A MICROSCOPIC STUDY OF SOME RANIGANJ COALS

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ABSTRACT

Coal samples from Poniati, Dishergarh, Samla, Narainkuri and Nega seams (top and bottom) from Raniganj Coalfield were examined microscopically to know the physical composition and nature of the coal seams. The study reveals that the coals are banded component types derived from heterogenous phyto-organic material. Lignogene (Vitrinite) constituents derived from lignified cell walls are conspicuous microcomponents of the coals. 'Liptogene (Liptinite) constituents derived from pollen and spore coat, plant cuticles and fusinised resins form secondary proportions in the coal composition.

The macerated coal consists of tracheids, cuticles, spores and pollen. About 20 genera were identified in conformity with the latest trends in spore morphography. The most frequently encountered spore genera in descending order are *Striatopiceites, Sulcatisporites, Striatopodocarpites, Horriditriletes, Cyclogranisporites, Thymospora, Leiotriletes* and other minor forms.

Major portion of organic constituents were probably derived from rich gymnospermous flora and the later coal-forming swamps were coalified mostly by Vitrinization process. It is apparent that during the formation of the peat the cell wall substances reacting to biochemical dissolution and decay were humified arresting the disintegration and the plant material became compacted initiating the Vitrinization.

INTRODUCTION

IN the face of existing variations in rank and type caused by differences in the composition of basic organic material and the metamorphic evolution, it has become essential that many lines of evidence should be utilized in order to appreciate the suitability of different coals. However, scientific information on these coals has previously been mainly restricted to chemical analysis and no previous work has been carried out on microscopic analysis. The present work aims at elucidating qualitatively and quantitatively the microscopic constituents (petrographic and palynological) of coals from the major seams mined at Raniganj Coalfield in order to provide a basis for comparison of the physical composition, nature and correlation with other seams in the coalfield.

GEOLOGICAL DETAILS

Raniganj Coalfield is one of the major coal producing areas now being worked in India. It lies in Damodar valley at the border of the states of W. Bengal and Bihar and belong to the L. Gondwana system. The succession of strata in this Coalfield as given by Mehta (1956) is as follows:

Lower Gondwana	Panchet Series	
	Damudda Series	Raniganj Stage Ironstone Shale Stage Barakar Stage
	Talchir Series	

Raniganj Coalfield from which the samples came lies in Raniganj Stage. It consists of fine sandstones, shales and coal seams. The sandstones are greyish in colour and the shales are limited. Coal seams are extensively developed.

The coal seam between Chinchuria and Hijalgora, known as the Poniati seam, is the oldest and one of the thickest seams of Raniganj Coalfield. Between Chinchuria and Shibpur (23°40′30″: 87°3′40″) the seam is about 4·8-5·4 metres thick and is only at places affected by mica peridotite intrusives. The Poniati seam is worked out at a number of places and continues within 90 foot horse-fault that delimits Barabani Colliery (23°44′45″ : 87°30′).

Dishergarh seam, doubtless of greatest importance, can be followed almost continuously from the north side of the Damodar river, east-north-eastward to Sitarampur, around and to the west of which the seam is worked extensively. Dishergarh seam is 4·8-5·4 m. thick in the west, sometimes 6·0 m. in total thickness, the seam thins out to about 3·6 m. near Sitarampur and 2·4 m. at Kanyapur and Chinchuria. The coal seam decreases rapidly in the east and near Nonia Khal it is only 1 m. in thickness. Further east the seam is delimited by south-westerly continuation of the fault.

The Samla seam crops out within the inclines of Samla Colliery to the south of Adjai river and is intercepted by an oblique cross-fault. The coal seam underlies the alluvium up to the north of Adjai river. Beneath the Adjai, further east the Samla seam crops-out in the south-easterly direction, but to the north of Gobindpur it again encroaches on the southern side to the river and continues up to the north of Konda and Natandanga village. The seam is almost uniform in occurrence ranging from 4·5-5·4 m.

Narainkuri seam crops out between Ardhagram (23°35′15″ : 87°4′50″) and Napur (23°35′5″: 87°8′25″) and is now being worked by Ardhagramkhas colliery. It is about 2·4-3·6 metres thick and has a northerly dip.

The coal seam between Majiara and Jameri (23°38′50″: 87°4′20″) is known as Nega seam. The seam splits into Top and Bottom Nega seams between Majiara and north of Mohishila. The top Nega seam is about 1-2 metres and bottom Nega seam is about 1·2-1·5 metres, with a parting of 15m. The split Nega seam again joins to form one thick seam near Mohantagram. The Nega seam in between Mohantagram and Jameri is about 5·48-6·1 metres thick.

MATERIAL AND METHODS

The material for the present investigation, sent from Central Fuel Research Institute, Dhanbad, for analysis, consists of 80 B.S. mesh size overall coal samples from Poniati, Dishergarh, Samla, Narainkuri and Nega seams worked at different collieries, the details of which are given in Table 1. The maceration of coal has been followed on the lines suggested by Bharadwaj (1962) and Bharadwaj and Salujha (1964). Petrological analysis has been done in incident light as described by Navale (1964).

TABLE 1

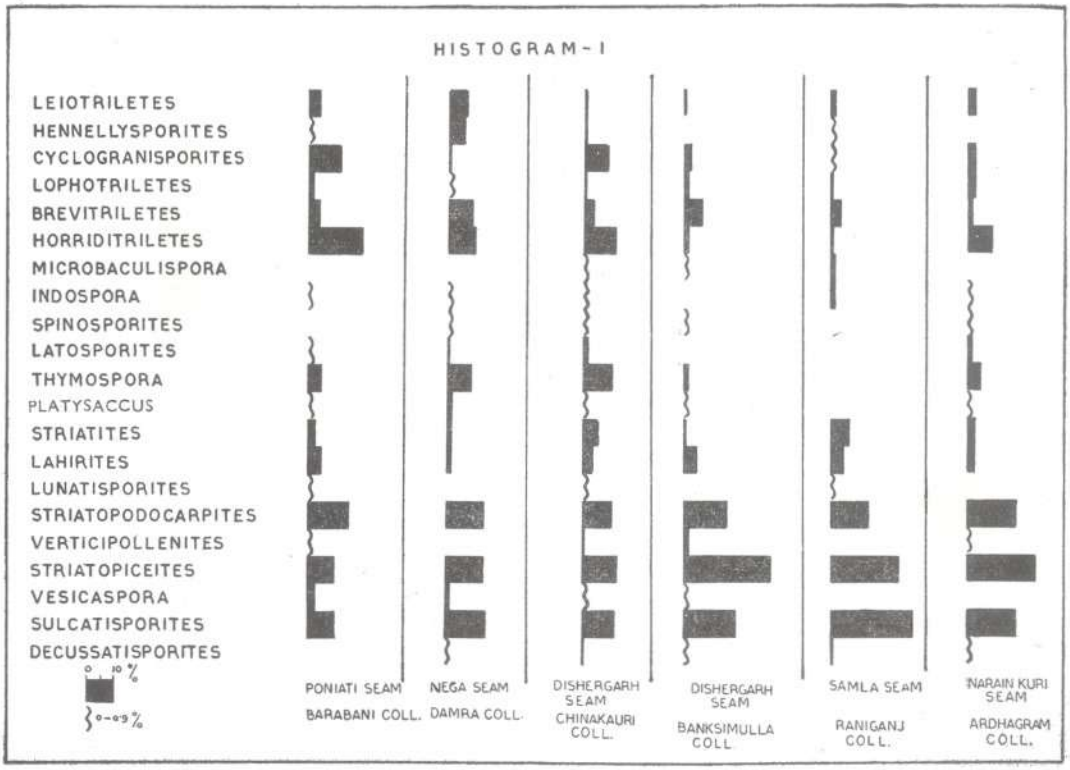
LAB. SAMPLE No.	COAL SAMPLE M. CH. OVERALL	LOCALITY
1	Poniati seam	Barabani colliery
2	Dishergarh seam	Chinakauri colliery
3	Dishergarh seam	Banksimulla colliery
4	Samla seam	Raniganj colliery
5	Nega seam	Damra colliery
6	Narainkuri seam	Ardhagramkas colliery

PETROGRAPHIC COMPOSITIONS

The organic and inorganic fractions of coal are composed of altered microcomponents of plant material and mineral matter. They are differentiated variously according to criteria of texture and composition by different system of coal petrology (Int. Lexique, 1963). In the present study, the material being disoriented coals as mentioned earlier, the texture could not be determined, and the terms that have textural implications have been avoided since they involve size limits. Hence, terms that have no size connotations for reporting physical composition of coals are preferred. Keeping in view the various phyto-organic substances incorporated in variable coalification process, the coals are composed of Lignogene and Liptogene suites of organic material (Spackman & Thompson, 1964). The former includes those constituents that are commonly formed through coalification of lignified cell walls (namely, Vitrinite, Fusinite, Micrinite constituents) and the latter are normally derived from waxy and resinous plant cell secretions.

Raniganj coal characteristically reveal banded microscopic components comprising Vitrinite, Fusinite and Liptinite group of constituents. The descriptive form banded component is preferred to emphasize the fact that these constituents occur as thin to thick usually distinctive lamina or bands (Pl. 1, Figs. 1-3).

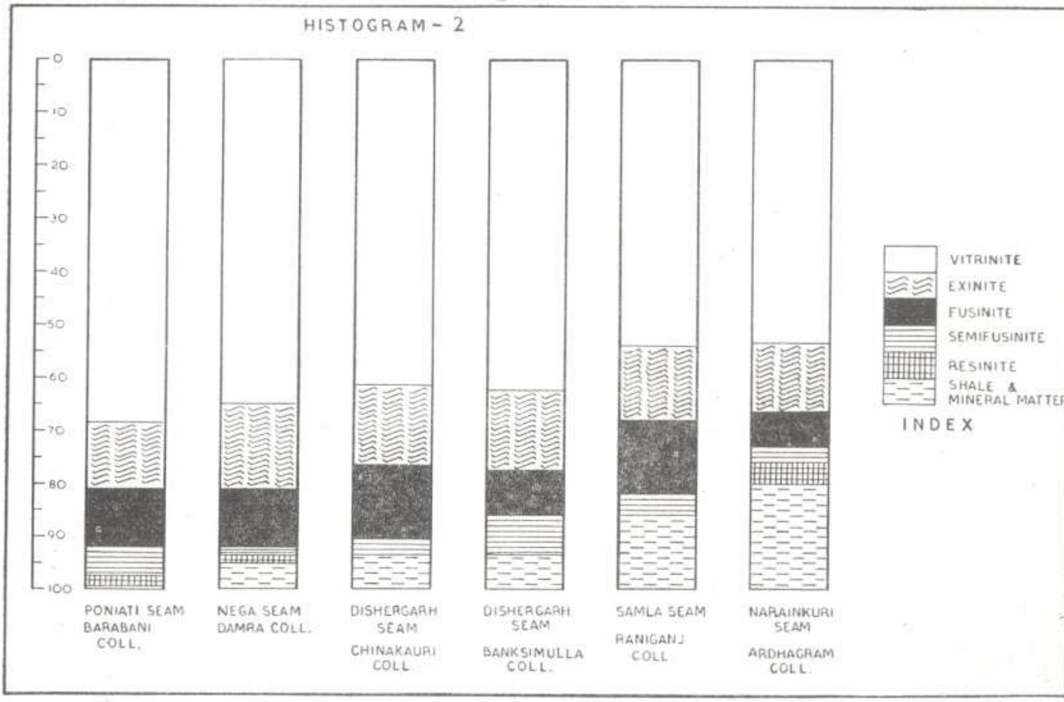
Vitrinite constituents— It is mainly derived from wood. Some shows evidence of cellular structure (Pl. 1, Figs. 4, 6). The fragmentary plant remains most often preserved are derived from parts of plant including stems, branches and bark. Commonly the tissues of these plant parts are described as woody but by strict botanical definition only xylem tissues of stems, roots constitute wood. Cortex and bark tissues of stem are not true wood yet are important source of Vitrinoid substances (Pl. 1, Fig. 5). Well preserved cellular structure may be compared directly with the structure of known wood (Pant, 1965). The surface lustre of vitrinoid substances may vary depending on the source material. The vitrinoids derived from wood, bark and other tissues reveal variable lustre, texture and fracture and these form characteristic feature of the component. The reflective property of vitrinoids which is related to lustre when



accurately measured with optical instrument can be used to define the degree of coalification, in other word ranks. No dettrital matter such as clay, silt or sand particle is incorporated in Vitrinite. The cracks are filled with mineral matter (Pl. 1, Figs. 1, 2; Pl. 2, Fig. 7). In addition to extraneous mineral substance the vitrinoid substances contain inorganic impurities. Vitrinite forms the chief maceral group in the assemblage of coal composition ranging from 53·6 to 68·6 per cent (Histogram 2). The critical examination of the Vitrinite series shows its origin from specific plant tissues as is quite apparent in coal sections and has distinctive qualities.

Liptinite constituents — Microscopic study reveals that these constituents are derived from metamorphosis of very finely divided plant remains such as (1) spores and pollen, (2) cuticular covering of stems, leaves, seeds and fruits, (3) secreted products of certain wood, bark and leaf tissues. The small size of these botanical constituents and their heterogenity in dull coal bands are of fundamental importance in the formation of coal. The original plant substances, spore exines were resistant to decay and hence preserved as attrital constituents when the woody plant debris of the peat was largely destroyed. The remains of spores and pollen are readily distinguished by their colour and structure (Pl. 2, Figs. 9, 12). Because of limited nature of cross-sectional view by sections they have been palynologically studied due to its importance in coal microscopy. Megaspore exines, many times larger than the microspores, are few and rare (Pl. 2, Fig. 11).

The reflectivity of spores gradually changes with the increase of rank. Cuticular remains are few, when complete they are readily distinguished from megaspores by serrated inner border and thin edges (Pl. 2, Fig. 7). Resinous substances of coal having round rod like irregular shaped are few to rare and they show fusinised nature (Pl. 2, Fig. 12). In general Liptinite constituents are secondary in importance in the composition of coals. The distribution of the maceral group range up to 16 per cent and relatively high percentage of microspores are associated with Vitrinite (Histogram-2).



Fusinite constituents — These constituents form one of the banded components of Raniganj coals but less important in quantitative analysis. Details of cellular structure of woody tissues are preserved in some Fusains (Pl. 2, Fig. 8) as in Vitrain. Many of the cellular cavities are filled with mineral substance. It occurs in thin layers interlaminated with Vitrinite and Liptinite consistently (Pl. 1, Fig. 3). Layered Fusinite constituents probably were formed in one place by fusinization process which results in a rapid mass of conversion of cell walls into carbon rich substance. Possibly smaller particles of fusinites were transported into peat swamp from outside sources. Critical microscopical study indicates that these constituents are progressively altered like other constituents. Often partly fusinised substances are seen (Pl. 1, Fig. 2) known as Semifusinite having faint colouration and some degree of relief. This recognizes that fusain that appears homogeneous may be gradational in fundamental composition. Many individual sheets representing former bark or wood tissues exhibit transition between the condition of Vitrain and Fusain. This group forms 9-14 per cent in the composition (Histogram-2).

Micrinite constituents — These fine grained and massive or amorphous inert organic material that lack definite cellular or woody structure which neither falls in the group Vitrinization or Fusinization of Lignogene suit are very meagre in the physical composition of Raniganj coals. They occur as granules less than few microns and disseminated throughout the coals (Pl. 2, Fig. 9). It may be inferred due to least amount of micrinization that disaggregation cell walls and production of granular residue is very low.

Mineral matter — Particles of clastic mineral matter finely disseminated interstitial to organic constituents through bright constituents and more abundantly in dull constituents (Pl. 2, Fig. 10) are generally seen in these coals. It is apparent that the ash content of seam differ due to varying percentage of mineral matter in the coals (Histogram 2). The nature and distribution of sedimentary minerals are important part of information useful in predicting the properties of coal.

PALYNOLOGICAL COMPOSITION

In coal, the most undestructible and longest lasting is the fine yellow pollen which has its own peculiar and characteristic size, shape and ornamentation for every species of plant. The yellow waxy protective covering remain almost undestructible unless temperature of rock in which they have been trapped is raised by proximity to molten magma. Because of their distinctive character and undestructible nature, spores have become most valuable asset in recognition of a particular seam. Identification of specific forms of microspores is not easy when they are observed in more or less limited way in cross-sectional view in polished section. However, they can be isolated from coal by maceration and may be studied by palynological methods. Such studies in the coals of Raniganj have been done by Ghosh and Sen (1948), Bharadwaj (1962), Bharadwaj and Salujha (1964, 1965a, b) and Salujha (1965) extensively. In the present study specific coal seam have been analysed in order to resolve the basic source material of the coals which form heterogenous composition already described in the earlier part and to establish index histogram for comparison with other coal seams for evaluation of properties.

MIOSPORE DISTRIBUTION

The mioflora of the Raniganj coals investigated consists of 21 genera (*sensu* Bharadwaj (1962), Bharadwaj and Salujha (1964) which are described as hereunder. The distribution of various genera in each seam has been graphically represented in Histogram 1.

Leiotriletes is a genus found consistently in all the seams and occurs on an average up to 2·2 per cent. It is represented only by a single species — *L. sp.*

Hennellysporites is rather poor in distribution and is represented by only one species viz. *H. diversiformis*. It is always found to occur in less than 1 per cent.

Cyclogranisporites is represented by *C. gondwanensis* only and forms 5·9 per cent of the total assemblage. In Poniati seam it has the highest representation (12·4 per cent).

Lophotriletes has been met with 2 species, viz.

L. rectus
L. minutus

L. rectus is rather more common than *L. minutus*. However, this genus is poorly represented and does not occur more than 1·9 per cent on an average.

Brevitriletes occurs in two species, viz.

B. communis
B. minutus

The average frequency of this genus is 5·6 per cent but in Nega seam it is present up to 10·2 per cent.

Horriditriletes occurs consistently in all the seams and has the average distribution of 9·1 per cent. In Poniati seam it rises up to 20 per cent. This genus is represented by *H. curvibaculosus* and *H. brevis*.

Microbaculispora is very poor (0·5 per cent) in occurrence and is represented by *M. tentula* only.

Indospora, like *Microbaculispora*, occurs scantily and is represented by only one species viz. *I. clara*. It constitutes only 0·6 per cent of the total assemblage.

Spinosporites occurs inconsistently with an average up to 0·8 per cent. The specimens of this genus were not sufficient so as to give them any specific designation.

Latosporites is represented by *L. colliensis* only and is present up to 1·3 per cent in the total assemblage.

Thymospora is present in the form of a single species, viz. *T. gondwanensis*. It has an average frequency of 5·7 per cent but in Nega seam and Dishergarh seam (Chinakauri colliery) it forms one of the sub-dominant groups.

Platysaccus is again inconsistent in occurrence as it forms only 0·9 per cent of the total assemblage. *P. papilionis* is the only species which has been identified in the present investigation.

Striatites has the average frequency up to 4·2 per cent and is represented by 4 species which are listed below:

S. communis
S. rhombicus
S. irregularis
S. indicus

Lahirites is represented by 3 species, viz.:

L. singularis
L. rarus
L. parvus

Amongst the above three species *L. singularis* and *L. parvus* are more common than the third one. The average frequency of this genus is 44%.

Lunatisporites is poor in occurrence and constitute only 0·3 per cent of the total assemblage. The species of this genus recorded here is *L. fuscus*.

Striatopodocarpites is one of the dominant components in the present assemblages. It has the average frequency up to 14·9 per cent and occurs almost homogeneously in all the seams. The species recorded in this genus are:

S. magnificus
S. decorus
S. venustus

Out of these *S. magnificus* occurs more commonly than the other two species.

Verticipollenites is a poorly represented genus and is met with 2 species, viz.

V. gibbosus
V. finitmus

The former species is more common in occurrence than *V. finitimus*. The genus represents only 0·8 per cent of the total assemblage.

Faunipollenites is rather abundant in all the seams studied and averages up to 20·5 per cent. It is represented by 4 species, viz.:

F. varius
F. copiosus
F. lateralis
F. sp.

F. varius and *F. copiosus* are more commonly found than the other two species.

Vesicaspora ovata is the only species identified in the present assemblage which has a poor representation up to 0·8 per cent.

Sulcatisporites has the average percentage of 17·4 per cent and forms a significant association with the rest of the dominant genera. Two species has been recorded here, viz.

S. maximus
S. tentulus

S. maximus is abundant as compared to the other species and forms the bulk of the total assemblage.

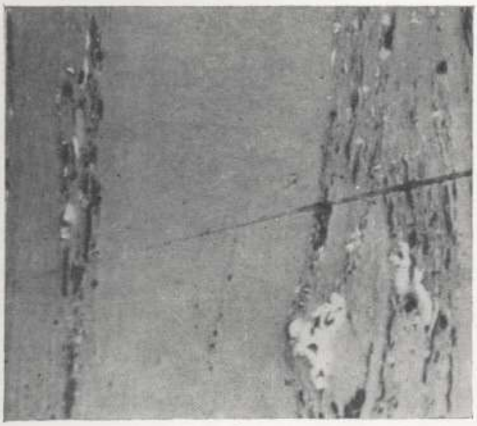
Decussatisporites is also one of the poorly represented miospores as it forms only 0·8 per cent of the total assemblage. The species of this genus could not be identified due to scarcity of the specimens.

The miofloristic aspect of the distribution not only characterizes bisaccate grains comparable to gymnospermous group as the basic plant material forming the coals but also signifies the diagnostic elements of Raniganj Stage. The association of the individual forms of different seams may be utilized for purpose of correlation of coal seams and their formation (Histogram 1).

GENESIS AND PHYSICAL PROPERTIES OF THE COALS

It is apparent from petro-palynological characteristics of the coals, that their origin is from diversified plant assemblage of trees and shrubs. The predominance of woody elements and their affinities, in the assemblage of physical constituents along with equally dominant disaccate pollen grains of exinite elements reveal a coal flora of evolving gymnospermous plant groups (Bharadwaj, 1962; Pant, 1965). It may be presumed from the abundance of Vitrinite constituents that most of the organic material have been diagenetically altered and during the formation of peat, cell wall substances reacting to biochemical dissolution and decay were humified. Further the plant material has become compacted arresting disintegration as revealed by limited fusinization and thus initiating the slow process of vitrinization. The generally distorted tissues and plastic adjustment of cell walls eliminating cell cavities and presence of interstitial tissue spaces were due to the pressure of the overburden. Tissues undergoing vitrinization shows progressive increase in the lustre (reflective property) with increasing metamorphic alteration. By many criteria, the coals are diagenetic in its inception although the major part of the process is actuated by metamorphism as the composition is changed over a long period of time. The other coalification processes namely Exinization, Fusinization and Micrinization are secondary in importance (as shown by their distribution in the composition) during the formation of Raniganj coals.

The general characteristics of the different seams as enunciated already is not only significant in the utilization but also the varying properties of the four constituent groups (Histogram 2) which when separated from different products. Natural sorting occurs from the moment of mining. This sorting is based on the fact that the four constituent groups are not equally tough. Vitrain and Fusain are brittle, Clarain and Durain are more resistant. The crushability of these constituents is in the ratio of Fusain 1: 8, Vitrain 3: 8, Clarain 5:1, Durain 13: 6. In consequence the degree of crushing is automatically a degree of sorting. The latter can be accomplished by screening. The different products may be used for different purposes. In order to provide the above data an analysis for different seams



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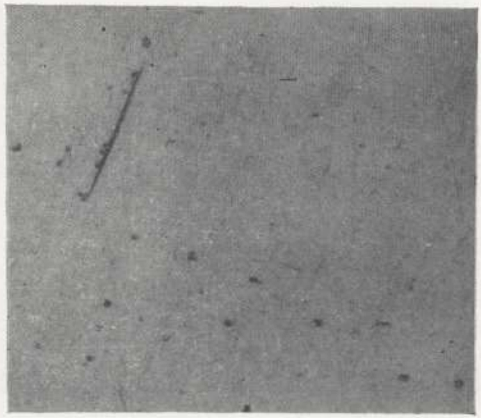

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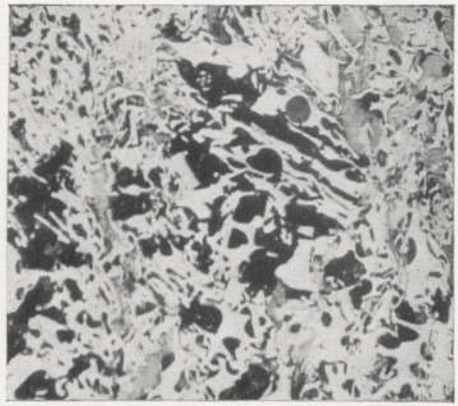

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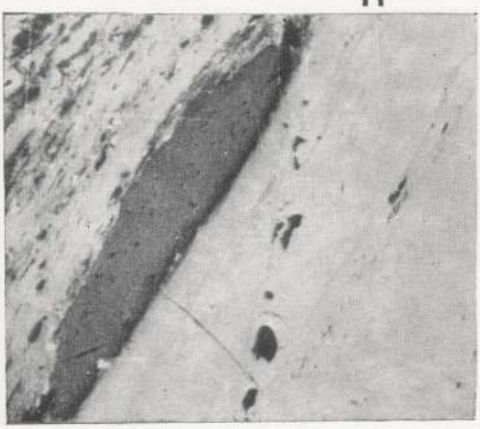

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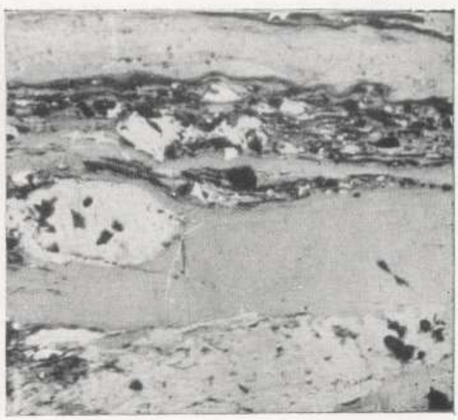

is made (Histogram 2) and this may serve as seam index to facilitate comparison of physical properties with other coal seams.

Recognition of characteristic spores and their affinities suggest particular type of flora which has formed the basic organic material and condition of deposition during the coal formation. Since mioflora is representative of source material of the seam, it constitutes genetical and most reliable basis for characterization of coals, it forms an important aspect in evaluating physical properties of coal. Present spore diagram (Histogram 1) helps in identification and correlation of the coal seams.

Generalizing, it may be concluded from the data that Poniati, Dishergarh and Samla seams are of better quality types while in other seams sedimentary minerals affect the quality of the coal.

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EXPLANATION OF PLATES

(All photomicrographs magnified 150 ×, Polished surface, Reflected light)

PLATE 1

1. A Durain showing Vitrinite associated with Liptinite and Micrinite, Dishergarh seam.
2. A banded Vitrinite associated with Fusinite, Liptinite and mineral matter.
3. A thin band of Fusinite associated with Liptinite and Vitrinite, Dishergarh seam.
4. A Vitrinized wood showing faint anatomical structures.
5. A Vitrinized bark tissue cut in various planes.
6. A Vitrinized wood showing distinct botanical structures.

PLATE 2

7. Vitrinite associated with cuticles arranged in the plane of stratification.
8. A woody Fusinite showing " Bogen-structure" and cavities filled with mineral matter.
9. A section of Durain showing Micrinites associated with Vitrinite and Liptinite.
10. A section of Durain from Nega seam showing mineral matter and Micrinite.
11. A section of megaspore associated with Vitrinite, Dishergarh seam.
12. A section of Durain showing Resinite, and Fusinite associated with Vitrinite.