ORIGIN AND CLASSIFICATION OF COAL

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Most of the classification are based on the chemical and technical properties of the coals. Following these various schemes the classification of Bapung coals is tried on the basis of proximate analysis, ultimate analysis and petrographic composition.

CLASSIFICATION BASED ON PROXIMATE ANALYSES

The difficulty in determining the ultimate analysis of coal and due to the simple nature of the proximate analysis, many systems of classification have been devised using proximate analysis alone. Moreover, proximate analysis includes a measure of the proportions nof volatile matter and the range of calorific value, both points of practical importance in relation to the utilisation of coal. The parameters generally used in classification are moisture, volatile matter or fixed carbon, fuel ratio and calorific value.

Fraser's classification

It is one of the earliest classifications of coal proposed by Fraser (1877) in the USA. He devised a system based on the fuel ratio, i.e., the ratio between volatile matter and fixed carbon content.

His scheme of coal classification is given in Table 8.1. As the fuel ratio is in between 1.10 and 1.42 (Table 8.2), the Bapung coal can be termed as bituminous coal according to the Fraser’s classification

Parr's classification

The coal classification system as introduced by S. W. Parr (1928) is mainly based on the proximate analysis and calorific value of the coal. The calorific value of the pure coal is plotted against the percentage of unit volatiles as shown in Fig. 8.1. ' In this classification, the Bapung coal mostly falls in the western type of bituminous although it ranges from western type of bituminous to black lignites.

A.S.T.M. Classification

Classification by proximate analysis of coal has been a favourite method in USA for more than a century. The A.S.T.M **(American Society for Testing and Materials)** system is generally used here, being a development of the best features of the systems based upon proximate analyses by Parr and others. The ASTM classification uses bases the fixed carbon or volatile matter for high rank coals, and the calorific value of the moist, mineral matter free coal for the low rank coals which contain high proportions of moisture.

The coals are classified into a series of classes and groups. In this classification which is numbered, commencing with the higher rank coals. Coals of higher rank than No. 4 high volatile – B bituminous coal, i.e., coals containing less than 31% of volatile matter, in dry mineral matter free basis, are classified according to their fixed carbon contents. Coals containing more than 31 % of volatile matter in dry mineral matter free basis are classified according to their 'moist calorific value’. Moist calorific value (moist B.Th.U) means the calorific value of the coal containing its 'natural bed moisture’, but not including visible water on the surface of the coal. The scheme of ASTM classification is given in Table 8.3. In this classification Bapung coal falls in the bituminous – High volatile A group (Table 8.4).

Indian Standard Classification

The coal classification system adopted by the Indian Standard Institute is mainly based on the yield of volatile matter and calorific value (on dry mineral matter free basis) together with the moisture content and caking nature of the coals. The classification is presented in Table 8.5.

The calorific value of Bapung coal ranges from 13471.34 to 14612.32 B.Th.U/ib with average value of 14007.65 B.Th.U/lb in dry mineral matter free basis. In this classification, Bapung coal falls in the high volatile bituminous (non-caking) group (Table 8.6).

By plotting the percentage of volatile matter as abscissa against the calorific value, a figure is obtained for the ISI classification. The data of Bapung coals are plotted in Fig. 8.2 and the plots mostly fall in the bituminous region.

CLASSIFICATION BASED ON ULTIMATE AND PROXIMATE ANALYSES

Seyler's classification

Seyler's classification is one of the outstanding historical classifications of coal based upon ultimate analysis. As originally presented in 1900, coals were grouped into a series of species according to carbon content and into series of genera according to hydrogen content.

The carbon and hydrogen as determined by ultimate analysis, were corrected for moisture, ash and combustible sulphur. The lowest carbon content included was 75%, thus excluding lignites, whilst the hydrogen range was too small to include such coals rich in hydrogen as cannels and bogheads.

Seyler's classification in tabular form (in part) is presented in Table 8.7. In this classification the prefix 'ortho- indicates 'true', 'typical' or 'normal', 'sub' means 'less than normal', whilst 'per' means 'more than normal'.

In Seyler's chart, a narrow band is drawn between the carbon limits 70.0-97.0% and hydrogen 2.0 to 5.8% which is believed to include the composition of all normal (humic) bright coals within this range of carbon content.

Later on Seyler has produced a series of graphical representations of his classification in the form of charts with carbon and hydrogen as rectangular co-ordinates, with further axes indicating calorific value and volatile matter at right angles to each other, but inclined at about 60° to the carbon axis (Francis, 1961).

In Seyler’s coal chart, the Bapung coal falls in the ortholignitous species (Fig. 8.3). According to hydrogen content the coat ranges from per-bituminous to bituminous genera and the average hydrogen content (in dry mineral matter free basis) falls in the bituminous genera.

Mott's Classification

Mott has made an intensive study into the subject of classification based upon ultimate and proximate analyses, and his classification covers a wide variety of coals.

The construction of the chart representing Mott's classification is on somewhat similar line to that of Seyler, except that the volatile matter and calorific value determinations are used as the principal rectangular co-ordinate, whilst hydrogen and carbon are subsidiary co-ordinates, inclined at an angle of approximately 40° to the main co-ordinates.

The **ultimate and proximate** analyses are calculated to the dry mineral matter free basis. The Mott's classification is tabulated in Table 8.8. The chief merit of Mott's classification lies in the recognition of the coal outside the coal band of Seyler.

Classification of Bapung coal according to the Mott's classification is tabulated in Table 8.9. From the table it is seen that Bapung coal ranges from high volatile bituminous to lignitic transitional group but the average composition falls in the lignitic transitional group. The data are plotted in the coai band (Fig. 8.4) and observed that the plots mostly fall in the lignitic region.

Hickling's Classification

Hickling (1927) proposed a classification and constructed a chart by. plotting .the percentage of carbon against oxygen (unit coal basis).

The carbon and oxygen contents of Bapung coals as per this system are plotted in Fig. 8.5 and it is observed that coal is bituminous.

Williamson's Classification

Williamson (1957) plotted the percentage of carbon against the calorific value in B.Th.U/lb in dry ash free basis to have a coal classification.

It is observed that the plots of Bapung coal in this system falls in the bituminous type and thereby confirming the bituminous nature of the Eocene coals (Fig. 8.6).

Classification by International Geological Congress

In the classification proposed by International Geological Congress letters are substituted for names (Table 8.10). The parameters used are V.M., fuel ratio, calorific value and carbon. In a general way the classification conforms to the nomenclature used in America as follows :

Ai = Anthracite coal

A2 = Semi-anthracite coal ■

B1 = Anthracite coal and high carbon bituminous coal

B2 = Bituminous coal

The classification of Bapung coals as per IGC system is given in Table 8.11. It is observed that all the samples of Bapung belong to B2 type (bituminous).

Basic curves by Francis

On the basis of carbon, hydrogen and oxygen contents of coal,

Francis (1961) has drawn basic curves for the Humic coal series from

Peat to Graphite.

The data of these elements of Bapung coals are

plotted on These curves and observed them to be of bituminous type

(Fig. 8.7).

8.4 PETROGRAPHIC CLASSIFICATION

8.4.T Classification based on vitrinite

An attempt has been made by Sen (1978) to classify and codify Indian coals on the basis of petrographic analysis. Vitrinite has been chosen as the most important parameter for classification as proposed in Table 8.12. Here coals have been divided into a number of coal types such as per-vitrinous, meta-vitrinous, ortho-vitrinous, para-vitrinous and sub-vitrinous according to decreasing proportion of vitrinite content (in visible mineral matter free basis) of coals.

purpose of codification the coal types have further been divided into groups as shown in Table 8,12. The vitrinite content of Bapung coal varies from 76.9 to 87.26%. On the basis of vitrinite percentage Bapung coal ranges from per-vitrinous (B) to meta-vitrinous (A) types and average vitrinite percentage (82.15%) falls in the meta-vitrinous (A) type (Table 8.13).

Classification based on exlnlte

Sen has also classified the Indian coals on the basis of exinite content. Coals have been grouped into eight genera with corresponding group numbers according to exinite content (volume % on the basis of VMMF basis) as shown in Table 8.14. Exinite content of Bapung coal varies from 1.25 to 4.46% in visible mineral matter free basis with an average of 2.26%. On the basis of exinite per cent, Bapung coal falls in sub-exinous to paraexinous genea and the average content falls in the sub-exinous genera (Table 8.15).

Classification based on reflectance and volatile matter (rank)

Rank is of paramount importance in deciding the chemical, physical and technological properties of coal. In some classifications in addition to maceral composition, rank is also taken into consideration.

This may be achieved by considering the reflectance of vitrinite. Mean maximum reflectance (in oil) of vitrinite is recommended for this purpose. Reflectance values of vitrinite have been divided into reflectance numbers and group numbers based on carbonisation properties as deduced from correlation of volatile matterper cent and carbon per cent with maximum reflectance per cent.

The span of bituminous range has been divided between reflectance of 0.51% (volatile matter approximately 40-50%) and reflectance 2.1% (volatile matter 13%). The entire range of bituminous coal has been divided into 5 groups each having equal range of reflectance of 0.30%, except the last one which has a span of 0.40%. In this classification provision has been made for placing anthracite and low rank coals.

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The scheme of this classification is given in Table 8.16. The volatile matter content (in air dried basis) and corresponding reflectance value of Bapung coal are given in Table 8.17. From the table it is seen that Bapung coals are non-caking coal having Group no. 2. **8.5**

PETROGRAPHIC CODIFICATION OF BAPUNG COAL

Sen (1978) has employed three different parameters of petrographic classification for petrographic codification of Indian coal.

When only maceral composition of coals is known, the same can be expressed by two digital code numbers in which the first digit relates to coal type (vitrinite %), while the second one denotes thegenus (exinite %). Following two digital code, the Bapung coals are plotted in Fig. 8.8 and observed that the code for most of the samples is 71

Sen (1978) employed the reflectance number of coals as the third parameter in petrographic codification. Group members of the three parameters arranged in the sequence, coal type (vitrinite %), genus (exinite %) and reflectance number (R0%) are used to form a code number. Using these three parameters the Bapung coals are codified in Table 8.18. Considering the average value, the Bapung coal is codified as 712.

SUMMARY OF COAL CLASSIFICATION

The different classifications of Bapung coals are summarised in abstract form in Table 8.19 for chemical composition and in Table 8.20 for petrographic composition. It is observed from the summary tables that Bapung coal is of bituminous type, whether it is classified on the basis of proximate or ultimate composition. The petrographic composition places the coals to be metavitrinous (A) - Group no. 7 on the basis of vitrinite per cent and subexinous - Group no. 1 on the basis of exinite per cent.

ORIGIN OF COAL

During the last century there was lengthy controversy as to the Chapteractual mode of accumulation of coal deposits. On the one hand, they were considered to have accumulated from vegetable matter which remained more or less in the place of growth as in situ or autochthonous deposits. Alternatively it was argued that much of the vegetation had been eroded and redeposited many miles from source to form drift or allochthonous coals.

The principal evidences relevant to the drift or allochthonous origin of the coal seams of the Bapung coalfield are enumerated below:

1. The rocks associated with coal are distinctly sedimentary and the coal seams directly rest over sandstone and shale, i.e., coal seams are interstratified with shale and sandstone.
2. Fire clay or lithomargic clay is absent on the floor of the coal seams.

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3. The repetition of regular sequence of sandstone, shale and coal seams suggest continuous deposition in a sedimentary basin.

4. The coal measures of Bapung area (Lakadong sandstone) is overlying by Sylhet limestone and this is another evidence for sedimentary basin.

From the above discussion, it can be concluded that the present coal seams of the Bapung area are of drift origin. The ash percentage is very low as compared to the Gondwana coals of India.

This favours the short distance transportation of the vegetable matters

Table 8.1 Fraser's Classification of Coal

Type	Fuel ratio (FCA/M, unit coal basis)
Anthracite	100-12
Semi-Anthracite	12-8
Semi-bituminous	8-5
Bituminous	5-0

nous	8-5
	5-0

Bapung coal in Fraser's classification

e No.	Fuel ratio	Ty
	1.32	Bitun
	1.40	Bitun
	1.31	Bitun
	1.28	Bitun
	1.14	Bitun

[illegible]	[illegible]	[illegible]	
2. Anthracite	98-92	2-8	No agg
3. Semi anthracite	92-86	8-14	
1. Low volatile	86-78	14-22	
2. Medium volatile	78-69	22-31	
3. High volatile A	69-	31+	Eitl agg or r we
	Moist B.Th.U.		
4. High volatile B	14000-13000		

	57.08	43.47	Bituminous	
	56.32	44.03	Bituminous	
	53.50	46.99	Bituminous	
	54.13	46.46	Bituminous	
	55.12	45.28	Bituminous	
	58.50	42.12	Bituminous	
	55.91	44.64	Bituminous	
	53.59	47.27	Bituminous	
	58.26	42.37	Bituminous	
	55.69	45.06	Bituminous	

Subdivision or Group		Volatile percentage at 900°C±15°C	Value Kcal/kg (B.Th.U/lb) (unit coal basis)	p (m
				*A
nthracite	A_1	3-10	8330 to 8670 (15000 to 15600)	2 t
emi- nthracite	A_2	10-15	8440 to 8780 (15200 to 15800)	1.5 3.0
ow volatile aking)	B_1	15 to 20	8670 to 8890 (15600 to	1.5 2.5

	14019.12	Bituminous	(noncaking)
9	13648.17	Bituminous	Highly volatile (noncaking)
6	13759.92	Bituminous	Highly volatile (noncaking)
28	13840.99	Bituminous	Highly volatile (noncaking)
2	14396.61	Bituminous	Highly volatile (noncaking)
4	13876.95	Bituminous	Highly volatile (noncaking)
7	13695.73	Bituminous	Highly volatile (noncaking)
7	14319.12	Bituminous	Highly volatile (noncaking)
6	13987.40	Bituminous	Highly volatile (noncaking)

...no-	Para-	Meta-
...on % ...87.0	Carbon % 87.0-84.0	Carbon % 84-80
...ous ...ho- ...ous)	Per-bituminous (per-para-bituminous)	Per-li...
		Lig...
...ous	Para-bituminous	Meta
		Sub-l...
...ous ...tho- ...ous)	Sub-bituminous (sub-para-bituminous)	Meta
...- ...aceous ...tho- ...ous)	Pseudo-carbonaceous (sub-para-bituminous)	
...-	Pseudo-...	

	Low volatile Bituminous	14-20	1600
)	Medium volatile Bituminous	20-31	1600
	High volatile Bituminous	31-47	1575
	Lignitic	38-47	1400
	Per-hydrous lignitic	47-56	1400
	Lignite	38-47	
	Per-hydrous lignite	47-56	1350
	Super-hydrous lignite	56-75	

[illegible]	[illegible]	[illegible]	Bitu
43.47	14215.21	Bituminous	Hig Bitu
44.03	14019.12	Bituminous	Lign
46.99	13648.17	Transitional	Lign
46.46	13759.92	Transitional	Lign
45.28	13840.99	Transitional	Lign
42.12	14396.61	Bituminous	Hig Bitu
44.64	13876.95	Transitional	Lign
47.27	13695.73	Transitional	Lign
42.37	14319.12	Bituminous	Hig Bitu

[illegible]	Over 12	[illegible]	
7-12	7-12	15000-15500	
12-15	4-7	15200-16000	
12-26	1.2-7	14000-16000	

Classification of Bapung coal by Int
Geological Congress

V.M.%	Fuel Ratio	C.V. B.Th.U/lb	Carbon%	
DMMF basis				

	free basis)	
s (A)	More than 95	9
s (B)	95-85.1	8
us (A)	85.0-75.1	7
us (B)	75.0-65.1	6
us (A)	65.0-55.1	5
us (B)	55.0-45.1	4
s (A)	45.0-35.1	3
s (B)	35.0-25.1	2
s (A)	25.0-15.1	1

82.80	Meta-vitrinous (A)	
84.79	Meta-vitrinous (A)	
79.99	Meta-vitrinous (A)	
81.51	Meta-vitrinous (A)	
86.11	Per-vitrinous (B)	
79.25	Meta-vitrinous (A)	
84.73	Meta-vitrinous (A)	
84.53	Meta-vitrinous (A)	
84.84	Meta-vitrinous (A)	
83.16	Meta-vitrinous (A)	
83.09	Meta-vitrinous (A)	

us	0-0.9	0
us	1.0-2.5	1
ous	2.6-5.0	2
s (A)	5.1-10.0	3
s (B)	10.1-15.0	4
(A)	15.1-20.0	5
(B)	20.1-25.0	6
(C)	More than 25.0	7

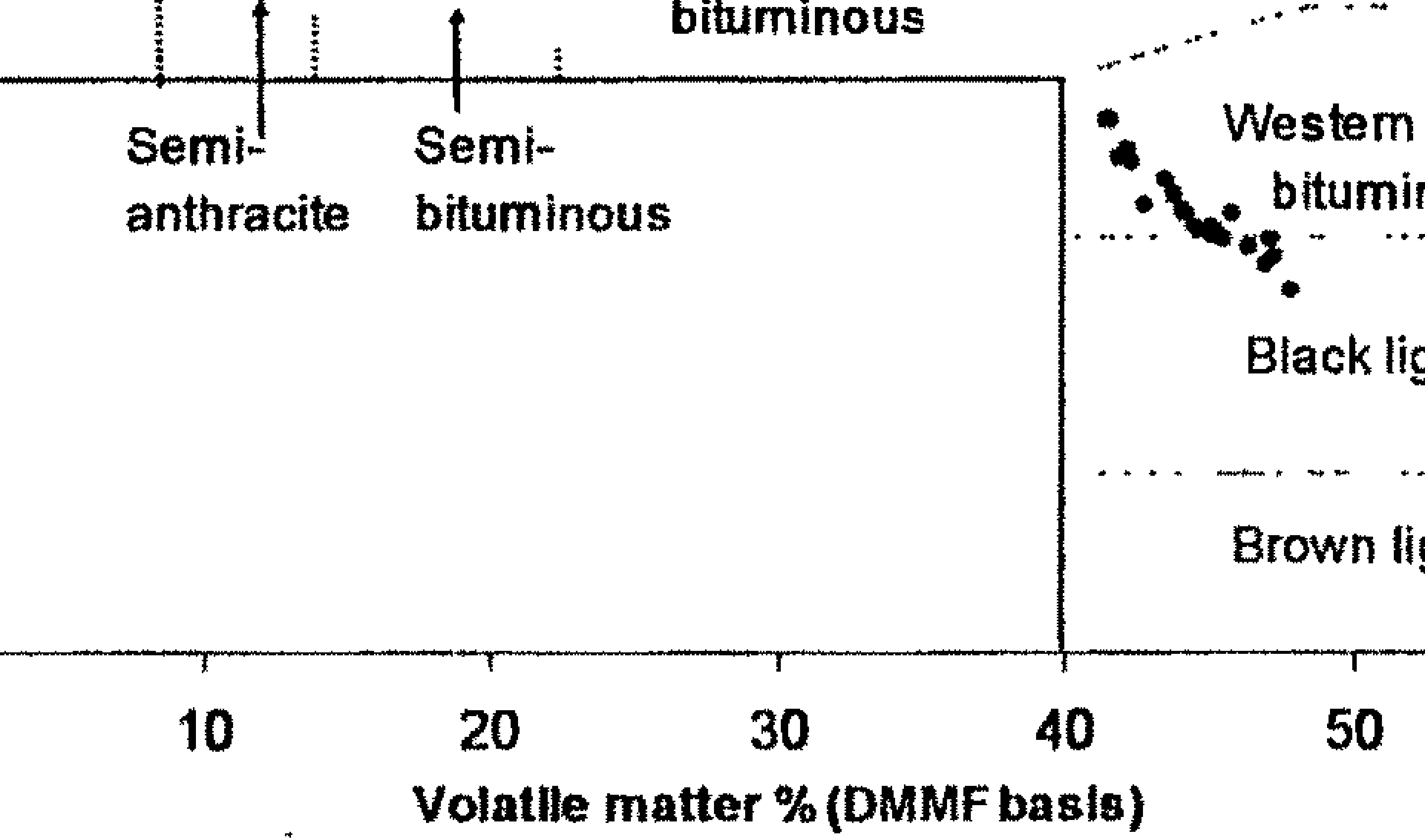
	(V.M.M.F. basis)		
	3.47	Para-exinous	
	1.61	Sub-exinous	
	3.13	Para-exinous	
	1.31	Sub-exinous	
	1.34	Sub-exinous	
	2.25	Sub-exinous	
	2.05	Sub-exinous	
	1.76	Sub-exinous	
	1.29	Sub-exinous	
	2.31	Sub-exinous	

R_o max%		matter % of vitrain	
Less than 0.20	0	More than 50	S
0.20-0.50	1		
0.51-0.80	2	50-42	M
0.81-1.10	3	42-32	fr
1.11-1.40	4	32-24	c

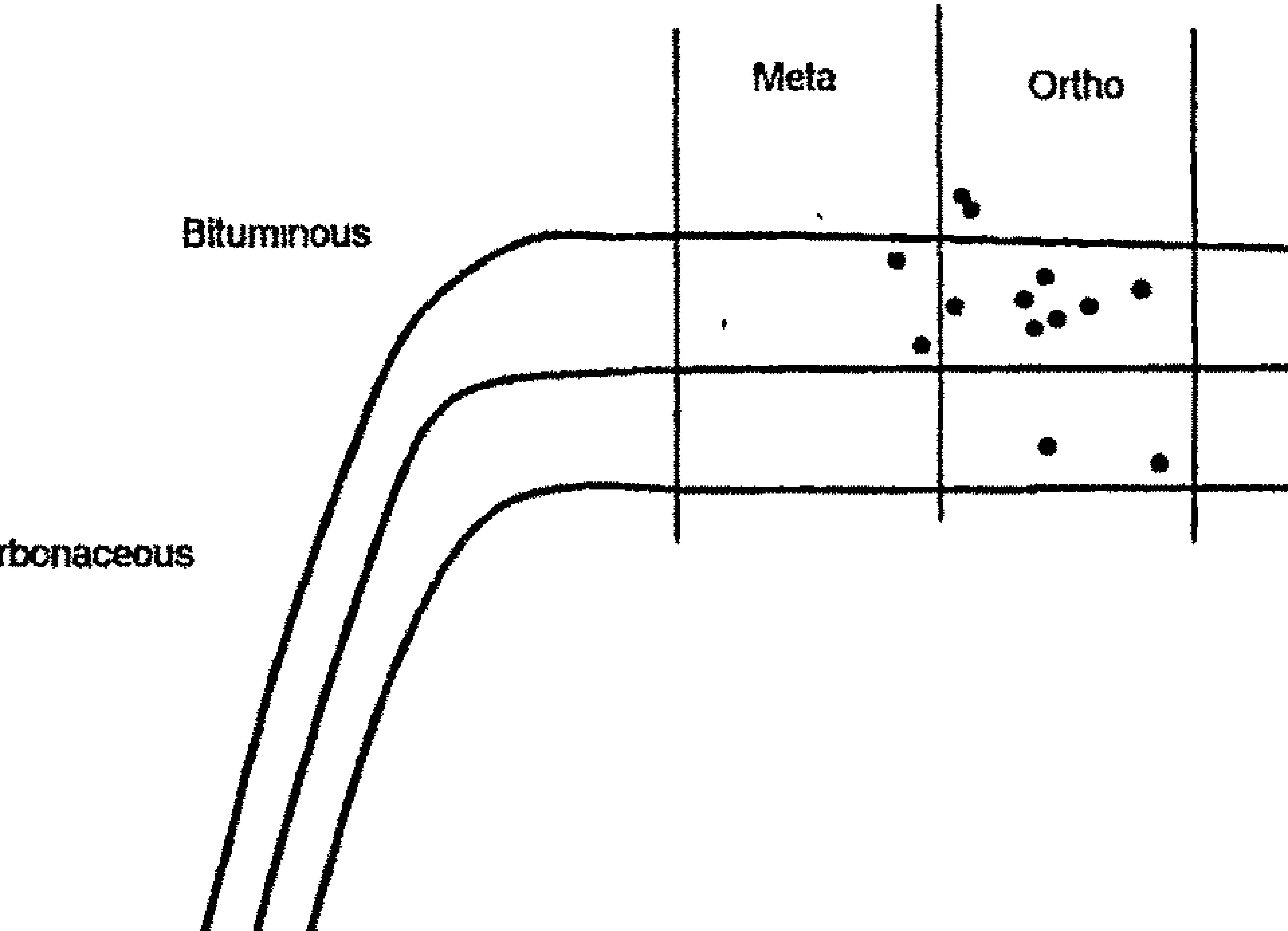
0.66	2	2	42.15	nc
0.62	2	2	40.25	nc
0.58	2	2	41.20	nc
0.67	2	2	40.10	nc
0.59	2	2	42.75	nc
0.61	2	2	44.10	nc
0.65	2	2	40.25	nc
0.63	2	2	42.35	nc

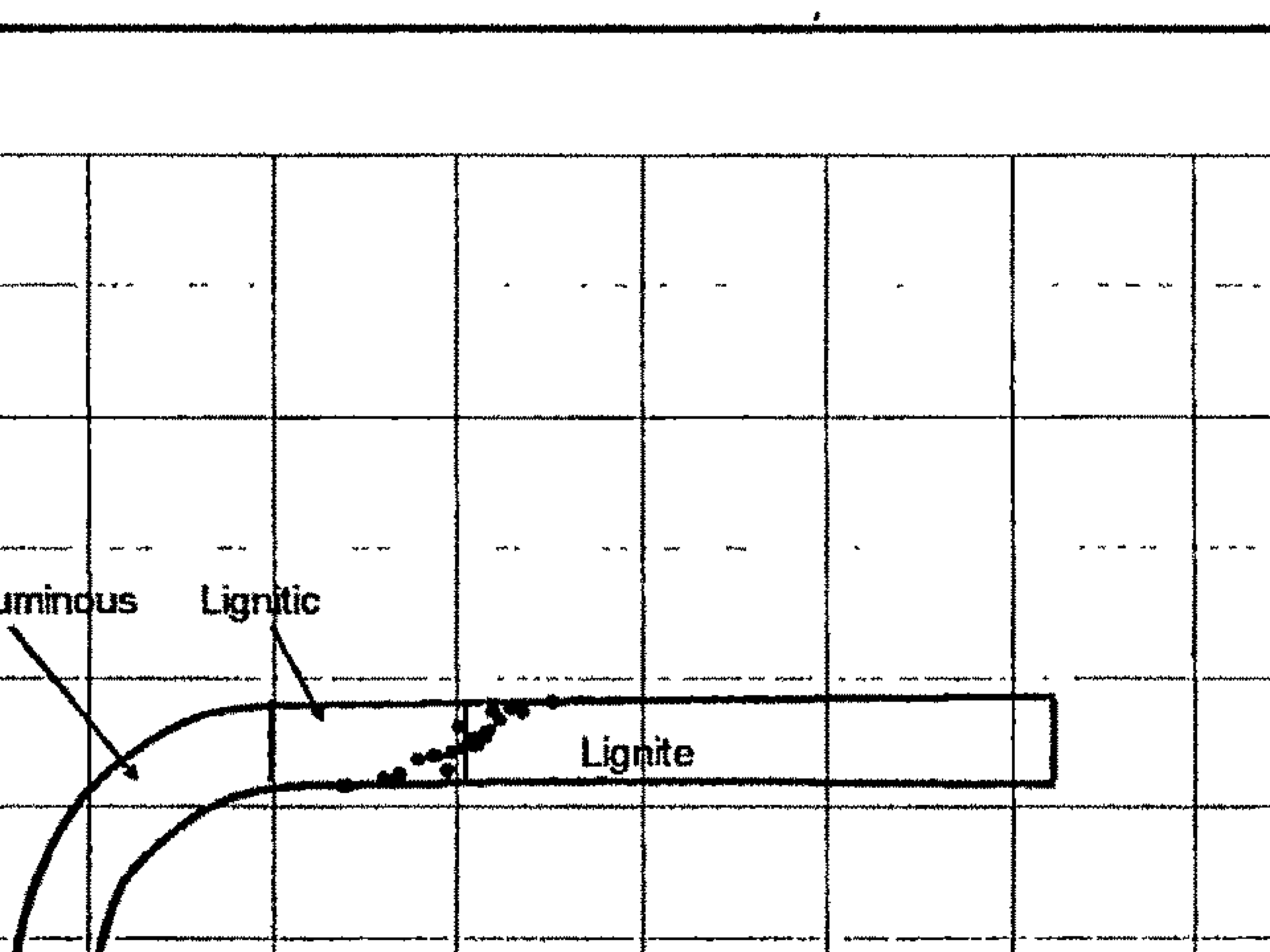
Vitrinite % with Group No.	Exinite % with Group No.	Reflectance with Group No.	C
87.26(8)	3.47 (2)	0.66(2)	
82.80(7)	1.61(1)	0.62(2)	
84.79(7)	3.13(2)	0.58(2)	
84.73(7)	1.76(1)	0.67(2)	
84.53(7)	1.29(1)	0.59(2)	
84.84(7)	2.31(1)	0.61(2)	
83.16(7)	2.33(1)	0.65(2)	

	Volatile matter and calorific value	Black lignites
	Fuel ratio	Bituminous c
	Fixed carbon, volatile matter and calorific value	Bituminous - volatile A
	Volatile mater and calorific value	Bituminous (volatile, non-
	Carbon and hydrogen	Ortho-lignito
	Volatile matter and calorific value	Lignitic trans group
	Carbon and oxygen	Bituminous
	Carbon and calorific value	Bituminous
	Volatile matter, fuel ratio,	

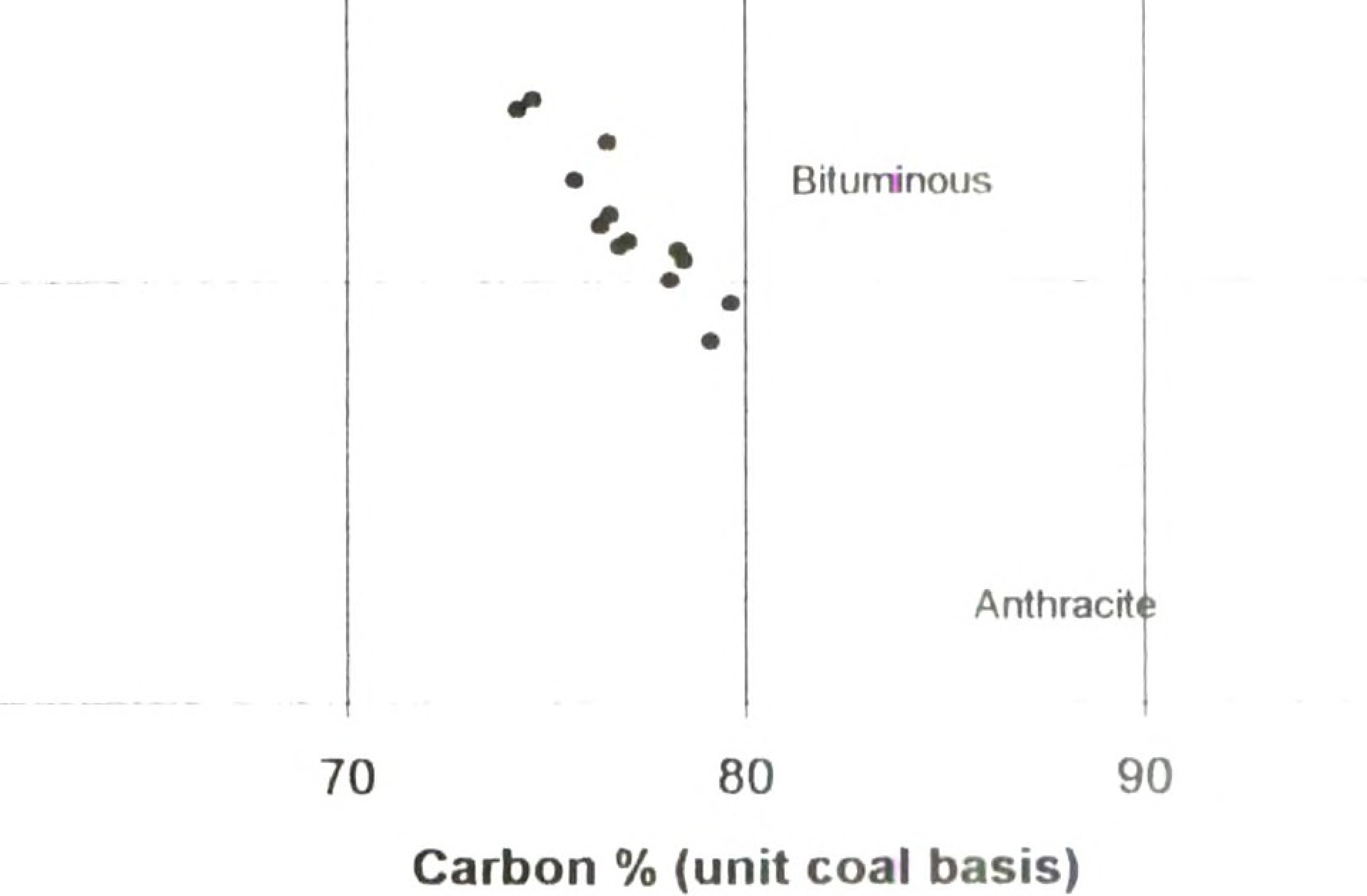


3.1 Plots of Bapung Coal in Parr's Classification

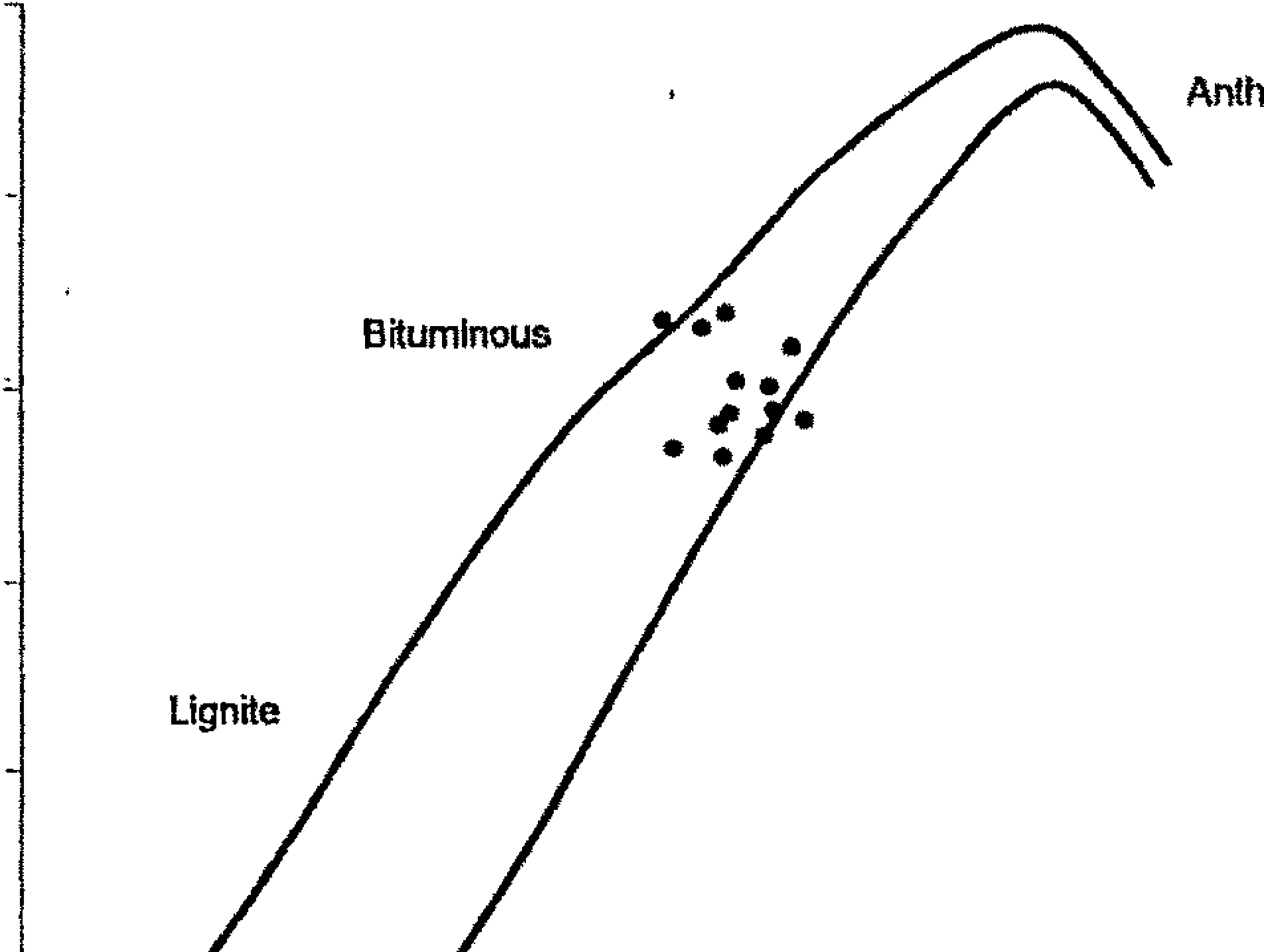

Meta
Ortho
Bituminous
rbonaceous

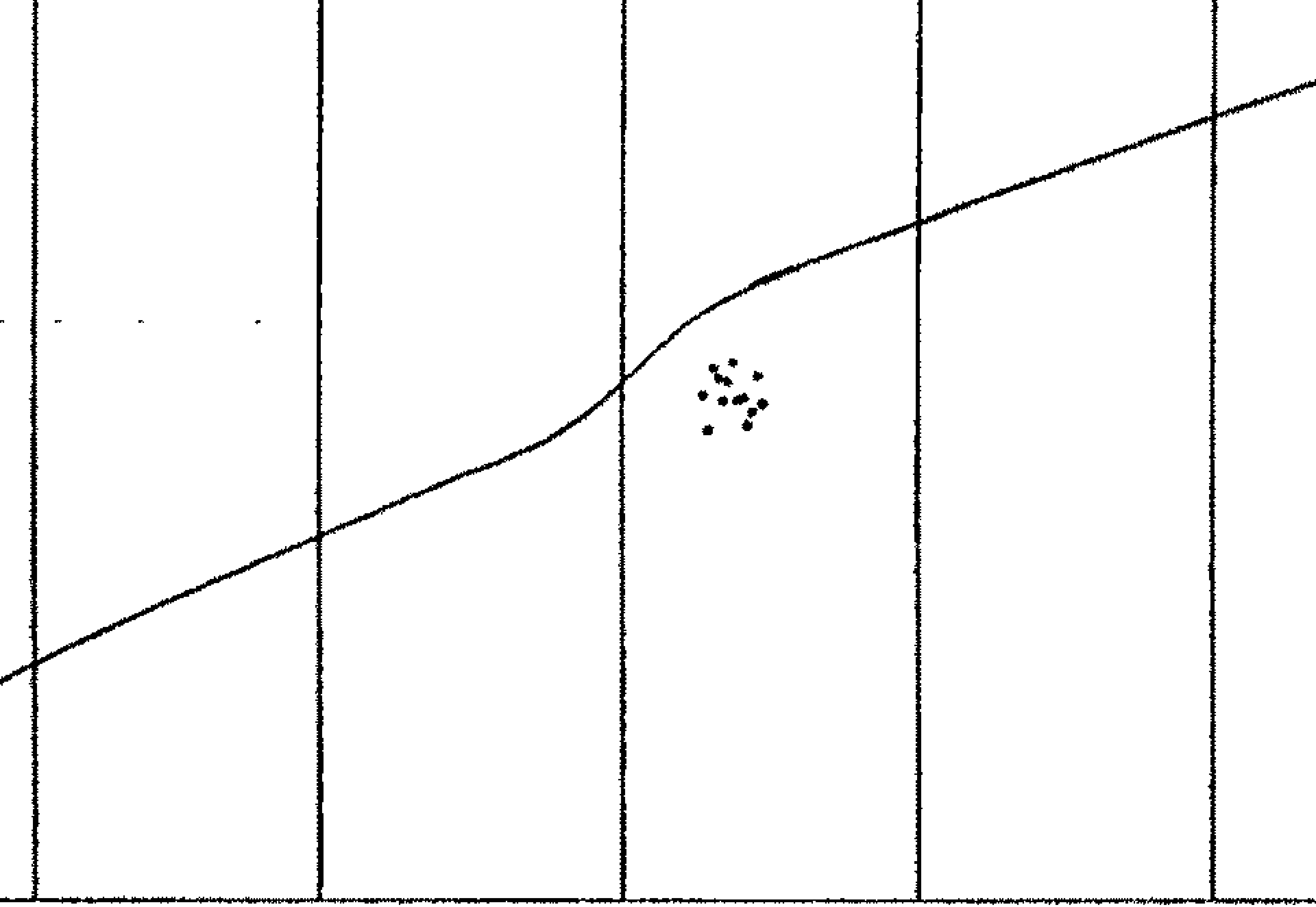


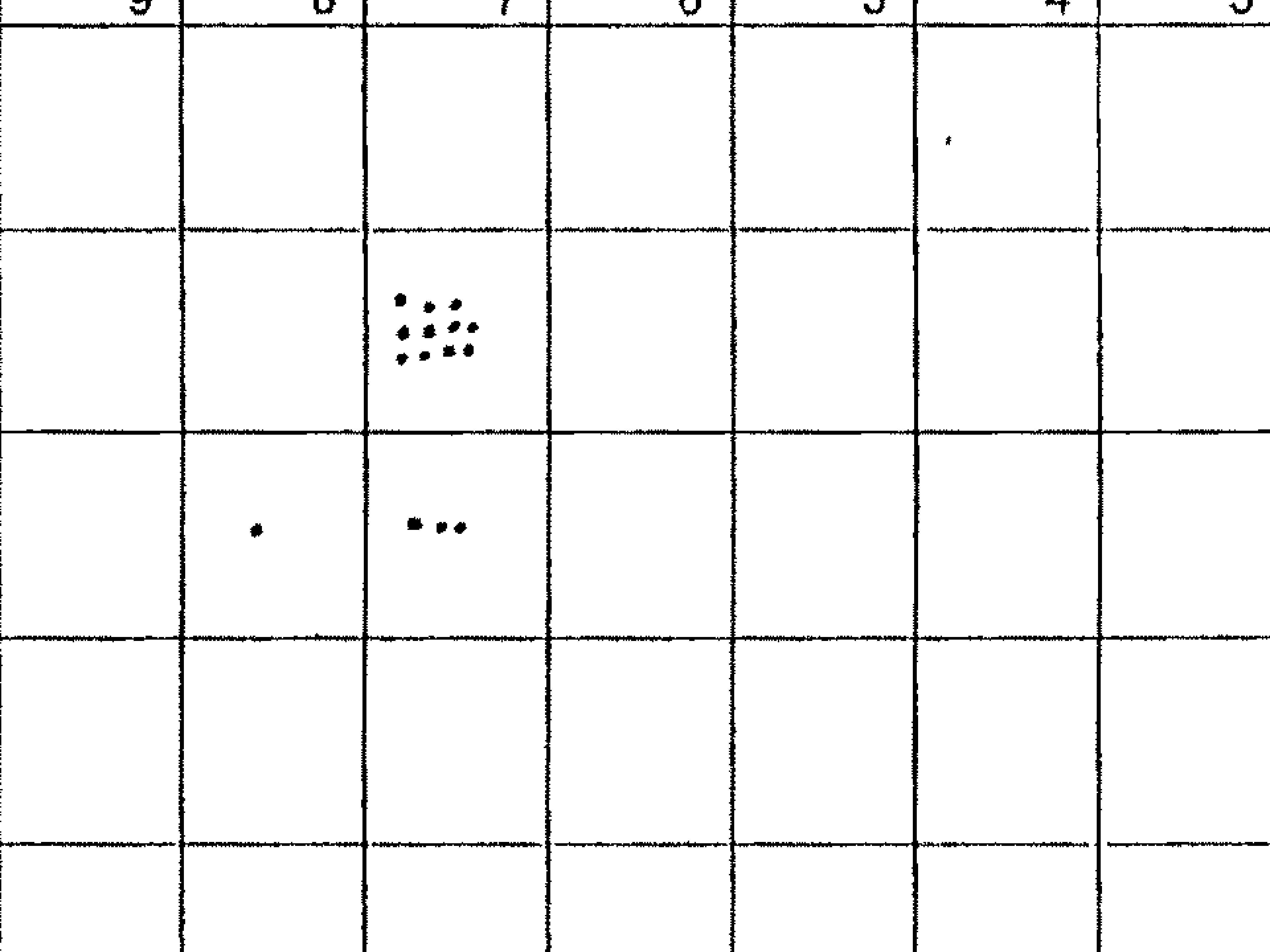
uminous
Lignitic
Lignite



Bituminous
Anthracite
70
80
90
Carbon % (unit coal basis)


Anth
Bituminous
Lignite





THANK YOU