THE PETROLOGY OF COALS OF THE
DALTONGANJ COALFIELD

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INTRODUCTION

The Daltonganj coalfield is situated in the Valleys of Koel and Amanat in the Palamau District of Bihar about eight miles due north of Daltonganj town. It is one of the three coalfields in the Palamau District, the other two being those of the Aurunga and Hutar.

The author visited this coalfield in December 1952 when he was directing the field work of his post-graduate students in that area. Representative specimens of coals were collected for an examination of their microscopic constituents and further collections were kindly made available later by the Manager of the Rajhara colliery. I am grateful to him for this act of kindness and also for supplying the bore-hole records and some information regarding the occurrence of coals in that colliery.

This study was undertaken firstly in order to examine the microscopic constituents of the Daltonganj coals and to establish their relationship, if
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any, with coals of the neighbouring coalfield of Hutar where similar studies were made at about the same time. Secondly, the Daltonganj coals showed some marked physical features which made them appear quite distinct from the Hutar coals as also from those of the Damodar Valley coalfields. There was no data available in the field which would offer a possible explanation for this distinction and it was felt that the microscopic study might furnish a possible clue to account for the different nature of these coals.

GEOLOGY OF THE AREA

This coalfield was first known as the Palamow coalfield but was changed to the Daltonganj coalfield by Hughes (1872).

The area enclosed by the Lower Gondwana formations is about 200 square miles. Of this the Barakar formations cover an area of about 30 square miles. The coal-bearing deposits are surrounded on all sides by the Talchir formations. According to Hughes (1872) and Ball (1881) the Talchirs are about 500 feet thick. The coal-bearing beds were assigned Karharbari age by Feistmantel (1883). The boundary of the coalfield is generally not well defined except on the north side, where there is a strong fault which brings the coal measures almost in contact with the crystalline rocks. With the exception of this main fault which is crossed by a secondary fault there are only small faults which have not effected the coal seams greatly. There are no younger formations except the intrusives in this field. The Aurunga and Hutar coalfields have Upper Gondwana formations also preserved but in the Daltonganj coalfield only the Talchir and Barakar series are present. Fox (1934, p. 32) observes: “This northern field has evidently been subject to far more denudation as only the Tatchir and Barakar (Karharbari) series are present.”

Hughes (1872) has mentioned two instances of ‘burnt outcrops’ of coal and carbonaceous matter in the northern part of the field. The associated shales have been converted into ‘a brick red rock’.

La Touche (1891) has recorded instances of two intrusions. One at Singra in the southern part of the field is a vertical dyke from 12 to 15 feet thick cutting across the coal seams from south-west to north-east, and the coal in its vicinity has been altered. The other is in the northern part of the field where the trap “occurs in two bosses or necks, probably connected with each other, the sandstones and shales surrounding them being burnt to a deep red colour.”

Coal Seams

The distribution of coal appears to be irregular and although two thick seams of any importance are found besides many thin seams, only one of
these is being worked at the moment. Ball and Simpson (1922) have ascertained the maximum thickness of this seam near Rajhara as 29 feet.

In the colliery at Rajhara two seams each of about 14 feet thickness have been proved. These are designated as the Top seam and the Bottom seam. The Top seam is restricted to a small area which has been worked completely, so that only the Bottom seam is being worked now and its thickness has remained more or less constant so far. The Bottom seam has been explored over an area of about 2 square miles. The dip of this seam is not constant. The average gradient is 1 in 15. There are indications of slight folding at some places. The physical characteristics of the coal of this seam do not remain constant.

The Manager of this colliery has kindly supplied details of two bore hole records. One was put down to a depth of 150 feet where the Bottom seam has been met with. Another was put down about 500 feet away from the first and a coal seam 14 feet thick was located at a depth of 42 feet. The strata above this seam comprise of yellow and brown sandy clay. This bore-hole goes down to a depth of 200 feet but no other important seam is located.

A section of No. 13 Pit of Rajhara colliery as kindly supplied by the Chief Mining Engineer, Bengal Coal Co. Ltd., appears in Figure 1.

In hand specimens these coals are distinctly of two varieties. One is laminated coal showing thick persistent bands of vitrain which may often split, and dull bands of durain. In the specimens examined the vitrain bands vary considerably in thickness. There are a few bands about 1 to 1.5 cm. thick and many thinner bands varying in thickness from 1 to .4 mm. Vitrain shows cleats and fractures and is bright to greasy in lustre with a conchoidal fracture. The dull bands appear dark grey to black and finely granular showing innumerable shining specks or granules uniformly dispersed in the bands. Here and there thin strips of vitrain may be seen in these bands. Fusain layers occur abundantly and strips of charred wood are exposed in large numbers if the coal is split along fusain layers.

The second variety differs from the type described above in the fact that it is generally non-laminated. There are a few thin bands of vitrain about 1 to 3 mm. thick, the major part of coal being formed of the dull variety of the same nature as described above. Fusain layers appear more numerous in this type of coal.

There appears a gradual transition of one variety into the other.
### Description of Strata

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*(After Bengal Coal Company, Ltd.)*

**Fig. 1. No. 13 pit. RAJHARA COLLIERY**
MICROSCOPICAL EXAMINATION

The microscopic examination was made on polished surfaces in reflected light under oil immersion. All attempts to obtain thin sections have met with no success. This is due to the fact that these coals are largely composed of high rank tissues of fusain and vitro-fusain and the durain seems to be devoid of any low rank constituents like spore exines, resins and low rank vitrinite. A noteworthy feature is the presence of fungal bodies in large numbers which have disintegrated and destroyed the woody tissues. Fusinised materials are very abundant and closely associated with the fungal bodies. Large patches in vitrain bands are filled with pyrite grains which are scattered abundantly in the durain also. The durains appear more compact and markedly different than those of the other Indian Lower Gondwana coals.

A detailed description of constituents in the different coal components follows.

(a) Fusain and Vitr-in-fusain

It is well known that these components of coal are largely composed of woody tissues. Their different modes of preservation are shown in Plate I, Figs. 1 to 6 and Plate II, Figs. 1, 2 and 3.

A transverse section showing wood fibres with empty cavities is shown in Plate I, Fig. 1. Some fibres show secondary thickenings of their walls. This is specially well seen in the top left-hand corner of this figure.

Plate I, Fig. 2 shows serially arranged secondary elements in wood with more or less rectangular cells slightly thickened at the corners. In the upper and lower sides this structure is seen to pass into a broken and crushed mass of cells produced on account of compression. Plate I, Fig. 4 shows that the bogen structure in the right-hand side is passing in the central part into fibres of wood cut longitudinally and folded at places due to effects of pressure. In the left-hand side bogen structure is again preserved. Typical thick-walled tracheids of wood cut transversely showing a considerable degree of scalariform thickening appear in Plate I, Fig. 3.

Two oval patches of fusain in a closely compressed durain band appear in Plate I, Fig. 5. The walls of these fibres are comparatively thinner and show scalariform thickenings here and there. This tissue has a higher reflectance as compared to that in Plate I, Fig. 3 and may have consequently undergone a greater degree of carbonization.

A tangential section of woody tissue in fusain is seen in Plate I, Fig. 6. It shows a band of closely compressed long tracheids with pits. Uniseriate
ray cells with thin walls are clearly seen in this tissue. The width of rays is equal to that of a single cell, and in height there are generally three rows of cells. A longitudinal section showing comparatively thick fibres with rows of bordered pits clearly preserved appears in Plate II, Fig. 1. The pits are distinctly seen in a fibre near the upper edge of this figure. Another band with considerably thickened fibres which have been partly decomposed by the action of fungal organisms is seen in Plate II, Fig. 2. Some of the decomposition product is seen in the top right-hand side.

A tissue in vitro-fusain showing bogen structure and passing into a structureless apparently uniform band on the left-hand side appears in Plate II, Fig. 3. It is clear that we are dealing here with one band as the cell walls are continuous and merge with the structureless part. It is rather difficult to explain how this phenomenon is brought about. The bogen structure is produced by increasing compression in a band of tissue in which the cell cavities were largely empty. It may be that we have here two metamorphic steps in the transformation of vitrain to fusain as shown by Seyler (1948).

(b) Vitrain

The components of vitrain do not generally reveal any structures in polished surfaces owing to the fact that the cell cavities are usually filled with a pale coal substance which has almost the same reflectance as that of the cell wall. A band of woody tissue in vitrain showing the cells slightly folded and filled with some coal substance appears in Plate II, Fig. 4. The reflectance of vitrain components is considerably lower than those of fusain and vitro-fusain materials with the result that vitrinite bands appear less bright. Owing to a slight difference in the reflectance of cell contents and those of the cell walls the structure has come out rather clearly. This picture confirms the observation that unlike fusain the vitrain tissues show cells which have their cavities filled and have yielded to pressure by having undergone a slight deformation. On the other hand vitro-fusain and fusain tissues have generally empty cell cavities and can resist the pressure to a considerable extent, but the cell walls usually break under strong compression producing bogen structures.

Inclusions of pyrite occur quite commonly in the bands of vitrain. A large cavity filled with small grains of pyrite appears in Plate II, Fig. 5.

Fungal bodies

A characteristic feature of the Rajhara coals is the presence of large numbers of fungal bodies in bands of wood in the different coal components. These fungal bodies are shown in Plate II, Fig. 6 and Plate III, Figs. 1 to 5.
They have produced considerable decay of woody material and are found associated with fusain in large numbers. Some of them are no doubt similar to those described in the Hutar coals (Ganju, 1955).

Plate II, Fig. 6 shows an oval fungal body resembling sclerotia. It has a carved outline and is embedded in a band of wood. A group of round and oval fungal bodies with a hard thick outer rim enclosing a mass of cellular tissue appears in Plate III, Fig. 1. They are seen to have produced a complete decomposition of the surrounding woody tissues.

A different form of a fungal body in a band of wood is seen in Plate III, Fig. 2. A long narrow body tapering at one end and rather blunt at the other end appears in Plate III, Fig. 3. It is associated with rounded and irregular bodies of probable fungal origin. Plate III, Fig. 4 shows the fungal bodies occurring in large numbers in a band of fusain which has been disintegrated and decomposed by the action of these organisms. This fact is seen perhaps more clearly in Plate III, Fig. 5 where a colony of round fungal bodies resembling sclerotia have produced a complete disintegration of a woody tissue in fusain. A part of an undecomposed woody band is seen near the upper edge.

A peculiar object having a carved outline and showing a thick-walled rim appears in Plate III, Fig. 6. The probable origin of this solitary object is difficult to explain till some more material of this nature is observed.

(c) Durain

The durain is compact and generally devoid of low rank tissues of vitrain, spore exines and resin bodies. The mineral matter appears to be scarcely present, but small grains of pyrite occur abundantly. All that is visible is a compact mass of highly carbonized, disintegrated and partly decomposed woody tissue closely associated with fungal bodies. This fact is clearly revealed in Plate III, Fig. 4. Plate III, Figs. 7 and 8 show two durains in which the action of fungal bodies is apparent. Figure 7 shows a broad band of wood with empty irregular cavities which have no doubt been produced as a result of decomposition. A noteworthy feature lies in the fact that this band shows a clear line of demarkation into two, one having a greater reflectance than the other. This phenomenon may again show that we are probably dealing with two distinct steps in the process of transformation of vitrain into fusain which was observed earlier in Plate II, Fig. 3. Figure 8 reveals that the decomposition has proceeded in round and oval patches presumably due to the action of fungal bodies like sclerotia. Nothing is seen of these organisms except some remnants observed in a patch in the lower part of the figure.
Causes of Carbonization

It is quite clear from the microscopical examination that the Daltonganj coals are composed mostly of highly carbonized materials associated with fungal bodies in large numbers. Increased carbonization in coals could possibly be brought about in three ways (Lewis, 1934; Stadnichenko, 1934):

1. Due to increasing metamorphism on account of deep seated horizontal thrust pressures or due to the depth of cover and the rise in temperature and pressure gradients associated with it.

2. On account of high temperatures produced from intrusive and igneous rocks. The effect is local and in this way natural coke is produced rather than a high rank coal.

3. Due to the activities of bacterial and fungal organisms. These produced rapid destructive changes and attacked all woody materials in the peat stage when the vegetation was rotting in the air or decaying under water.

Results of several proximate analyses of Daltonganj coals (Hughes, 1872; Ball, 1881; La Touche, 1891; Fox, 1934) show that they are very variable in composition and contain a high percentage of ash. They may be classed as low volatile bituminous coals with high ash contents.

Regarding the nature of rocks in the northern part of this coalfield Hughes (1872, p. 339) observes: “The rocks undulate very much and rise up often in swelling bosses, producing a repetition of beds and irregularity in their line of outcrops.”

La Touche (1891) has described two intrusions of igneous rocks in this coalfield. One of these is a vertical dyke about 12 to 15 feet thick which has cut across the coal seams and altered it in its neighbourhood; the other is a highly vesicular trap which occurs in two bosses or necks. This author observes: “Probably the greater disturbance of the coal measures east of Rajhara is due to the existence of these outbursts of trap and it is not unlikely that they are connected with dykes beneath the surface...”

It is, however, not probable that the carbonization was brought about due to the action of any igneous intrusions for the reason that dykes and sills are comparatively absent in the workings. An igneous intrusion produces a marked effect on coal in its neighbourhood. The coal loses its banding, its structure is destroyed and it is converted into coke. The change takes place abruptly and may be spread up to a distance of 15 feet or so from the contact, but further away the coal shows no visible signs of alteration. Marshall (1936) has described in detail the effects of igneous
dyke alteration of coal. He observes: "The evidence of the microscope indicates that the coal becomes plastic at a very early stage in the alteration and responds readily to distorting pressures. The alteration rapidly destroys the structure of the coal, and bubble cavities, veins and cracks appear in increasing numbers. The sole relicts of the original structure of the coal at this stage are fragments of fusain which survive unchanged the most severe conditions of alteration."

The present thickness of overburden above the bottom seam is less than 150 feet, but its original thickness was probably much greater at one time and a considerable load of overlying strata may have been removed when they were later tilted and subsequently denuded away. It is very likely, therefore, that the increased carbonization was brought about in part by an increase in temperature and pressure due to the thickness of overburden or due to effects of deep-seated horizontal thrust movements. Although there is no evidence of any extensive faulting in this coalfield, the boundary on the north side is marked by a strong fault and in addition there are many small faults.

Another possibility is that the fungal organisms and perhaps bacteria have played a substantial part in the carbonization of woody tissues in the peat stage producing a large proportion of fusain. In this connection reference may be made to the interesting work of Mackenzie Taylor (1927, 1928) who observes (1927, p. 499): "As peat can be decomposed by bacteria under an alkaline roof, and as vegetable material decomposed in such a situation yields a solid reduction residue with a fusain structure, the occurrence of a peat deposit containing fusain under an alkaline soil points to the conclusion that fusain is a decomposition product of peat under the alkaline anaerobic conditions imposed by a roof containing hydrolysing sodium-clay."

Regarding the action of fungi Moore (1947) observes: "The action always seems to result in a change from the production of oxygenated hydrocarbon compounds of the living plant to a breaking up of these into such simple compounds as the oxides of carbon."

The occurrence of fungal organisms in such large numbers in these coals and their close association with the decomposition products of the fusain materials makes it probable that the carbonization was in part brought about by the action of fungal bodies.

The nature of microscopic constituents of these coals is more or less similar to those of the Hutar coalfield. The woody tissues preserved as fusain and vitro-fusain and growth of similar types of fungal organisms is observed in the coals of both these coalfields. One point of distinction,
however, lies in the fact that the Daltonganj coals are highly carbonized and their tissues are greatly decomposed by fungal organisms. It is clear that in the nature and composition of their constituents the coals of the Daltonganj coalfield like those of the Hutar coalfield are markedly different from coals of the Damodar Valley coalfields. This fact may lead to the probable conclusion that the Daltonganj and Hutar coals were formed in nearby basins under nearly similar conditions.

**SUMMARY AND CONCLUSIONS**

The Daltonganj coalfield is one of the three coalfields in the Palamau District of Bihar. The Lower Gondwana formations include the Talchir and Barakar series. Two thick coal seams of some importance besides many thin seams are found. The distribution of coal appears to be irregular.

An examination of the representative specimens of coals from the Bottom seam in the Rajhara Colliery reveals that in their physical characteristics these coals are of two distinct varieties. One is a banded type showing thick persistent bands of vitrain with a bright to greasy lustre and a conchoidal fracture and dark grey to black and finely granular bands of durain. The other type is generally non-banded but may sometimes show a few thin bands of vitrain. Fusain layers showing charred strips of wood occur abundantly in both these varieties, but seem to be more numerous in the latter type.

An examination of microscopic constituents on polished surfaces has shown that these coals are largely formed of highly carbonized opaque constituents. The fusain and vitro-fusain tissues are composed of wood fibres often showing scalariform thickening and clearly preserved bordered pits. Uniseriate ray cells are observed in tangential sections. Due to the effects of compression the tissues have undergone folding and fracturing producing the characteristic bogen structure. The woody tissues in vitrain have the cell cavities filled with some coal substance and show considerably lower reflectance as compared to the constituents of fusain and vitro-fusain. Transition between vitro-fusain tissues showing typical bogen structure and those which are structureless is also noticed. Inclusions of pyrite occur abundantly in bands of vitrain.

Different forms of fungal bodies some of which almost certainly resemble sclerotia are present in large numbers. They have produced a large-scale decay of woody elements and are found generally associated with fusain materials.

The durain is compact and generally devoid of low rank tissues of vitrain, spore exines and resin bodies. Decomposition products produced
by fungal organisms are abundant. The mineral matter appears to be scarcely present, but small grains of pyrite occur abundantly.

It is likely that the high carbonization of different tissues in these coals was brought about in part by an increase in temperature and pressure due to the thickness of overburden, or due to the effects of deep-seated horizontal thrust movements and partly by the action of fungi and bacteria in the peat stage when the vegetation was rotting in the air or decaying under water.

In the nature of their microscopic constituents these coals are more or less similar to the Hutar coals but markedly different from those of the Damodar Valley coalfields. It is probable that the Daltonganj and Hutar coals were formed in neighbouring basins under similar conditions.

**ABSTRACT**

An examination of coals from the Bottom seam in the Rajhara Colliery has revealed that in their physical characteristics these coals are of two varieties. One is a typically banded coal and the other largely non-laminated. The vitrain bands are bright to greasy in lustre and the dull coal is dark grey to black in colour and finely granular.

The microscopic examination of polished sections reveals that these coals are generally composed of highly carbonized woody tissues preserved as fusain and vitro-fusain. The constituents of vitrain are also largely composed of woody elements showing their cell cavities filled with some coal substance. Folding and fracturing of tissues as a result of compression is evident. Inclusions of pyrite are fairly common in bands of vitrain.

Fungal bodies some of which resemble sclerotia are abundant and have produced a widespread decomposition of the tissues. They are found closely associated with fusain materials.

The durain is compact and appears to be generally devoid of low rank tissues, spore exines and resin bodies. Mineral matter is scarcely present.

It is likely that the high carbonization was brought about partly by metamorphism due to superincumbent load or due to deep-seated horizontal thrusts and partly due to the action of fungi and bacteria in the peat stage.

In their microscopic composition these coals resemble those of the Hutar coalfield and it is probable that similar conditions of deposition were prevailing in the two basins.
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.. “Base exchange and the formation of Coal,” ibid., 1928, 121, 789–90.

EXPLANATION OF PLATES

(All figures are from polished surfaces in reflected light under oil immersion)

PLATE I

Figs. 1–6. Fig. 1. A transverse section of wood fibres showing secondary thickenings clearly preserved in the top left-hand corner, ×100. Fig. 2. A group of serially arranged scalariform tracheids. In the upper and lower sides this structure passes into a crushed mass of cells formed probably on account of compression, ×220. Fig. 3. A transverse section of thick-walled tracheids of wood showing a considerable degree of scalariform thickening, ×220. Fig. 4. Thin fibres of woody tissue in fusain cut longitudinally and slightly folded are seen in the central part. This structure passes into bogen structure at the right-hand and left-hand sides, ×100. Fig. 5. Two oval patches of fusain showing transversely cut woody elements with scalariform thickening. The reflectance of this tissue is higher than that in Fig. 3 suggesting that it has undergone a greater degree of carbonization, ×100. Fig. 6. A tangential section of woody tissue in fusain showing closely compressed long tracheids with pits in the walls. Uniseriate thin-walled ray cells are conspicuous in this tissue. The rays are a single cell in width and generally three cells in height, ×220.
PLATE II

Figs. 1-6. Fig. 1. A longitudinal section of thick fibres showing rows of bordered pits. The fibre near the upper edge shows it very clearly, ×220. Fig. 2. A band of considerably thickened fibres showing that it is partly decomposed by the action of the fungal bodies. A part of the decomposition product is seen in the top right-hand side, ×100. Fig. 3. A transverse section of a band of vitro-fusain showing its typical bogen structure at the right-hand side and appearing structureless apparently uniform on the left-hand side, ×220. Fig. 4. A band of wood in vitrain showing that the cell cavities are filled with some coal substance. The cells have undergone slight deformation due to compression, ×220. Fig. 5. A large inclusion in a band of vitrain filled with closely packed small grains of pyrite, ×220. Fig. 6. An oval body with a carved outline resembling sclerotia, in a band of wood, ×220.

PLATE III

Figs. 1-8. Fig. 1. A group of oval and rounded fungal bodies showing a hard thick outer rim and a mass of cellular tissue inside. The surrounding tissue has been completely decomposed due to the action of these fungi, ×220. Fig. 2. Two fungal bodies in a partly decomposed band of wood, ×220. Fig. 3. A long narrow body tapering at one end and blunt at the other end is associated with rounded and irregular bodies of probable fungal origin. The surrounding tissue shows signs of decomposition, ×220. Fig. 4. A group of fungal bodies in a band of fusain which has been decomposed and disintegrated, ×100. Fig. 5. A colony of round fungal bodies resembling sclerotia which have produced a complete disintegration of a woody tissue in fusain, ×220. Fig. 6. An oval body with a carved outline and a thick-walled rim, in a compressed durain, ×220. Fig. 7. A durain showing a broad band of wood with irregular cavities produced due to fungal decomposition. Fragments of cells of fusain material are seen irregularly distributed. The band of wood shows a line of demarkation in two parts, one having a greater reflectance than the other, ×220. Fig. 8. A band of wood showing fungal decomposition in oval and rounded patches. In the lower part the patch shows some fungal remnants, ×220.