ROBERTSON RESEARCH (SINGAPORE) PRIVATE LIMITED

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THE RESULTS OF PETROGRAPHIC ANALYSES OF ELEVEN COAL SAMPLES SUBMITTED BY CYCLONE ENGINEERING SALES LIMITED

by

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INTRODUCTION

Eleven coal samples were submitted to Robertson Research (Singapore) Private Limited by Robertson Research (North America) Limited, on behalf of Cyclone Engineering Sales Limited, for maceral analysis. In addition, the client requested that vitrinite reflectivity analysis be carried out on the two composite coal seam samples, T-5 and T-7.

T-5 is a composite of coal samples C-12 to C-18, inclusive, and T-7 is a composite of coal samples C-24 and C-25. The two sets of coal samples were collected from boreholes about 1,200' apart; despite their different response to the coke button test, the two sets of coal samples are thought to represent the same coal seam.

The client provided the following data for the coal samples :-

Sample	Ash %	Sulphur %	FSI	Wt.% composite
C-12	16.24	n.a.	1	16.85
C-13	26.35	n.a.	1	15.14
C-14	11.23	n.a.	½	14.36
C-15	28.51	n.a.	1	13.57
C-16	21.57	n.a.	½	8.83
C-17	21.63	n.a.	1	13.47
C-18	28.92	n.a.	½	17.78
T-5	23.06	0.63	½	100.00
C-24	19.94	n.a.	7	38.71
C-25	23.75	n.a.	4½	61.19
T-7	21.91	0.53	6	100.00

FSI = Free Swelling Index (Crucible Swelling Index)
n.a. = not available

II

RESULTS OF PETROGRAPHIC ANALYSIS OF COAL SAMPLES

The procedures followed in routine coal petrographic analysis are summarized in an appendix. The results of the petrographic analysis of the eleven coal samples are presented in tables 1 to 3, inclusive.

Table 4 presents the recalculated maceral data, using Parr's formula to derive the mineral matter percentage, and prediction of selected use parameters for the coal samples.

Figure 1 presents a VEI diagram (a triangular plot of vitrinite, exinite and inertinite components on a mineral matter free basis) for the coal samples.

The predicted values for Free Swelling Index (FSI) for samples C-24 and C-25, and their composite T-7, compare favourably with the measured FSI values. The measured FSI values for samples C-12 to C-18, inclusive, and their composite T-5, are much lower than the FSI values predicted on the basis of coal rank and type.

The vitrinite in samples C-12 to C-18, inclusive, and T-5 was observed to exhibit evidence of oxidation. The original sulphide veinlets in the vitrinite appear to have been replaced by hydrated iron oxides. Oxidation of vitrinite exerts a deleterious effect on caking and coking properties of coal.

The differences between the FSI values measured and predicted for samples C-12 to C-18, inclusive, and T-5, are ascribed to the effects of oxidation.

Although it may not be possible to provide a definite correlation between composite samples T-5 and T-7, on the basis of coal petrographic analyses, it appears that these coals are of very similar rank and type.

III

CONCLUSIONS

On the basis of the petrographic analysis of the eleven coal samples it is possible to draw the following conclusions.

(1) The difference in coke button test (FSI = Free Swelling Index) behaviour between the two sets of coal samples appears to be due to oxidation of the vitrinite in samples C-12 to C-18, inclusive, and T-5.

(2) The two coal composite samples, T-5 and T-7, are very similar in coal rank and coal type and they may, therefore, represent the same coal seam. However, it is necessary to check other possible correlations by petrographic analysis, prior to making this a definite correlation.

TABLE 1

Results of petrographic analysis of coal samples C-12, C-13, C-14 and C-15

SAMPLE IDENTIFICATION	C-12	C-13	C-14	C-15
Polished Particulate Block Number	AS 891	AS 892	AS 893	AS 894
	(A) MACERAL ANALYSIS			
Vitrinite %	60.4	63.4	43.0	42.4
Sporinite %	0.2	trace	trace	trace
Resinite %	0.2			
Total Exinite %	0.4	trace	trace	trace
Fusinite %	0.8	0.2	0.2	1.0
Semifusinite %	24.7	19.8	38.1	21.1
Very low reflectance semifusinite %	3.5	6.8	6.3	8.8
High-reflectance macrinite %	0.8	0.2	0.4	trace
High-reflectance inertodetrinite%	1.0	0.8	1.2	0.2
Low-reflectance macrinite %	1.2	1.0	1.6	0.7
Low-reflectance inertodetrinite %	2.1	2.0	1.6	1.0
Fine (Granular) micrinite %	0.4	0.2	0.3	0.2
Total Inertinite %	34.5	31.0	49.7	33.0
Quartz %	0.6	0.4	-	0.2
Carbonate %	-	-	-	-
Fine-grained clay mineral %	3.5	4.6	6.4	24.0
Altered iron oxides %	0.6	0.6	0.9	0.4
Sulphide %	-	-	-	trace
Total Mineral Matter %	4.7	5.6	7.3	24.6
Large Inertinite Macerals %	29.0	26.8	44.6	30.9
Small Inertinite Macerals %	5.5	4.2	5.1	2.1
High-reflectance inertinite %	2.6	1.2	1.8	1.2
Low-reflectance inertinite %	31.9	29.8	47.9	31.8
(Vitrinite+Exinite)% (m.m.f.)	63.8	67.2	46.4	56.2
	(B) REFLECTANCE DATA			
$\bar{R}_o$ max. % Vitrinite (546nm)	-	-	-	-
Range of R_o max. % values	-	-	-	-
Comments on the distribution of mineral matter	Disseminated clays and segregations of clay minerals in vitrinite. Discrete "dirt" partings. Altered iron oxides in veinlets. Oxidation of vitrinite	Clay minerals as patches, disseminations and cell lumens infillings in vitrinite. Altered iron oxides in veinlets. Oxidation of vitrinite.	Clay minerals as patches and disseminations in vitrinite. Altered iron oxides in veinlets. Oxidation of vitrinite.	Clays occur as discrete "dirt" partings, disseminations and patches. Altered iron oxides in veins; traces of sulphide. Oxidation of vitrinite.

TABLE 2

Results of petrographic analysis of coal samples C-16, C-17, C-18 and T-5

SAMPLE IDENTIFICATION	C-16	C-17	C-18	T-5
Polished Particulate Block Number	AS 897	AS 896	AS 897	AS 900
	(A) MACERAL ANALYSIS			
Vitrinite %	54.7	66.4	57.9	50.0
Sporinite %	) trace	trace	trace	) trace
Resinite %	)	0.2	0.2	)
Total Exinite %	trace	0.2	0.2	trace
Fusinite %	0.4	0.9	0.4	0.2
Semifusinite %	20.1	13.8	9.1	23.2
Very low reflectance semifusinite %	6.7	6.9	1.8	6.0
High-reflectance macrinite %	0.2	0.4	0.2	0.2
High-reflectance inertodetrinite%	0.8	0.5	0.4	0.4
Low-reflectance macrinite %	1.0	0.9	0.9	2.0
Low-reflectance inertodetrinite %	1.6	1.9	2.5	1.6
Fine (Granular) micrinite %	0.2	trace	0.2	0.6
Total Inertinite %	31.0	25.3	15.5	34.2
Quartz %	-	0.2	-	0.1
Carbonate %	-	-	-	0.1
Fine-grained clay mineral %	14.3	7.5	25.3	15.3
Altered iron oxides %	-	0.4	1.1	0.3
Sulphide %	-	-	-	-
Total Mineral Matter %	14.3	8.1	26.4	15.8
Large Inertinite Macerals %	27.2	21.6	11.3	29.4
Small Inertinite Macerals %	3.8	3.7	4.2	4.8
High-reflectance inertinite %	1.4	1.8	1.0	0.8
Low-reflectance inertinite %	29.6	23.5	14.5	33.4
(Vitrinite+Exinite)% (m.m.f.)	63.8	72.5	78.9	59.4
	(B) REFLECTANCE DATA			
$\bar{R}_o$ max. % Vitrinite (546nm)	-	-	-	1.19%
Range of R_o max. % values	-	-	-	1.06-1.35%
Comments on the distribution of mineral matter	Clay as disseminations patches and cell lumen infilling in vitrinite. Oxidation of vitrinite.	Clay as disseminations in vitrinite and as discrete "dirt" partings altered iron oxides as veinlets. Oxidation of vitrinite.	Clay minerals as disseminations in vitrinite and as discrete "dirt" partings. Altered iron oxides as veinlets. Oxidation of vitrinite.	Clay minerals occur as disseminations fine-grained segregations and cell lumen infilling material. Altered iron oxides are present as veinlets; the iron oxides appear to be a replacement of original sulphide mineral Oxidation of vitrinite.

TABLE 3

Results of petrographic analysis of coal samples C-24, C-25 and T-7

SAMPLE IDENTIFICATION	C-24	C-25	T-7
Polished Particulate Block Number	AS 898	AS 899	AS 901
	(A) MACERAL ANALYSIS		
Vitrinite %	63.2	47.5	56.9
Sporinite %	0.1	trace	trace
Resinite %	trace		
Total Exinite %	0.1	trace	trace
Fusinite %	0.5	0.4	0.2
Semifusinite %	18.6	25.6	26.1
Very low reflectance semifusinite %	2.2	2.9	1.6
High-reflectance macrinite %	0.4	0.3	trace
High-reflectance inertodetrinite%	0.5	1.0	0.2
Low-reflectance macrinite %	1.2	1.1	1.4
Low-reflectance inertodetrinite %	1.2	3.0	1.6
Fine (Granular) micrinite %	0.2	0.5	0.2
Total Inertinite %	24.8	34.8	31.3
Quartz %	0.7	0.4	0.3
Carbonate %	1.7	4.5	1.4
Fine-grained clay mineral %	8.1	12.7	10.1
Altered iron oxides %	-	-	-
Sulphide %	1.4	0.1	trace
Total Mineral Matter %	11.9	17.7	11.8
Large Inertinite Macerals %	21.3	28.9	27.9
Small Inertinite Macerals %	3.5	5.9	3.4
High-reflectance inertinite %	1.4	1.7	0.4
Low-reflectance inertinite %	23.4	33.1	30.9
(Vitrinite+Exinite)% (m.m.f.)	71.9	57.7	64.5
	(B) REFLECTANCE DATA		
$\bar{R}_o$ max. % Vitrinite (546nm)	-	-	1.23%
Range of R_o max. % values	-	-	1.10-1.39%
Comments on the distribution of mineral matter	Carbonate veins in vitrinite and semi-fusinite. Clay present as cell lumen infillings, disseminations and patches in vitrinite and as discrete "dirt" partings. Sulphide occurs in veinlets.	Clay in cell lumens and disseminations in vitrinite. Carbonate veins (cleat infilling ?)	Carbonate in veins (cleat infilling ?). Disseminated clay, clay segregations and clay cell lumen infillings in vitrinite. Traces of sulphide in veinlets.

TABLE 4

Recalculation of maceral data using Parr's formula and prediction of selected use parameters for coal samples

SAMPLE	C-12	C-13	C-14	C-15	C-16	C-17	C-18	Calculated composite of C-12 to C-18 inclusive	T-5	C-24	C-25	Calculated composite of C-24 and C-25	T-7
WEIGHT % IN COMPOSITE	16.85	15.14	14.36	13.57	8.83	13.47	17.78	100.00	100.00	38.71	61.29	100.00	100.00
ASH %	16.24	26.35	11.23	28.51	21.57	21.63	28.92	22.17	23.06	19.49	23.75	22.11	21.91
SULPHUR %	-	-	-	-	-	-	-	-	0.63	-	-	-	0.53
Maceral Analysis (as measured)													
Vitrinite	60.4	63.4	43.0	42.4	54.7	66.4	57.9	55.8	50.0	63.2	47.5	53.6	56.9
Exinite	0.4	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.0	0.1	0.0	0.0	0.0
Fusinite	0.8	0.2	0.2	1.0	0.4	0.9	0.4	0.6	0.2	0.5	0.4	0.4	0.2
Semifusinite	28.2	26.6	44.4	29.9	26.8	20.7	10.9	26.3	29.2	20.8	28.5	25.5	27.7
Micrinite	5.5	4.2	5.1	2.1	3.8	3.7	4.2	4.2	4.8	3.5	5.9	5.0	3.4
Mineral Matter	4.7	5.6	7.3	24.6	14.3	8.1	26.4	13.1	15.8	11.9	17.7	15.5	11.8
Vitrinite reflectivity	-	-	-	-	-	-	-	-	1.19%	-	-	-	1.23%
Recalculated maceral data using Parr's formula for mineral matter													
Vitrinite	57.6	57.5	43.5	47.4	56.3	63.6	66.2	56.4	51.9	64.0	50.2	55.8	56.8
Exinite	0.4	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.0	0.1	0.0	0.0	0.0
Fusinite	0.8	0.2	0.2	1.1	0.4	0.9	0.5	0.6	0.2	0.5	0.4	0.4	0.2
Semifusinite	27.0	24.1	44.9	33.4	27.6	19.8	12.5	26.6	30.3	21.1	30.1	26.5	27.6
Micrinite	5.3	3.8	5.2	2.4	3.9	3.6	4.8	4.2	5.0	3.6	6.3	5.2	3.4
Mineral Matter	8.9	14.4	6.2	15.7	11.8	11.9	15.8	12.1	12.6	10.7	13.0	12.1	12.0
Free Swelling Index (FSI)													
(a) Observed value	1	1	½	1	½	1	½	½-1	½	7	4½	5.5	6
(b) Predicted value	7-7½	7-7½	5	6	7	8½	9	7	6	8½	6	7	7

TABLE 4 (contd)

SAMPLE	C-12	C-13	C-14	C-15	C-16	C-17	C-18	Calculated composite of C-12 to C-18 inclusive	T-5	C-24	C-25	Calculated composite of C-24 and C-25	T-7
Predicted values for other use parameters													
[b]Volatile matter % (d.a.f.)	26.5	26.5	25.5	26.0	26.5	27.0	27.0	26.5	26.0	26.0	25.5	25.5	25.5
[b]Calorific value (d.m.m.f.) Btu/lb	15600	15600	15550	15575	15600	15625	15650	15600	15600	15650	15600	15625	15625
Kcal/kg	8667	8667	8639	8653	8667	8681	8694	8667	8667	8694	8667	8681	8681
[c]Hardgrove Grindability Index (HGI)	80-85	80-85	80-85	80-85	80-85	80-85	80-85	80-85	80-85	80-85	80-85	80-85	80-85
[b]Carbon% (d.a.f.)	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.3	88.7	88.7	88.7	88.7
[b]Hydrogen% (d.a.f.)	5.05	5.05	4.9	4.95	5.05	5.1	5.15	5.05	5.0	5.1	4.95	5.0	5.0
[d]A.S.T.M. + 1" Stability Index	55-60	55-60	55	55-60	55-60	55-60	55-60	55-60	55-60	55-60	+60	+60	+60
[d]A.S.T.M. + ¼" Hardness Index	+65	+65	60-65	60-65	+65	60-65	60-65	+65	+65	+65	+65	+65	+65

a. Parr's formula is Mineral Matter% = $\frac{(\text{Ash\%} \times 1.08) + (\text{Sulphur\%} \times 0.55)}{2}$

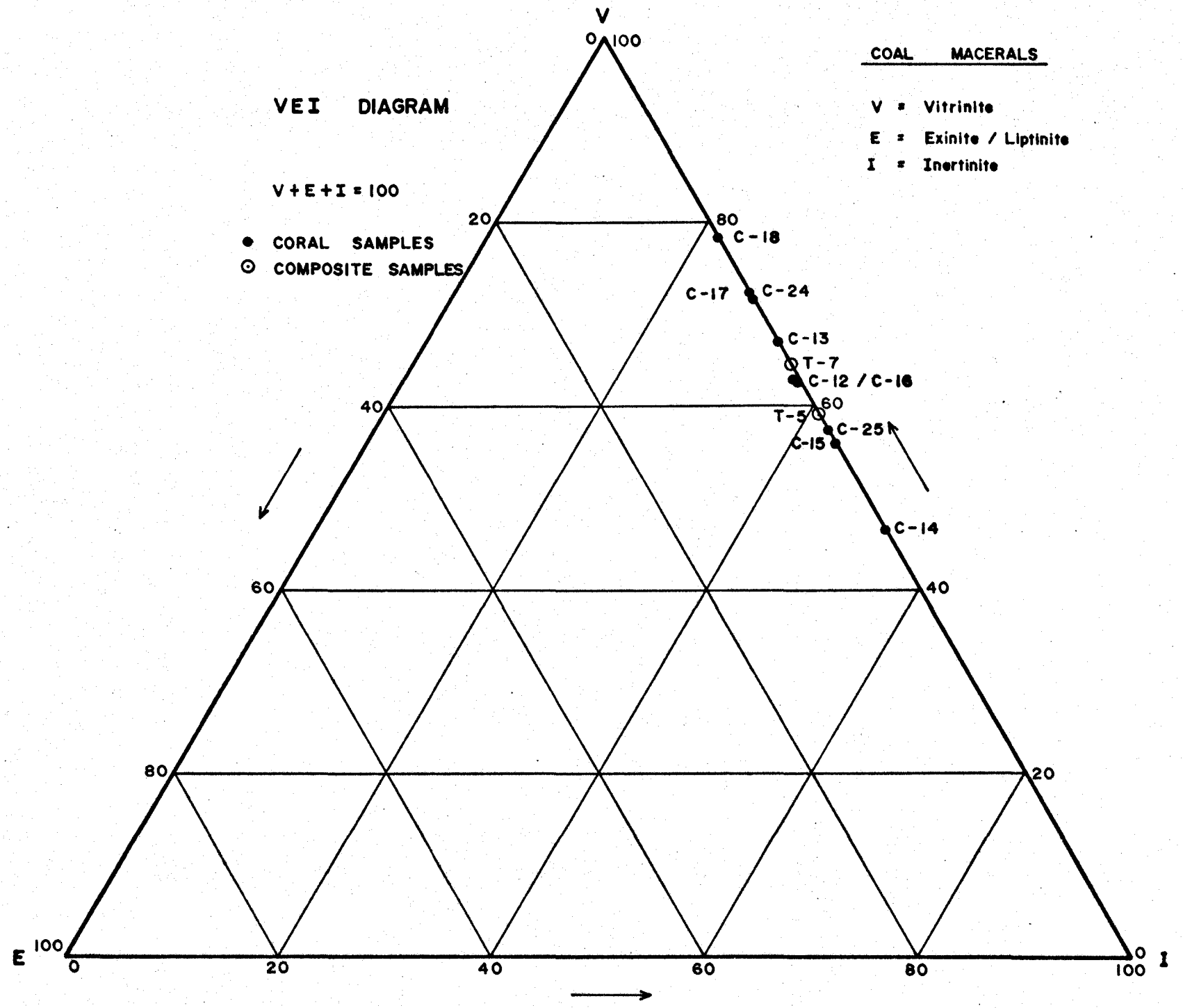
The sulphur value of the composite sample has been used to calculate the mineral matter value for individual coal samples making up the composite

b. Graphical data taken from C.S.I.R.O. publications.

c. Values derived graphically from JCB/QCB data for Australian coals.

d. Data based on 15 lb. coke oven tests carried by AIS laboratory, Fort Kembla, N.S.W.

FIGURE 1


V
0
100
VEI DIAGRAM
V + E + I = 100
CORAL SAMPLES
COMPOSITE SAMPLES
COAL MACERALS
V = Vitrinite
E = Exinite / Liptinite
I = Inertinite
20
80
C-18
C-17
C-24
C-13
T-7
C-12 / C-16
40
60
T-5
C-25
C-15
C-14
60
40
80
20
E
100
0
20
40
60
80
0
100
I

PROCEDURES IN ROUTINE COAL PETROGRAPHIC ANALYSIS

I INTRODUCTION

Petrographic examination of coal in reflected light may be carried out on polished coal blocks or on polished particulate coal mounts. Polished coal blocks have particular relevance in microlithotype analysis and the preparation of sections of vitrinite perpendicular to the bedding, i.e. for accurate determination of mean minimum reflectivity and the bireflectance ($\bar{R}_o$ max.%-$\bar{R}_o$ min.%) of vitrinite.

In the Singapore Laboratory, routine petrographic analysis of coal, i.e. reflectivity determination, maceral analysis, etc., are carried out on polished particulate coal mounts. The preparation of polished particulate coal mounts involves the selection of a representative subsample from the bulk coal specimen, preparation of a resin-bonded, particulate coal block and correct polishing of the coal mount.

II PREPARATION

An outline of the preparation procedure is presented below. Steps (1) and (2) are not always required since many coal specimens are submitted in a ready-crushed state.

(1) The bulk coal specimen is reduced by crushing to the -½"/+¼" size range with the production of a minimum amount of fine coal particles.

(2) Float/sink analysis of the bulk coal may be required to produce a clean coal fraction, i.e. the float fraction obtained using perchloroethylene of specific gravity 1.40-1.60. (In practice, a rapid method for producing a coal concentrate involves the use of a saturated zinc chloride solution to separate the coal from the mineral matter:qualitative analysis only).

(3) The crushed coal, either raw coal or clean-coal fraction, is split by means of a ½" riffle box so as to provide a representative subsample of about 50g; a minimum of 20-30g is desirable, but smaller amounts of coal may be used if absolutely necessary.

(4) The subsample is reduced by hand with a pestle and mortar to the -10 mesh/+30 mesh (average 14 mesh) size range with the production of a minimum of fine coal particles. (Note: Brown coal readily absorbs

moisture from the atmosphere. This absorbed moisture may interfere with the curing properties of the resin used in (5). This problem may be avoided by allowing the crushed brown coal to soak in alcohol in order to extract the loosely-held moisture. The alcohol may be removed from the crushed brown coal by means of acetone. The crushed brown coal may then be stored in a dessicator for a short period of time until it is required. It is not advisable to store brown coal in this way for any long period of time).

(5) About 5g of the crushed subsample are used in the preparation of the particulate coal mount. A suitable coal-setting resin is used to bond the coal particles. The resin, previously mixed with the correct proportions of catalyst and, if necessary, promoting agent, is added to a rectangular rubber or tin-foil mould (measuring, say, 1" x 1" x $1\frac{3}{4}$") or a cylindrical nylon mould (measuring 25mm in diameter x 20mm in height); however, the latter should not be used for maceral and/or microlithotype analysis, for the reasons outlined in (6).

(6) Once the resin has cured, the particulate coal mount may be removed from the mould. The coal mount is cut longitudinally for the purposes of polishing. This is to ensure that a representative suite of coal particles are present on the final polished surface, i.e. the effects of different settling velocities of particles in the resin due to size, shape and specific gravity are eliminated.

(7) The initial polishing of the coal mount is carried out under water on "wet and dry" silicon carbide papers, using 120 mesh, 240 mesh, 400 mesh and 600 mesh grades, in that order. Care should be taken to produce an even polishing action during the initial polishing.

(8) Final polishing of the coal mount is carried out on a rotating lap. The use of the correct polishing cloth, the consistency of the polishing medium and the lap speed are important factors influencing the quality of the final polish. Green Chrome Oxide followed by Light Magnesium Oxide can be used to produced a scratch-free, relief-free final polish suitable for reflectivity determinations. Prolonged polishing of the coal mount on the rotating laps should be avoided since the knap of the polishing cloth tends to give rise to strong polishing relief. 1.0μ, 0.3μ and 0.05μ Alumina are used as alternative polishing media to Green Chrome Oxide and Light Magnesium Oxide. For bituminous coals a polishing medium with a thick creamy consistency and moderate lap speeds are employed for the production of a final polish. Anthracites require a higher lap speed and a "very dry" polishing medium. Brown coals are best

given a final polish by hand on a stationary lap, if strong polishing relief is to be avoided. The coal mount should be washed thoroughly with water before transfering from one polishing medium to another.

For the purposes of maceral and/or microlithotype analyses, the final polish need not be of the highest quality. For reflectivity determinations the surface of the coal particles must be free from pervasive, small-scale, scratches, and any tarnishing or smearing. Scratch-free surfaces may be difficult to achieve if the coal specimen contains disseminated mineral matter grains. The latter tend to pluck out at all stages of the polishing and scour the surface of the coal mount.

(9) The polished particulate coal mount is carefully dried by placing polished surface down on a clean filter paper. Any remaining moisture is removed by means of a stream of air from hand bellows. Ideally, the coal mount should be stored in a dessicator until it is required. This is particularly important in the case of brown coals which readily absorb atmospheric moisture and thus yield erroneous reflectivity values. It is good practice to carry out reflectivity measurements on the polished particulate coal mount as soon as possible after it has been polished.

A list of materials used in polished particulate coal mount preparation is presented in an appendix.

III REFLECTIVITY DETERMINATIONS

In the Singapore Laboratory reflectivity determinations are carried out on Zeiss (Type 01) Microscope-Photometer - Zeiss Universal Microscope equipment, combined with a digital read-out system. All reflectivity readings are made at the internationally-accepted wave length of 546 nanometres (546 Å) under Zeiss immersion oil (R.I. = 1.516). In practice, a measuring stop diameter of 5-15 microns at a magnification of x 400 to x 600 is exployed for routine reflectivity measurements.

The photometer is calibrated by means of high-quality glass standards which possess reflectivity values in oil similar to those of coal macerals, e.g. 0.4-2.0%. A series of *glass standards may be used to check the linearity of the photometer. Prior, during and after a reflectivity determination, one of the glass standards may be used as a primary standard to check the stability of the light source and the photometer. Except at high amplification (high gain) or when large measuring stop diameters are employed, there is no need to apply corrections for background instrumental noise or for back reflection from the lenses and prisms in the optical system of the microscope.

(*The oil reflectivity values for the glass standards at 546mm are 0.452%, 0.697%, 0.935%, 1.179% and 1.435%).

The usual practice is to select, as a primary standard, the glass standard with a reflectivity nearest that of the coal maceral being measured. A "zero" standard is prepared by dispersing carbon black through a cold-setting resin block; the "zero" is set whilst the objective is immersed in oil in a small hollow drilled in the top of the resin block.

The manufacturers of the glass standards provide the details of the refractive index of the glass at various wavelengths. Knowing the refractive index of the immersion oil, the reflectance of the glass standard may be calculated from the Fresnel Equation.

$$Ro\% = (Ng-No)^2/(Ng+No)^2 \times 100$$

Ng=refractive index of glass at a given wavelength
No=refractive index of oil at the same wavelength, i.e. 1.516 for Zeiss immersion oil.

(This relationship holds true for non-absorbing media like the glass standards).

As long as the surface of the glass standard is free from tarnish and relatively free from dust particles it will yield the correct reflectance value. Once the glass standard becomes too dirty the immersion oil should be removed with xylol and the glass standard carefully buffed on a clean polishing cloth. The glass standard should be carefully dried and buffed on a clean soft cloth or lens tissue. If the surface of the glass standard becomes badly scratched or oxidized it must be carefully polished with Light Magnesium Oxide. When not in use, standards are usually stored in a dust-free container.

The mean maximum reflectivity in oil of total seam, clear, band vitrinite A, greater than 25 microns in width, is regarded as the best correlative index of coal rank (degree of coalification). Dark, resinous vitrinite and/or vitrinite B, forming the groundmass for, and hence intimately associated with, exinite and inertinite macerals are generally excluded from the reflectivity determination.

In practise the mean maximum reflectivity in oil of vitrinite is determined in plane polarized light; at a wavelength of 546 nanometres; as an average of seventy to a hundred separate reflectance readings. The readings are taken as pairs of maximum reflectance values - the coal macerals behave in a manner similar to uniaxial negative minerals in transmitted light: however, this relationship may not be strictly applicable to anthracites, which may exhibit biaxial characteristics.

If the total vitrinite component is measured it is necessary, particularly in low-rank bituminous coals, to inspect the distribution of maximum reflectivity values by means of a histogram of frequency percentage against

½V stage (0.05% reflectivity class intervals). In this way, the individual vitrinite components may be determined graphically. Individual vitrinite components usually exhibit a range in mean maximum reflectivity of 0.20-0.25% in a single seam of average thickness. A larger range in maximum reflectivity values may indicate that more than one vitrinite component has been measured; or material transitional to semifusinite has been included in the reflectivity measurements; or that oxidized vitrinite is present. The transition between vitrinite and semifusinite occurs at about the stage that open plant cell structures are present and it is often accompanied by the development of a granular mosaic of anisotropic domains of variable orientation. Oxidized vitrinite usually exhibits curved fractures and distinct zones of higher reflectivity bordering the margins of the curved fractures and the particle boundaries.

Thermal metamorphism, in particular thermal metamorphism under pressure, may give rise to strong anisotropy in vitrinite; but this does not affect the mean maximum reflectivity value. However, recognition of local thermal affects is of importance in assessing the regional rank of coal, in particular, in relation to the establishment of depth - reflectivity curves in sedimentary basins.

Owing to the heterogenous nature of the huminite macerals of brown coals; reflectivity measurements carried out on huminite(as a precursor of vitrinite)are less definitive than measurements carried out on vitrinite. The best approach appears to involve confining reflectivity readings to the clear band huminite components, namely, the humotelinite macerals, texto-ulminite and ulminite and the humocollenite maceral gelinite. In very low rank, xylitic brown coals it may be necessary to carry out measurements on the humotelinite maceral textinite, although this may not conform with the concept of a clear, band huminite component.

III MACERAL/MICROLITHOTYPE ANALYSIS

The maceral and/or microlithotype analyses carried out in the Singapore Laboratory are performed in accordance with the nomenclatural recommendations of the I.C.C.P. (International Committee for Coal Petrology) as set out in the International Handbook of Coal Petrography. A minimum of 500 macerals, or microlithotypes, are counted for the purpose of each analysis. In microlithotype analyses the minimum width for the definition of a microlithotype is set at 50μ in accordance with I.C.C.P. recommendations.

The Stopes-Heerlen hard-coal maceral nomenclature and the analogous I.C.C.P. brown coal maceral nomenclature are employed, depending on the rank of the coal. Coals transitional between brown coal and subbituminous coal, require the use of a combination of the nomenclatural systems.

IV BLUE-LIGHT FLUORESCENCE INCIDENT-LIGHT MICROSCOPY

The liptinite/exinite macerals may be examined under conditions of blue-light fluorescence, incident-light microscopy. The latter is achieved by replacing the normal H-P1 reflector by the F1500 dichroic mirror reflector and using a pair of exciter filters, BP 435-490, in place of the polarizer and the 546nm interference filter, and barrier filter LP520 in place of the analyser.

The wavelength of the fluorescence colours of liptinite/exinite increases and fluorescence intensity decreases with increase in coal rank. Fluorescence colours are not visible at vitrinite reflectivities much above $\bar{R}o$ max. % = 1.0%. During the maceral analysis of soft brown coal and lignite, liptinite/exinite, in particular the detrital maceral liptodetrinite, often occurs intimately associated with groundmass huminite/vitrinite (humodetrinite/degradinite). Following the normal maceral analysis under white-light, incident-light conditions, a rapid maceral analysis may be carried under blue-light fluorescence, incident-light conditions to permit a more accurate determination to be made of the liptinite/exinite component.

V PREDICTION OF CARBONIZATION BEHAVIOUR AND COKE PROPERTIES

The prediction of carbonization behaviour and coke properties may be carried out on the basis of coal petrographic data obtained for coals in the coking range, i.e. $\bar{R}o$ max. = 0.6-2.0%. Coal petrographers from different countries employ different graphical solutions and/or methods of calculation. Australian, Japanese or North American practices, as required, are followed in predicting these properties.

I.C.C.P. (1963) International Handbook of Coal Petrography, 2nd edition. C.N.R.S., Paris

\- (1971) International Handbook of Coal Petrography, supplement to 2nd edition. C.N.R.S., Paris.

APPENDIX

MATERIALS USED IN COAL PREPARATION

1. RESINS:

Cold-setting Polyester resins. Two components:-

1. Promoted Resin
2. Catalyst

e.g. FGI "Polylite", Struer's "Serifix", Metserv "Metset" resins, etc. These form tough, clear, colourless solids, with minimum shrinkage and exothermic reaction during curing (setting).

2. CARBORUNDUM PAPER:

Tri-met "wet and dry" waterproof silicon carbide paper.

Manufactured by 3M Company
Grades 120#, 240#, 400#, 600#

3. POLISHING CLOTHS

Buehler AB Selvyt cloth
AB Nylon cloth

4. POLISHING COMPOUNDS

1. Buehler AB Green Chromic Oxide
   AB Magomet (Magnesium Oxide)

2. Buehler AB Aluminium Oxide
   1 micron, 0.3 micron and 0.05 micron grades