interspersed in different macerals, from cleats, cracks and fissures.

MACERAL CONSTITUTION

Seam I

The top part of this seam contains fusic type of coal having dominance of inertinite (33%) group of macerals, followed by vitrinite (27%) and liptinite (13%) respectively. Mineral matter association is recorded to be 27%. The underlying coal sequence is vitric in nature and contains an abundance of vitrinite with frequency



Text Figure 4. Reflectance (R_o mean%) analysis of the coal seams intersected in borehole No. AK-8, Ashtona area, Wardha Valley Coalfield, Maharashtra.

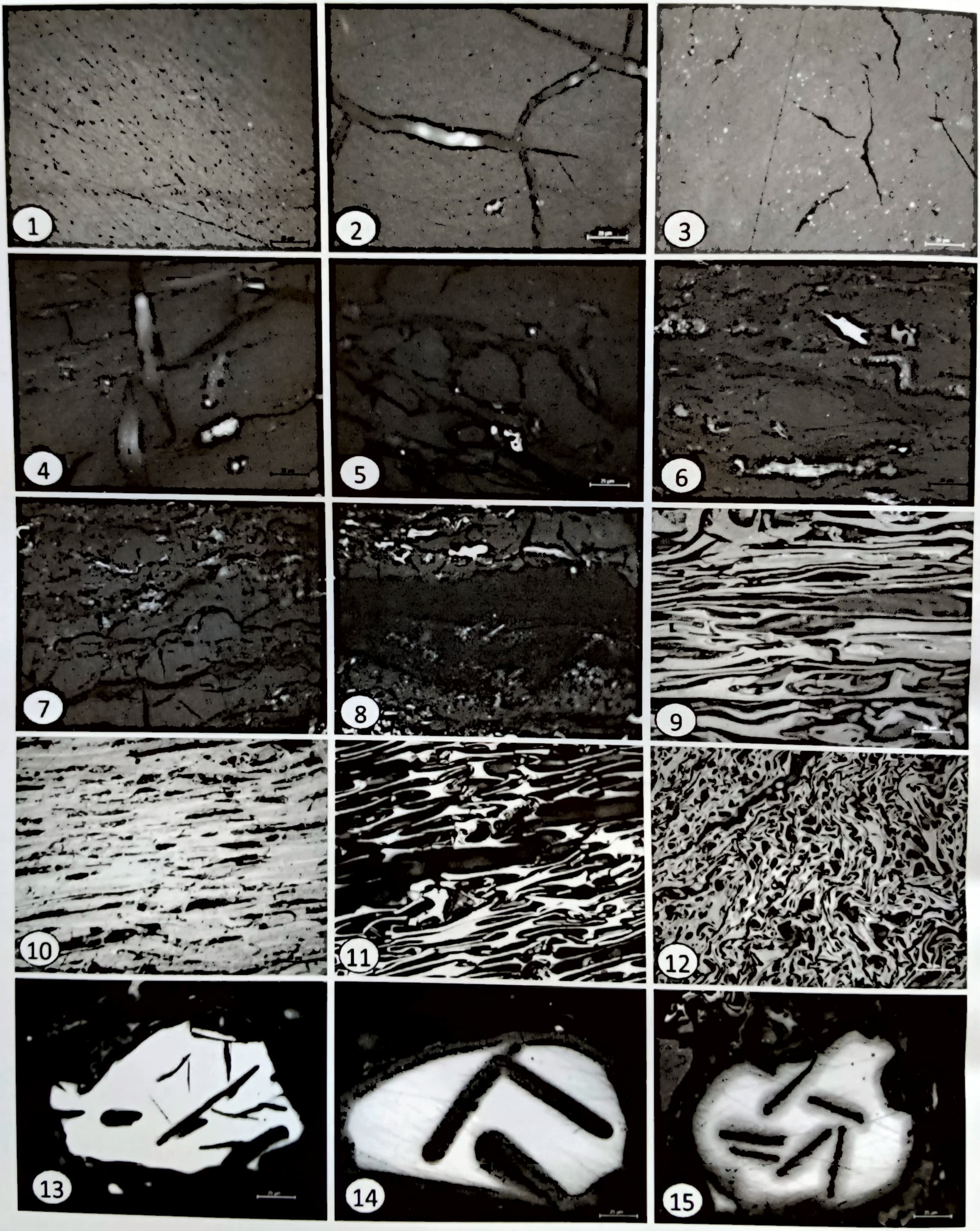


Plate 1

Figs. 1-5. Collotelinite with cleats and pyrite grains. 6-7. Cutinite in Collotelinitic ground mass. 8. Broken Megaspore. 9-12. Fusinite with cellular compression and disintegration. 13-15. Secretinite.

distribution at the top and bottom parts ranging from 52% to 58% respectively, with lesser representation of 41% to 44% in the middle part of the seam. Liptinite however, has scanty distribution of 6% to 12% with a decreasing trend towards the bottom part of the seam. Mineral matter association in this seam ranges between 17% and 24%, except for a coal band in the middle part with maximum representation of mineral matter 28%. Inertinite macerals in general have been recorded around 11% and 18% except for one band in the middle region where the maximum range of 25% has been recorded.

Seam II

This seam is represented exclusively by vitric type of coal. The vitrinite group of maceral has been exclusively recorded in the seam having variation between 38% and 62% and a steady decreasing trend of distribution towards the bottom part of the seam. Inertinite macerals (11% to 18%) and liptinite (6% to 20%) have an increasing tendency towards the middle part with a slight decrease at the base. Mineral matter (20% to 24%) shows a steady increase towards the base of the seam.

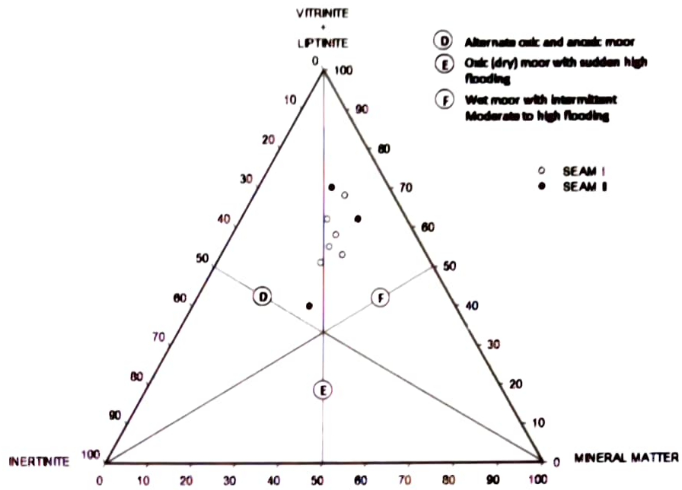
Seam III

The maceral study has revealed that the seam is mostly represented by shaly fraction with quite high mineral matter association (57%), besides inertinie (23%), vitrinite (13%) and liptinite (7%) respectively (Table 3, Text Figure 2).

The ternary m.m.f. (mineral matter free) maceral plotting has indicated that the coals of seam I contain both the vitric and fusic type of coals, whereas, the seam II is constituted mainly by vitric type of coals (Text Figure 3).

REFLECTANCE ANALYSIS

The random vitrinite reflectance (R_0 mean %) study on the topmost I and its underlying II seams have indicated that the vitrinite reflectance values in these seams ranges between 0.38 % and 0.42%, which suggests that the coal seams of the present study have attained sub-bituminous C to B stages of rank (Text Figure 4).



Text Figure 5. Facies diagram showing depositional environment of coal seams intersected in borehole No. AK-8, Ashtona area (after Singh & Singh 1996).

Similarly, the facies diagram based upon maceral and mineral matter plotting (after, Singh & Singh, 1996) suggests that the vegetal resources responsible for the formation of coals of the seams I and II have been deposited during the prevalence of wet moor with intermittent moderate to high flooding, however, a small fluctuation of change in climatic conditions to alternate oxic and anoxic moor conditions is also recorded (Text Figure 5).

RESULTS AND DISCUSSION

The coal seams of the study area can broadly be compared with the Top Seam of Kosar area and the basal part of the Middle Seam of the Mahadoli area located in the southeastern extremity with respect to its maceral constitution and rank (Sarate 2004). The Gondwana sediments have been laid down initially with glacial influence regime in a slowly sinking platform, in either stagnant swamps, with fluvitile/lacustrine or deltaic conditions (Stach et al. 1982).

CLIMATIC CONDITIONS

The coals of the Seam I have shown the predominance of vitrinte group of macerals, the genesis of which needs cold climatic conditions as the prerequisite. The prevalence of the mixed type of coals recorded from certain parts of this seam indicates a shift in the climate to warm and moderate conditions.

Seam II however, has witnessed cold climatic conditions during its depositional phase. Similar views such as prevalence of cold temperate climate with high floodings and alternate dry spells during the Gondwana regime have been expressed by King (1958, 1961) and Kräusel (1961). Plumstead (1961) studied the palaeogeographic location of the Gondwana land during the Permian Period, the morphological and anatomical features of the Glossopteris and flora which has characteristic broad-leaved structures and the existence of feldspar along with the coal seams, and opined the prevelance of cold climatic conditions, Chandra & Chandra (1987) have also studied the Gondwanan Glossopteris flora and have drawn similar climatic inferences which supports the climatic interpretations, of the present study.

The coal deposits of the study area contain quite high frequency of the vitrinite rich maceral constitution along with low mineral matter association, therefore, represent better quality coal, which can find better commercial usages.

ACKNOWLEDGEMENTS

I wish to express my gratitude to Prof. Sunil Bajpai, Director, BSIP for his permission to submit the manuscript for publication and to Mr. V. S. Sawakhande, former Director, Directorate of Geology and Mining Government of Maharashtra, Nagpur, for providing the coal samples along with relevant details.

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