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BRANDSTOFNAVORSINGSINSTITUUT
VAN SUID-AFRIKA

FUEL RESEARCH INSTITUTE
OF SOUTH AFRICA

ONDERWERP:
SUBJECT: THE PETROGRAPHIC CHARACTERISTICS AND COKING PROPERTIES OF THE COAL SEAMS IN ZONES 4, 3 AND 2 FROM THE WATERPOORT AREA IN THE SOUTPANSBERG DISTRICT.

AFDELING:
DIVISION: CHEMISTRY

NAAM VAN AMPTENAAR:
NAME OF OFFICER: B. MOODIE AND F.H. KUNSTMANN

W.P.—39162—5/10/60.

FUEL RESEARCH INSTITUTE OF SOUTH AFRICA.

REPORT No. 14 OF 1963.

THE PETROGRAPHIC CHARACTERISTICS AND COKING PROPERTIES OF THE COAL SEAMS IN ZONES 4, 3 AND 2 FROM THE WATERPOORT AREA IN THE SOUTPANSBERG DISTRICT.

Introduction:

Towards the end of 1961 a series of 27 large diameter boreholes, giving 10" cores, were drilled on the farm Bergwater 123 in the Waterpoort Area of the Soutpansberg District.

The boreholes were drilled 100 feet apart in an East-West direction i.e. parallel to the strike of the coal-bearing formation. Thus the distance between the first and last borehole is just under half a mile.

The purpose of drilling these boreholes was to obtain large samples for washing and coking tests at the Institute's pilot plants in Pretoria West.

As the drilling progressed samples were taken of the coal seams occurring in the different zones in boreholes B.W.T. 1, 2, 3, 10, 11, 12, 25, 26 and 27. These samples representing coal seams from Zones 4, 3 and 2 were analysed to establish the petrographic characteristics and the coking properties of the coal of this coal-field and possibly to characterise the zones by these means. The results of the petrographic analysis and of the laboratory coking tests are discussed in this report.

Sampling of the coal cores.

Samples were taken from every coal seam intersected with the exception of a coal seam in Zone 4 of borehole B.W.T. 1 which was so interbanded with shale that sampling did not appear justifiable. In another instance (the bottom portion of Zone 3 in Borehole B.W.T. 2) only one sample was taken over 124 inches due to alternations of thin coal seams and carbonaceous bands.

The samples taken from boreholes B.W.T. 25, 26 and 27 were put under water immediately after sampling to avoid oxidation which could impair the laboratory coking properties.

After crushing the samples to -3/16" they were floated at 1.42 s.g. and all the analyses were carried out on the float

material ...../

material. The yields obtained are not an indication of the coal-shale ratio since all visible bands of shale and carbonaceous shale were excluded whenever possible during sampling operations. This procedure was followed because the main interest was centred in the petrographic constitution and the laboratory coking properties of the coal in particular. The yields obtained can therefore be regarded as being on the optimistic side.

In all, 126 seams were encountered and sampled but three relatively thin seams, two of which were encountered in borehole B.W.T. 2 and one in borehole B.W.T. 3 were not sampled since they occupied positions more or less half-way between the different zones and could not therefore be regarded as members of any particular coal zone.

Presentation of Results.

1. The petrographic analyses of all the coal seams sampled are recorded in Table 1.

2. The average petrographic analyses of all the combined coal seams occurring in the separate zones of all the boreholes are recorded in Table 2.

3. The average petrographic analyses of the combined coal seams occurring in Zones 4, 3 and 2 are recorded in Tables 3, 4 and 5, respectively.

4. The average petrographic analyses of the composites of the various zones and the average analysis of all the seams in the 3 zones are recorded in Table 6.

5. Data relating to the laboratory coking properties of the seams occurring in the different zones in boreholes B.W.T. 25, 26 and 27 are recorded in Table 7.

6. The average data relating to the laboratory coking properties of the composites of the various zones are recorded in Table 8.

7. A graphic representation of the distribution of the microlithotypes and macerals in the seams encountered as well as those in 5 Natal coking coals are presented in Diagrams 1 and 2.

8. A graphic representation of the petrographic constitution of the Soutpansberg coals and of 5 Natal coking coals are presented in Diagram 3.

9. Borehole sections showing the positions of the

seams intersected are represented in Figure 1.

Discussion of Results:

In a previous report* on the petrographic characteristics of the coal from 2 boreholes drilled in the Waterpoort area on the farms Sulphur Springs 1029 and Sterkstroom 15 it was stated that the coal contains a high proportion of vitrite and that none of the coking coal reserves in the Republic (with the possible exception of Waterberg of which very little is known) contain coal approaching that of the Soutpansberg in petrographic constitution and coking properties. This report was based on a number of samples not specially prepared for petrographical analysis but consisting of -16 mesh B.S.S. coal prepared for analytical purposes.

Since the samples of the coal seams from the number of boreholes covered by the present report have been prepared specifically for petrographical analysis a more accurate evaluation has been possible. However, the general conclusions reached at that time have been verified in all respects.

The general petrographic characteristics of the coal:

A study of the occurrence of the vitrite (i.e. the free vitrinite) in the seams analysed indicates that none of the coal seams contained less than 30% of this microlithotype. In some seams vitrite constituted as much as 90% of the bulk of the coal. Normally, however, it is between 50 and 60 per cent of the bulk. On the other hand, it was found that the vitrite in the 5 best known Natal coking coals constituted only from 10 to 40% of the bulk of the coal.

None of the Soutpansberg coal seams contained more than 20% vitrinertite. Only 10% of the seams examined contained between 10 and 20% of this microlithotype while 52% of the seams contained between 5 and 10% vitrinertite. In the case of the Natal coking coals, none contained less than 20% vitrinertite while 60% of the seams contained between 30 and 40 per cent.

The occurrence of the other microlithotypes viz. clarite, intermediate material (claro-durite and duro-clarite), fusite and carbonaceous shale of the Soutpansberg and Natal coking coals is very similar.

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* Report No. 20 of 1960.

The occurrence of the microlithotypes and the macerals are presented diagrammatically in Diagrams 1 and 2 where the differences between the Soutpansberg coal and the coking coals from Natal are illustrated.

In Diagram 3 the average petrographical analysis of the Natal coking coals is superimposed on the average petrographical analysis calculated for all the Soutpansberg coals.

The predominance of the fusible constituents - i.e. the macerals vitrinite and exinite - in the Soutpansberg coals give rise to exceptionally high ratios of active to inert constituents and a few cases have been recorded where the ratios were over 40:1. The highest ratio recorded was 66:1 (a seam of 7" thickness in borehole B.W.T. 1). The average ratio of active to inert constituents calculated for all the seams amounted to 15:1 in comparison with the average ratio for Natal coking coals which is roughly 2:1.

Although the exceptionally high ratios of active to inert constituents in the Soutpansberg coals may appear to be very significant at first, it also indicates one great shortcoming in the coal as a primary source of coking raw material namely the absence of inert matter in the coal. Experience has shown that when high volatile coking coals (especially when the ratio of active to inert constituents is high) are carbonised, excessive frothing in the coke mass during the plastic stage invariably results in a porous coke having very thin cell walls and very large pores, the strength of the coke being impaired thereby.

The value of inert material in the coal is perhaps best illustrated in the Natal coking coals where ostensibly low ratios of active to inert constituents, according to European standards, still yield a strong coke on carbonisation. In fact, with the Natal coking coals the position is often reversed namely that there may not always be sufficient fusible constituents to wet or to bind the infusible particles.

It would appear that the coals from Soutpansberg can best be utilised as additives to the existing coking coals in order to augment the active constituents required for bonding the inerts already present in the coals.

<u>The variation of the coal seams in the zones.</u>

The analyses of the coal seams recorded in Table 1 show that the values are very constant. This fact is even

more ...../

more evident if the average analytical figures obtained for each zone are studied. These figures are recorded in Tables 2 to 5 at the end of this report. Table 2 gives all the relevent data in connection with the seam averages but in Tables 3 to 5 the average data are given for each of the zones separately

From the data recorded in Table 2 it can be noted that the only appreciable variation in petrographic constitution occurred in borehole B.W.T. 1 where the difference in average analyses between the seams of Zone 4 and Zone 2 amounts to 12.6 per cent for the vitrinite. In the rest of the boreholes there is very little difference in the vitrinite content between the coal seams occuring in Zones 4, 3 and 2.

Inspection of Table 6, where the average petrographic analyses of the coal seams occurring in each zone as well as that of the coal from all the seams are recorded reveals that the average petrographic analyses obtained for the zones are practically identical.

The following is a summary of the variability of the microlithotypes and macerals in the coal for Zones 4, 3 and 2 based on the average values:

	Maximum	Minimum	Difference
Vitrite (%)	57.4	57.0	0.4
Clarite (%)	7.6	6.3	1.3
Vitrinertite (%)	8.3	5.2	3.1
Intermediate Mat. (%)	27.9	25.4	2.5
Fusite (%)	1.1	0.8	0.3
Carb. shale (%)	1.7	1.5	0.2
Vitrinite (%)	88.5	88.1	0.4
Exinite (%)	5.9	4.8	1.1
Inertinite (%)	3.9	3.2	0.7
Visible Minerals (%)	2.8	2.6	0.2

The differences recorded in the third column are all within the experimental error of the determination. Thus (!!!) from a petrographic point of view there is no difference in constitution between the coals of the different zones, a fact which should be advantageous when mining the coal.

<u>The coking properties of the Soutpansberg coals, as determined in the Laboratory:</u>

The coal samples originating from boreholes B.W.T. 25, 26 and 27 were put under water immediately after sampling

(!!!) as so many figures were averaged, I should say the differences exceeding 1% are significant in quantity, but do not really have much practical significance

in ...../

in the field to avoid any possible oxidation.

The initial softening and resolidification temperatures were determined in the "Brabender Plastograph" and the plastic range was calculated from these figures. The degree of fluidity (Max.div./min.) was determined in the Gieseler-type plastometer.

Composite samples were prepared for each zone from each borehole and another composite sample was prepared for each of the zones in the three boreholes. These results are recorded in Table 7 and Table 8.

If the results in Table 7 are compared, appreciable variations can be noted in the fluidity figures only. Thus the figure for the maximum fluidity (max.div./min.) of the coal in Zone 4 in borehole B.W.T. 25 is much higher than that of the same zone in boreholes B.W.T. 26 and B.W.T. 27, and this could leave the impression that appreciable differences in the coking ability exist. In this connection, however, it has to be stated that the unit usually employed to describe the fluidity (max.div./min.) is somewhat misleading. According to experience a more realistic picture of these differences is obtained by comparing the logarithms of these values (see last column of tables 7 and 8) rather than the values as such. Considering this fact, the results of Table 7 indicate that there are no marked differences in the coking capacity of the samples.

This impression is even more striking when the results on the composites of the seams comprising the separate zones are studied (Table 8). The variations in the results are so small, that the conclusion can be drawn that there is no difference in the coking quality of the coal of the three seams, at least as judged by these laboratory tests.

Conclusion:

The petrographic analyses and laboratory coking tests carried out on the coal seams from Zones 4, 3 and 2 of the Soutpansberg coal-field confirm that the coal has not only a remarkable petrographic constitution but that it also has very potent coking properties.

Furthermore, that from a petrographical and coking point of view the coal seams in the different zones can, for practical purposes, be regarded as being similar.

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AND F.H. KUNSTMAN
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18th September, 1963.

TABLE 1 (Continued).

PETROGRAPHIC ANALYSES OF THE COAL SEAMS ON THE FARM BERGWATER 123 - SOUTPANSBERG DISTRICT.

Sample No.	Borehole No.	Zone No.	Thickness Sampled (Ins.)	% Yield at 1.42 s.g. (-3/16")	Microlithotype Analysis						Maceral Analysis				
					Vt. %	Cl. %	V.I. %	I.M. %	Fu. %	C.S. %	Vn. %	Ex. %	In. %	V.M. %	Ratio of Active to Inert Const.
62/581A	B.W.T.27	4	14	46.3	57.8	5.0	12.9	19.3	0.7	4.3	88.6	3.8	1.3	6.3	12.2:1
B		4	18	35.9	52.1	3.5	9.4	32.7	0.0	2.3	86.3	6.3	4.0	3.4	12.5:1
C		4	12½	47.8	67.7	4.7	4.1	20.0	0.6	2.9	91.1	4.5	2.2	2.2	21.7:1
D		4	19	33.3	49.7	10.6	9.3	29.2	0.6	0.6	83.1	9.9	3.5	3.5	13.3:1
E		4	36	48.3	69.1	3.9	6.4	19.6	0.0	1.0	91.0	3.0	2.5	3.5	15.7:1
F		3	15	28.6	56.8	8.3	5.9	27.8	0.6	0.6	86.0	5.5	5.0	3.5	10.8:1
G		3	23½	48.7	75.0	5.6	4.4	12.5	0.0	2.5	90.4	4.5	1.9	3.2	18.6:1
H		3	9½	27.3	51.2	6.0	8.0	32.3	1.5	1.0	85.3	6.6	5.1	3.0	11.3:1
I		3	40½	49.6	57.6	7.0	8.2	21.5	0.6	5.1	81.4	9.3	4.0	5.3	9.8:1
J		3	9	61.3	51.9	2.5	10.6	33.1	0.6	1.3	82.2	5.7	8.3	3.8	7.3:1
K		3	32	41.2	62.6	4.8	2.7	27.8	0.0	2.1	89.7	4.6	1.7	4.0	16.5:1
L		3	24	51.5	54.7	4.9	8.4	28.9	1.8	1.3	83.7	6.1	7.1	3.1	8.8:1
M		3	6	57.0	40.0	12.0	6.3	37.1	1.7	2.9	74.4	12.5	7.4	5.7	6.6:1
N		2	24½	49.4	53.1	7.2	6.7	29.9	0.5	2.6	83.0	8.8	4.7	3.5	11.2:1
O		2	19	60.2	42.4	2.3	14.7	35.0	2.8	2.8	87.5	5.1	3.4	4.0	12.5:1
P		2	43	46.6	57.1	5.1	8.3	24.9	2.3	2.3	85.7	7.4	2.8	4.1	13.5:1

TABLE 3.

THE AVERAGE PETROGRAPHIC ANALYSES OF THE COAL SEAMS OCCURING IN ZONE 4.

Borehole	B.W.T. 1	B.W.T. 2	B.W.T. 3	B.W.T. 10	B.W.T. 11	B.W.T. 12	B.W.T. 25	B.W.T. 26	B.W.T. 27
No. of Seams in Zone	6	3	5	4	5	3	3	6	5
Thickness of Coal(In.)	90	101	92½	93	103	74	100	106	99½
Microlithotype Anal.									
Vitrite (%)	58.6	51.3	47.9	53.2	54.4	57.1	65.4	63.8	60.7
Clarite (%)	10.8	13.4	11.4	7.8	5.7	4.3	3.2	5.8	5.4
Vitrinertite (%)	3.0	6.9	3.7	5.2	3.9	4.7	6.7	4.4	8.1
Interm. Mat (%)	25.8	26.3	33.6	31.6	33.8	31.0	22.8	23.4	23.8
Fusite (%)	0.5	0.7	1.7	0.5	1.0	1.3	0.4	0.6	0.3
Carb. shale (%)	1.3	1.4	1.7	1.7	1.2	1.6	1.5	2.0	1.7
Maceral Anal.									
Vitrinite (%)	87.3	89.3	85.4	87.5	89.5	90.1	90.0	87.9	88.3
Exinite (%)	6.2	5.6	6.6	6.3	5.9	6.2	5.1	5.8	5.2
Inertinite (%)	5.2	3.6	4.8	2.7	2.2	1.5	2.4	3.1	2.8
Visible Minerals (%)	1.3	1.5	3.2	3.5	2.4	2.2	2.5	3.2	3.7
Ratio Active: Inert Const.	14.4:1	18.6:1	11.5:1	15.7:1	20.7:1	26.0:1	19.4:1	14.9:1	14.4:1

TABLE 4.

AVERAGE PETROGRAPHIC ANALYSES OF THE COAL SEAMS OCCURING IN ZONE 3.

Borehole	B.W.T. 1	B.W.T. 2	B.W.T. 3	B.W.T. 10	B.W.T. 11	B.W.T. 12	B.W.T. 25	B.W.T. 26	B.W.T. 27
No. of Seams in Zone	11	3	6	6	7	6	5	6	8
Thickness of Coal (In.)	200½	169	222½	189½	205	164	152½	140	159½
Microlithotype Anal.									
Vitrite (%)	59.0	77.2	49.3	55.1	47.7	53.6	56.8	66.0	59.3
Clarite (%)	7.2	7.2	8.3	8.3	10.4	6.0	7.1	7.2	6.0
Vitrinertite (%)	6.8	4.0	6.5	5.2	5.3	5.9	6.5	4.5	6.4
Intermediate Mat. (%)	24.5	9.1	33.5	28.8	33.3	31.9	27.4	20.0	25.0
Fusite (%)	0.9	0.5	0.5	1.3	1.5	1.1	1.1	1.3	0.7
Carb. shale (%)	1.6	2.0	1.9	1.3	1.8	1.5	1.1	1.0	2.6
Maceral Anal.									
Vitrinite (%)	90.0	93.8	86.5	88.2	85.4	86.4	88.0	90.1	85.2
Exinite (%)	4.0	2.6	6.6	5.8	7.5	6.1	6.3	4.8	6.6
Inertinite (%)	3.2	0.9	2.9	3.9	4.2	5.7	3.4	2.8	4.2
Visible Minerals (%)	2.8	2.7	4.0	2.1	2.9	1.8	2.3	2.3	4.0
Ratio Active: Inert Const.	15.7:1	26.8:1	13.5:1	15.7:1	13.1:1	12.3:1	16.5:1	18.6:1	11.2:1

TABLE 5.

AVERAGE PETROGRAPHIC ANALYSES OF THE COAL SEAMS OCCURING IN ZONE 2.

Borehole	B.W.T. 1	B.W.T. 2	B.W.T. 3	B.W.T. 10	B.W.T. 11	B.W.T. 12	B.W.T. 25	B.W.T. 26	B.W.T. 27
No. of Seams in Zone	2	2	2	2	3	3	3	5	3
Thickness of coal (In.)	63	76	35	66	99	84	85	145	86½
Microlithotype Anal.									
Vitrite (%)	70.9	51.3	43.0	63.6	53.2	60.1	55.2	60.3	52.7
Clarite (%)	6.3	9.2	7.0	3.9	8.0	6.8	7.9	4.0	5.1
Vitrinertite (%)	5.1	8.0	11.4	6.9	6.9	4.1	10.2	11.3	9.3
Intermediate Mat (%)	15.9	28.4	33.9	25.1	30.1	25.7	24.5	21.8	28.5
Fusite (%)	0.2	0.8	2.1	0.1	0.9	1.8	0.8	1.4	1.9
Carb. shale (%)	1.6	2.3	2.6	0.4	0.9	1.5	1.4	1.2	2.5
Maceral Anal.									
Vitrinite (%)	93.9	86.8	85.8	91.3	87.4	88.4	88.0	88.8	85.3
Exinite (%)	2.1	5.1	5.5	4.0	6.2	4.9	5.2	3.5	7.3
Inertinite (%)	1.0	3.0	5.9	2.8	4.7	4.2	4.3	5.1	3.5
Visible Minerals (%)	3.0	5.1	2.8	1.9	1.7	2.5	2.5	2.6	3.9
Ratio Active: Inert Const.	24.0:1	11.3:1	10.5:1	20.3:1	14.6:1	13.9:1	13.7:1	12.0:1	12.5:1

TABLE 6.

THE AVERAGE PETROGRAPHIC ANALYSES OF THE COAL SEAMS OCCURING IN EACH ZONE AND THE AVERAGE PETROGRAPHIC ANALYSES OF ALL THE SEAMS.

Average analyses of:	Zone 4	Zone 3	Zone 2	All Seams
No. of Seams Considered	40	58	25	123
Microlithotype Anal.				
Vitrite (%)	57.0	57.4	57.4	57.3
Clarite (%)	7.5	7.6	6.3	7.3
Vitrinertite (%)	5.2	5.9	8.3	6.2
Intermediate Mat. (%)	27.9	26.4	25.4	26.6
Fusite (%)	0.8	1.0	1.1	1.0
Carb. shale (%)	1.6	1.7	1.5	1.6
Maceral Anal.				
Vitrinite (%)	88.3	88.1	88.5	88.2
Exinite (%)	5.9	5.6	4.8	5.5
Inertinite (%)	3.2	3.5	3.9	3.5
Visible Minerals (%)	2.6	2.8	2.8	2.8
Ratio Active: Inert Const.	16.2:1	14.9:1	13.9:1	14.9:1

TABLE 7.

COKING PROPERTIES OF SOUTPANSBERG CORE-SAMPLES FROM FARM BERGWATER.

	Sw. No.	Roga Index	Con-traction %	Dila-tation %	Dilat. Amplit. %	Init. Soft. T. °C	Resolid. Temp. °C	Plast. Range °C	Max. Div./min.	Log. Max.D./m.
Sample: 62/579; Borehole: B.W.T. 25										
A-C Zone 4	7½	82.1	26	179	205	388	458	70	5200	3.72
D-H Zone 3	8	80.1	30	178	208	390	454	64	3400	3.53
I-K Zone 2	8	82.3	30	167	197	391	456	65	3300	3.52
Sample: 62/580; Borehole: B.W.T. 26										
A-F Zone 4	7-7½	83.4	29	169	198	389	459	70	3300	3.52
G-L Zone 3	8	81.9	29	175	204	387	457	70	3000	3.48
M-Q Zone 2	8	81.1	30	189	219	390	457	67	3700	3.57
Sample: 62/581; Borehole: B.W.T. 27										
A-E Zone 4	6½	83.7	30	181	211	386	452	66	4000	3.60
F-M Zone 3	8	78.3	28	166	194	391	458	67	5400	3.73
N-P Zone 2	8	82.5	30	162	192	395	461	66	4800	3.68

TABLE 8.

RESULTS ON THE COMPOSITE SEAMS COMPRISING EACH ZONE.

Samples: 62/579 - 581; Boreholes B.W.T. 25 - 27.

	Sw. No.	Roga Index	Con-traction %	Dila-tation %	Dilat. Amplit. %	Init. Soft. T. °C	Resolid. Temp. °C	Plast. Range °C	Max. Div./min.	Log. Max.D./m.
Zone 4	7½	81.0	28	172	200	384	453	69	3400	3.53
Zone 3	8	81.4	31	170	201	390	459	69	3300	3.52
Zone 2	8	80.3	27	178	205	393	458	65	3400	3.53

TABLE 1.

PETROGRAPHIC ANALYSES OF THE COAL SEAMS ON THE FARM BERGWATER 123 - SOUTPANSBERG DISTRICT.

Sample No.	Borehole No.	Zone No.	Thickness Sampled (Ins.)	% Yield at 1.42 s.g. (-3/16")	Microlithotype Analysis						Maceral Analysis				
					Vt. %	Cl. %	V.I. %	I.M. %	Fu. %	C.S. %	Vn. %	Ex. %	In. %	V.M. %	Ratio of Active to Inert Const.
62/177A	B.W.T. 1	4	9	38.4	65.0	5.5	3.3	24.0	1.0	1.0	89.5	3.5	6.5	0.5	13.3:1
B		4	10	62.4	72.5	6.6	1.9	17.8	0.4	0.8	91.8	3.3	3.3	1.6	19.4:1
C		4	20	40.7	56.1	12.6	3.5	26.8	0.5	0.5	85.9	7.1	6.1	0.9	13.3:1
D		4	7	43.9	55.9	9.8	2.7	30.8	0.4	0.4	83.1	10.5	5.0	1.4	14.6:1
E		4	11	62.6	41.6	15.2	2.8	38.2	0.0	2.2	82.7	10.5	4.7	2.1	13.7:1
F		4	33	34.3	60.2	11.2	3.1	23.0	0.5	2.0	88.5	5.0	5.0	1.5	14.4:1
G		3	10	32.9	44.2	13.2	3.0	38.3	0.0	1.3	85.7	7.4	4.3	2.6	13.5:1
H		3	24	46.5	78.8	0.5	4.9	15.3	0.0	0.5	89.7	3.6	5.2	1.5	13.9:1
I		3	20	68.3	55.1	8.0	7.4	27.8	1.1	0.6	90.4	2.8	4.5	2.3	13.7:1
J		3	21	46.6	53.8	15.4	3.2	23.9	2.1	1.6	89.1	5.7	2.8	2.4	18.2:1
K		3	8	47.8	50.0	13.5	7.3	27.1	1.6	0.5	88.5	5.5	5.0	1.0	15.7:1
L		3	7	46.4	76.8	6.2	1.8	13.4	0.0	1.8	96.5	2.0	0.5	1.0	65.7:1
M		3	31	49.3	62.8	6.5	3.3	25.6	0.9	0.9	93.5	3.5	0.4	2.6	32.3:1
N		3	29	51.4	43.2	9.6	11.9	31.2	0.0	4.1	89.8	5.6	0.9	3.7	20.7:1
O		3	23½	41.8	60.8	5.1	9.2	21.9	1.0	2.0	89.7	2.3	4.0	4.0	11.5:1
P		3	16½	27.2	63.9	5.6	7.5	20.2	0.5	2.3	87.4	4.5	4.5	3.6	11.3:1
Q		3	20½	45.4	52.5	5.3	8.0	30.5	2.1	1.6	86.6	4.3	5.9	3.2	10.0:1
R		2	10	40.5	61.4	6.3	8.7	20.2	1.0	2.4	90.5	3.8	1.4	4.3	16:5:1
S		2	53	37.4	72.7	6.3	4.4	15.1	0.0	1.5	94.6	1.8	0.9	2.7	26.8:1

62/178A	B.W.T. 2	4	41½	25.3	53.6	11.1	9.6	23.7	1.0	1.0	90.7	4.1	5.1	2.1	[illegible]
B		4	30	63.4	45.0	19.6	3.8	29.7	0.0	1.9	85.4	8.0	5.2	1.4	14.2:1
C		4	29½	46.4	54.9	10.2	6.2	26.5	0.9	1.3	91.4	5.1	2.7	0.8	27.6:1
D			7	36.6	60.3	5.0	3.0	27.7	1.0	3.0	84.5	5.0	7.2	3.3	8.5:1
E		3	20	49.5	72.6	11.4	2.3	13.1	0.6	0.0	91.3	6.7	0.5	1.5	49.0:1
F		3	25	43.6	40.8	26.9	1.6	27.5	2.7	0.5	88.9	7.0	2.9	1.2	23.4:1
G		3	124	19.0	85.4	2.6	4.7	4.7	0.0	2.6	95.2	1.1	0.5	3.2	26.0:1
H			8	35.5	50.8	13.1	4.4	29.0	0.5	2.2	88.7	7.4	0.9	3.0	24.6:1
I		2	19	38.5	59.6	6.6	4.8	27.2	0.0	1.8	87.2	6.6	3.1	3.1	15.1:1
J		2	45	38.7	48.7	10.0	9.0	28.8	1.0	2.5	86.7	4.6	2.9	5.8	10.5:1
62/179A	B.W.T. 3	4	4½	53.0	52.5	8.8	6.1	27.6	2.8	2.2	84.9	5.2	5.8	4.1	9.1:1
B		4	9	47.4	47.3	11.5	2.9	37.3	0.0	1.0	87.2	5.4	4.4	3.0	12.5:1
C		4	12	30.7	56.9	15.7	6.6	20.3	0.0	0.5	88.9	6.1	4.0	1.0	19.0:1
D		4	14	35.5	50.8	8.4	5.2	29.8	2.1	3.7	84.5	6.5	5.5	3.5	10.1:1
E		4	53	50.7	44.8	11.4	2.7	37.3	2.2	1.6	84.5	7.1	4.8	3.6	10.9:1
F			12	70.3	69.6	1.0	5.3	23.6	0.0	0.5	94.3	1.0	2.6	2.1	20.3:1
G		3	11	38.4	74.5	6.7	2.4	13.5	0.5	2.4	94.5	1.8	1.4	2.3	26.0:1
H		3	32	35.3	44.7	11.9	9.0	32.9	0.5	1.0	83.3	6.8	4.7	5.2	9.1:1
I		3	7	57.1	44.3	16.2	7.8	29.2	1.9	0.6	88.0	5.7	3.4	2.9	14.9:1
J		3	74	57.4	48.5	8.2	6.2	34.5	0.5	2.1	86.5	7.8	1.6	4.1	16.5:1
K		3	36	51.0	42.6	11.7	6.3	39.7	0.4	1.3	87.0	6.5	1.4	5.1	14.4:1
L		3	48½	47.0	53.1	2.4	6.3	34.8	0.5	2.9	86.6	5.8	4.9	2.7	12.2:1
M		2	22	48.0	42.9	5.7	12.0	36.0	1.7	1.7	87.3	5.2	5.8	1.7	12.3:1
N		2	13	17.7	43.2	9.3	10.3	30.4	2.9	3.9	83.4	6.0	6.0	4.6	8.4:1
62/437A	B.W.T. 10	4	16	54.5	61.4	3.5	8.3	24.6	0.9	1.3	91.5	2.8	4.1	1.6	16:5:1
B		4	13	66.4	46.6	8.5	4.3	39.3	0.4	0.9	87.6	8.4	1.8	2.2	24.0:1
C		4	17	56.6	69.5	1.9	3.8	21.9	0.5	2.4	91.8	3.9	1.7	2.6	22.3:1
D		4	47	43.2	46.3	11.2	4.9	35.4	0.4	1.8	84.6	7.7	2.8	4.9	12.0:1
E		3	16	42.9	32.9	16.9	2.1	46.5	1.2	0.4	88.3	7.1	3.8	0.8	20.7:1
F		3	15½	69.4	74.4	8.4	0.9	14.4	0.0	1.9	95.2	1.3	1.3	2.2	27.6:1
G		3	10	35.3	47.1	3.6	6.7	40.8	1.8	0.0	84.6	6.8	6.3	2.3	10.6:1
H		3	49	46.8	49.6	11.9	2.2	34.5	0.0	1.8	88.1	7.3	2.8	1.8	20.7:1
I		3	50	80.4	59.8	3.6	6.7	26.3	2.1	1.5	89.1	5.4	2.4	2.9	17.9:1
J		3	49	76.1	58.3	7.8	8.7	22.1	2.2	0.9	85.6	5.5	6.8	2.1	10.2:1
K		2	17	28.6	41.8	7.6	4.0	45.8	0.4	0.4	89.3	6.7	2.2	1.8	24.0:1
L		2	49	72.8	71.2	2.6	7.9	17.9	0.0	0.4	92.0	3.0	3.0	2.0	19.0:1

TABLE 1 (Continued).

PETROGRAPHIC ANALYSES OF THE COAL SEAMS ON THE FARM BERGWATER 123 - SOUTPANSBERG DISTRICT.

Sample No.	Borehole No.	Zone No.	Thickness Sampled (Ins.)	% Yield at 1.42 s.g. (-3/16")	Microlithotype Analysis						Maceral Analysis				
					Vt. %	Cl. %	V.I. %	I.M. %	Fu. %	C.S. %	Vn. %	Ex. %	In. %	V.M. %	Ratio of Active to Inert Const.
62/438A	B.W.T.11	4	18	24.3	80.9	2.5	5.4	8.3	1.2	1.7	94.5	2.1	1.7	1.7	28.4:1
B		4	20	47.1	51.5	3.7	5.5	38.3	0.5	0.5	87.4	6.3	3.4	2.9	14.9:1
C		4	12	60.6	43.3	7.3	5.9	41.5	1.0	1.0	85.0	7.5	3.2	4.3	12.3:1
D		4	11	43.6	52.5	8.1	3.3	35.4	1.0	0.0	89.2	5.4	1.6	3.8	17.5:1
E		4	42	55.0	48.4	6.9	2.1	39.9	1.1	1.6	89.9	7.0	1.6	1.6	30.3:1
F		3	19	48.7	51.6	7.6	4.4	34.2	1.3	0.9	86.3	5.7	4.7	3.3	11.5:1
G		3	17	73.8	60.3	11.1	1.6	23.8	1.1	2.1	90.8	4.3	2.2	2.7	19.4:1
H		3	15	45.3	43.3	2.3	7.5	43.2	2.8	0.9	83.6	5.8	9.2	1.4	8.4:1
I		3	60	50.8	47.5	9.4	3.0	36.6	1.0	2.5	84.7	10.8	2.0	2.5	21.2:1
J		3	20	52.7	47.2	9.3	8.1	30.4	2.5	2.5	84.3	4.8	6.1	4.8	8.2:1
K		3	48	37.2	42.4	15.2	6.9	33.2	1.4	0.9	85.4	7.7	3.9	3.0	13.5:1
L		3	26	67.8	49.4	10.9	7.5	28.0	2.1	2.1	85.3	5.6	6.5	2.6	10.0:1
M		2	24	40.9	55.1	7.3	6.7	30.3	0.0	0.6	87.7	8.0	3.1	1.2	22.3:1
N		2	19	39.8	37.2	9.5	4.5	45.9	0.4	2.5	86.0	6.2	4.9	2.9	11.8:1
O		2	56	77.1	57.8	7.8	7.8	24.7	1.4	0.5	87.7	5.4	5.4	1.5	13.5:1
62/439A	B.W.T.12	4	10	57.3	39.1	10.0	7.3	39.1	0.9	3.6	86.8	6.8	1.4	5.0	14.6:1
B		4	16	73.2	51.3	5.7	5.3	33.8	1.3	2.6	86.2	9.3	1.8	2.7	21.2:1
C		4	48	29.6	62.7	2.7	4.0	28.3	1.4	0.9	92.1	5.1	1.4	1.4	34.7:1
D		3	14	48.9	44.9	7.5	5.2	39.6	1.4	1.4	87.8	6.1	4.5	1.6	15.4:1

E		3	21	72.0	51.0	10.6	7.1	26.8	0.0	4.5	83.0	9.0	4.0	4.0	11.9:1
F		3	59	33.9	54.0	7.3	4.0	33.2	1.2	0.0	87.8	5.9	5.1	1.2	14.9:1
G		3	45	41.7	55.0	3.1	7.0	32.3	0.9	1.7	87.2	5.5	5.9	1.4	12.7:1
H		3	25	34.0	55.8	3.3	7.9	28.4	2.3	2.3	84.1	5.3	8.7	1.9	8.4:1
I		3		96.4	49.9	6.0	6.0	35.8	0.0	2.3	88.7	6.6	1.9	2.8	20.3:1
J		2	20	76.8	54.3	6.2	7.8	28.8	0.0	2.9	86.8	6.8	2.3	4.1	14.6:1
K		2	17	60.2	65.6	8.5	1.5	22.4	1.5	0.5	90.0	5.3	3.3	1.4	20.3:1
L		2	47	62.9	60.7	6.4	3.4	25.6	2.6	1.3	88.6	3.9	5.3	2.2	12.3:1
62/579A	B.W.T.25	4	37½	39.2	56.7	4.9	6.3	30.6	1.0	0.5	87.8	6.1	3.6	2.5	15.4:1
B		4	18½	51.3	75.4	2.7	7.7	13.1	0.0	1.1	93.3	3.3	1.7	1.7	28.4:1
C		4	44	39.3	68.6	2.0	6.6	20.3	0.0	2.5	90.5	5.0	1.7	2.8	21.2:1
D		3	50	49.7	59.2	6.9	6.9	25.4	0.0	1.6	89.2	5.1	2.6	3.1	16.5:1
E		3	25	30.4	55.5	4.9	5.9	31.7	1.0	1.0	87.1	6.7	4.3	1.9	15.1:1
F		3	23½	22.4	63.4	4.5	6.5	23.6	1.0	1.0	87.8	5.6	3.6	3.0	14.2:1
G		3	22	63.8	45.9	3.7	11.1	34.7	3.2	1.4	86.2	6.2	6.2	1.4	12.2:1
H		3	32	36.9	57.2	13.4	3.0	24.7	1.3	0.4	88.2	8.6	1.8	1.4	30.3:1
I		2	22	45.5	51.4	12.6	4.7	27.6	0.9	2.8	85.2	8.0	5.1	1.7	13.7:1
J		2	16½	63.1	47.6	8.8	6.6	34.8	0.0	2.2	86.8	6.4	3.2	3.6	13.7:1
K		2	46½	27.2	59.6	5.4	14.0	19.4	1.1	0.5	89.8	3.4	4.4	2.4	13.7:1
62/580A	B.W.T.26	4	8	37.6	88.6	1.1	2.3	8.0	0.0	0.0	96.3	1.6	1.6	0.5	46.6:1
B		4	16½	38.8	62.9	5.3	6.0	23.8	0.0	2.0	90.8	5.4	1.6	2.2	25.3:1
C		4	20	56.7	70.1	4.2	4.2	20.5	0.5	0.5	93.1	3.9	2.0	1.0	32.3:1
D		4	18½	25.7	72.0	3.6	3.6	17.2	0.6	3.0	87.6	3.8	5.9	2.7	10.6:1
E		4	13½	43.3	64.8	4.7	7.6	18.2	0.6	4.1	87.1	4.3	3.7	4.9	10.6:1
F		4	29½	45.7	47.9	10.3	3.1	35.6	1.0	2.1	80.8	10.8	3.0	5.4	10.9:1
G		3	26	56.7	60.4	10.4	4.2	23.4	0.0	1.6	89.4	8.0	1.3	1.3	37.5:1
H		3	14	47.7	55.7	12.9	6.5	21.4	1.0	2.5	89.8	4.6	1.4	4.2	16.9:1
I		3	13	44.5	60.7	4.8	6.9	26.6	0.5	0.5	88.5	5.0	3.5	3.0	14.4:1
J		3	54	45.6	67.2	6.5	3.3	21.6	0.7	0.7	90.6	4.7	2.0	2.7	20.3:1
K		3	10	37.2	75.5	6.5	3.2	12.3	1.9	0.6	93.0	2.3	1.2	3.5	20.3:1
L		3	23	38.3	74.9	3.2	5.9	11.2	4.3	0.5	89.3	2.7	7.5	0.5	11.5:1
M		2	15½	41.5	79.4	2.5	5.0	11.6	1.0	0.5	92.7	3.4	2.9	1.0	24.6:1
N		2	10½	37.1	54.4	6.0	11.4	24.6	1.8	1.8	85.6	3.3	7.2	3.9	8.0:1
O		2	9	48.0	65.5	11.0	4.8	16.7	1.0	1.0	91.8	3.4	4.3	0.5	19.8:1
P		2	18	44.0	48.3	5.4	12.4	30.6	1.1	2.2	86.6	5.4	3.5	4.5	11.9:1
Q		2	92	40.9	59.7	3.1	12.8	21.9	1.5	1.0	88.7	3.1	5.6	2.6	11.2:1

TABLE 2.

THE AVERAGE PETROGRAPHICAL RESULTS FOR THE COAL IN ALL THE ZONES IN ALL THE BOREHOLES.

Borehole No.	B.W.T. 1			B.W.T. 2			B.W.T. 3			B.W.T. 10			B.W.T. 11		
Zone No.	4	3	2	4	3	2	4	3	2	4	3	2	4	3	2
Coal Thickness (In.)	90	200½	63	101	169	76	92½	222½	35	93	189½	66	103	205	99
Vitrite (%)	58.6	59.0	70.9	51.3	77.2	51.3	47.9	49.3	43.0	53.2	55.1	63.6	54.4	47.7	53.2
Clarite (%)	10.8	7.2	6.3	13.4	7.2	9.2	11.4	8.3	7.0	7.8	8.3	3.9	5.7	10.4	8.0
Vitrinertite (%)	3.0	6.8	5.1	6.9	4.0	8.0	3.7	6.5	11.4	5.2	5.2	6.9	3.9	5.3	6.9
Intermediate Mat. (%)	25.8	24.5	15.9	26.3	9.1	28.4	33.6	33.5	33.9	31.6	28.8	25.1	33.8	33.3	30.1
Fusite (%)	0.5	0.9	0.2	0.7	0.5	0.8	1.7	0.5	2.1	0.5	1.3	0.1	1.0	1.5	0.9
Carb. shale (%)	1.3	1.6	1.6	1.4	2.0	2.3	1.7	1.9	2.6	1.7	1.3	0.4	1.2	1.8	0.9
Vitrinite (%)	87.3	90.0	93.9	89.3	93.8	86.8	85.4	86.5	85.8	87.5	88.2	91.3	89.5	85.4	87.4
Exinite (%)	6.2	4.0	2.1	5.6	2.6	5.1	6.6	6.6	5.5	6.3	5.8	4.0	5.9	7.5	6.2
Inertinite (%)	5.2	3.2	1.0	3.6	0.9	3.0	4.8	2.9	5.9	2.7	3.9	2.8	2.2	4.2	4.7
Visible Minerals (%)	1.3	2.8	3.0	1.5	2.7	5.1	3.2	4.0	2.8	3.5	2.1	1.9	2.4	2.9	1.7
Ratio Active: Inert Const.	14.4:1	15.7:1	24.0:1	18.6:1	26.8:1	11.3:1	11.5:1	13.5:1	10.5:1	15.1:1	15.7:1	20.3:1	20.7:1	13.1:1	14.6:1

Borehole No.	B.W.T. 12			B.W.T. 25			B.W.T. 26			B.W.T. 27		
Zone No.	4	3	2	4	3	2	4	3	2	4	3	2
Coal Thickness (In.)	74	164	84	100	152	85	106	140	145	99½	159	86½
Vitrite (%)	57.1	53.6	60.1	65.4	56.8	55.2	63.8	66.0	60.3	60.7	59.3	52.7
Clarite (%)	4.3	6.0	6.8	3.2	7.1	7.9	5.8	7.2	4.0	5.4	6.0	5.1
Vitrinertite (%)	4.7	5.9	4.1	6.7	6.5	10.2	4.4	4.5	11.3	8.1	6.4	9.3
Intermediate Mat. (%)	31.0	31.9	25.7	22.8	27.4	24.5	23.4	20.0	21.8	23.8	25.0	28.5
Fusite (%)	1.3	1.1	1.8	0.4	1.1	0.8	0.6	1.3	1.4	0.3	0.7	1.9
Carb. shale (%)	1.6	1.5	1.5	1.5	1.1	1.4	2.0	1.0	1.2	1.7	2.6	2.5
Vitrinite (%)	90.1	86.4	88.4	90.0	88.0	88.0	87.9	90.1	88.8	88.3	85.2	85.3
Exinite (%)	6.2	6.1	4.9	5.1	6.3	5.2	5.8	4.8	3.5	5.2	6.6	7.3
Inertinite (%)	1.5	5.7	4.2	2.4	3.4	4.3	3.1	2.8	5.1	2.8	4.2	3.5
Visible Minerals (%)	2.2	1.8	2.5	2.5	2.3	2.5	3.2	2.3	2.6	3.7	4.0	3.9
Ratio Active: Inert Const.	26.0:1	12.3:1	13.9:1	19.4:1	16.5:1	13.7:1	14.9:1	18.6:1	12.0:1	14.4:1	11.2:1	12.5:1

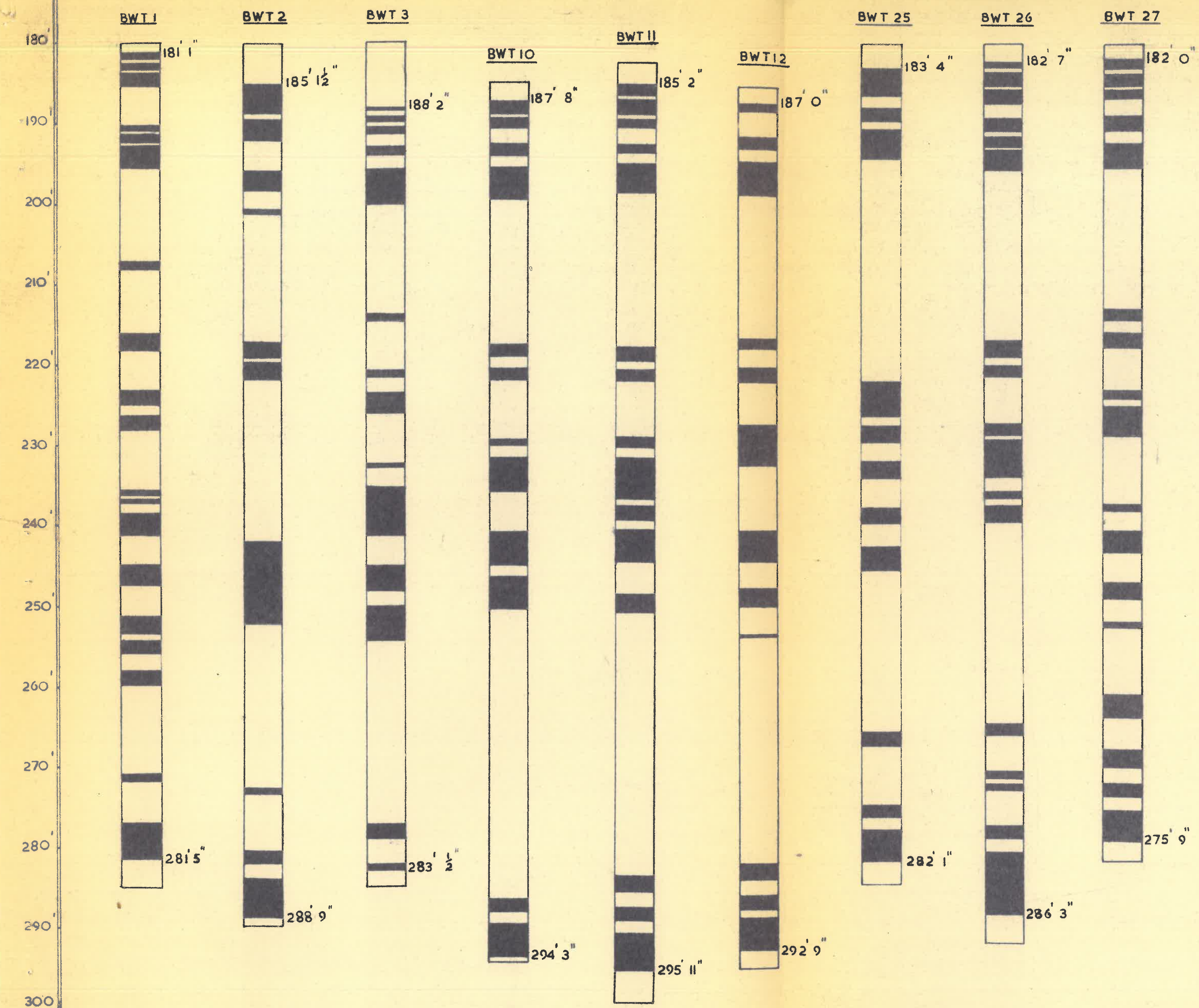


FIGURE 1

BOREHOLE SECTIONS SHOWING THE POSITION OF THE COAL SEAMS

DIAGRAM 1

THE AVERAGE MICROLITHOTYPE CONSTITUTION OF SOUTPANSBERG COALS AS WELL AS THAT OF

5 NATAL COKING COALS (CROSS HATCHED)

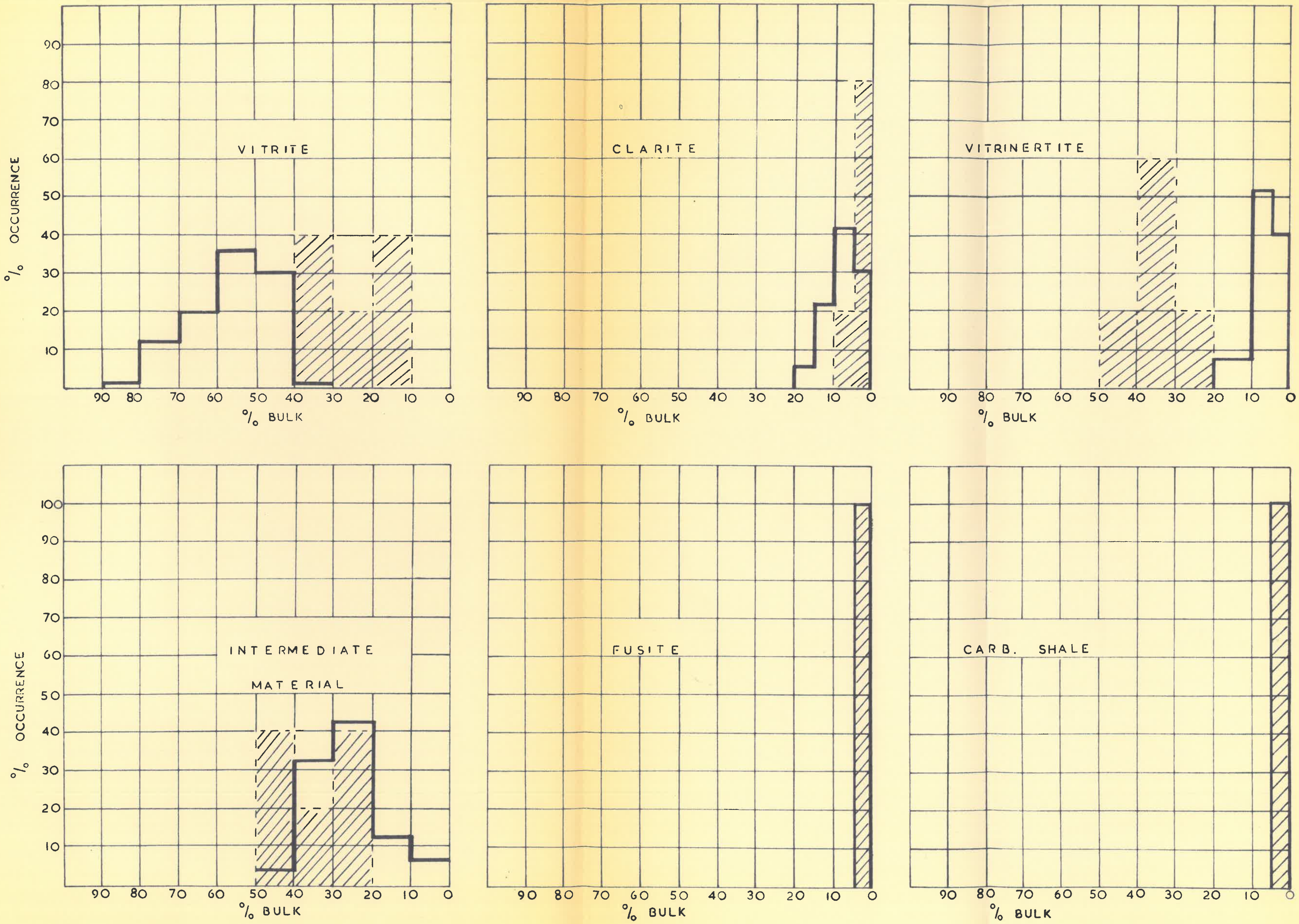


DIAGRAM 2

THE AVERAGE MACERAL CONSTITUTION OF SOUTPANSBERG COALS AS WELL AS THAT OF 5 NATAL COKING COALS (CROSS HATCHED)

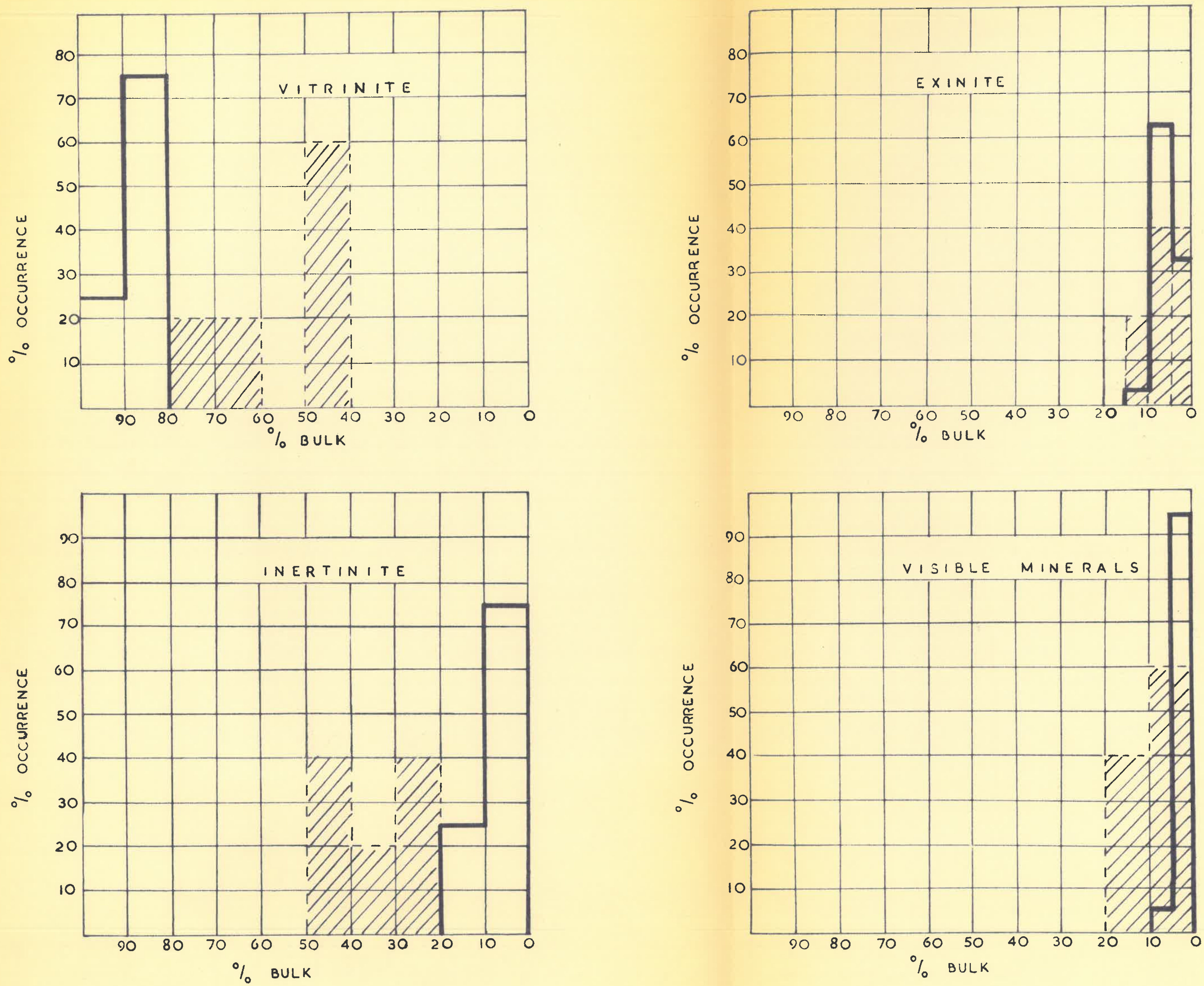
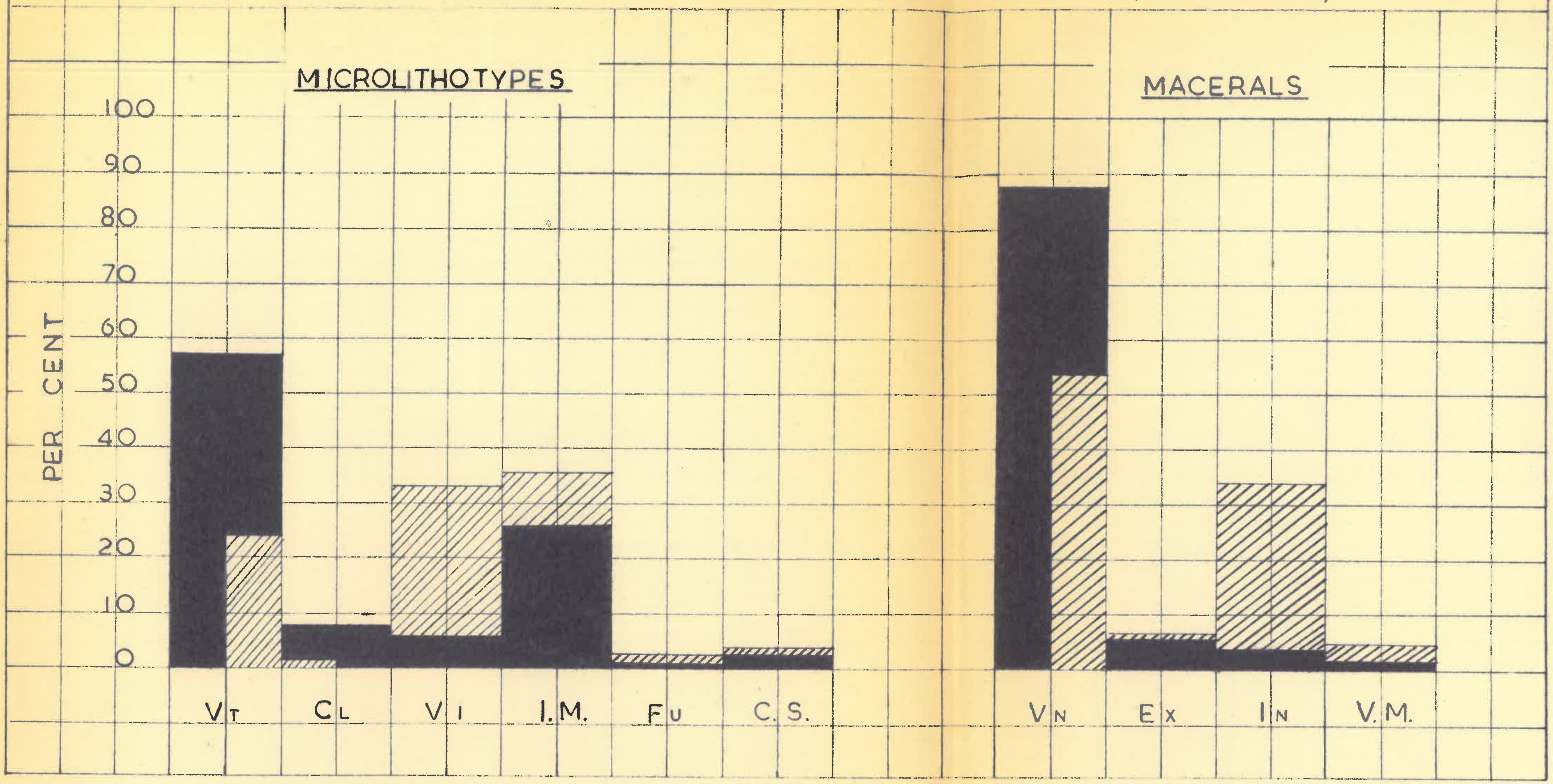


DIAGRAM 3

THE AVERAGE PETROGRAPHIC CONSTITUTION OF THE COAL FROM BERGWATER 123 SOUTPANSBERG DIST. AND THE AVERAGE PETROGRAPHIC CONSTITUTION OF 5 NATAL COKING COALS (CROSS HATCHED).



VT : VITRITE
CL : CLARITE
VI : VITRINERTITE

I.M. : INTERMEDIATE MATERIAL
FU : FUSITE
C.S. : CARB. SHALE

VN : VITRINITE
EX : EXINITE

IN : INERTINITE
V.M.: VISIBLE MINERALS