Observations on modes of sulphur in coals and coal bearing strata at four (4) mine sites along a geotraverse in the Bowen Basin of Queensland

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OBSERVATIONS ON MODES OF SULPHUR IN COALS AND
COAL BEARING STRATA AT FOUR (4) MINE SITES ALONG A
GEOTRAVERSE IN THE BOWEN BASIN OF QUEENSLAND.

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by

GEOFFREY D. HOKIN

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OBSERVATIONS ON MODES OF SULPHUR IN COALS AND COAL BEARING STRATA FOUR (4) MINE SITES ALONG A GEOTRAVERSE IN THE BOWEN BASIN OF QUEENSLAND.

Abstract:

Sulphur in coals can and does cause environmental problems. Much of the world's coal contains relatively high percentages of sulphur and is therefore environmentally undesirable. Australian coals have attained a dominant position in the world market by being able to provide low sulphur coals.

To maintain this position it is necessary to maximise sulphur removal from mine product to meet the increasing demand for sulphur free coal throughout the world.

Observations of modes and levels of sulphur occurrence in coals and coal bearing strata along a geotransverse in the North Bowen Basin of Queensland indicate that the modes of occurrence of sulphur are sufficiently distinct to indicate plant material as the principle source of sulphur in these coals, and to indicate sedimentary/climatic factors as playing an important role in the percentage level and modes of occurrence of sulphur present.

The sulphur inherent within the surrounding strata of these coal seams does not have a direct and significant effect on the percentage level or modes of occurrence of sulphur within the coal seams.

Key Words: Coal, Sulphur, Strata, Geotransverse, Significant, Bowen Basin, Queensland, Observations, Modes, Demand, Australia.
HYPOTHESIS

The sulphur inherent within the surrounding strata of coal seams has a direct and significant effect on the percentage level and modes of occurrence of sulphur within the coal seam.

A better understanding of modes of occurrence of sulphur as it occurs in coals and surrounding strata of the North Bowen Basin may enable it to be better removed from the mine product.
SUMMARY

Some observations on modes of sulphur in coals and coal bearing strata at four (4) mine sites along a geotraverse in the Bowen Basin of Queensland to determine if sulphur inherent within the surrounding strata of coal seams has a direct and significant effect on the percentage level and modes of occurrence of sulphur within the coal seams of the Nth Bowen Basin.

The experiment was undertaken to determine the sulphur levels in four coal seams within the North Bowen Basin and surrounding roof and floor strata in an effort to provide a better understanding of modes of occurrence and percentages of total sulphur in these coals. The experiment was designed to assist those involved in sulphur extraction of run-of-mine product to maximize sulphur removal from that coal to meet the increasing demand for sulphur free coal throughout the world.

To achieve this goal it is necessary, first, to define the modes of occurrence of sulphur through chemical analysis of the respective strata and then, by comparison, to ascertain trends across the sample area, within and between the roof floor and seam material. Direct observation of samples provides important information on rock type and mode of sedimentation to assist in the provision of data to correlate for possible sources of the sulphur present, and the direct interaction of the surrounding strata on the coal seams and their influence on sulphur within the coal. Information provided by published literature on the study area, and on sulphur in general, is invaluable in providing background.
The results of the study indicate that the coals, with few exceptions, do not vary markedly in their total sulphur percentages; while there is an apparent relationship between the amount of carbon material and the total sulphur content in the roof and floor material, and the mode of sulphur present.

The variation of modes of occurrence of sulphur in the roof, floor and coal material are sufficiently distinct to indicate plant material as the principle source of sulphur in these coals, and to indicate sedimentary/climatic factors as playing an important role in the percentage sulphur and its mode of occurrence present during the deposition and history of the coal. The surrounding roof and floor strata do not play a critical part in the enrichment of the sulphur present in these coal seams.

**Introduction:**

The major problem of sulphur in coals is the detrimental effect sulphur has upon the environment and the damaging effect acids of sulphur, in both gaseous and liquid forms, have on the machinery used to extract and utilize the coal and its inherent sulphur.

The purpose of this paper is to determine if sulphur levels in coal seams of the North Bowen Basin are enriched by sulphur/sulphate bearing water entering from adjacent strata; to better inform those involved in the extraction of sulphur rich coals as to the possible casual relationships controlling sulphur content in an attempt to aid them in the extraction of the sulphur in these coals.
Sulphur both organic and inorganic, concentrated in coals, can and does cause major problems in the environment and to equipment. With the present international market demand for low sulphur coals, a better understanding of modes of occurrence of sulphur is essential to meet that demand. Though total sulphur is defined, a better understanding of modes of occurrence and percentages of sulphur modes would conceivably be of great assistance to the area in review.

This study, defining modes of occurrence of sulphur in these coals, would enable, as a possible consequence, a better degree of removal of the sulphur and a better detection of high sulphur levels in the run-of-mine coals, with the prospect of discovering more efficient methods of sulphur minimisation.

Very little is known about the state of combination of the sulphur atoms in coal. From the presence of heterocyclic compounds in coal tar and the potential retention of sulphur in coke, it is likely that a proportion of the sulphur occurs in condensed aromatic structures (Pitt G.J. 1979).

Unfortunately much of the worlds coal exceeds the sulphur emission standards set out in the "Clean Air Act" of 1970 (A.T.Yu 1975). The demand for low sulphur coal thus created began to affect the supply of coking coal for the steel industry. Since power plants consume three times as much coal for fuel as the steel industry for coke, it would appear that by reducing the sulphur emissions we could go a long way towards easing the coal supply problem.
Cleaning coal to meet tighter environmental standards is an increasingly important factor in coal preparation (Davis H. 1978). Coal cleaning is required primarily to reduce the sulphur content, and to enable the opening of otherwise unprofitable reserves.

Australia has attained a dominant position in the exporting of coal to the world; as the utilisation of power stations increased, so did the consumption of black coal. The increase in production and exports indicates an increasing awareness of the need for low sulphur content in coals. As Australia is a major exporter of low sulphur coals, reducing the sulphur in our coals would further increase Australia's export potential.

Sulphur emissions from coal combustion are a major obstacle in using much of the world's reserves. Researchers in the U.S. are examining various physical and chemical methods to remove the sulphur that is trapped in coal as organic sulphur and pyrite (Davis H. 1979).

The origin of pyritic sulphur is unclear. Pyrite may have been formed in several different ways; hydrogen sulphides formed through decay of the peat bog can precipitate iron sulphide, or it may be formed from the reduction by organic matter in the peat or coal bed of iron sulphate present in percolating waters. Sulphate and iron bacteria may also play an important role.

The presence of sulphate-sulphur may indicate that the coals have been subject to weathering since their formation (Kreisinger 1937).
The disposal of tailings, the fine, wet waste material from coal washeries, presents a problem to the coal industry. This material is mostly water, but contains a proportion of very fine particles of mineral matter and coal. The use of large lagoons is environmentally undesirable, and disposal requires great care. Reduced sulphur compounds are produced in tailing pond effluents from the mining industry, and it is believed that they may lead to acid pollution of rivers surrounding the coal-using industries. (Tabatabi 1982).

The distribution of pyrite in coal is of particular interest, because an excessive sulphur content in a coking coal leads to a corresponding sulphur content in the coke, which is undesirable (Mackowsky M.-th 1982). In boiler fuel or domestic coal, high sulphur contents necessitate expensive installations for the desulphurisation of the flue gases in order to avoid pollution by emission of $\text{SO}_2$. In power plants, reaction between sulphur and alkalis or alkaline earths leads to the formation of complex sulphates, contamination of the heating surfaces and corrosion.

During the combustion of coal, sulphur is converted to oxides that may contribute to corrosion in equipment, to slagging of the combustion or boiler equipment, and to atmospheric pollution (Pretor M. 1983).

High mineral matter contents involve high mining and transportation costs, increase abrasive wear on preparation and conversion plants and involve higher material costs throughout (Gray D. 1977).
According to Eglinton (1969), pollution serves to emphasise the drastic effect modern industrial society is having on the contemporary environment. Gradual changes are less dramatic but more insidious. The northern hemisphere (where most of our coal goes) is suffering particularly rapid change as the pace of industrial development quickens, and it will become increasingly difficult to find natural environments relatively free from pollution.

The total sulphur value is one of the items often specified in coal contracts. Total sulphur data alone are an insufficient guide for reducing the sulphur content of coal by cleaning because only pyrite can be removed by specific gravity separation. Even the removal of pyritic sulphur depends on its distribution in the coal. If it occurs in very small crystals widely dispersed, it is difficult or even impossible to remove by specific gravity methods.

**Background:**

Much of the effort in studying sulphur is to be concerned not only with what is but with what was (Barton P.B. Jnr. 1970). To do this, we must be concerned with the environmental parameters, and activities of components that prevailed when the coal deposit was forming. After all, most sulphides evolved from a dominantly aqueaous fluid. The second major aspect of the problem is the intervention of post-depositional processes.

Sulphur seems to precipitate under arbitrary conditions. This means that at the source, enroute and at the site of deposition there are diverse types of reactions which can play important roles in determining the activities and depositional sites of sulphur.
Reaction with organic materials may reduce the oxygen activity and lead to the reduction of sulphur. Such chemistry might well be responsible for the generation of highly reduced, high pH solutions. (Barton P.B. Jnr. 1970). It is important to view the sulphurs occurring in coals in terms of the whole petrological environment.

With the advent of photosynthesis, the chemical weathering of sulphides began when vegetation emerged onto the land (Chukhrov F. 1974). It was at this time that the importance of sulphides increased dramatically. After the appearance of organic matter, the possibility arose for the bacterial generation of hydrogen sulphide, and this fact has an important implication for the precipitation of secondary sulphides.

In the upper part of the supergene zone (zone of oxidation), the sulphides are weathered owing to the presence of free oxygen in solution. Somewhat lower, where the oxygen concentration decreases, secondary supergene sulphides occur.

Most secondary minerals are brought into the oxidation zone by ascending solutions from the surrounding country rocks.

The regional geology of the study area is based on reports by previous workers, mainly Reid 1929, Isbell 1955, Dickens & Malone 1973, Jensen 1975 and Webb & Crapp 1960 and detail is therefore kept to a minimum here. (Further information is provided in appendix 2).

The Bowen Basin, comprising essentially Permian and Triassic rocks, is situated in Central and Southern Queensland (Map 1).
The history of the Permian-Triassic sequence is complex. In the Upper Permian, the basin was cut off from the sea by uplift along the eastern margin, and the main coal-producing Blackwater Group was deposited. The coal measures at the top of the group, which have been given different names in different areas, are almost continuous throughout the basin. These measures, and the Upper Measures in the Hunter River Valley of N.S.W., are among the most important sources of black coal in the southern hemisphere.

The Triassic Sequence (Mimosa Group) comprises three non-marine formations of basinwide extent: the Rewan, Clematis Sandstone and Moolayember Formations.

Uplift, folding and erosion took place in the Upper Triassic and, the Lower Jurassic, the Great Artesian Basin and its eastern lobe, the Surat Basin, were developed as separate structures.

The structure of the Bowen Basin and adjoining areas reflects the complex tectonic history. The structures within the basin and the strong igneous activity in the eastern hinterland reflect development during the Permian and Triassic.

The main mineral resource of the Bowen Basin is black coal, which has been found at many stratigraphic levels in Permian, Jurassic, and Cretaceous rocks. Most production has come from the Upper Permian Blackwater Group. (Jensen 1975, Dickens & Malone 1973).
MATERIALS AND METHOD

Method:
The method of testing the hypothesis consisted of collecting samples from four mines along a geotrace between Newlands and Curragh. (see Map 2)

The samples derived from coal seams of the North Bowen Basin. Their roof and floor material were subjected to chemical analysis using the Australian Standard "Methods for Analysis and Testing of coal and coke" and were subject to direct observation as taken from the working area.

The results of the analysis were studied for spatial variation between and within stratigraphic units and area, and were considered with data from published sources. The results of the analysis and other published data were correlated and interpreted.

Material:
The material for analysis consisted of shale, coal, sandstone, mudstone and siltstone. The samples were drawn from four localities: Newlands, Riverside, Saraji and Curragh minesites.

At each locality, samples were taken of the coal seam (the principle mined seam) and the roof and floor material of the seam.

Descriptions and diagrams of the profile were taken and horizons were marked on these profiles. (Attached as appendix 3)
Information on principle use of the coal was gathered, as was information pertaining to the basic analysis of the coal and, where available, the coal rank. Information on coal macerals, where available, was also taken.

Some of the samples of roof and floor material were carbonaceous; others were not. Each sample has a full description in the results section.

Other material used consisted of information provided by the respective mines, cross sections of the mines, profiles of the horizons and some basic analysis of the samples where available. Information from journals and trade publications such as the "Australian Coal Miner" was also used. Information was also drawn from published literature.

**Material Source:**
Samples and information were made available by the appropriate mines. Sampling was carried out and cross sections and profiles were provided by staff at each mine. Brief descriptions of sample localities were also provided by each mine.

**Experimental Procedure:**
To test the hypothesis it was necessary to take samples from the roof, floor and seam material from points along a geotraverse in the Northern Bowen Basin.

Each sample was visually inspected and described and was ground and chemically analysed to determine total sulphur content, and
pyrite sulphur, sulphate sulphur and organic sulphur content expressed as a percentage.

The procedures used for the analyses were the "Australian Standard Methods for the analysis and testing of coal and coke" part 6.3.1. - ultimate analysis of higher rank coal - Determination of total sulphur (Eschka method) (A.S. 1038.6.3.1.-1986) and part 11 - forms of sulphur in coals. (The detailed procedure is attached as appendix 1.)

The results were then subjected to tabulation and graphing.

**Equipment:**
The equipment used in analysis was standard laboratory equipment dictated by the Australian Standard for the analysis and testing of coal and coke.

No special equipment was used in the gathering of samples as each sample was drawn from the working face of the appropriate mine.

**Experimental Design:**
The experiment was designed to test the hypothesis that the sulphur inherent within the surrounding strata of coal seams has a direct and significant effect on the level and modes of occurrence of sulphur within the coal seam.

To test the hypothesis it was considered necessary to perform chemical analysis on the strata to determine the percentage mode of occurrence of the sulphur and to compare this data with the percentage mode of occurrence data of sulphur within the coal seam.
It was also considered necessary, to fulfil this objective, to compare visually the samples and attempt to discern if there were elements consistent between roof material and seam or floor material and seam.

The experiment was a simple one; the elements of which were:-

- Collection of samples and information
- Comparison of samples and information
- Analysis of samples
- Interpretation of results
- Draw conclusions from the results to support or disprove the hypothesis.
**RESULTS**

Table 1: Modes of sulphur percent occurring in samples of the Newlands, Riverside, Saraji and Curragh mines. (from analysis of samples according to A.S. 1038.6.3.1.).

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Sample ID.</th>
<th>% Total S</th>
<th>% Sulphate S</th>
<th>% Pyrite S</th>
<th>% Organic S</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Newlands N4.7 roof 1</td>
<td>0.49</td>
<td>0.02</td>
<td>0.05</td>
<td>0.42</td>
</tr>
<tr>
<td>2</td>
<td>Newlands S2.5 floor 1 3.8-4.Om</td>
<td>0.56</td>
<td>0.33</td>
<td>0.21</td>
<td>0.02</td>
</tr>
<tr>
<td>^3</td>
<td>Newlands N2.6 core 7 Bottom 3.96m</td>
<td>0.51</td>
<td>0.03</td>
<td>0.18</td>
<td>0.30</td>
</tr>
<tr>
<td>4</td>
<td>Newlands S2.6 roof 2</td>
<td>0.65</td>
<td>0.41</td>
<td>0.20</td>
<td>0.04</td>
</tr>
<tr>
<td>5</td>
<td>Newlands S2.5 Floor 1 0.3-0.4m</td>
<td>0.44</td>
<td>0.05</td>
<td>0.35</td>
<td>0.04</td>
</tr>
<tr>
<td>^6</td>
<td>Newlands N2.6 core 7 top 3m</td>
<td>0.38</td>
<td>0.13</td>
<td>0.16</td>
<td>0.09</td>
</tr>
<tr>
<td>7</td>
<td>Pollux floor Rion CES 07</td>
<td>0.50</td>
<td>0.06</td>
<td>0.42</td>
<td>0.02</td>
</tr>
<tr>
<td>8</td>
<td>Pollux roof Rion CES 08</td>
<td>0.37</td>
<td>0.03</td>
<td>0.34</td>
<td>0.01</td>
</tr>
<tr>
<td>^9</td>
<td>Pollux channel Rion CES 07</td>
<td>0.54</td>
<td>0.25</td>
<td>0.09</td>
<td>0.20</td>
</tr>
<tr>
<td>10</td>
<td>Saraji A1 floor</td>
<td>0.40</td>
<td>0.05</td>
<td>0.34</td>
<td>0.01</td>
</tr>
<tr>
<td>11</td>
<td>Saraji A4 roof</td>
<td>0.31</td>
<td>0.00</td>
<td>0.02</td>
<td>0.29</td>
</tr>
<tr>
<td>12</td>
<td>Saraji B3 roof</td>
<td>0.60</td>
<td>0.05</td>
<td>0.46</td>
<td>0.09</td>
</tr>
<tr>
<td>^13</td>
<td>Saraji B2 coal</td>
<td>0.52</td>
<td>0.03</td>
<td>0.05</td>
<td>0.44</td>
</tr>
<tr>
<td>14</td>
<td>Saraji A3 interbed</td>
<td>0.08</td>
<td>0.04</td>
<td>0.04</td>
<td>0.00</td>
</tr>
<tr>
<td>15</td>
<td>Saraji B1 floor</td>
<td>0.11</td>
<td>0.02</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>^16 *</td>
<td>Saraji B2 coal</td>
<td>0.57</td>
<td>0.04</td>
<td>0.05</td>
<td>0.48</td>
</tr>
<tr>
<td>^17</td>
<td>Saraji A2 coal</td>
<td>0.88</td>
<td>0.02</td>
<td>0.44</td>
<td>0.42</td>
</tr>
<tr>
<td>18</td>
<td>Saraji A4 roof</td>
<td>0.21</td>
<td>0.03</td>
<td>0.02</td>
<td>0.16</td>
</tr>
<tr>
<td>^19</td>
<td>Riverside 1A coal</td>
<td>0.51</td>
<td>0.07</td>
<td>0.38</td>
<td>0.06</td>
</tr>
<tr>
<td>20</td>
<td>Riverside 2B floor</td>
<td>0.19</td>
<td>0.01</td>
<td>0.02</td>
<td>0.16</td>
</tr>
<tr>
<td>21</td>
<td>Riverside 2C roof</td>
<td>0.18</td>
<td>0.03</td>
<td>0.01</td>
<td>0.14</td>
</tr>
<tr>
<td>22</td>
<td>Riverside 1C roof</td>
<td>0.27</td>
<td>0.07</td>
<td>0.16</td>
<td>0.04</td>
</tr>
<tr>
<td>^23 *</td>
<td>Riverside 2A coal</td>
<td>0.51</td>
<td>0.01</td>
<td>0.02</td>
<td>0.48</td>
</tr>
<tr>
<td>^24</td>
<td>Riverside 2A coal</td>
<td>0.58</td>
<td>0.01</td>
<td>0.02</td>
<td>0.55</td>
</tr>
<tr>
<td>25</td>
<td>Riverside 1B floor</td>
<td>0.24</td>
<td>0.02</td>
<td>0.05</td>
<td>0.17</td>
</tr>
</tbody>
</table>

^ These samples have equivalents which have published total sulphur data. This information is provided on the sample description of these samples. (Table 3b.)

* Samples no. 16 and 23 duplicate samples No. 13 and 24 respectively. The results are based on raw air-dried sample analysis. No pretreatment of washing or fining was performed on these samples.
% Total sulphur in coal seams on a north south traverse between Newlands and Curragh. Showing published total sulphur levels, coal rank and Mean Max. Ref. were available.

<table>
<thead>
<tr>
<th>Mine</th>
<th>Seam/sample</th>
<th>%S Total</th>
<th>Rank</th>
<th>Mean Max.R.</th>
</tr>
</thead>
<tbody>
<tr>
<td>^ Newlands</td>
<td>Top</td>
<td>0.38</td>
<td>Med.Vol.Bit.Steam</td>
<td></td>
</tr>
<tr>
<td>^ Newlands</td>
<td>Bottom</td>
<td>0.51</td>
<td>Med.Vol.Bit.Steam</td>
<td></td>
</tr>
<tr>
<td>^ Riverside</td>
<td>1</td>
<td>0.55</td>
<td>Med.Vol.Hard.Coke</td>
<td>1.45</td>
</tr>
<tr>
<td>^ Riverside</td>
<td>2</td>
<td>0.58</td>
<td>Med.Vol.Hard.Coke</td>
<td>1.45</td>
</tr>
<tr>
<td>* Goonyella</td>
<td></td>
<td>0.50</td>
<td>Hard Coking</td>
<td></td>
</tr>
<tr>
<td>* Peak Downs</td>
<td></td>
<td>0.55</td>
<td>Hard Coking</td>
<td></td>
</tr>
<tr>
<td>* Harrow Creek</td>
<td></td>
<td>0.55</td>
<td>Bit. Coking</td>
<td></td>
</tr>
<tr>
<td>^ Saraji</td>
<td>A</td>
<td>0.88</td>
<td>Hard Coking</td>
<td>1.52</td>
</tr>
<tr>
<td>^ Saraji</td>
<td>B</td>
<td>0.52</td>
<td>Hard Coking</td>
<td>1.48</td>
</tr>
<tr>
<td>* Norwich Park</td>
<td></td>
<td>0.65</td>
<td>Hard Coking</td>
<td></td>
</tr>
<tr>
<td>* German Creek</td>
<td>Aquila</td>
<td>0.6-0.8</td>
<td>Med.Low.Vol.Bit.Coking</td>
<td></td>
</tr>
<tr>
<td>* German Creek</td>
<td>Tieri</td>
<td>0.3-1.5</td>
<td>Med.Low.Vol.Bit.Coking</td>
<td></td>
</tr>
<tr>
<td>* German Creek</td>
<td>German Creek</td>
<td>0.3-1.0</td>
<td>Med.Low.Vol.Bit.Coking</td>
<td></td>
</tr>
<tr>
<td>* Oakey Creek</td>
<td>Aquila</td>
<td>0.87</td>
<td>Med.Vol.Coking</td>
<td></td>
</tr>
<tr>
<td>* Oakey Creek</td>
<td>German Creek</td>
<td>0.42</td>
<td>Med.Vol.Coking</td>
<td></td>
</tr>
<tr>
<td>* Yarrabee</td>
<td>Pollux</td>
<td>0.8</td>
<td>Anthracite</td>
<td></td>
</tr>
<tr>
<td>* Curragh</td>
<td>Orion</td>
<td>0.4</td>
<td>Hard Coke, Steaming</td>
<td></td>
</tr>
<tr>
<td>^ Curragh</td>
<td>Pollux</td>
<td>0.54</td>
<td>Hard Coke, Steaming</td>
<td></td>
</tr>
<tr>
<td>* Curragh</td>
<td>Castor</td>
<td>0.65</td>
<td>Hard Coke, Steaming</td>
<td></td>
</tr>
<tr>
<td>* Curragh</td>
<td>Aries</td>
<td>0.65</td>
<td>Hard Coke, Steaming</td>
<td></td>
</tr>
</tbody>
</table>

^ % total sulphur figures from analysis of samples
* % total sulphur figures from Australian Coal Year Book 1986
Table 3: Descriptive carbon organic levels roof and floor material in samples by mine grouping showing sulphur levels, and characteristics of samples.

<table>
<thead>
<tr>
<th>Mine</th>
<th>Sample</th>
<th>Description</th>
<th>%S_t</th>
<th>%S_p</th>
<th>%S_s</th>
<th>%S_o</th>
</tr>
</thead>
<tbody>
<tr>
<td>SARAJI</td>
<td>A3</td>
<td>Slight carbonaceous mudstone/siltstone.</td>
<td>0.08</td>
<td>0.04</td>
<td>0.04</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>A4</td>
<td>Very slight carbonaceous mudstone/siltstone.</td>
<td>0.31</td>
<td>0.02</td>
<td>0.00</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>A1</td>
<td>Carbonaceous coaly siltstone.</td>
<td>0.40</td>
<td>0.34</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>B3</td>
<td>Sandy coaly carbonaceous sandstone.</td>
<td>0.60</td>
<td>0.46</td>
<td>0.05</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>B1</td>
<td>Mudstone coal veins very slight carbonaceous siltstone.</td>
<td>0.11</td>
<td>0.05</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>RIVERSIDE</td>
<td>2C</td>
<td>Very slight carbonaceous siltstone.</td>
<td>0.18</td>
<td>0.01</td>
<td>0.03</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Slight carbonaceous siltstone.</td>
<td>0.24</td>
<td>0.05</td>
<td>0.02</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>1C</td>
<td>Leaf moulds very slight carbonaceous siltstone.</td>
<td>0.27</td>
<td>0.16</td>
<td>0.07</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>2B</td>
<td>Siltstones mudstone slight micaceous.</td>
<td>0.19</td>
<td>0.02</td>
<td>0.01</td>
<td>0.16</td>
</tr>
<tr>
<td>NEWLANDS</td>
<td>S2.6</td>
<td>Carbonaceous, minor carbon material, Iron pyrite common. White chalky silty</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Roof 2</td>
<td>mudstone. Replacement of leaf moulds showing vitrain.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Varved carbonaceous mudstone.</td>
<td>0.65</td>
<td>0.20</td>
<td>0.41</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>S2.5</td>
<td>Varved carbonaceous mudstone.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Floor 1</td>
<td>Many leaf moulds, minor coalified leaf moulds.</td>
<td>0.44</td>
<td>0.35</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>0.3-0.4m</td>
<td>Varved mudstone lot of pyrite along bedding planes very high % coalified organic material (duroclarain &amp; vitrain)</td>
<td>0.56</td>
<td>0.21</td>
<td>0.33</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>S2.5</td>
<td>Varved sandy siltstone grey.</td>
<td>0.49</td>
<td>0.05</td>
<td>0.02</td>
<td>0.42</td>
</tr>
</tbody>
</table>
CURRAGH (POLLUX SEAM)

Rlon

CES 08

Some specimen high coal content. Most very minor carbonaceous. Fine varved mudstone/siltstone, intervienal coal.  0.37 0.34 0.03 0.00

Rlon

CES 07

Very slight carbonaceous, micaceous. Some leaf moulds. Some coalified rootlets. Varved silty mudstone less than 1mm thick coal lenses numerous.  0.50 0.42 0.06 0.02

%St* = percent total sulphur

%Ss = percent sulphate sulphur

%Sp = percent pyritic sulphur

%S0 = percent organic sulphur
Table 3B: Description of coal samples by mine grouping.

<table>
<thead>
<tr>
<th>Mine</th>
<th>Sample</th>
<th>Total Sulphur %*</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saraji</td>
<td>A2</td>
<td>0.57</td>
<td>Clarain-duroclarain with discreet vitrain bands of 2mm thickness. Clean coal - no dirt bands or apparent ash. Sample blocky with low incidence of conchoidal fracturing. Ground sample dominant vitrain. Some pyrite apparent in small crystal clusters - mainly associated into bands but evenly distributed.</td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td>0.57</td>
<td>Clarain/vitrain vitrain dominant 80% approx. clean - no apparent dirt bands.</td>
</tr>
<tr>
<td>Riverside</td>
<td>2A</td>
<td>0.51</td>
<td>Duroclarain, minor vitrain bands 20%. some tuff bands, clean blocky.</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>0.55</td>
<td>Durain, minor vitrain bands, minor occasional tuff band, blocky conchoidal.</td>
</tr>
<tr>
<td>Newlands</td>
<td>N2.6 core7 bottom 3.96m</td>
<td>0.59</td>
<td>Fine powdery bright coal, vitrain-duroclarain clean coal. no visible evidence of dirt band in coal sample.</td>
</tr>
<tr>
<td></td>
<td>N2.6 core 7 top 3m</td>
<td>0.63</td>
<td>Fine powdery bright coal, vitrain-clarain clean coal, no visible evidence of ash or dirt bands in sample.</td>
</tr>
<tr>
<td>Curragh</td>
<td>Pollux Rion CES 07</td>
<td>0.67</td>
<td>Durain with numerous thin vitrain bands. Clean coal with few dirt bands. Generally a dull hard coal with numerous clarain/vitrain bands.</td>
</tr>
</tbody>
</table>

*% Total Sulphur data from Australian Coal Year Book 1986; and from information provided by each mine at sampling.
Table 4: Characteristics of the four coal seams studied.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Newlands mean%</th>
<th>Curragh mean%</th>
<th>Riverside mean%</th>
<th>Saraji mean%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>range</td>
<td>range</td>
<td>range</td>
<td>range</td>
</tr>
<tr>
<td>Moisture</td>
<td>2.8</td>
<td>3.06</td>
<td>7.5</td>
<td>9.5</td>
</tr>
<tr>
<td></td>
<td>2.8-2.8</td>
<td>7.0-8.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Ash (raw)</td>
<td>12.6</td>
<td>14.26</td>
<td>24.25</td>
<td>17.5</td>
</tr>
<tr>
<td></td>
<td>12.1-13.0</td>
<td>24.2-24.3</td>
<td>10.0-25.0</td>
<td></td>
</tr>
<tr>
<td>Total Sulphur</td>
<td>0.61</td>
<td>0.67</td>
<td>0.53</td>
<td>0.57</td>
</tr>
<tr>
<td></td>
<td>0.59-0.63</td>
<td>0.51-0.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSN No.</td>
<td>3.5</td>
<td>7</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Maceral Content:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exinite</td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Vitrinite</td>
<td></td>
<td></td>
<td></td>
<td>72.0</td>
</tr>
<tr>
<td>Inertinite</td>
<td></td>
<td></td>
<td></td>
<td>23.0</td>
</tr>
</tbody>
</table>
Graph 1
% S total in roof material

Graph 2
% S total in floor material
Graph 3
% S total coal

Graph 4
Cumulative % S total of roof, floor & coal samples
(by mine site)
Graph 5
Cumulative average % S total of all samples (by mine site)

Graph 6
% Organic S in roof material (by minesite)
Graph 7
% Organic S in coal seam
(by minesite)

Graph 8
% Organic S in floor material
(by minesite)
Graph 9

% Pyrite sulphur in roof material
(by minesite)

Graph 10

% Pyrite sulphur in coal seam
(by minesite)
Graph 11
Pyrite sulphur in floor material
(by minesite)

Graph 12
% Sulphate sulphur in roof material
(by minesite)
Graph 13
% Sulphate sulphur in coal seam
(by minesite)

Chart 14
% Sulphate sulphur in floor materials
(by minesite)
The coals, with a few exceptions, do not vary markedly in their total sulphur percentages.

There is an apparent relationship between the amount of carbon material and the total sulphur content of the roof and floor material. Roof and floor samples with high total sulphur levels do have a high carbonaceous level compared with other samples tested.

With a few exceptions, the roof and floor material has a relative low level of organic sulphur.

Those samples that do have high organic sulphur levels usually only have very slight carbonaceous levels. Roof and floor samples with high pyrite levels usually have a relatively high carbonaceous coaly component. Some samples show emplacement of pyrite along bedding planes and associations of pyrite with leaf moulds and occasionally petrification/replacement of plant tissue with pyrite. (Table 3)

According to Cook A.C. 1981, pyrite shows a preference for vitrinite and may occur as plant petrifications. Much of the carbon material in the roof and floor samples occurs as vitrain or clarain (bright coal).

With the exceptions of the Newlands area, all samples of roof and floor material show only minor variation of sulphate sulphur levels. The Newlands samples that show high sulphate sulphur levels also have high total sulphur levels (relative) and high pyrite sulphur levels (relative) to other samples. Both samples have distinctive pyrite
crystals either on bedding planes or as petrifications/replacement of leaf material. These samples also have high carbonaceous contents.

With the exception of the Newlands samples S2.6 roof 2 and S2.5 floor 1 3.8-4.0m and two of the Saraji samples (B3 roof & A1 floor) all coal seams have much higher levels of total sulphur than the roof and floor material (Table 1); and with similar exceptions, (Newlands N4.7 roof 1 & Riverside Floor 1B) organic sulphur levels are higher. The amount of carbon material in the sample does have an apparent bearing on the organic sulphur content. Samples with very low amounts of carbon material have high organic sulphur levels and variable total sulphur levels in the range of 0.08% to 0.49% apart from Rion CES 07 floor sample which has 0.02 % organic sulphur, 0.42% pyrite sulphur and 0.5% total sulphur.

Graphs 1 & 2 show that the Riverside mine has on average less sulphur in the roof and floor material than other sample areas.

Table 2 illustrates that the percentage of total sulphur in the coal along the geotraverse is reasonably constant. While Graph 4 shows the total amount of sulphur available in all forms in the roof, seam and floor material is lowest at the Riverside minesite.

Graph 5, the cumulative average of roof, seam and floor total sulphur levels, shows Riverside sample area has the lowest amount of sulphur and that Saraji and Curragh sample areas are equal, while the Newlands area has the highest total sulphur levels. Newlands is the only coal used exclusively for steaming purposes.
Across the sample areas, the pyritic sulphur levels in the coal samples vary, while the sulphate sulphur levels in the coal samples are generally low. The coals have relatively high levels of organic sulphur; and those roof and floor samples of the Newlands area have relatively high levels of pyritic sulphur, apart from the Newlands sample N4.7 roof 1, as do the Curragh roof and floor samples.

Saraji A1 floor sample and B3 roof also have high levels of pyritic sulphur; while Riverside roof and floor samples have low levels of pyritic sulphur.

Newlands coal seam samples have less pyritic sulphur than the surrounding roof and floor material, apart from samples N4.7 roof 1 at 0.05 % pyrite compared to the coal seams at 0.18% and 0.16% and the samples S2.6 roof 2 at 0.2% pyrite and S2.5 floor 1 0.3-0.4m at 0.35% pyrite sulphur, while the pollux seam sample has far less pyritic sulphur than the surrounding strata 0.09% compared to 0.42% floor and 0.34% roof.

The two Saraji coal samples are vastly different in their pyritic sulphur levels: sample B2 has 0.05% while sample A1 has 0.44%. Overall, however, pyritic sulphur levels are low at Saraji though the seam shows pyrite crystals in sample A2 coal, apart from locality A where seam and floor samples have high levels of pyrite.

Sulphate sulphur levels along the geotraverse at sample localities are low with two exceptions. Both exceptions are in the Newlands area. Newlands sample S2.5 floor 1 3.8-4.0m and Newlands S2.6 roof 2
samples have approximately 5 to 10 times greater the amount of sulphate sulphur found at other localities. (Table 1)

The seven coal samples analysed were consistently low in sulphate sulphur except for sample Pollux channel Rion CES 07 which gave a reading of 0.25% (this sample is a dull coal (Table 3b) and Newlands N2.6 Core 7 Top 3m with a reading of 0.13 (powdery bright coal).

Total sulphur contents across the Basin geotraverse are reasonably constant; there is little variation within the seams of total sulphur percentages. The occurrence of sulphur at the Riverside minesite is consistent within the seam in total sulphur percent to other areas but the surrounding strata has a much lower sulphur percent than other areas.

Discussion:
The sulphur in these coals, and strata, samples does not occur as such but is present in organic combination as part of the coal substance and in inorganic combination as pyrite or marcasite and, especially in weathered coals, as sulphate.

Organic sulphur is present in the organic matter making up the coal. In general, the sulphur content of these coals is low and largely organic (in 55.6% coal samples). The organic sulphur of coals of increasing total sulphur content tends to increase, but the pyritic sulphur tends to increase at a greater rate and make up a greater proportion of the total sulphur (which gives a reason for the higher pyritic content of some of the roof and floor strata (see Table 1.).
The sulphur present in these samples is variable in its occurrence both in amount and form. (Table 3.)

The normal behaviour of coals according to Gibson J. (1979) may be affected by the presence of mineral matter (particularly sulphur) but in these samples the higher sulphur values are associated with the lowest ash contents and the highest ash values give lowest sulphur contents (Table 4).

The relative dominance of organic sulphur content (55.6% of samples) in these coals is, according to Teichmuller & Teichmuller 1982, due to the fresh water origin of the peats and the surrounding strata as distinct from those coals deposited in brackish marine areas that are usually rich in sulphur, ash and nitrogen.

Under anaerobic conditions, particularly in swamps and poorly drained or water logged soils, the main form of inorganic S in soils is sulphide and often elemental sulphur (Tabatabi 1982). This would explain the presence of relatively high amounts of pyritic sulphur found in 33.3% of coal samples analysed and many of the roof and floor strata samples (53.3%), as would the findings of Teichmuller & Teichmuller 1982, Chukhrov F.V. 1974, and Bayh W. & Sellschop M. 1974 that H₂S is produced in peats and organic-rich sediments by sulphate-reducing bacteria. These sulphate-reducing bacteria have a special role in peats and organic muds, reducing sulphate to sulphur, thus making possible the formation of marcasite and pyrite. FeS₂ in peats and organic sediments can only form by bacterial activity, since, on the basis of reaction kinetics, there is insufficient energy.
for a purely chemical reaction of sulphates to disulphides. (Scott S.D. 1974, and Teichmuller & Teichmuller 1982).

pH value, bacterial activity, sulphur availability and the acidity of a peat influences bacterial life and with it the structural and chemical composition of plant remains.

Bacterial composition of proteins leads to the formation of CO2 and H2S and a variety of intermediate products (Chilinger G.V.; Bissel H.J. & Wolfe K. H. 1967). Bacteria may produce biocatalysts or enzymes which can activate chemical reactions which modify their environment. The sulphate sulphur dominating in 11.1% of coal samples could therefore be a factor of incomplete reactions of sulphate to sulphides (Barton P.B. Jnr. 1970).

With complete reaction, the pyrite presence is explained according to Jensen M.L. (1967) because biogenic sulphides are formed by the reaction of any metal with hydrogen sulphide produced by sulphate-reducing bacteria through their reduction of sulphate ions. The microbial mechanism may act as an intermediate stage for the transfer of elements extracted from the primary minerals into the microorganic environment. The mechanism of mineral disintegration by microorganisms is extremely variable. Carbonyl and phenol groups react with the mineral elements forming various compounds. This is succeeded by decomposition of the minerals, their elements passing into solution. Various mineral acids (nitric, sulphuric), as well as organic ones and material belonging to the category of strong reducers, attack primary minerals with the result
that various elements are extracted from them (Chukhrov F.V. 1974 and Bayh W. & Sellschop M. 1974).

In nature, oxygen-consuming organisms are the principal agents in providing the correct environment for sulphur-reducing bacteria. The aerobic bacterial attack on buried organic matter quickly removes all free oxygen. The anaerobic bacteria then take over and attack the sulphate anion, the most readily divisible ion containing oxygen. The only gas phase left is H$_2$S. The setting is now appropriate for the pyrite reaction (Fairbridge R.W. 1967).

Anywhere that organic content of sediments is above 2% there is an excess of H$_2$S. The principle minerals formed are the common ferrous sulphides (Table 5) (Cooper B.S. & Murchison D.G. 1969). These are produced by reduction of iron oxides and the various hydrates by the action of H$_2$S liberated by sulphate reducing bacteria and by bacterial breakdown of organic sulphur compounds (Dapples E.C. 1967, Welte D.H. 1969).

With this information, and given the percentage of total sulphur present in the roof and floor material (Graphs 1 & 2), there does not appear to be any relation between sulphur content of the roof and floor strata and the amount of total sulphur or its mode of occurrence in the coal.

From the results of analyses it is apparent that there is no increase of total sulphur over the north south traverse or vice-a-versa, or modes of occurrence of the sulphur. This would suggest that the development of the coal facies across the basin area sampled is
consistent. According to Teichmuller & Teichmuller (1982), the facies of a coal seam expresses itself through its mineral and maceral contents of the coal and certain chemical properties, which are independent of rank.

**Table 5. Some sulphur minerals identified in coal:** (After table presented in Stach's Textbook of Coal Petrology 3rd. Ed. 1982)

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron Disulphides</td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td>Rare-common *</td>
</tr>
<tr>
<td>Marcasite</td>
<td>Rare</td>
</tr>
<tr>
<td>Melnikovite</td>
<td>Rare</td>
</tr>
<tr>
<td>Sulphides</td>
<td></td>
</tr>
<tr>
<td>Sphalerite</td>
<td>Rare</td>
</tr>
<tr>
<td>Galena</td>
<td>Rare</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>Very Rare</td>
</tr>
<tr>
<td>Pyrrhotite</td>
<td>Very Rare</td>
</tr>
<tr>
<td>Sulphates</td>
<td></td>
</tr>
<tr>
<td>Baryte</td>
<td>Rare</td>
</tr>
</tbody>
</table>

* Rare: 5 - 1% \} of the total mineral matter content of the coal.
Vary Rare: <1% \}
Common: 5 - 10% \}

As shown in Table 4 the characteristics of the coal are very similar, and thus the environmental conditions dominating at the time of deposition of the peat were very similar across the basin traverse, as were the conditions which applied at the time of deposition of the surrounding strata respectively.

The dominant roof and floor material is siltstone. Those samples that do not have a dominance of siltstone, but are either more sandy
or contain more mudstone, have higher total sulphur levels and higher pyrite sulphur levels. The evidence therefore seems against the assumption that surface solutions, derived from weathering of ordinary rocks through percolation (descending H₂S containing solutions), formed concentrations of sulphide minerals in the samples. The presence of tuff bands in these coals indicates volcanism in the greater region. Volcanic processes providing material into the sedimentary system offers one possibility for a source of sulphur in solutions contemporaneous with deposition and thereby a source of much of the inorganic sulphur in these samples. (Krauskopf B.K. 1967).

The source of the forms of sulphur in these samples is therefore diverse.

**Conclusions:**

In addition to purely organic substance, both the macerals and microlithotypes of coal invariably contain smaller or larger amounts of inorganic components. These inorganic components are classified in three groups according to their origin:-

a) inorganic matter from the original plant;

b) inorganic and organic complexes and minerals which formed during the first stage of coalification, or which were introduced by water or wind into the deposits as they were forming;

c) minerals deposited during the second phase of the coalification process, after consolidation of the coal, by ascending or descending solutions or by alteration of primary deposited minerals. (Mackowsky M.-Th 1982).
The minerals and sulphur in these coal samples occur in two forms:
1) in a finely divided state dispersed throughout the coal;
2) in macroscopically visible bands and lenses. The second type of mineral matter is likely to be removed during washing while the first is not.

The total sulphur levels in the roof and floor and coal samples indicate that much of the sulphur of the prepared coal has not come from the inclusion during mining of roof and floor rock. Though a certain degree of inclusion is difficult to avoid the principle sulphur content of the prepared coal is inherent within that coal as an organic component.

44.4% of the coal samples indicate a non-organic origin of the sulphur. This fraction, according to Thiessen G. (1945) and Ode W.H. (1963), should therefore be capable of being removed by coal cleaning methods.

According to Mackowsky M.-Th (1982), it is the aim of coal preparation to upgrade the run-of-mine coal which, as a rule, is not saleable and to transform it by sizing and cleaning into a marketable product. Selective mining practices, such as exclusion of roof and floor material and major ash bands, should therefore assist in the minimisation of sulphur in the run of mine product.

The ash levels, as distinct from sulphur levels, apparent in some of the raw coals as high as 25% is no doubt a factor of inclusion of dirt bands and roof and floor material during mining. Most of this material may be removed by coal cleaning methods.
Much of the sulphur inherent in coal as either organic or inorganic has been shown by Teichmuller M. & Teichmuller R. (1967), and Wollrab V. & Streibl M. (1969) to be due to a combination of factors. Those factors are microfauna and microflora, bacteria and climate interrelated through the peat and coalification phase.

A beginning has been made in the measurement of physical properties of these coals. Because the properties of coal vary with composition and condition of the vegetation at the time of its accumulation and burial (type) and with the modification of progressive alteration after burial (rank) the selection and precise definition of material for investigation is difficult, (McCabe L.C. & Baley C.C. 1945 and Cook A.C. 1975). In these samples, pyrite tends to be preferentially associated with vitrinite and, as evidenced in the Newlands samples S2.5 floor 1 3.8 - 4.0m and S2.6 roof 2, may occur as plant petrifications. This is in accordance with the findings of Cook A.C. (1981).

Some of the sulphur in all of the coal samples occurs as part of the organic matter and in inorganic combination as pyrite and sulphates. From the analyses carried out on multiple samples, the organic sulphur in the coals is uniformly distributed throughout the coal material, while the pyrite is not uniformly distributed but rather is disseminated throughout the coal material as very fine crystals and macroscopically visible crystals and occasionally as small veins. Though the pyrite is common in these coals and strata samples, it occurs for the most part to only a small total extent, which is consistent with the findings of Chandra D. and Taylor G.H. (1982) and Pretor M. (1983).
In the samples analysed, the principle form of sulphur present is organic sulphur. The pyritic sulphur levels are low as are the sulphate sulphur levels. Overall, the total sulphur levels are very low and the levels in the coal seams are approximately the same as the total sulphur levels of the surrounding strata but are sufficiently distinct to draw the following conclusions.

The principal conclusions to draw from this study are:-

1. The sulphur inherent within the surrounding strata of coal seams does not have a direct or significant effect on the level or modes of occurrence of sulphur within these coal seams.
2. The level of the sulphur and its modes of occurrence is such that increased liberation of sulphur to concentrate in the refuse will not be easily achieved.
3. Pyrite is common in these coals but is not the eminent mode of occurrence.
4. Though the percentage modes of occurrence of the sulphur change from site to site, there is no increase of total sulphur over the North South traverse studied.
5. Organic sulphur is the dominant mode of occurrence of sulphur in the coal seam.
6. The dominant roof and floor material is siltstone.* Those samples that are not dominated by siltstone but are dominated by coarser (sandy) or finer (muddy) sediments have higher

* The Blackwater Group was laid down in a terrestrial environment. Most of the sediment, according to Dickens & Malone (1973), was deposited by rivers, but in places beds were laid down in lakes or swamps, and towards the top of the sequence coal measures were deposited in an extensive system of swamps and sluggish rivers. This mode of deposition explains the differing sediments above the coal seams and below, and the influence of depositional environment on the sulphur content of the coal.
total sulphur levels and higher pyritic sulphur levels, showing a depositional influence on the sulphur content of the coal.

7. The presence of tuff bands in some samples indicates that volcanic processes providing material into the sedimentary system offers one possibility for a source of sulphur contemporaneous with deposition of the coal facies and thereby a source of inorganic sulphur in these samples.

8. The study area was not sufficiently sampled to draw conclusions indicative of the Basin as a whole.
BIBLIOGRAPHY:

**Australian Standard**


**Australian Standard**


**Barton P.B. Jnr.**


**Bayh W. & Sellschop M. 1974:** Determination of the specific free surface energy of heterogenous single crystal faces. Spec. Issue: IMA papers 9th meeting Berlin - Regensburg 197-201pp.
Chandra D. &

Chilinger G.V.,
Bissell H.J. &


Teichmueller M. &


Teichmueller M. &


Webb E.A. &


METHODS FOR THE ANALYSIS AND TESTING OF COAL AND COKE

The determination of the modes of sulphur in the samples tested was undertaken using the Australian Standard A.S. 1038.6.3.1. - 1986 and the Australian Standard A.S.11 - 1982.

Part 6.3.1. - Ultimate analysis of higher rank coal - Determination of total sulphur (Eschka method).

1) This standard sets out procedures for the determination of total sulphur in the analysis sample of higher rank coal by the Eschka method.

2) **Principle** - a known mass of sample is ignited in intimate contact with Eschka mixture in an oxidising atmosphere at 800°C to decompose organic material and to convert all sulphur to sulphate. The sulphate is then dissolved in dilute hydrochloric acid and determined gravimetrically by precipitation with barium chloride.

3) **Reagents** - unless otherwise specified, all reagents shall be of analytical reagent quality. Distilled or deionised water shall be used throughout.

**Special reagents** - Eschka mixture - light calcined MgO and Na₂CO₃ in the ratio of 2:1 by mass.

Hydrochloric acid 1.18g/mL, ammonia solution 0.88g/mL
Barium chloride solution (100g/L). Dissolve 100g crystalline barium chloride dihydrate in water and dilute to 1 litre.

Potassium sulphate solution (2g/L). Weigh about 2g (to nearest 0.1mg) of potassium sulphate (K2SO4), previously dried at 110°C for 2 hours. Dissolve in water and dilute to 1 L.

Silver nitrate solution (16g/L). Dissolve 16g of AgNO3 in water and dilute to 1 L. Methyl red indicator. Dissolve 0.02g of Methyl red in 60 ml of ethanol (950ml/L) and dilute to 100ml with water.

4) **Apparatus** - the following apparatus is required.

Muffle furnace, crucibles of 25 ml capacity, silica plate for easy sliding of crucibles into furnace. Silica crucibles of 25 ml capacity. Samples.

5) **Procedure** - determination of sulphur in the sample.

Weigh 1 g of the sample to the nearest 0.1 mg and mix intimately with 3 g of Eschka mixture in the crucible. Level the contents of the crucible and cover with 1 g of Eschka mixture.

Place the charged crucible into the cold muffle furnace, raise the temperature of the furnace slowly to 800°C over 1 hr. maintain temperature for 1.5 hr., withdraw the crucible and allow to cool. Examine contents. If any unburnt carbon
remains in the crucible, mix the contents and return to
furnace for a further 30 min. Re-examine contents after this
time and repeat as necessary.

Transfer the charge to a 400 ml beaker containing 25 ml of
water and wash the crucible thoroughly with about 50 ml of
water (hot), adding the washings to the beaker. Cover beaker
with clock glass and add carefully with stirring sufficient
hydrochloric acid, warming the contents, to effect solution.
Some mineral matter will remain insoluble. Boil for 5 min. to
expel carbon dioxide and filter into a 400 ml beaker using a
medium speed filter paper. Wash the filter with four 20 ml
portions of hot water.

To the combined filtrate add 2 or 3 drops of methyl red
indicator and carefully add ammonia solution until the colour of
the indicator changes and a precipitate is formed. Add just
enough hydrochloric acid to redissolve the precipitate then
add 1 ml in excess. Dilute solution to 200 ml with water, heat
covered beaker until solution boils and then reduce heat to just
below boil.

Add 10 ml of cold Barium chloride solution from a pipette with
a delivery time of 20 sec's while agitating solution. keep
contents just below boil for 30 min.

Filter through an ashless filter paper and wash the precipitate
until free of chlorides, as indicated by 1 drop of filtrate no
longer giving a while cloudiness with 1 ml of silver nitrate solution.

Fold the wet filter paper and contents into a weighed silica crucible and place in muffle furnace at 800°C. Heat for 15 min. cool in a dessicator and weigh.

Carry out a blank determination at the same time and under the same conditions as the actual determination but omitting the sample. When the acidity of the solution is adjusted by the addition of 1 ml excess hydrochloric acid add 25 ml of potassium sulphate solution. Dilute the solution to about 200 ml with water and complete the determination as described above.

6) **Calculation of results** - calculate the sulphur content by the following formula:

\[
S(\text{ad}) = \frac{M^2 - (M_3 - 0.0355M_4)}{M_1} \times 13.74
\]

Where

- **M1** = mass of sample taken in grams.
- **M^2** = mass of barium sulphate found in determination in grams.
- **M3** = mass of barium sulphate found in blank in grams.
- **M4** = mass of potassium sulphate per litre in solution, in grams.
- **S(\text{ad})** = percentage of total sulphur in the analysis sample.
This standard sets out methods for determining the amount of sulphate sulphur, pyritic and organic sulphur in coal.

1) **Determination of sulphate sulphur**

The sample is extracted with boiling dilute hydrochloric acid for 30 min. to bring the sulphate sulphur into solution. After filtration, sulphate sulphur is precipitated from the filtrate as barium sulphate and determined gravimetrically.

**Apparatus:** Condensor. A cold finger condensor which will fit loosely into the neck of a 250 ml conical flask. Muffle furnace. Silica plate. Volumetric glassware.

**Reagents:** Hydrochloric acid (1160 kg/m$^3$ to 1180 kg/m$^3$), Hydrochloric acid solution (1160 kg/m$^3$ to 1180 kg/m$^3$) diluted 1 + 1; ammonia solution (800 kg/m$^3$), diluted 1 + 2, barium chloride solution (100 g/L); potassium sulphate solution (2 g/L); methyl red indicator.

**Procedure:** Carry out the analysis in duplicate on each sample. Carry out a blank test in parallel using the same procedure but omitting the sample.

a) Weight 5 g to nearest 0.001 mg of sample into a 250 ml conical flask and add 50 ml hydrochloric acid. Insert condensor, through which a slow stream of water is passing, and boil for 30 min.
b) Remove condensor, filter the mixture into a 400 ml beaker and wash the residue 6 times with hydrochloric acid using 30 ml in all and boil for 10 min. Cool slowly, add 20 ml ammonia solution then 2 or 3 drops of indicator followed by the addition of ammonia solution until the solution is just alkaline then add 5 drops in excess. Boil for 2 to 3 min. then filter through a fast, hardened paper into a 400 ml beaker.

c) Wash precipitate with 3 x 20 ml portions of hot water. Discard precipitate. Add concentrated hydrochloric acid to filtrate until just acid then add 1 ml in excess. Add 25 mls of potassium sulphate solution and dilute to 200 ml with water.

d) Heat covered beaker until solution boils, add 10 mls cold barium chloride dropwise while stirring and maintain just below boil for 30 min. Continue stirring until precipitation has visibly commenced, allow to stand overnight.

e) Transfer the precipitate to ashless filter paper and wash with water till free from chlorides. Fold the paper and precipitate into a crucible and place in furnace at 815°C. Heat for 15 min. remove capsule, cool in dessicator and weigh.
Calculation of results: the amount of sulphate sulphur can be calculated by the following formula:

\[
S (s) = \frac{M2 - M3}{M1} \times 13.74
\]

where \( S(s) \) = percentage of sulphate sulphur in sample

\( M1 \) = mass of sample used in grams.

\( M2 \) = mass of barium sulphate in grams.

\( M3 \) = mass of barium sulphate in blank in grams.

2) Determination of pyritic sulphur

The sample is extracted with boiling dilute hydrochloric acid to dissolve non-pyritic iron. The residual coal is then further extracted with boiling nitric acid to bring the pyritic iron into solution. The extract is filtered and the amount of iron in the filtrate is determined. The pyritic sulphur is calculated from the iron content.

Apparatus: Condensor; a cold finger condensor which will fit loosely in to the neck of a 250 ml conical flask. Atomic absorption spectrophotometer - wavelength 248.3 nm or 372.0 nm, flame air/acetylene. Volumetric glassware.

Reagents: Hydrochloric acid (1160 kg/m\(^3\) to 1180 kg/m\(^3\)), diluted 1 + 1; Nitric acid solution (1420 kg/m\(^3\)) diluted 2 +
13; Hydrogen peroxide solution (300 g/l); ammonia solution (880 kg/m³), diluted 1 + 2.

**Procedure:** Carry out analyses in duplicate and carry out a blank test in parallel with the analyses using the same procedure as for the analysis but omitting the sample.

a) Weigh, to nearest 0.001 mg, about 1 g of sample into a 250 ml conical flask and add 50 ml of hydrochloric acid solution. Insert condensor and boil for 30 min., shaking occasionally to ensure sample is always wetted by acid.

b) Filter the mixture, and wash the residue 6 times using 20 ml HCL in all. Wash twice with distilled water and discard filtrate.

c) Transfer extracted coal and filter paper to the 250 ml flask and add 50 ml of nitric acid; insert condensor and boil for 30 min. shaking as before. Filter mixture and wash 6 times with nitric acid using 20 ml in all.

d) Cool the filtrate, add 20 ml of ammonia solution, mix and dilute to 250 ml with water in a volumetric flask. Mix thoroughly.

e) Measure the absorbance and calculate the percentage of iron in the sample by reference to a calibration graph.
f) The calibration graph can be prepared by use of standard iron solutions to cover the expected range by transferring necessary amount of stock soln. to a 100 ml flask. Add 28 ml of nitric acid and 8 ml ammonia soln. Dilute to 100 ml with water and mix.

**Calculation of results:** the pyritic sulphur content can be calculated from the following formula:

\[ S(p) = \frac{0.02871 \times a}{m} \]

where

- \( S(p) \) = percentage of pyritic sulphur in sample.
- \( a \) = iron content of sample solution in micrograms per millilitre.
- \( m \) = mass of coal used in grams.

**Calculation of organic sulphur:** The organic sulphur is obtained by calculation by using the following formula:

\[ S(o) = S - (S_s + S_p) \]

where

- \( S(o) \) = organic sulphur component.
- \( S \) = total sulphur present in sample in percent.
- \( S_s \) = percent of sulphate sulphur present in sample.
- \( S_p \) = pyritic sulphur present in sample in percent.
APPENDIX 2

A BRIEF GEOLOGICAL HISTORY OF THE NORTH BOWEN BASIN

Part of the Permo-Triassic succession in the Bowen Basin consists of coal measures (Blackwater Group) overlain by a redbed sequence (Rewan Group) and a sequence composed essentially of quartz-rich sandstone (Clematis Group) (Jensen A.R. 1975, Dickens & Malone 1973).

The coal measures of the Bowen Basin were formed at the close of the Permian when earth movements created a rapidly subsiding intermontane basin, possibly with an internal drainage system.

The Basin was principally formed during the Permian and Triassic, when a thick pile of marine and continental sediments accumulated over a wide area.

The Basin has become increasingly important with the discovery of large deposits of coking coal within the Permian sequence.

In the Bowen Basin, sedimentation began in the Early Permian and continued with little interruption into the Late Triassic. The sea transgressed westwards into the Basin during the Early Permian and marine sedimentation continued into the Late Permian, with a partial regression late in the early Permian. The earliest Late Permian was marked by a widespread transgression and the sea extended farther west than at any previous time during the Permian. During the Late
Permian, the sea finally withdrew and thick coal measures were formed on the newly emerged lowlands.

In the Upper Permian, the Basin was cut off from the sea by uplift along the eastern margin, and the Blackwater Group was deposited. The coal measures at the top of the group are almost continuous throughout the Basin.

The Triassic sequence overlying the Permian Blackwater Group comprises three non-marine formations of basinwide extent: The Rewan Formation, directly overlying the Blackwater Group, Clematis Sandstone, and Moolayember Formation (Dickens & Malone 1973).

Uplift folding and erosion took place in the Upper Triassic, and, in the Lower Jurassic, the Great Artesian Basin and its western lobe, the Surat Basin, were developed as separate structures.

**Stratigraphy of the Blackwater Group:**

The group comprises three formations: the Fair Hill Formation, The Burngrove Formation and the Rangal Coal Measures.

The Fair Hill formation is relatively homogenous and consists of about 85 m of fine to coarse-grained micaceous, calcareous sandstone which is conglomeritic in places, interbedded with very minor brown calcareous mudstones. The base of the sequence consists of brown calcareous sandstone containing scattered pebbles of shale and volcanic rocks, with some conglomerate lenses up to 12 m thick.
Higher in the sequence, conglomerates are rare and the units consist of alternating lithic sandstone and mudstone.

The sequence between the Fair Hill Formation and the Triassic Rewan Group comprises the Burngrove Formation and the Rangal Coal Measures.

The Burngrove Formation is about 90 m thick. At the boundary between the Fair Hill Formation and the overlying Burngrove Formation, there is generally a sudden change from cross stratified calcareous sandstone to greyish brown carbonaceous mudstone with thin beds of green chert, extremely carbonaceous shale or shaly coal, and light green mudstone. The basal beds are overlain by hard, fine-grained sandstone thinly interbedded with hard grey or green mudstone.

The Rangal Coal Measures form the upper unit of the Blackwater Group. The sequence consists of sandstone, coal, shale and carbonaceous shale, siltstone and thin kaolinite clay bands. In the lower part of the unit, the sandstone is coarse-grained and trough cross-stratified, but the sandstone interbedded with coal seams is generally very fine to fine grained and laminated or cross laminated. The thicknesses of the coal seams vary from about 10 m down to a few centimetres, and seam splits are common.

In the north, fine-grained igneous rocks are interbedded with all of the Blackwater Group. Some of the interbedded igneous rocks are sills, but some flow rocks may be present.
The sandstone of the Rangal Coal Measures is generally moderately well sorted and fine to coarse grained. The characteristic greyish white colour is due to the abundance of kaolinite cement, and to the replacement of feldspar and rock fragments by kaolin. Most of the fragments are of volcanic origin but fragments of fine grained sedimentary rocks are present.

The boundary between the coal measures and the Rewan Group is taken above the youngest coal seam. But, in places, the youngest coal seam is overlain by a conglomerate composed of rounded cobbles of volcanic rocks. As similar conglomerates are interbedded with the coal seams, the boundary is placed above the conglomerate.

The Rewan Group is composed principally of yellowish brown muddy siltstone and siltstone, which occurs as relatively thick beds interbedded with sandstone, and yellowish green siltstone in relatively thin layers within the red-brown mudstone.

Most of the red-brown mudstone exhibits very fine lamination due to the alternation of fine and coarse layers of silt or very fine sand, and mud. Some of the lamination is disrupted by bioturbation.
MAP 1: Map of central Queensland showing the Bowen Basin and operating mines.
MAP 2: Map of Central Queensland showing the Bowen Basin and the mines used for sampling, to achieve a north-west to south east geotraverse through the Basin.
### Lithology

<table>
<thead>
<tr>
<th>Age</th>
<th>Group</th>
<th>Formation</th>
<th>Seam</th>
<th>Column</th>
<th>Thickness Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tertiary</td>
<td>Sutter Fm</td>
<td></td>
<td>Tb</td>
<td>≈50m</td>
<td></td>
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<tr>
<td>Triassic</td>
<td>Mimosa Gp</td>
<td>Rewan</td>
<td></td>
<td>400 - 600m</td>
<td></td>
</tr>
<tr>
<td>Upper Permian</td>
<td>Blackwater Gp</td>
<td>Rangal C.M.</td>
<td>50m</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Lns</td>
<td>200m</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**River Alluvium.** Medium to coarse grained quartz, minor clays & conglomerate.

**Vesicular, blocky basalt flows.** flowed along Tertiary valleys.

Medium to very coarse grained angular quartz sandstones. Occasional yellow & orange mudstones.

Green, fine coarse lithic sandstone.

Occasional carbonaceous chips.

Thin red beds.

Dark carbonaceous mudstone.

Laminated mudstone & siltstone with occasional lithic sandstone lenses.

Two rider seams & the upper Newlands seam. Carbonaceous mudstone & siltstone.

Highly banded & tuffaceous coal seam.

A sequence of carbonaceous mudstone, siltstone and sandstone. Highly tuffaceous and abundant fossil wood. Several thick conglomerates. Highly banded & tuffaceous coal seam.
SAMPLE REPORT - PART A

SAMPLE NO.: N2.6 CORE TOP 2 m, 32.5 FL 1.3-4 m 52.6 FL 4-7 m, 2 DATE: 16.12.87
N2.6 CORE TOP 3.96 m, 32.5 FL 1.3-4 m, NA TIME:

NAME OF MINE: NEWLANDS COAL
LOCATION OF MINE: 77 KM SOUTH OF COLLINVILLE
NAME OF SEAM: UPPER NEWLANDS
DEPTH OF SEAM: 34 m (AFTER PRE-STRIP)
AVE. OF THICKNESS OF SEAM: 6.8 m
APPROX. LOCATION OF SAMPLE WITHIN MINE: SEE ATTACHED PLAN
APPROX. DEPTH OF SAMPLE WITHIN SEAM: TOP: 3 m BOTTOM: 3.96 m

ROOF TYPE: SANDSTONE, SILTSTONE, MUDSTONE
FLOOR TYPE: SILTSTONE, SANDSTONE, MUDSTONE, TUFF AND COAL
ORIGINAL WEIGHT OF SAMPLE: 30.8 KG TOP 37.2 KG BOT.
AMBIENT AIR TEMP.: 31°C
AMBIENT AIR MOISTURE:

TYPE OF COAL (eg steaming, H.Vol. coking, low Vol. coking etc.): STEAMING

PRINCIPAL USE OF COAL (eg steaming, coking): STEAMING

COAL RANK (if available):

BASIC ANALYSIS OF COAL (if available):

(1) Ash Content: 3.1 %

Mineral Content: 13 %

Moisture Content: 2.8 %

Total Sulphur Content: 0.63 0.59 %

Swell Factor: 0.63 (GSN NO.)

(2) COAL MASERALS:

Vitrinite: NIL %

Emitite: NIL %

Intermitite: NIL %

Comments:

(*) Depths of coal samples from top of seam
Depths of floor samples from base of seam
Depths of roof samples just above top seam.
SAMPLE NO: CURRAGH OLD MINING LTD
DATE: 14/12/87
TIME: 11.00 a.m.
NAME OF MINE: BLACKWATER, I.O.L.
LOCATION OF MINE: POLLYCUP
NAME OF SEAM: POLLYCUP
DEPTH OF SEAM: 40m
AVERAGE THICKNESS OF SEAM: 2.5m
APPROXIMATE LOCATION OF SAMPLE WITHIN MINE: PIT CEAST RION CESO7
APPROXIMATE DEPTH OF SAMPLE WITHIN SEAM: WHOLE SEAM CHANNEL SAMPLE
ROOF TYPE: SANDSTONE
FLOOR TYPE: SHALE + SANDSTONE
ORIGINAL WEIGHT OF SAMPLE:
AMBIENT AIR TEMP.:
AMBIENT AIR MOISTURE:
TYPE OF COAL (eg, steaming, H.Vol. coking, low Vol. coking etc.):
PRINCIPAL USE OF COAL (eg, steaming, coking.): LOW ASH COALING WITH DOMESTIC
AND EXPORT STEAM MIDDINGS.
COAL RANK (if available):
'BASIC ANALYSIS OF COAL (if available):

RAW(1) Ash Content: 14.26 %
          Mineral Content: — %
          Moisture Content: 3.06 % (TOTAL MOISTURE)
          Sulphur Content: 0.67 %
          Swell Factor: 3.5 (GSN NO.)

(2) COAL MASCERALS:
          Vitrite: %
          Erinite: %
          Intertinite: %

Comments:
NAME OF MINE: CURRAGH  
PRINCIPAL SEAM NAME:  

DESCRIPTION:  

HORSE SQUARE BANDS INTERBEDDED SANDSTONE  

BASE HEIGHT OF WEATHERING  

INTERBEDDED  

SILTSTONE WITH SANDSTONE BANDS  

SANDSTONE BED  

"ORGANIC" COAL BAND AND SHALE  

CARB SHALE FLOOR WITH SANDSTONE BELOW  

COMMENTS:  

DATE: 16/12/87
SAMPLE REPORT - PART A.

SAMPLE NO: Z A coal
B floor
C roof

DATE: 10-12-87

NAME OF MINE: Riverside

LOCATION OF MINE: Moree - Central Qld

NAME OF SEAM: Goonyella Lower Seam

DEPT OF SEAM: 40m

AVE. OF THICKNESS OF SEAM: 4.5m

APPROX. LOCATION OF SAMPLE WITHIN MINE: Southern end of seam

APPROX. DEPTH OF SAMPLE WITHIN SEAM: 2m above floor for coal

ROOF TYPE: Siltstone

FLOOR TYPE: Siltstone

ORIGINAL WEIGHT OF SAMPLE: A 8 =

AMBIENT AIR TEMPERATURE:

AMBIENT AIR MOISTURE:

TYPE OF COAL (eg steaming, H.Vol. coking, low Vol. coking etc.): Med Vol. coking

PRINCIPAL USE OF COAL (eg steaming, coking.): COKING

COAL RANK (if available):

BASIC ANALYSIS OF COAL (if available):

(1) Ash Content : 9.7 % raw coal = 24.8 %
Mineral Content : %
Moisture Content: 9 % inertial moisture = 15 %
Sulphur Content : 0.51 %
Swell Factor : 7 % (GSN NO.)

(2) COAL MACERALS:

Vitrinite : - %
Erlinite : - %
Intertinite : - %

Comments:
SAMPLE REPORT - PART A.

SAMPLE NO: 1

A coal
B floor
C roof.

DATE: 10-12-17

NAME OF MINE: Riverside
LOCATION OF MINE: Moranbah - Central QLD.
NAME OF SEAM: Goonyella Lower Seam
DEPTH OF SEAM: AVE. FROM 40m
AVE. OF THICKNESS OF SEAM: 8.0m
APPROX. LOCATION OF SAMPLE WITHIN MINE: Northern end of coal dig.
APPROX. DEPTH OF SAMPLE WITHIN SEAM: 2m off floor for coal.

ROOT TYPE: Siltstone
FLOOR TYPE: Siltstone
ORIGINAL WEIGHT OF SAMPLE: A 594.9
B 606.1
C 471.6

AMBENT AIR TEMP.: A 22.0°C
B 17.4°C
C 14.7°C

AMBENT AIR MOISTURE: A 9.0%
B 8.3%
C 8.9%

TYPE OF COAL (eg. steaming, H.Vol. coking, low Vol. coking etc.):
Med. Vol. coking

PRINCIPAL USE OF COAL (eg. steaming, coking.): COKING

COAL RANK (if available):

BASIC ANALYSIS OF COAL (if available): F1.45 Quality

(1) Ash Content : 9.2% Raw ash 24.2%
Mineral Content :
Total Moisture Content: 7% Inherent moisture 15%
Sulphur Content : .55%
Swell Factor : 7.4 (GSN NO.)

(2) COAL MACERALS:
Vitrinite :
Etrinite :
Intertinite :

Comments:
LEGEND

- COAL
- Carb. shale, shale & coal
- Shale, mudstone
- Siltstone
- Sandstone
- Tuff

THIESS PEABODY MITSUI COAL Pty. Ltd.

RIVERSIDE
STRATIGRAPHIC SECTIONS

Vertical Scale: 1:25
SAMPLE NO: A

DATE: 12-02-88
TIME: 10.00 a.m

NAME OF MINE: SARASJ MINE
LOCATION OF MINE: CENTRAL QUEENSLAND
NAME OF SEAM: DYSART
DEPTH OF SEAM: 47m
AVE. OF THICKNESS OF SEAM: 4.0m
APPROX. LOCATION OF SAMPLE WITHIN MINE: RAMP 0 NTH STRIP 9 BLOCK LINE 8
APPROX. DEPTH OF SAMPLE WITHIN SEAM: 2.0m

ROOF TYPE: SILTSTONE
FLOOR TYPE: 

ORIGINAL WEIGHT OF SAMPLE:

AMBIENT AIR TEMPERATURE: 32 °C
AMBIENT AIR MOISTURE: 

TYPE OF COAL (eg steaming, H.Vol. coking, low Vol. coking etc.):
MEDIUM VOL. COKING
PRINCIPAL USE OF COAL (eg steaming, coking.):
COKING
COAL RANK (if available): 1.52 M atm M atm ReH.

BASIC ANALYSIS OF COAL (if available):

(1) Ash Content : 9.5 %
Mineral Content : 5.0 %
Moisture Content : 9.5 %
 Sulphur Content : 0.57 %
 Swell Factor : 9 (CN NO.)

(2) COAL MACERALS:
Vitrinite : 72.0 %
Exinite : 0.0 %
Inertinite : 23.0 %

Comments:
HIGHLY WEATHERED SANDSTONE LEACHED MOTTLED

SANDSTONE FINE GRAIN LITHIC

STRIP 9 HIGH WALL
LEGEND

Depth of Weathering
Unconformity

TERTIARY
Unconsolidated Clays
Sands and Gravels

PERMIAN
Sandstone
Siltstone-Shale
Claystone
Coal

SCALE

CENTRAL QUEENSLAND COAL ASSOCIATES
SARAJI MINE

LONGITUDINAL SECTION
ACACIA RAMP 0-N STRIP 9

DRAWING No: 3

DESIGNED
MO HARGREAVES

DRAWN
MOH

CHECKED

APPROVED

DATE 11/11/85

AMEND. No:
SAMPLE REPORT - PART A.

SAMPLE NO: B.

NAME OF MINE: SARASI MINE
LOCATION OF MINE: CENTRAL QUEENSLAND
NAME OF SEAM: DYSART
DEPTH OF SEAM: 26.5m
AVE. OF THICKNESS OF SEAM: 1.0 m
APPROX. LOCATION OF SAMPLE WITHIN MINE: RAMP 13 SOUTH, STRIP F, BLOCK LINE
APPROX. DEPTH OF SAMPLE WITHIN SEAM: 0.5 m

ROOF TYPE: SANDSTONE
FLOOR TYPE: SILTSTONE
ORIGINAL WEIGHT OF SAMPLE:
AMBIENT AIR TEMP.: 32°C
AMBIENT AIR MOISTURE:
TYPE OF COAL (e.g. steaming, H.Vol. coking, low Vol. coking etc.):
MEDIUM VOL. COKING
PRINCIPAL USE OF COAL (e.g. steaming, coking):
COKING
COAL RANK (if available): 1.48 MEAN MAX. REFLECTENCE
BASIC ANALYSIS OF COAL (if available): RAW 10.0 % ASH
(1) Ash Content: 9.5 %
Mineral Content: 5.0 %
Moisture Content: 2.5 %
Sulphur Content: 0.57 %
Swell Factor: 9 (GSM No.)

(2) COAL MACERALS:
Vitrinite: 72.0 %
Erinite: 1.0 %
Interrinite: 21.3 %

Comments:
LEGEND

--- Depth of Weathering

Unconformity

TERTIARY

Unconsolidated Clays
Sands and Gravels

PERMIAN

Sandstone
Siltstone-Shale
Claystone
Coal

SCALE 1:250(H); 1:250(V)

CENTRAL QUEENSLAND COAL ASSOCIATES
SARAJI MINE

LONGITUDINAL SECTION
FIDDLEWOOD STRIP 7

DATE 03/11/86 DRAWING No:

DESIGNED M HARGREAVES

DRAWN M HARGREAVES

CHECKED

APPROVED

AMEND. No: