

PETROLOGY AND PALYNOSTRATIGRAPHY OF SOME WARDHA VALLEY COALS, MAHARASHTRA, INDIA

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ABSTRACT

The present paper deals with the petrographic and palynological studies of Wardha Valley coals of Maharashtra, India. The coals are generally dull, hard, granular and indistinctly banded. Durain forms the dominant constituent in the coal seams. It occurs as thick bands of hard, compact and granular mass, having dull lustre. Clarain is the next dominant constituent of these coals which is more common in the south-eastern part of the coalfield. Fusain is present in the form of thin patches and lenses. Vitrain occurs as thin bands except at places where it has attained considerable thickness of local importance. Microscopic study of durain components indicates inertinite, vitrinite and exinite as main macerals. Microspores and megaspores are found mainly in exinite constituents. Microscopic analysis of coals also indicates that durite, fusite and vitrite are the important microlithotypes. The inorganic mineral matter is mostly composed of clay minerals; silica and pyrite.

Sporological study of Wardha Valley coals reveals the presence of trilete, monolete, monosaccate and disaccate forms. *Brevitriletes*, *Horriditriletes*, *Lophotriletes*, *Microbaculispora*, *Microfoveolatispora*, *Parasaccites* and *Scheuringipollenites* are well represented genera in these coals suggesting the Lower Barakar affiliation.

The petro-palynological study of Wardha Valley coals indicates that the coals are derived from Permian coal swamps of Lower Barakar entities (based on spores and pollen analysis) which metamorphosed into a dull coal type (durain type — characteristic of Barakar Stage) showing variable coalification towards the south eastern part of the coalfield due to probable changes in physico-chemical conditions. The petrological composition shows a high proportion of "inerts" and sedimentary matter in the coals which may cause problems in coal preparation for utilization. However, the coal quality may be improved by selective sampling, screening and cleaning processes. The petrographic analysis of coals from different collieries reveals better type of coal in the southern part of the coalfield and hence, it is suggested that this area is more promising for working, and for future exploration.

INTRODUCTION

IN India the Lower Gondwana coal deposits are well known. Their occurrences in various parts of the country have been extensively investigated, in view of the problems related with their origin, constitution, identification and nature etc. However, very little is known in the literature regarding Wardha Valley Coalfield. This paper incorporates some aspects of the physical constituents of the coals particularly petrological and palynological aspects with a view to understand the nature of coal constituents and their relation with other Lower Gondwana deposits.

The earliest reference of the Wardha Valley coal is given in "Gleanings of Science" (1831) in which the occurrence of coal has been mentioned on the banks of Wardha River near Kumbhari (19°57': 79°6'). Blanford (1867) found a 1.82 m thick coal seam towards the Ballarpur side on the bank of Wardha River. Oldham (1869) has given a summarised account of Wardha Valley coals. In 1870, a colliery was set up at Ghugus (19°56': 79°7'). Hughes (1877) has given the systematic account of the Wardha Valley Coalfield.

The Wardha Valley Coalfield has been resurveyed during last few years. Geological Survey of India and Directorate of Geology and Mining, Maharashtra are now engaged in systematic geological mapping and prospecting of coal in the area. Hemmady examined the Majri area and its surroundings and proposed the exploratory drilling through the Kamthi beds near the contact with the Talchirs between Sumthan and Avndh (20°04': 79°13') to find out the

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extent of its overlapping the Barakars and the presence of possible coal seams.

As regards petrological and palynological studies of Wardha Valley coals, the former has been analysed by Pareek from Majri area, whereas, the later has been studied by Agashe and Chitnis (1969, 1972) from Hindustan Lalpeth Colliery (Chanda area). The above studies are rather preliminary and restricted to a particular area.

GEOLOGY OF THE AREA

The Wardha Valley Coalfield covers an area of about 1440 sq km between Latitudes 19° 28' and 20°27', Longitudes 78°50' and 79° 45' for a length of about 115 km from NW to SE almost in a straight line. There are large tracts of wide spread alluvium deposits of sand and gravels. Only at few places isolated out-crops of rocks are found. The Archaean rocks are found in the eastern part whereas, the Puranas and the Vindhya are towards the west. The rocks found near Chandrapur are folded forming an anticline with its axis much nearer towards the south-western limits of the area. Due to the folding, the Gondwana outcrops are divided into two arms, each extending north-westwards along one side of both the boundary faults towards the south west. The shales and the limestones of the Pakhal Series are found bordering the Gondwana tract with a few scattered patches of Sullavai Sandstones.

The Wardha Valley Coalfield has been divided into 8 different areas in Chandrapur (Chanda) and Yeotmal districts. (for geological map see Hughes, 1877).

1. Warora
2. Majri
3. Ghugus-Telwasa
4. Rajur and Wun
5. Bandar
6. Chandrapur Town
7. Ballarpur
8. Sasti-Rajura

GEOLOGICAL SETTING

The following stratigraphical succession is found in the area under discussion.

Recent to Pleistocene	Alluvium, Older gravels and laterite

Lower Gondwana	Kamthi Group Barakar Group Talchir Group
-----Unconformity-----	
Purana Formation	Vindhyan Limestones and Shales.

VINDHYANS

The Vindhya lie unconformably upon the metamorphics and occupy a large area in Yeotmal and Chandrapur districts. The limestones, dolomitic limestones, sandstones and purple shales are the constituent rock types. The limestones and shales are mostly found towards the western part of the Wardha Valley, while the sandstones are found mainly towards the east. The areas in which the Vindhya are well exposed are Kelapur and Wani of Yeotmal district and Warora, Brahampuri and Sironcha of Chandrapur District.

TALCHIRS

In the central part of the Wardha Valley the Talchir beds with disconnected and thin outcrops of Barakars in its neighbourhood are present. The Talchirs are represented by boulder beds, greenish sandstones and greenish shales. The boulder beds are composed of the boulders of different size and shape, some having glacial markings.

BARAKARS

The coal is found in the Barakar group, which is the most important lithological unit of the area. The rocks are sandstones and shales with interbedded coal seams. Sandstones are white, buff to reddish in colour, coarse-grained containing quartz, feldspar and mica as major mineral constituents. Thinly bedded carbonaceous shales are found interbedded with the coal seams.

KAMTHIS

The Kamthis are very well developed in the area. These are mostly exposed in

the eastern part of the coalfield. Kamthis rest unconformably over the Barakars and overlap them extensively. Although, Kamthis do not contain coal seams but their occurrence is helpful in deciphering the presence of coal in the strata below them. The lithological units are mainly sandstones, shales, clays and conglomerates.

ALLUVIUM AND SOILS

Under these, is included all the area covered by the soils and subrecent gravels which are seen exposed on the banks of Wardha River. The soil near Chandrapur is red in colour but in the other parts of the area they are grey and blackish.

The Wardha Valley Coalfield includes 8 different areas in Chandrapur and Yeotmal districts. They are (1) Warora (2) Majri (3) Ghugus-Telwasa (4) Rajur-Wun (5) Bandar (6) Chanda town (7) Ballarpur and (8) Sasti-Tajura. Out of these 8 areas, only 5 areas namely, Majri, Ghugus, Chanda town, Ballarpur and Sasti are the working horizons. As the present study is confined to only working areas the nature of the seams and description of each coal horizon is given in brief:

MAJRI AREA

In Majri (20° 8': 79° 2'), the northernmost coal horizon of Wardha Valley Coalfield, Barakars underlie a thick cover of Kamthis and Lametas. The working coal seam of this area is 9.2 m thick. The bottom portion (3.5 m) of the seam possesses good quality of coal while upper part of the seam is shaly in nature. The coal seam dips at 12°-15° towards south-west. The seam is not found outcropping at the surface. Hughes (1877) reported a coal seam of 15.24 m thickness between Majri and Wardha River at the depth of 22.86 metres. Fox (1934) reported two coal seams of 4.57 m and 17.37 m thickness in separate boreholes towards west of Majri near Konalgaon. The thick seam represents the two lower seams of the Warora area which are united in the Majri area.

GHUGUS-TELWASA AREA

This area consists of two parts: (a) Northern part is Telwasa and (b) Southern

part extends from Nilijai to Ghugus and further south to Penganga River. A coal seam of 18.59 m thickness with partings was recorded at Junera opposite Telwasa. In a borehole at Nilijai, 2 seams of 9.98 and 11.37 m thickness have been found. A 10 m thick seam is being worked at Robertson Incline and Pit no. 2 of Ghugus Colliery. The trend of the seam is NNW-SSE, dipping 8° towards west. The seam has been divided as top, middle and bottom on the basis of shale partings.

CHANDA TOWN AREA

Chanda (19° 56': 79° 18') is situated on Kamthi rocks on the eastern edge of a large tract of Talchirs. Barakar out-crops occur south west of Chanda about Hingnala (19° 54': 79° 17') and in the Erai River south of Chanda at Charwat (19° 53': 79° 18'). The thick seam is now being worked in two working collieries of this area namely Hindustan Lalpeth and Rayatwari. The third, Mahakali Colliery is now abandoned due to flooding in the mine.

The strike of the coal seam is NW-SE and dips about 10° to 14° towards NE. The individual thickness of the seam in these collieries varies from 8 to 16 m.

BALLARPUR AREA

Ballarpur Colliery is situated near the Ballarshah town (19° 51': 79° 21') in the Chandrapur District. This area is the continuation of the Chanda Town Coalfield towards south. Hughes (1877) reported only two thin seams, 3 m and 6 m thick at a depth of 60 m in a borehole. In 1900, a systematic study was carried out at Ballarpur which produced good results.

The seam in Ballarpur Colliery is 16 m thick and has been divided on the basis of shale partings into three sections, top (4.26 m), middle (1.2 m) and bottom (3.2 m) thick. The top and bottom sections are being worked at present. The seam dips about 4° towards ESE.

SASTI-RAJURA AREA

This coal horizon is situated on the south western bank of the Wardha River and opposite to Ballarpur Colliery. The thick seam of Ballarpur extends south of the

Wardha River into this area. The thickness of the seam in this area is about 10.64 m and is being worked in three sections as in Ballarpur Colliery. This field includes three areas Rajura, Antargaon and Lathi. A 7.0 m thick seam was proved in a borehole near Dapta ($19^{\circ} 48': 79^{\circ} 20'$) north of Rajura. Hughes (1877) has recorded a 1.82 m thick coal seam on the bank of Wardha River south of Lathighat near Antargaon ($19^{\circ} 33': 79^{\circ} 29'$).

MATERIAL AND METHOD

The material for investigation was collected from the following working collieries of Wardha Valley Coalfield namely Majri, Ghugus, Rayatwari, Lalpeth, Ballarpur and Sasti representing complete thickness of the coal seam worked in them. A systematic channel sampling was carried out in order to represent the entire thickness of the coal seams investigated. The technique of examining the coal in polished surface through incident light has been applied in the present investigation of micro-constituents of Wardha Valley coals. Different lithotype blocks were suitably cut into 8×4 cm size, embedded and polished for general observation of the structure of the coal. In addition to this about 5-10 gm of the material from overall coal samples crushed up to ± 18 B. S. size was utilised in the preparation of coal pellets and the quantitative estimation of different macerals.

As embedding material, molten carnuba wax and sometimes Araldite C. Y. 230 has been used. The method of embedding the material was same as described by Navale (1963) and Navale and Srivastava (1967). Grinding was done over an electrically operated brass disc using successively finer grades of carborundum powder (80, 200 and 300). This grinding was continued till a fresh and even surface of the coal was exposed. The final grinding was done over a glass plate using the finest grade of carborundum powder (600) till a uniform scratch free surface emerged out. Polishing was done over an electrically operated brass disc covered with a thick soft felt cloth using a colloidal solution of Aluminium oxide grades I and II as polishing medium. Continuous fine jet of the polishing medium

and water was maintained throughout the whole process in order to get a smooth and scratch free surface of the coal.

The coal blocks were studied in reflected light under high magnifications. The proportion of the various macerals were evaluated through the point counter method.

For separation of the microfossils the coal from homogeneous representative samples was taken for maceration. The maceration procedure adopted during the investigation was same as described by Bharadwaj (1962) and Bharadwaj and Salujha (1964). About 15-20 gm of the crushed material was taken from each sample, washed 2-3 times with water and covered with commercial nitric acid. After complete acid action the material was washed with water several times. The material was then treated with 10% KOH solution and again washed 3 or 4 times to remove the debris and to make the macerate alkali free. The residue was made water free by centrifuging the material. Slides were made in glycerine jelly. From each sample 200 miospores were counted.

PETROLOGICAL CHARACTERISTICS

Megascopic observation of Wardha Valley coals shows that durain is the most dominant component in almost all the areas of the coalfield. Clarain and fusain are the next lithotypes occurring in order of dominance. Vitrain occurs mainly in the form of thin streaks and patches. Thick and persistent vitrain bands are rare. At places these coals are semibright in nature due to the presence of thin vitrain layers mostly in the south-eastern part of the area namely, Ballarpur and Lalpeth collieries. Fusain is widely distributed and occurs in the form of lenses and patches, mainly in the northern areas of the basin. In Majri and Ghugus collieries, fusain occurs in thick bands up to 10 cm in thickness and locally known as Bhusa Coal. Apart from the organic components, inorganic mineral matter is also present in these coals, mainly in the form of shales.

Microscopically, the coals are characterised by the fine state of maceral division and by the presence of significant proportion of mineral matter finely dispersed and intimately associated with the organic

constituents of the seam (Histogram-I). The proportion of mineral matter generally increases with that of organic inerts changing coal type from clarain to duroclarain and finally to durain.

The general petrological analysis of Wardha Valley coals has revealed a characteristic pattern of changes in the various organic microconstituents of the coal. The most interesting feature of these changes is the variation in the microlithotype and maceral compositions of the coals occurring in the northern and the southern sectors of the coalfield. The coals in the northern areas (Majri) are mainly rich in the inertinite contents whereas, the coals of the southern areas (Ballarpur) are rich in vitrinite (Histogram-I). Between these (Ghugus and Rayatwari) a transitional stage is present in which both vitrinite and inertinite occur almost in equal proportions. Hence, a gradual change in the coal type is evident in the area.

The percentage compositions of microlithotypes and macerals have been plotted in Histogram-I and Histogram-II respectively. Both these histograms are contemporary to each other and show that the variations in the macerals and microlithotypes are almost identical. In Majri area the durite and fusite are closely followed by the vitrite and clarite. Similarly, inertinite is the dominant maceral group in the Majri area followed by the vitrinite and exinite macerals. Contrary to this, vitrite with clarite has become the dominant microlithotype in the Ballarpur and Sasti areas followed by durite and fusite. Macerals also form the same pattern, vitrinite being dominant component followed by inertinite and exinite. The rest of the areas occurring between these show the intermediate position in the percentages of vitrite, clarite, durite, and vitrinite and inertinite with some minor variations.

On the basis of microscopic studies of these coals three main coal types (A, B & C) have been suggested (Histogram-III & IV).

COAL TYPE 'A'

This type is characterised by the dominance of clarain and durain lithotypes. The coal is intrinsically striated by dull constituents and has an appearance in

between vitrain and durain. The durains are dull and hard in appearance. Vitrain bands are uncommon. Fusain is present in the form of thin patches and lenses. Shale bands are frequent.

Microscopically, the coal type A is characterised by the clarain rich microconstituents of vitrinite and exinite maceral groups (Histogram III). Vitrinite is the dominant constituent of this coal type and occurs up to 45%. It is mostly of non-structured (collinite) variety. Structured vitrinite is rarely seen. Inertinite is the subdominant constituent and occurs up to 28%. Fusinite is the important maceral of inertinite group and occurs up to 16%. In this coal type fusinite is less in comparison to the other two coal types. Semifusinite and micrinite do not show any remarkable incidence, whereas fusinised resins are common and mostly confined in the bottom section of the seam. These fusinised bodies occur up to 4%. They are present in various forms. Large vesicular bodies with numerous vacuoles often accompanied with detrital infillings are common.

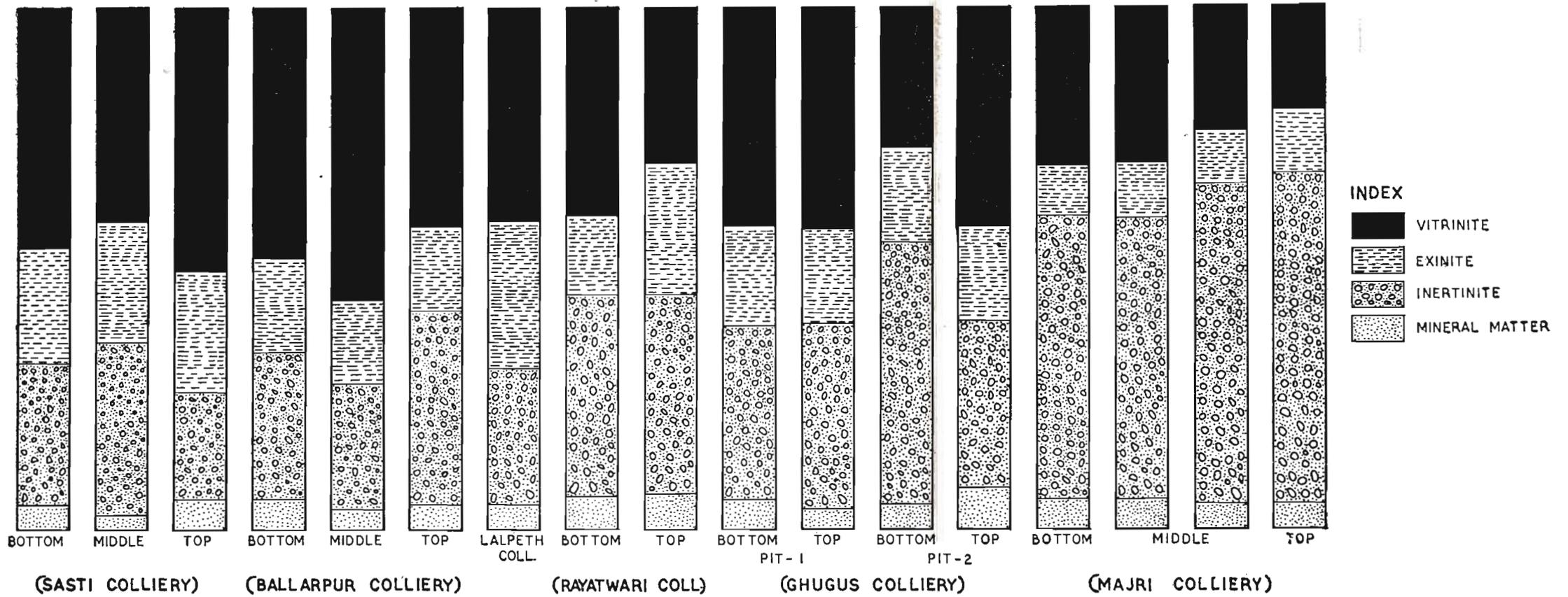
The microlithotypes recognised under the microscope are vitrite, clarite, durite and fusite. This type of coal is characterised by clarain rich microconstituents. Vitrite and clarite forming the dominant microlithotypes occur up to 39% by volume. (Histogram-IV). Durite is the subdominant microlithotype and occurs up to 33%. Durite is rich in exines and composed of microspores, megaspores, cuticles and other organic material often associated with mineral matter. Fusite and trimacerite (trimaceral group) are more or less present in the same proportion. Fusite shows various stages of fusinisation of bark and wood cells of the plant material.

The coals of the working horizons of Sasti, Ballarpur and Lalpeth collieries are included in this coal type.

COAL TYPE 'B'

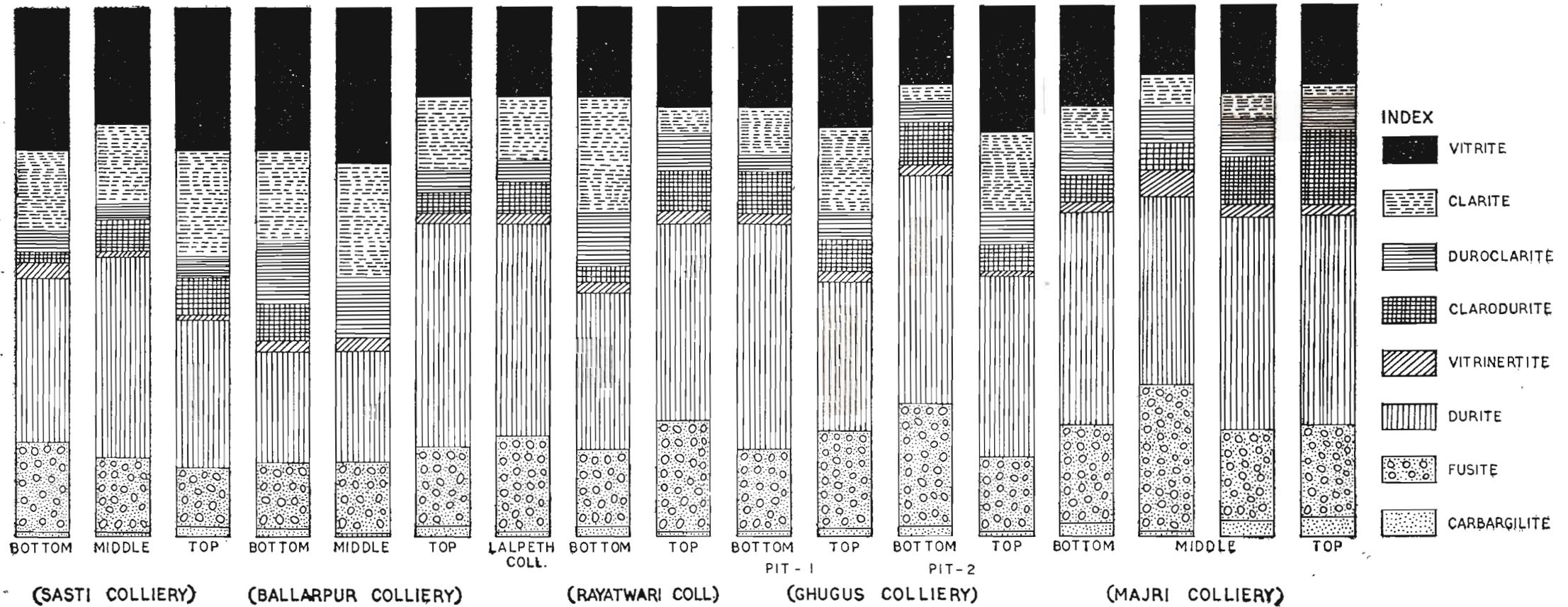
The coals included in type-B are indistinctly banded, dull, hard and granular in general appearance. This type is characterised by the inertinite and vitrinite group of macerals. Inertinite is the dominant microconstituent and occurs up to 38% by volume. Vitrinite which is the dominant constituent in coal type-A has become

DISTRIBUTION OF ORGANIC AND INORGANIC MICROCONSTITUENTS OF WARDHA VALLEY COALS



Histogram-I

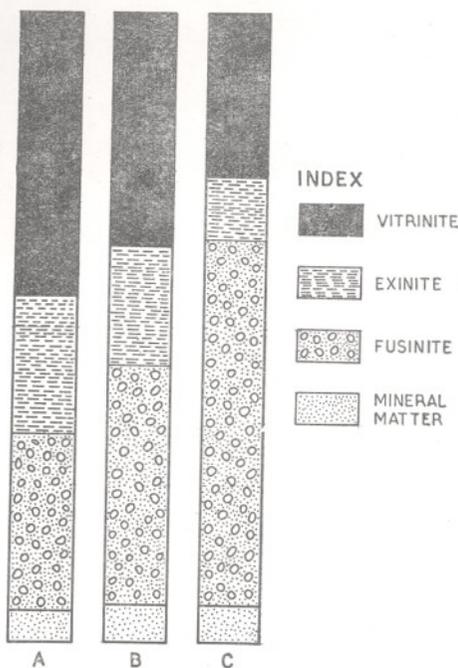
DISTRIBUTION OF MICROLITHOTYPES IN WARDHA VALLEY COALS



- INDEX**
- VITRITE
 - CLARITE
 - DUROCLARITE
 - CLARODURITE
 - VITRINERTITE
 - DURITE
 - FUSITE
 - CARBARGILITE

Histogram-II

COAL TYPES BASED ON MACERAL ANALYSIS



Histogram-III

subdominant and occurs up to 37% by volume. Inertinite and vitrinite have more or less the same proportion. The exinite is also well represented and occurs up to 19%. It shows a gradual decrease in the proportion of exinite from coal type-A. Among the inertinite group of macerals, fusinite occurs in considerable amount and fusinised resins do not show any remarkable change. The fusinite cells are mostly filled with clay or carbonate minerals. The sedimentary mineral matter is widely distributed and occurs up to 6% by volume (Histogram-III).

Among the microlithotypes, durite is the dominant microconstituent and occurs up to 35% by volume. This microlithotype does not show much variation in proportion than type-A excepting a slight increase in distribution. Vitrite and clarite which are the dominant microlithotypes in type-A have become subdominant constituents and occur up to 31% by volume. Fusite occurs

as thin streaks to thick bands showing cellular structure of the woody source material. It occurs up to 18% by volume. Fusite is intrinsically associated with the micrinite and the cell walls are more disintegrated than in coal type-A. The cell lumens are mostly filled with clay minerals. The trimaceral group does not show any remarkable change but it is more in proportion than in type-A. The carbargilite is well distributed and associated with organic matter (Histogram-IV).

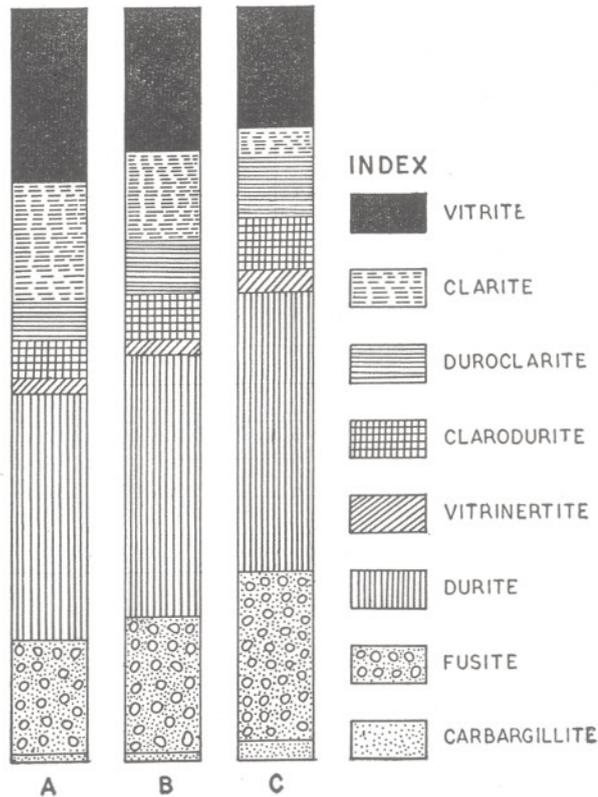
The coals of Rayatwari and Ghugus come under this type forming the transition between type-A and type-C coals.

COAL TYPE 'C'

The coal type-C is different from the types -A and B described earlier. This coal is very hard, dull and shaly in appearance. In general outlook it resembles coal type-B but on closer examination, it is found more indistinctly banded. This is characterised by the abundance of durain. Fusain is also widely distributed and present in the form of thin patches and lenses. The sedimentary mineral matter which is chiefly responsible for high ash content is widely distributed. Indistinct vitrain bands are present.

Microscopically, this type of coal is characterised by the abundance of inertinite group of macerals. Vitrinite and exinite are the other dominant groups present in the coal. Their distribution is less than in types-A and B. Inertinite which is the dominant microconstituent occurs up to 57% by volume. In maceral composition the fusinite which is less dominant in the types-A and B has become most dominant constituent in the present coal and represents up to 64% of the total volume. Fusinite is mostly associated with mineral matter and differs from type-A in which mineral matter is less in proportion. The cell lumens are mostly filled with clay and carbonate minerals. Semifusinite which is present in low proportion in other two coal types has also become conspicuous. It occurs up to 3% by volume. Fusinised resins and other macerals of inertinite group do not show any remarkable change and are present in low proportion. Vitrinite which is dominant in type-A has become less in distribution (26%). It shows gradual de-

COAL TYPES BASED ON MICROLITHOTYPE ANALYSIS



Histogram-IV

crease in proportion from type-A to C. It also reveals that the proportion of dull constituents are increasing from type-A to type-C. Exinite constituents are also less than coal type-A occurring only up to 10% by volume (Histogram-III).

The microlithotypes recognised under the microscope are chiefly durite, vitrite, clarite, fusite, trimaceral and carbargillite. Durite is the dominant microlithotype and occurs up to 37% by volume. Durite which is the subdominant constituent in coal type-A has become the most dominant constituent in this type. The durite is mostly rich in inertinite constituents. In this respect it differs from type-A. Sedimentary mineral matter is generally evident and occurs homogeneously throughout the durite contents.

Local concentration of clay mineral complex is quite common in this microlithotype. The mineral matter is more than in types -A and B. Vitrite and clarite together form the second dominant microlithotype constituent and occur up to 20%. This group has become subdominant, and differs from type-A where it forms a dominant group. Fusite also shows the variations from type-A to C. In this coal type it has become more prominent and occurs up to 21% which shows a gradual increase in distribution. This coal type is characterised by mixed fusite which is mostly associated with micrinite and inorganic constituents. The cell lumens are filled with clay minerals. The trimacerals which are less in proportion in types-A and B have become prominent

and occur up to 15% by volume. Carbargilite is also more than the coal types-A and B (Histogram-IV).

COMPARISON WITH OTHER COALS

The general petrological characteristics of the Wardha Valley coals described above clearly suggest their resemblance to the Barakar Coal type (Pareek, 1967; Navale, 1971, 72; Ghosh, 1962). Durain is the dominant lithotype in the Barakar Coal type. It is characterised by vitrinite, inertinite and exinite group of coal macerals. These maceral groups combine in variable proportions forming duroclarite, clarodurite and durofusite microlithotypes. The Barakar flora formed the source material for the formation of the Barakar Coal type.

Comparing with the Barakar coals of the major Gondwana basins the Barakar coals of Damodar Basin (Raniganj, Jharia, Giridih, Bokaro and Karanpura Coalfields) may be differentiated by their characteristic broad lamination of vitrinite and exinite macerals. Fairly big tissues and persistent sheets of vitrinites showing well preserved structures are common. Inertinite group of macerals are minor in composition. The Barakar coals of Mahanadi (Talcher Coalfield, Ib-River Coalfield), Satpura and Godavari basins resemble the present coals in the nature and composition of coal constituents. All these coals are characterised by durite and fusite microlithotypes. Inertinite constituents are conspicuous in the composition showing fusinised, semifusinised and resinoid tissues. Vitrinite constituents exhibit intensive fragmentation and decay with the result no structural details are found. Although regional variation in petrological composition prevails from one area to another due to physio-chemical conditions to which the coals have been subjected, yet the nature of coal forming plants and the petrological characteristics appear to be similar in all these basins, (Wardha, Godavari, Mahanadi and Satpura).

PALYNOLOGICAL CHARACTERISTICS

The palynological study of the coal samples from Wardha Valley Coalfield has revealed rich microflora. Different types and forms

have been observed mainly in clarain and in durain lithotypes of the coal. Important amongst these are triletes and disaccates. Quantitative evaluation of the above miospores reveals that the following genera form the characteristic association in the present assemblage.

Brevitriletes
Horriditriletes
Parasaccites
Scheuringipollenites
Ginkgocycadophytus
Pilasporites

The following genera consistently occur in all the samples closely following the quantitatively more prominent miospores (Histogram-V).

Cyclogranisporites
Lophotriletes
Microbaculispora
Microfoveolatispora
Hennellysporites
Striatites
Lahirites
Faunipollenites
Illinites
Vesicaspora
Tiwariasporis

In addition to above, the following genera are also present but in rare amounts.

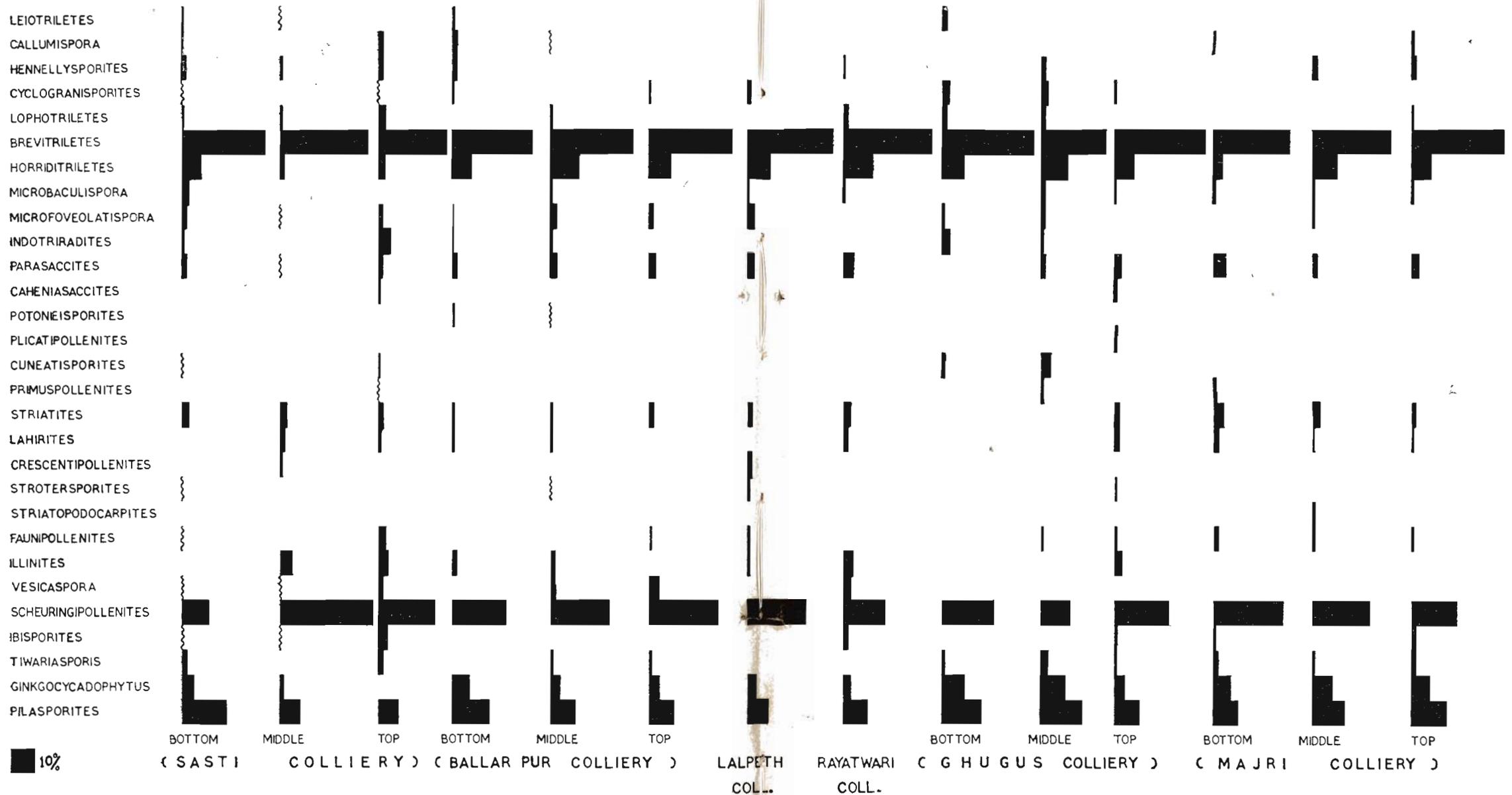
Leiotriletes
Callumispora
Indotrivadites
Caheniasaccites
Potonieisporites
Plicatipollenites
Strotersporites
Cuneatisporites
Primuspollenites
Crescentipollenites
Ibisporites

The microfioral studies of Wardha Valley coals from various collieries reveal that the present miospore assemblage consists of one characteristic association excepting some variations which are considered as the local changes of less importance. In general, the Wardha Valley coals are characterised by the dominance of following miospores.

<i>Brevitriletes</i>	36%
<i>Scheuringipollenites</i>	25%
<i>Horriditriletes</i>	12%
<i>Pilasporites</i>	14%

Thus, it is evident that the coal seam worked at various places, namely Sasti, Ballarpur, Lalpeth, Rayatwari, Ghugus and

PERCENTAGE FREQUENCY HISTOGRAM OF MIOSPORE GENERA IN VARIOUS COLLIERIES OF WARDHA VALLEY COALFIELD



Histogram-V

Majri represent one and the same seam sporologically.

MIOFLORISTICS AND STRATIGRAPHY

The Lower Gondwana succession in Wardha Valley consists of three main formations. The lowest formation, Talchir, comprises boulder beds, green needle shales and sandstones followed by a thick series of fluvialite or lacustrine deposits of sandstones, shales and coal seams (Barakar). Barakar is the main coal bearing group. The sandstones of this group are mostly whitish grey in colour, loosely packed and feldspathic in nature. These are overlain by the Kamthi beds. It comprises sandstones, shales and clays. The sandstones are mostly red in colour. Coal seams occur only in Barakar Stage and occupy a very small area in comparison to Talchir and Kamthi beds.

The coal seams in 6 working collieries of Wardha Valley Coalfield contain miospore assemblage, where *Brevitriletes* is most prominent followed by *Scheuringipollenites* and *Horriditriletes*. Therefore, this assemblage forms the index spore assemblage for the Wardha Valley coals. The miofloral comparison provides sufficient data for the estimation of the stratigraphic position of these coal beds. The present mioflora is also separable from the Karharbari mioflora described by Kar (1973) from North Karanpura Coalfield in the absence of the Karharbari index assemblage dominated by the varitriletes group of miospores. The Lower Barakar assemblages described by Bharadwaj and Srivastava (Assemblage A, 1969 from Chirimiri Coalfield and Bisrampur Coalfield, Assemblage A, 1970) bear some similarities with the mioflora of Wardha Valley coals. These assemblages though comparable with the present mioflora due to the dominance of *Brevitriletes* and *Scheuringipollenites* in significant amounts, differ in the absence of *Microbaculispora* and *Microfoveolatispora*. Bharadwaj, Navale and Anand-Prakash (1974) have worked out the Barakar mioflora of PENCH-KANHAN Coalfield and have described a distinct miofloral zone in the Lower Barakar Stage. The mioflora of Wardha Valley Coalfield compares very closely with the younger assemblages E and F of the PENCH-KANHAN Coalfield. Thus, the present mioflora occupies a place

identical to the E and F assemblages of PENCH-KANHAN Coalfield, i.e. in the Lower Barakar Stage of the Lower Gondwana stratigraphy.

GENERAL DISCUSSION AND CONCLUSIONS

The petro-palynological investigation of some Wardha Valley coals has been undertaken with a view to determine the structure, the coal type based on the composition of organic and inorganic components and the stratigraphical value of the dispersed fossil spores and pollen grains.

The Archeans and the Pre-Cambrians (Vindhya) formed the basement for the deposition of Gondwana sediments which were deposited in shallow fresh water conditions in a slowly sinking basin. Initially the coal was deposited in the form of drifted vegetal matter, which was later buried under the sediments. This process involved various cycles and thereby formed the coal seams.

In Wardha Valley Coalfield the Lower Gondwana sediments are mostly developed around Chandrapur forming an anticlinal fold. The whole area appears as a trough between two parallel faults. The Vindhya occupy a large area in Yeotmal and Chandrapur districts. The important lithological units are limestones and shales. Talchirs are present in the central part of the coalfield. The coal is found in the Barakar Stage. Kamthis are very widely distributed and do not contain any coal seam. The rest of the area is occupied by alluvium and soils.

The coal samples from 5 working areas have been palynologically and petrologically studied. The miospore assemblage recovered from these coals has been placed in the Lower Barakar Stage. The mioflora consists of *Brevitriletes*, *Horriditriletes*, *Parasaccites*, *Scheuringipollenites*, *Ginkgocycadophytus* and *Pilasporites* as the dominant genera while *Cyclogranisporites*, *Lophotriletes*, *Microbaculispora*, *Striatites*, *Illinites*, *Vesicaspora*, *Ibisporites*, etc. are less significant in the assemblage. The Histogram-V prepared on the basis of palynological analysis provides the index spore assemblage for Wardha Valley coals for identification and correlation of seams. It is closely comparable

with the assemblages E and F of the youngest succession of Pench-Kanhan Coalfield (Bharadwaj, Navale and Anand-Prakash, 1974).

The petrological study of Wardha Valley coals has revealed the presence of vitrain, durain, clarain, fusain, megaspores, microspores and resin bodies as the main organic components of the coals. Durain is the most dominant coal lithotype in almost all the areas of the coalfield. Clarain and fusain are the next important lithotypes. Inertinite constituents are characteristic of the coal type. They occur in various degradational stages of fusinised tissues and resin bodies apart from completely disintegrated organic matter (macrinite and micrinite). The vitrinitised tissues occur as very thin layers. Vitrinite constituents exhibit intensive fragmentation. No structural details are found in vitrain bands.

The above diagnostic features of the Wardha coals are typical of the Barakar coal type (Pareek, 1967; Navale, 1971, 72) recognised in Mahanadi (Talcher and Ib-River coalfields), Godavari, Satpura and Wardha basins. The nature and composition of these coals are broadly comparable with each other (based on their genesis and formation). It may, therefore, be reasonable to presume that the conditions of vegetal depositions and coal formation were by and large similar in Mahanadi, Pench-Kanhan, Wardha and Godavari basins.

Regional variation in petrological composition of coals from basin to basin prevails due to local factors (physio-chemical conditions of the basins). In the present coals the petrological composition has shown a characteristic pattern of changes in the various organic microconstituents. A distinct variation in the microlithotype and maceral composition of the coals has been found between the northern and southern parts of the coalfield. The coals of northern side (Majri & Ghugus) are rich in inertinite constituents, whereas, the coals of southern side (Ballarpur) are rich in clarain contents. A transitional stage is found in the coals of the area present between them which shows intermediate petrological characters. Based on the present study 3 coal types have been suggested, i.e. coal type-A, B and C.

The petrological behaviour of these coals suggests variable coalification of the vegetal

matter in the basin. The gradual increase of vitrinite content towards the southern areas suggests that the basin was deeper in the south and shallow in the north. Similarly, the gradual increase of inertinite content towards north also supports the above possibility. This might have been the reason for more of fusinisation of the peat material caused by the shallow water conditions in the northern parts of the basin. Contrary to this, in the south the deeper water conditions during the formation of the peat has created favourable conditions for the jellification of the peat material resulting into the formation of vitrain. Sedimentary matter is widely distributed in these coals which show high ash content. The thickness of the coal seam is also more towards southern part of the coalfield. Therefore, the major coal reserves in the Wardha valley are present in the south eastern part of the coalfield. The conditions of coal formation were probably better towards the south and it may be suggested that this part of the basin may provide more promising area for present and future coal explorations.

The petrological composition of coal seams has particular bearing on coal preparation, identification and correlation of coal seams. Therefore, standard analysis based on broad groups of important coal constituents of Wardha Valley coals has been made for assessment and comparison purposes (Histogram-I, II). The analysis reveals high proportion of "inert" constituents and sedimentary matter in the northern part of the coalfield. These entities make the problem of coal preparation for utilization more difficult. Nevertheless an optimum product would probably emerge out by selective sampling and efficient "cleaning process",

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