

Spontaneous combustion of the organic matter in discards from the Witbank coalfield*

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SYNOPSIS

The paper opens with a summary of the major factors responsible for spontaneous combustion in coal discards. These include heat arising from the oxidation of coal and pyrite, and from the wetting of dry or oxidized coal and pyrite; and certain petrographic conditions leading to self-ignition of the coal such as low rank, the presence of a high proportion of reactive constituents, and the occurrence of highly porous and botanically structured inertinite macerals.

The analyses of 6 samples from 2 discard dumps in the Witbank coalfield are included, which show that, according to a three-grade classification of liability to spontaneous combustion, one dump is 'reasonably liable' and the other is 'most liable'.

It is pointed out that factors other than liability to self-ignition determine the possible utilization of such discards, and that the prevention of oxidation is of great importance if they are to be utilized and spontaneous combustion to be prevented.

SAMEVATTING

Die referaat begin met 'n opsomming van die belangrikste faktore wat vir selfontbranding in steenkoolafval verantwoordelik is. Hierdie faktore sluit in hitte wat ontstaan deur die oksidasie van steenkool en piriet en die benetting van droë of geoksideerde steenkool en piriet; en sekere petrografiese toestande wat tot die selfontsteking van die steenkool lei soos 'n lae rang, die aanwesigheid van 'n hoë verhouding reaktiewe bestanddele en die voorkoms van uiters poreuse en botanies gestruktureerde inertinietmacerale.

Daar word ontledings van 6 monsters afkomstig van 2 afvalhope in die Witbanksteenkoolveld ingesluit wat toon dat een hoop, volgens 'n driegraadklassifikasie van vatbaarheid vir selfontbranding, 'redelik vatbaar' is en die ander een 'uiters vatbaar'.

Daar word op gewys dat ander faktore as vatbaarheid vir selfontsteking die moontlike benutting van sodanige afval bepaal, en dat die voorkoming van oksidasie van groot belang is as die afval benut gaan word, en om selfontbranding te voorkom.

Introduction

Many of the large heaps of coal discards in and around the collieries of Southern Africa are producing smoke and fire as a result of unchecked eruptions of spontaneous combustion. These events result in unsightly and unpleasant pollution, in the form of both gaseous emission and ground-water contamination, and mar the aesthetics and beauty of the local countryside.

In order to improve the situation, several organizations are making a serious effort to understand the phenomenon of spontaneous combustion better, and to prevent its recurrence by improved methods of discard storage. An attempt is also being made to find a use for the material in such discards.

The present paper is a pilot study on the evaluation of the organic combustible material of two such dumps in the Karoo coalfields, with particular reference to

- (i) the reasons for spontaneous combustion;
- (ii) the liberation aspects for the extraction of such materials; and

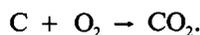
- (iii) the effects of storage and spontaneous combustion on the quality and expected performance of the organic products and their ultimate utilization.

Major Factors in Spontaneous Combustion

A knowledge of the major factors in the spontaneous combustion of discard material is necessary to provide an understanding of the problems involved.

Oxidation of Coal

All coals in contact with the atmosphere sooner or later show signs of oxidation and weathering, with resultant decreases in calorific content, volatile matter, and swelling capacities. The oxidation of coal is a strongly exothermic reaction. Thus, if the heat produced is not dissipated by a flow of air or by the conductive properties of the coal, it increases rapidly, finally reaching the temperature at which the coal ignites and burns, and creating a 'hot spot' in the seam or stockpile. The rate of this reaction is directly related to the temperature, i.e. with each 10°C rise in temperature, the oxidation process will approximately double. The process is as follows:



The oxidation of coal is therefore one of the most important aspects in a consideration of the liability of coal to spontaneous combustion. The factors affecting oxida-

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tion include the following.

- (1) *The maceral composition of the coal.* The process of oxidation attacks the non-aromatic parts of the coal molecule first. These forms are common in exinite and vitrinite, particularly in the low ranks (although vitrinite is the most susceptible maceral group at all levels of rank).
 - (2) *The rank of the coal.* The rate of oxidation (i.e. oxygen reactivity) decreases with increasing rank because the rate or amount of oxygen consumed per unit of time is equal to the reaction rate at the reacting boundary or oxidation edge. While the reaction process at this boundary is considered to be independent of the character of the coal, the transport of oxygen into the reacting zone has a relatively high activation energy, which increases with rank. Van Krevelen¹, summarizing the work of Somers and Peters, therefore compares this activated diffusion with a solid-state diffusion (or a place-exchange process), which in the case of coal appears to be more difficult since the aromaticity of a coal increases with its rank.
 - (3) *Ambient conditions.* These include the rate of air (oxygen) flow, and the natural fluctuations in daily temperature and in the availability of moisture (in the form of changes in humidity and the presence or absence of rainfall). Accessibility to oxygen is self-explanatory; marked increases in daily or seasonal temperatures will increase the rate of oxidation, and wide variations in moisture, particularly on previously dry or oxidized coal, will result in drying and rewetting, thereby causing further temperature rises due to exothermic reactions.
- (a) The first step is the adsorption and chemisorption of oxygen. During this stage, the coal increases in weight as the oxygen is adsorbed. This process requires a very low activation energy (3 to 4 kcal/mol), and occurs markedly up to 70°C and continues up to 350°C. However, the oxygen-enriched adsorption complex is unstable, and it may decompose and react further.
 - (b) At the second stage, i.e. above 80°C, the adsorption complex decomposes, and the weight of the coal decreases. This process requires a relatively low activation energy (6,5 kcal/mol) and is therefore common in the relatively low-temperature ranges, i.e. between 80 and 150°C. The decomposition of this complex yields mainly carbon monoxide. Inherent moisture is driven off between 100 and 150°C.
 - (c) During the third stage, which takes place between 150 and 230°C, further chemical reaction leads from the unstable adsorption-chemisorption complex to the formation of the stable oxygen-carbon compound oxycoal, with an excessive evolution of heat. This process requires high activation energy (16 kcal/mol). During this process, the decarboxylation of the carboxyl groups in the oxycoal leads to the evolution of carbon monoxide, a product that is more dominant in these higher-temperature reactions.
 - (d) At even higher temperatures, the formation of oxycoal stops and combustion begins. The oxycoal appears to be broken down into smaller units, leading to the subsequent formation of the humic acid, anhydride. This reaction requires an activation energy of 20 kcal/mol. With the sharp rise in temperature, there is a rapid decrease in weight, with the excessive formation of soot, and the coal substance begins to incinerate.

A brief summary of the process occurring during the oxidation of coal is necessary if the role of the inherent properties of coal is to be understood. As reviewed by Van Krevelen¹, the way in which oxidation takes place is best revealed under the microscope, i.e. as a conversion process proceeding along the entire external surface of a coal particle, and in some instances along the fissures and cavities observed at microscopic levels in coal. The total reactive surface area exposed to oxidation is therefore larger than the outer surface alone. From these surfaces, an oxidation edge or rim develops that becomes wider as oxidation advances. These edges of 'oxycoal' show a higher reflectivity in polished sections than the normal coal matrix. The width of the oxidation rims formed in a given length of time and at a given temperature is a measure of the 'reactivity' of coal to oxygen. At very high levels of rank (anthracites), oxidation rims cannot be identified because the increasing reflectance of the coal matrix begins to match the reflectance of the oxycoal.

In contrast, the diffusion of oxygen into the coal mass (i.e. through internal pores and molecular structure) proceeds much more slowly¹. The sharp margin of the inner edge of the oxidation rim indicates that the transport of oxygen towards this reacting boundary is probably the rate-determining factor.

The mechanisms involved in the oxidation of coal and leading to spontaneous combustion form a complicated process, consisting of four overlapping stages¹.

In many instances, it appears that this process proceeds more easily (or is less retarded) in some coals than in others. If this is so, the rate of reactivity of progression will depend in the first place upon the inherent properties of the coal. For example, the fastest reaction can be expected from coals possessing

- (i) large external surface areas including microfissures (such as those occurring during oxidation), botanical cavities (as found in semi-compacted empty cell cavities in fusinite and semi-fusinite), and fine sizes.
- (ii) low ranks, and
- (iii) a relatively high proportion of volatile-rich reactive (vitrinite and exinite) macerals.

The effects of external factors such as temperature, moisture, and availability of oxygen may then be superimposed upon these characteristics.

Sources of Heat

Apart from the heat produced during the process of oxidation, which, if not dissipated, will increase rapidly, two other sources of heat must be considered²:

- (1) heat of oxidation of pyrite, and
- (2) heat of rewetting of dry or oxidized coal and pyrite.

The air-oxidation of pyrite has long been regarded as a contributory cause to the generation of heat in spontaneous combustion. The oxidation products on the surface of pyrite have been calculated to produce up to 840

kJ/mol, thus creating expansion in the minerals, stress cracks in the host organic matrix, and a significant increase in heat.

The rewetting of partly dry coal (organic matter and pyrite) is now regarded as a more serious trigger for the production of heat. Laboratory measurements have shown that such heats of wetting can range as high as 85 to 105 J/g, sufficient to raise the oxidation temperature of the coal by 25 to 30°C and increase oxidation rates six- to eight-fold². Wetting of coal takes place when stockpiled coal is exposed to rain after a period of dry, sunny weather, or when wet coal is placed on a dry pile.

Coals of low rank (lignite to low-rank bituminous coals) and coals possessing high proportions of cellular cavities or porous matrices in bands of inertodetrinite, or in oxidized cleats and fractures, are particularly vulnerable. With the loss of original inherent moisture, oxidation can occur on these large surfaces, thereby leading to increases in temperature. The rewetting of these dry surfaces leads to the removal of the original oxidation products and the start of oxidation on new fresh surfaces. This, in turn, leads to even larger temperature increases, which, if continued, can lead to very rapid self-ignition.

Ignition and Initial Temperatures

Methods for the determination of the temperature at which a coal will ignite have been developed by many authors. These results have then been related to the spontaneous combustion of coal. Based on the work of several authors reviewed by Van Krevelen¹, two major points have been recognized.

The ignition point is defined as the temperature corresponding to the point of intersection or cross-over of the temperature curve of the coal sample and a line running parallel to, but 6°C above, the temperature line of the furnace. As defined, this ignition temperature is a function of rank; that is, in general the higher the temperature, the higher the rank. The spread of values at the same rank suggests that the composition of the coals or the degree of oxidation, for example, may assert additional influences.

The second point, the initial temperature, is the minimum temperature at which coal will continue to heat itself, thus resulting in spontaneous combustion; that is, heating will proceed by exothermal reaction with oxygen but without the supply of additional heat from external sources. As in the case of ignition temperature, the initial temperature is influenced primarily by rank, but also by such factors as the oxidized nature of the coal (higher initial temperatures occurring in oxidized coal), increasing thickness of coal bed, and decreasing sizes of particles¹.

Prediction of Liability towards Spontaneous Combustion

As the coals in the Southern Hemisphere are now known to be far more variable in composition, rank, and types of weathering than those of Europe and America, and as proximate analyses and empirical tests do not identify these differences in many cases, several more factors need to be considered in investigations of the liability potential of these coals. Furthermore, because many of these variations are attributable to the origin, formation,

and subsequent history of coalification and can be identified by petrographic methods, it follows that a petrographic classification would serve as a framework on which to base the potential liability index of any given coal. Once identified as 'most liable', 'reasonably liable', or 'least liable', a coal could be handled accordingly, ranging from extreme care to moderate caution.

Falcon^{3,4} proposed a graphic representation of such a basic classification. It summarizes the most relevant petrographic data known to lead towards spontaneous combustion (Fig. 1). Two primary inherent factors are employed: coal type (determined by maceral composition) and rank (determined by vitrinite reflectance). Within this framework, three sets of conditions have been selected in order to grade coals into 'most likely', 'reasonably likely', and 'least likely'.

Set 1 is characterized by degrees of rank, the lower the rank the more likely the coal being to self-ignition, i.e. at low ranks, coals possess the following characteristics:

- Lowest initial and ignition temperatures
- Highest moisture content (inherent and moisture-retention capacity)
- Highest molecular porosity and total internal surface area
- Highest exothermal production (heat) during wetting
- Fast rate of oxygen consumption and oxidation.

Set 2 is characterized by high proportions of vitrinite and exinite, the highly reactive constituents in coals, particularly in the lower ranks. Vitrinite, in particular, is said to be the most reactive maceral to oxidation at all levels of rank, i.e. the higher the proportion of vitrinite, the more liable is the coal to spontaneous combustion¹. The reasons can be summarized as follows:

Vitrinite possesses more non-aromatic (and therefore potentially reactive) parts in its molecular structure than inertinite. Oxygen is therefore adsorbed onto the molecular structure more abundantly per unit area and with lower activation energies, thus leading to easier, and possibly more rapid, forms of oxidation at lower temperatures in the earlier stages than inertinite of the same rank.

Inertinite, on the other hand, is densely aromatic in molecular structure, thus implying the need for higher activation energy in the adsorption-chemisorption of oxygen. However, the higher porosity (both microscopic and sub-microscopic) suggests that the internal spaces (voids) provide more volume for the better passage and storage of air in the coal mass than that encountered in vitrinite.

Exinite is by description the least porous maceral but one of the most reactive to the adsorption of oxygen. However, its occurrence in coals in the Southern Hemisphere is low in comparison with that in the coals of Europe and America, and for this reason it is not considered to be a major problem in most Southern African coals.

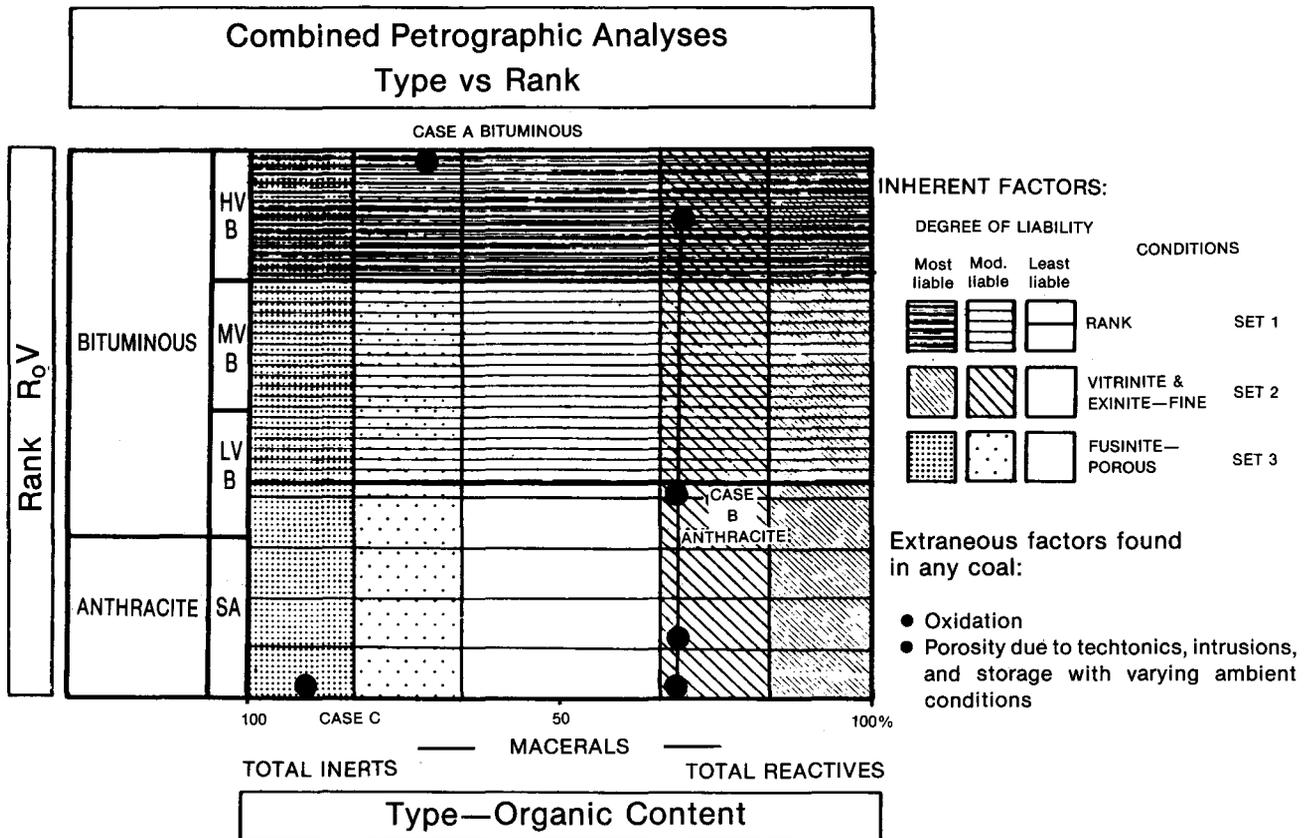


Fig. 1—Liability of coals to spontaneous combustion as determined by inherent petrographic characteristics³. Cases A, B, and C are coals that have undergone rapid spontaneous combustion

Set 3 includes coals of all ranks enriched in highly porous and botanically structured inertinite macerals (i.e. semi-compacted fusinites and semifusinites in particular). In some cases, the presence of micrinite, fine inertodetrinite, and clay particles in these cavities leads to even further increases in surface area. This latter set of conditions appears to be relatively unique to the Southern Hemisphere in coals of Palaeozoic age.

In addition, there are several secondary parameters, including degree of oxidation, size of particle, form and amount of pyrite, and storage and climatic conditions. It is not necessary for *all* the factors to occur together for spontaneous combustion to take place. While several of the major categories usually occur together, only one factor (e.g. a rainstorm) can trigger off the reaction¹. Table I summarizes the contributory factors, and Table II lists the petrographically identifiable features that dictate or influence each one.

Samples from the Eastern Transvaal

During the course of recent investigations, samples were taken from several dumps in the vicinity of the coalfields in the eastern Transvaal and, more specifically, from sites in and around centres of spontaneous combustion. This paper is concerned with two such sets of examples from the Witbank coalfield; these results form part of a larger investigation to be conducted by a number of organizations in the near future.

Descriptions of the discards (labelled Discard Dump

1 and Discard Dump 2) in terms of their method of compaction, heating characteristics, and whether they were covered by a layer of soil or not, are given in Table III. The relative location of each sample from the discards is briefly listed.

Sampling and Analytical Procedures

The sampling procedures were not fully statistical but were undertaken for the purpose of gaining a relatively representative idea of the coal-discard material stored in specific locations. The samples were crushed, riffled, and prepared for petrographic analysis, the results of which are also given in Table III.

The analytical procedures included the following.

- (1) Group maceral analyses (not included here owing to their limited value).
- (2) Microlithotype analyses (highlighting the differences between the bands of coal rich in organic matter and those rich in intergrown minerals).
- (3) The most common mineral-group distributions (i.e. fine minerals well distributed or coarse minerals concentrated in layers, aggregates, or nodules).
- (4) The approximate proportions of heat-affected products (i.e. non-heat-affected up to char and soot products).
- (5) The broad distribution of rank categories as determined by vitrinite reflectance.

TABLE I
SUMMARY OF CONDITIONS REQUIRED FOR SPONTANEOUS COMBUSTION

Condition	Reason
Exposed surface area (porosity)	Provides passages for gas and water Increases surface area for chemical reaction
Source of oxygen	Causes oxidation of coal and pyrite Forms oxidation products on surfaces Results in heat increase (heat of adsorption)
Moisture	Dries out in low-rank or porous coals, causing decrepitation and cracking Adsorbs onto previously dried or oxidized surfaces, resulting in heat increase (re-wetting) Removes oxidized products on internal surfaces, thus re-exposing the surfaces for oxidation
Pyrite	Oxidizes rapidly, forming oxidation products on surfaces Provides high-temperature increases during oxidation
Emission of gas	Provides combustible gases, resulting in explosions
Source of heat	To effect combustion: Heat of oxidation of pyrite (adsorption) Heat of wetting of dry surfaces of coals (particularly reactive coals, i.e. with large internal surface areas)

TABLE II
CONDITIONS LEADING TO INCREASED LIABILITY TOWARDS SPONTANEOUS COMBUSTION

Exposed surface area	<ul style="list-style-type: none"> ● Sub-microscopic pores in low ranks of vitrinite ● Natural pores or cavities in fusinites ● Gas pores—cracks in heat-affected coals ● Stress fractures in tectonic zones ● Old oxidation cracks
Source of oxygen (oxidation)	<ul style="list-style-type: none"> ● In original swamp ● Subsequent movement of ground-water or gas During transportation ● In uncompacted storage
Moisture	<ul style="list-style-type: none"> ● Surface or inherent moisture in porous coals (or in low ranks) ● Fluctuating ground-water levels Fluctuating humidity or rainfall
Pyrite	<ul style="list-style-type: none"> ● Various sizes and forms
Emission of gas	<ul style="list-style-type: none"> ● In low to medium ranks ● From reactive macerals ● From oxidizing surfaces

● As observed petrographically

The terminology and methods are those currently used by the International Committee for Coal Petrology; the distributions of heat-affected material and mineral groups were obtained by methods evolved for in-house purposes and used in several confidential reports.

Results and Assessment

The results, which are given in Table III, indicate the following.

Discard Dump 1

In Discard Dump 1, all the samples with the exception of the burnt coal (Sample 4) are relatively similar in the distribution of organic and mineral matter and in rank (i.e. they do not show any marked signs of heat effects). Sample 2 is slightly different in that it is enriched in minerals, particularly coarse carbonates and pyrite. This suggests that the very hard limestone-like bands observed microscopically were encountered more during the

mining of this area than during the mining of the areas represented by the other two discards.

The proportions of organic matter to mineral-rich particles suggest that crushing to 300 μm or less and washing at densities of approximately 1,6 to 1,7 would produce lower-ash coal of approximately three-quarters to one-half the original bulk. Within this organic-rich fraction, fine clay and nominal proportions of fine pyrite and fine carbonates would be found in association with high proportions of vitrinite and of intermediate and inertinite-rich microlithotypes. This is likely to produce a product as good in quality as normal conventionally produced middlings, but smaller in size. Coals not subjected to oxidation for any extended period would have relatively high calorific values and would yield reasonable amounts of volatile matter.

In terms of oxidation, Sample 1 (approximately one week old) was observed to be a fresh coal with no visible signs of oxidation. The boundaries on the organic par-

TABLE III
PETROGRAPHIC ANALYSES OF DISCARD SAMPLES

Sample	Description	Distribution of organic matter						Distribution of mineral matter						Heat-affected products						
		Micro lithotype						Mineral groups						Distribution of reflective groups						
		Vitri- nite	Inter- mediate	Inert- detrinite	Semi- fusinite	Total inert- inite	Carbo- minerite	Total organi- c-rich matter	Clay or quartz	Pyrite		Carbonate		Clean coal	Low rank	Med. to high rank	Semi- anthra- citic	Soot or char	Ash	
<i>Discard Dump 1</i> No compac- tion No burning Heated	1. Fresh coal, 1 week old	11,6	11,2	26,6	21,6	48,2	29,0	71,0	39,3	26,0	4,7	13,0	0,3	15,7	1,0	100	-	-	-	
	2. Coal, 1 month old	9,3	6,3	22,3	19,8	42,1	42,3	57,7	27,0	13,3	1,7	16,3	1,3	3,9	1,4	100	-	-	-	
	3. Coal, near- er burning site	6,7	12,5	33,0	23,3	56,3	24,5	75,5	43,0	24,7	2,3	13,3	0,7	14,7	1,3	100	-	-	-	
	4. Coal, burnt out, ash remains	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,0	4,0	4,3	90,7
<i>Discard Dump 2</i> Partly com- pacted, non-burning Partly heated (edges), no soil cover	5. Good-qua- lity coal discard	13,7	14,7	30,7	18,7	49,4	22,3	77,6	50,0	48,0	-	2,0	-	-	-	12	28	60	-	-
	6. Heated coal	16,3	10,0	30,7	22,7	53,4	20,3	78,6	54,6	41,0	-	1,4	-	1,0	2,0	2	15	83	-	-

ticles were characteristically sharp, angular to smoothly rounded, and lacked the marginal abrasion and cracking normally associated with oxidation. Sample 2 exhibited minor signs of marginal cracking in approximately one-quarter of the particles, particularly in the vitrinite, and Sample 3 (the oldest sample) showed considerable signs of cracking, crumbling, and decrepitation in about one-third of the particles. The inertodetrinite bands were more friable and softer, and showed significantly more changes in coloration than the vitrinite particles. The latter merely possessed slightly more random cracks emanating from the margin. A significantly higher proportion of fines was observed. The smaller particles of both vitrinite and inertinite bands exhibited more signs of oxidation than the larger (and therefore stronger and more cohesive) particles.

Sample 4, the remains of a burnt-out section of the discard dump, was characterized by an overwhelming proportion of red granular mineral matter, with minor amounts of other discrete mineral grains and 9,3 per cent organic matter (by volume). The organic material was composed of varying proportions of highly oxidized, semi-porous burnt char (4,3 per cent), relatively high-rank particles with reflectances in the low-rank bituminous and semi-anthracitic ranges (4,0 per cent), and a very small, fine-sized fraction of the normal low-rank bituminous coal (possibly 1,0 per cent contaminants). The anthracitic particles were smooth, non-wavy, and strongly anisotropic. Some exhibited small gas pores.

The presence of highly friable and oxidized inertodetrinite bands suggests that the cause of combustion may have been the continued oxidation (and probable wetting) of these already highly oxidized and now increasingly porous particles. The presence of abundant coarse, cleaved pyrite forms intruding the vitrinite bands may also have been a contributory cause. However, the organic matter analysed did not show any signs of expansion or swelling around such minerals. It is therefore more likely that the latter is a subsidiary factor, and organic oxidation the primary one.

Discard Dump 2

Despite the difference in locality, the two samples from this discard dump showed remarkable consistency in the distribution of organic and mineral matter. The normal non-heat-affected coal was characterized by a higher rank than the samples from Discard Dump 1, being predominantly medium- to high-rank bituminous to semi-anthracitic.

In terms of the proportion and form of organic matter relative to mineral matter, the analyses indicated that approximately three-quarters of the coal particles possess relatively small amounts of mineral matter and are therefore excellent products for certain purposes. Within this organic fraction, approximately 25 to 30 per cent of the bands are relatively reactive-rich in terms of maceral and microlithotype content.

In contrast to the samples from Discard Dump 1, the mineral matter in these samples possesses very little pyrite and carbonate minerals, but has a significant amount of finely and coarsely distributed quartz and clays. Some further liberation is possible, and a relatively good low-ash product may be produced if separation, based upon

froth flotation, is pursued. Heavy-medium separation is unlikely to prove adequate since the density of these higher-ranking particles with finely distributed mineral matter may result in large near-density fractions and difficult cut-off levels.

In terms of oxidation, the vitrinite is unusually smooth, hard, and resistant; the inertinite bands and inertodetrinite in particular are very friable, separating into abundant small fractions (discrete particles of sclerotinite and inertodetrinite).

The degree of heat effect in Sample 6 is shown by the much higher proportion of anthracitic materials (83 per cent, compared with 60 per cent in the previous sample). Apart from the much higher reflectance, the heat-affected vitrinite particles also exhibited a very distinct, smooth anisotropic nature, some very small gas pores, but no flow or coking structure. This suggests that the original coal was too high in rank to produce porous chars and cokes; in addition, the temperatures reached in the vicinity of this sample may not have been high enough to cause actual combustion or sintering.

The inherent cause of combustion in coals of this nature appears to be the oxidation of the more porous inertinite bands (rich in inertodetrinite). Pyrite is virtually absent, and vitrinite is relatively high in rank and therefore considerably less reactive to oxidation than the coals in Discard Dump 2.

Category of Samples

According to these findings, the current samples fall into the 'reasonably liable' category (Discard 2) and 'most liable' category (Discard 1). Discard 1 is low in rank, possesses high proportions of vitrinite fines that are in varying degrees of oxidation, and contains pyrite usually in the form of large nodules and finely dispersed forms within the organic matrix. Discard 2 is least to reasonably liable to spontaneous combustion because of the presence of oxidized and decrepitating inertinite (particles of inertodetrinite). The rank of the coal is relatively high, pyrite is absent, and the vitrinite appears to be relatively stable, uncracked, and unoxidized.

Conclusion

The significance of these results lies in the fact that, apart from liability towards spontaneous combustion, other factors, including the degree of oxidation, the rank, and the nature and distribution of the reactive and inert macerals, will determine such important utilization properties as the following:

- Degree of decrepitation during handling and in a boiler
- Ignition and peak combustion temperatures
- Rate of devolatilization
- Composition of gases
- Rate of burn-out of particles
- Unburnt carbon in the final fly ash.

Such properties are especially important in fluidized-bed and gasification units. Minerals such as carbonates are equally important in terms of the production of inert gas and slagging, clinkering, and fouling; their liberation is very necessary in certain fields.

The blending of coal particles of widely differing ranks

and composition is a further aspect worthy of consideration. The design conditions for fresh low-rank coally particles will not be met adequately if highly oxidized or burnt particles are blended in any significant proportion. Flame stability in pulverized units, for example, may not be easily maintained without adequate homogenizing facilities.

While there is a large and significant proportion of relatively easily won organic matter in the two discard dumps so far analysed, the qualities of the ultimate products must be monitored carefully according to their future utilization. The prevention of oxidation is of great importance if this storehouse of energy, both current and future, is to be used adequately and useless self-ignition is to be avoided. Much more research in this field of energy-reserve assessment is required, and will become increasingly important in regard to the avoidance of pollution and the preservation of South Africa's countryside.

GOLD 100

This international conference on gold, which is to be held in Johannesburg from 15th to 18th September, 1986, marks one hundred years of gold mining on the Witwatersrand, and aims to bring together people interested in various facets of the gold industry. It will allow the delegates to be exposed to a broad field of interest including aspects of the following topics:

- Economics and Marketing of Gold
- Mining Technology
- Industrial Uses of Gold
- Extractive Metallurgy of Gold.

The Conference will be held in parallel or plenary sessions over a period of four days. A programme of one-day and extended technical tours is planned for after the Conference, in addition to an affiliates programme during the Conference. Several evening social events are also included in the Conference programme.

GOLD 100 offers a unique opportunity for persons with a technical, economic, or investment interest in gold, gold mining, or gold metallurgy to increase their knowledge and expertise. The following topics should be of interest:

Economics and Marketing of Gold

To gold traders, stockbrokers, investment analysts and advisors, bankers, economists, gold and gold-share investors, institutional investors.

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Gold Mining Technology

To mining engineers, mine managers, those engaged in mining research and development, mining geologists, assayers.

Extractive Metallurgy of Gold

To production metallurgists, plant managers, research and development scientists, design engineers.

Symposium on the Industrial Uses of Gold

To industrial and commercial research workers and those interested in the development of new uses for gold in the electronics, dental, and decorative sectors.

The Conference is being organized by the Chamber of Mines of South Africa, The South African Institute of Mining and Metallurgy, the Council for Mineral Technology (Mintek), and The School of Business Leadership of the University of South Africa.

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