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ACARP REPORT

Australian Coal Research Limited

INERTINITE

THE MISCONCEPTIONS REGARDING INERTINITE CAN LARGELY BE TRACED TO THE WIDELY ACCEPTED SCHAPIRO-GRAY SYSTEM OF COKE STABILITY CALCULATIONS WHICH ACCEPT ONLY 1/3 OF CONTAINED INERTINITE (EXCLUDING FUSINITE) AS BEING FUSIBLE

NEW RESEARCH SHOWS THAT INERTINITE IS NOT AS INERT AS FIRST THOUGHT

SUMMARY

Inertinite is generally perceived to be a troublesome group of coal macerals, because it is believed that its members have variable reactivity in most industrial processes.

This does not conform to Australian experience because although a number of Australian export coals contain large amounts of inertinite, their performance compares very favourably with overseas coals containing less inertinite.

Research at the University of Newcastle over a number of years into the behaviour of inertinite from both northern and southern hemisphere coals has found that previous perceptions are substantially wrong. A sizeable proportion of the inertinite group of macerals is in fact far more reactive than previously thought.

The misconceptions regarding inertinite can largely be traced to the widely accepted Schapiro-Gray system of coke stability calculations which accept only 1/3 of contained inertinite (excluding fusinite) as being fusible.

Because of the consistent failure of the Schapiro-Gray system to give correct estimates of coke stability indices in ICCP ring analyses of Permian (and Cretaceous) coals, it has been suggested in the past that the inertinite of Permian Gondwana coals must be more reactive than the inertinite of Carboniferous coals, on which the Schapiro-Gray system was based.

This is not the case and it can now be shown that the failure was due to an underestimation of the fusibility of a considerable percentage of inertinite group macerals.

Recent work by Professor C.F.K. Diessel et al. has shed new light on the problem and has demonstrated a method of deriving a more accurate estimation of inertinite reactivity based on modern microscopic methods.

COAL MACERALS

The International Committee for Coal Petrology (1963, 1971, 1975) distinguishes between three types of petrographic entities, called lithotypes, microlithotypes and macerals. Macerals constitute the smallest reasonably homogenous microscopic constituents of coal. They are divided into three groups, called vitrinite, liptinite and inertinite. Their classification and analysis procedures are covered by national and international standards e.g., AS 2856-1986.

Macerals and maceral groups differ in their chemical composition and thus their technical performance characteristics. As indicated in Figure 1, for much of the coalification range from brown coal (approx. 65% carbon) to medium volatile bituminous coal (approx. 90% carbon), the macerals of the Liptinite group contain more hydrogen and are more generally reactive than the macerals of the inertinite group, while vitrinite group macerals range between the two.

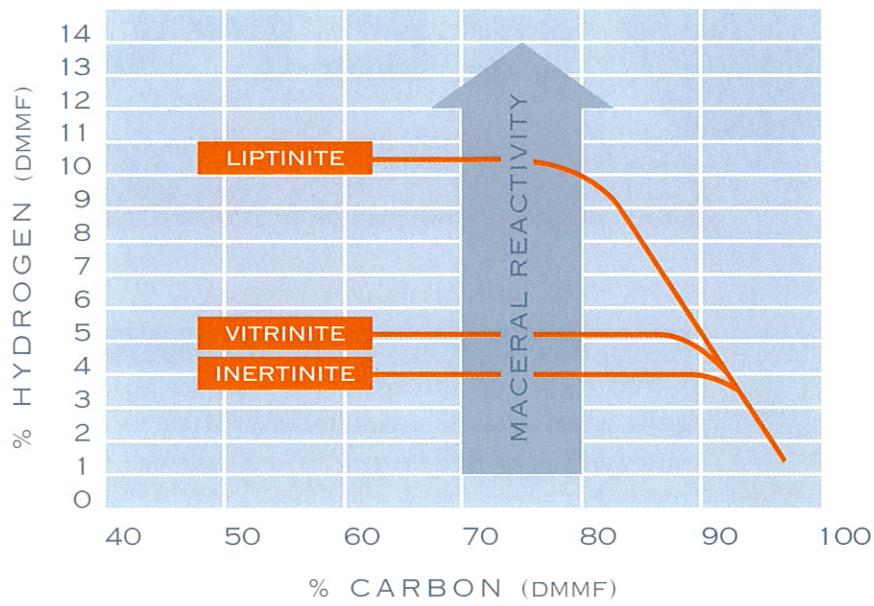

FIGURE 1
PART OF CALLCOTT'S (1986) COAL CHART SHOWING THE HYDROGEN, CARBON AND OXYGEN (BY DIFFERENCE) CONTENTS FOR THE THREE MACERAL GROUPS IN RELATION TO COAL RANK. AS INDICATED, MACERAL REACTIVITY INCREASES WITH HYDROGEN CONTENT

USE OF OPTICAL TECHNIQUES

OPTICAL TECHNIQUES CAN PROVIDE A QUANTITATIVE MEASURE OF THE FUSIBILITY OF INDIVIDUAL MACERALS

It has been shown that optical techniques can provide a quantitative measure of the fusibility of individual macerals. Several methods have been developed to do this, for example by Pearson & Price(1985), Kruszewska (1989), Diessel and Wolff-Fischer (1986,1987), Hall and Coin (1989), Wilkins et al. (1993) and Wilmshurst et al. (1991).

Because of the close links between inertinite fusibility and both reflectance and fluorescence, which were established over a series of research projects, Professor Diessel's group at the University of Newcastle was able to use these optical properties to investigate whether coals of different ages and origins contained:

(a) different proportions of fusible inertinite, and/or
(b) differed in the degree of inertinite fusibility.

ASSESSMENT OF INERTINITE FUSIBILITY

Conventionally, the fusibility of coal is assessed indirectly in terms of indices derived from various laboratory tests such as crucible swelling, Gieseler plastometry, dilatation and more recently, Proton Magnetic Resonance Thermal Analysis (PMRTA). Whereas these tests measure the bulk response of the sample under investigation, modern microscopic methods can provide a quantitative measure of the fusibility of individual macerals.

MODERN MICROSCOPIC METHODS CAN PROVIDE A QUANTITATIVE MEASURE OF THE FUSIBILITY OF INDIVIDUAL MACERALS

It is important however to recognise that inertinite fusibility encompasses many gradations which come under three broad categories:

INFUSIBLE INERTINITE which occurs in coke as unmelted inclusions with sharp boundaries and is formed mainly from fusinite and high-reflecting semifusinite. (see Figure 2)

PARTIALLY FUSIBLE INERTINITE which can be recognised as separate entities although contacts with the surrounding coke matrix are diffuse because of partial melting which also leads to the formation of some anisotropy and a limited amount of degassing pores. (see Figure 3)

COMPLETELY FUSIBLE INERTINITE - often indistinguishable from vitrinite-based fused coke matrix, although its presence can be detected in single-component cokes by variations in the anisotropy pattern. (see Figure 4)

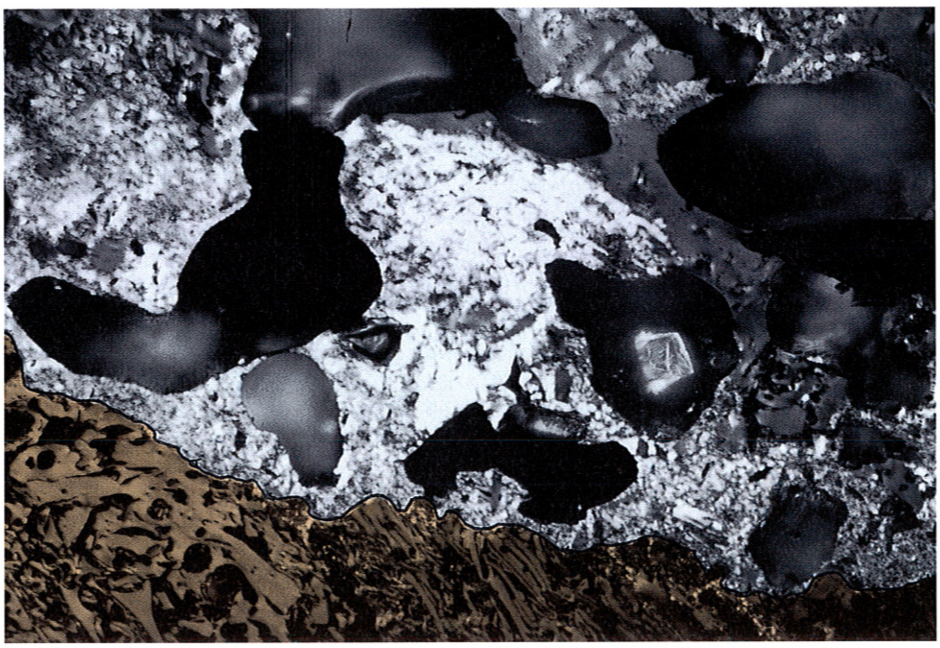

FIGURE 2
PHOTOMICROGRAPH OF A METALLURGICAL COKE CONTAINING UNFUSED INERTINITE (FUSINITE) NEAR BOTTOM OF FRAME. (COLOURED AND ENCIRCLED) INCIDENT LIGHT, OIL IMMERSION, HALF CROSSED POLARISERS; THE ACTUAL LENGTH OF THE LONG EDGE OF THE FRAME IS 0.34MM

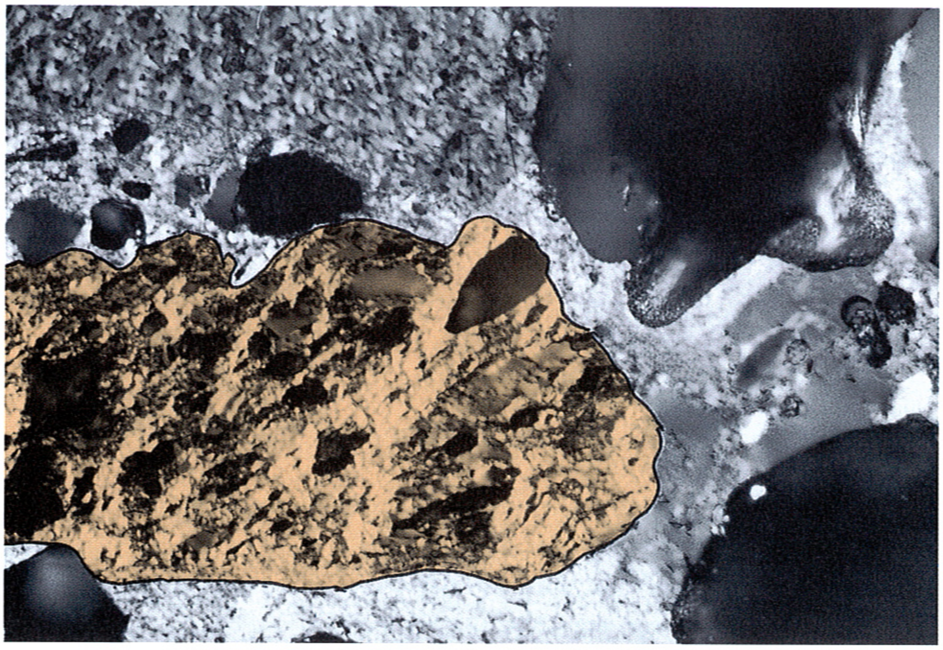

FIGURE 3
PHOTOMICROGRAPH OF A METALLURGICAL COKE CONTAINING PARTLY FUSED INERTINITE (SEMIFUSINITE) IN CENTRE AND LEFT HALF OF FRAME (COLOURED AND ENCIRCLED). INCIDENT LIGHT, OIL IMMERSION, HALF CROSSED POLARISERS; THE ACTUAL LENGTH OF THE LONG EDGE OF THE FRAME IS 0.34MM

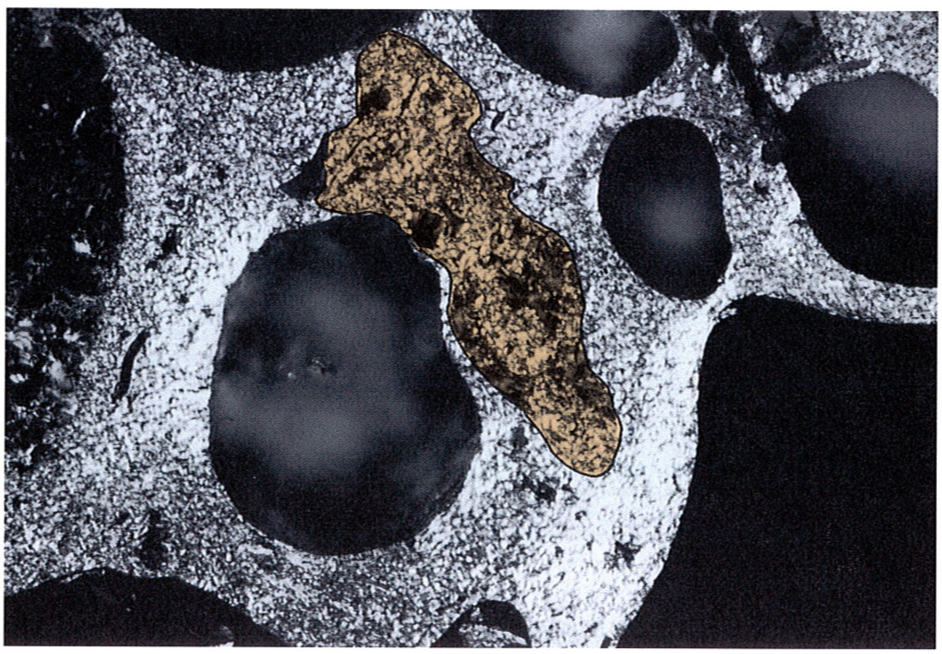

FIGURE 4
PHOTOMICROGRAPH OF A METALLURGICAL COKE CONTAINING COMPLETELY FUSED INERTINITE (COLOURED AND ENCIRCLED) IN CENTRE OF FRAME. INCIDENT LIGHT, OIL IMMERSION, HALF CROSSED POLARISERS; THE ACTUAL LENGTH OF THE LONG EDGE OF THE FRAME IS 0.34 MM

Two optical properties which indicate fusibility are:

- reflectance
- fluorescence intensity

HIGH REFLECTING INERTINITE IS ALWAYS INFUSIBLE, BUT THE FUSIBILITY INCREASES WITH DECREASING INERTINITE REFLECTANCE, I.E., THE MORE IT APPROACHES THE REFLECTANCE OF THE ASSOCIATED VITRINITE

Reflectance measurements are widely used in the determination of coal rank and when applied to the assessment of thermoplastic properties in inertinite, it was found that an inverse relationship exists between the reflectance of inertinite and the degree of its fusibility.

High reflecting inertinite is always infusible, but the fusibility increases with decreasing inertinite reflectance, i.e., the more it approaches the reflectance of the associated vitrinite.

It is possible to establish a cut off reflectance between fusible and partially fusible and between partially and totally fusible inertinite. (see Diessel & Wolff-Fischer, 1986, 1987) These threshold values are rank-dependent and follow a sliding scale (Figure 5)

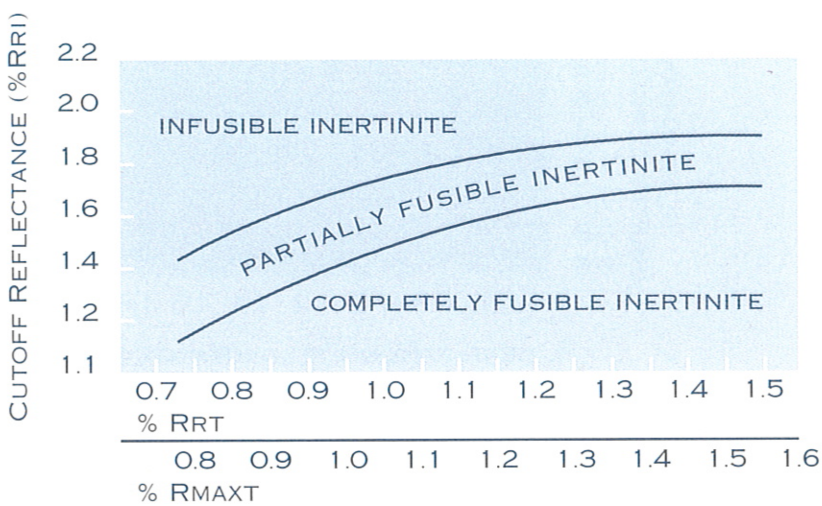

FIGURE 5
THE RELATIONSHIP BETWEEN THE FUSIBILITY AND REFLECTANCE OF INERTINITE IN REFERENCE TO THE RANK OF THE HOST COAL EXPRESSED IN RANDOM AND MAXIMUM TELOVITRINITE REFLECTANCE.

Since the reflectance values of fusibility and infusibility thresholds vary with the coal rank, application of the reflectance method is restricted to single-seam coals. Monochromatic microfluorescence is the only readily measurable optical coal property method which allows calibration with maceral fusibility in multi-component blends.

DO COALS OF DIFFERENT GEOLOGICAL AGE AND ORIGIN DIFFER IN THEIR INERTINITE FUSIBILITY?

The group at the University of Newcastle conducted of a systematic survey of the reflectance and microfluorescence intensity distribution of inertinite in 75 Australian, North American and European bituminous coals with samples chosen to include high and low concentrations of inertinite macerals and a range in rank.

CARBONIFEROUS VERSUS PERMIAN COALS

The study did not reveal any significant differences in the inertinite reflectance distribution between Carboniferous and Permian coals. It concluded therefore that the proportions of fusible, partly fusible and infusible inertinite macerals do not vary significantly between coking coals of different ages and origins (see Figure 6).

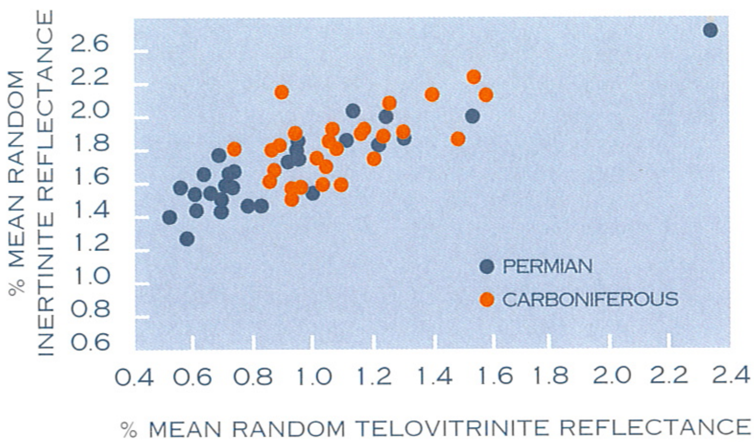

FIGURE 6
THE CORRELATION BETWEEN MEAN INERTINITE REFLECTANCE AND COAL RANK MEASURED AS MEAN RANDOM TELOVITRINITE REFLECTANCE

The fluorescence intensity measurements illustrated in Figure 7 also show considerable overlap between the studied samples. Therefore a characteristic compositional variation in the inertinite macerals of different ages and origins does not seem to exist. Likewise, no significant differences were found in the intensity of inertinite fluorescence in the samples. Since good thermoplastic properties are indicated by high fluorescence intensities, whereas poor thermoplastic properties are matched by low fluorescence intensities, it was concluded that the degrees of inertinite fusibility were broadly similar in coals of similar rank, irrespective of their origins and ages.

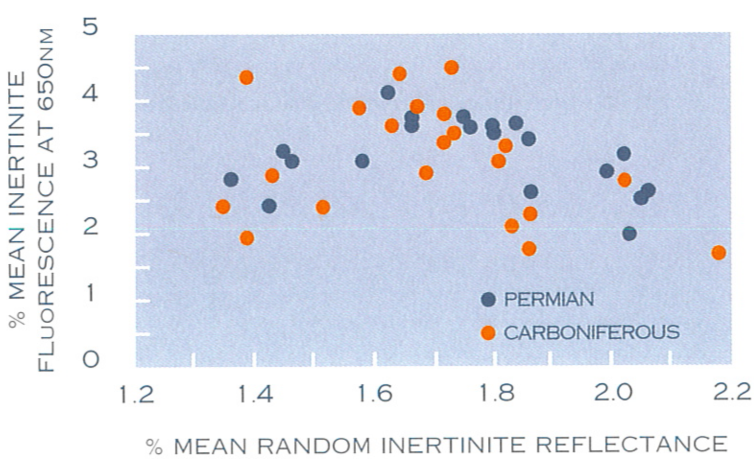

FIGURE 7
THE RELATIONSHIP BETWEEN INERTINITE FLUORESCENCE AND REFLECTANCE PERMIAN AND CARBONIFEROUS COALS

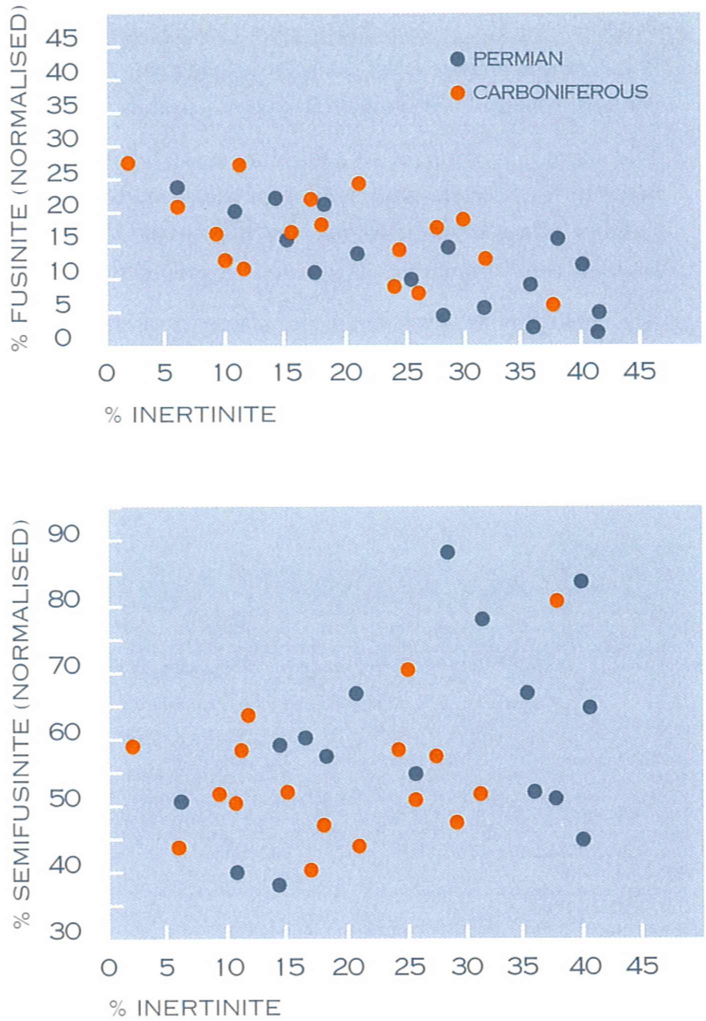

FIGURE 8.
TWO DIAGRAMS SHOWING THE CONTRASTING DISTRIBUTION PATTERN OF HIGH REFLECTING FUSINITE (TOP) AND LOW REFLECTING SEMIFUSINITE (BOTTOM) IN COALS WITH VARYING TOTAL INERTINITE CONTENT

AN IMPORTANT FINDING IS THE EXISTENCE OF A REGULAR PATTERN IN INERTINITE COMPOSITION OF HIGH AND LOW INERTINITE COALS

While Australian and overseas coals do not appear to differ significantly in their inertinite fusibility, an important finding of the study is the existence of a regular pattern in inertinite composition of high and low inertinite coals. As illustrated in Figure 8, high proportions of high reflecting, infusible fusinite are likely to occur in coals with a low total inertinite content. As the total inertinite content increases, the proportion of low reflecting semifusinite rises faster than the other inertinite macerals so that high amounts of total inertinite in a coal are mostly due to high concentrations of semifusinite at the expense of the other macerals. Since low reflecting semifusinite provides much of the fusible and partly fusible inertinite, inertinite-rich coals contain relatively more of the "reactive" inertinite than the low-inertinite coals on which the 1/3 fusibility cutoff in the Schapiro-Gray method is based.

CONCLUSIONS

- A substantial proportion of the inertinite in coals with a high total inertinite content is likely to be completely or partly fusible
- The imposition of a rigid 30% fusibility cutoff for semifusinite and other inertinite macerals has been the main reason for failure to give correct estimates of coke stability indices in international ring analyses of Gondwana coals organised by the International Committee of Coal and Organic Petrology (ICCP)
- The concept of an across-the-board reactivity of one third of the inertinite - or any other fixed proportion is therefore untenable

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