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PSEUDOVITRINITE WORKING GROUP

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1. **INTRODUCTION**

Many coal petrographers are still uncertain about the precise nature and properties of the material referred to as *pseudovitrinite* and the need for its recognition in rank studies and coal utilization. Particular attention is drawn in the present discussion to the significance of this material in determination of coal rank by vitrinite reflectance measurements in high-volatile bituminous coals.

The term *pseudovitrinite* was introduced by Benedict, Thompson, Shigo & Aikman (1968) to describe vitrinite-like material which displays higher than telocollinite reflectance, slitted structure, remnant cellular structure and an absence of pyrite inclusions. During the coking process pseudovitrinite is poorly reactive.

The most recent event in a historical survey of the work carried out by the ICCP on pseudovitrinite seems to be that report by A.H.V. Smith (1980) on *An appraisal of the work carried out on Pseudovitrinite by the ICCP and the direction of future work*. That report summarised work done up to 1980 by an ICCP Sub-Committee, and gives suggestions for the future work. However, so far as is known no further discussion on this subject have been reported.

Renewed interest in this material was expressed at the last meeting of the ICCP in Cracow, and discussion on this subject was scheduled for the present meeting in Heerlen.

2. NATURE AND SIGNIFICANCE OF PSEUDOVITRINITE

Pseudovitrinite, first described from Appalachian coals by Bennedict et al (1968), occurs in Carboniferous as well as in Gondwana coals (Stach et al., 1982). It is present in coals of different age and different rank. It has been noticed, for example, in the Lower Cretaceous Bickford Formation of British Columbia, Canada by Kalkreuth (1982); by Newman and Newman (1982) in the Upper Cretaceous bituminous coals at Pike River Coalfield (New Zealand); and by Trinkle and Hower (1984) from the middle Pennsylvanian (Westphalian B) Upper Elkhorn No. 3 coal of eastern Kentucky. It has also been identified in Gondwana coals of southern Africa by Falcon and Snyman (1986). However, no previous record apparently exists of pseudovitrinite having been noted in the Permian coals of Australia.

Brown, Cook and Taylor (1964) introduced the concept of vitrinite A and B for Australian Gondwana coals. Bennett (1968) described ‘granular’ vitrinite in Gondwana coals, which has higher bireflectance than normal and a granular optical texture. However none of these materials is referred as pseudovitrinite or has the features described by Benedict et al. (1968) in pseudovitrinite.

Examination of high volatile bituminous coals in the Gunnedah Basin, New South Wales, Australia, however, has shown evidence of material resembling that described by Benedict et al. (1968) as pseudovitrinite. The presence of this material has caused a previously unsuspected variability in reflectance data, which could lead to faulty interpretations in rank studies when not taken into consideration (Gurba and Ward, 1996).

VITRINITE REFLECTANCE

It has been long known that vitrinite from high volatile bituminous coals shows two different levels of reflectance. The respective materials were subsequently referred to as Vitrinite A and B by Brown, Cook and Taylor (1964), and more recently as telocollinite and desmocollinite.

The most outstanding feature of pseudovitrinite is that it has a higher reflectance than the normal vitrinite (telocollinite) in the same coal. Measurements obtained from coals of the Gunnedah Basin (as well as on some other coals from the Sydney and Bowen Basins) indicate three populations of vitrinite with different levels of reflectance in the same sample. The reflectance (Rv_{max}) of pseudovitrinite in these coals is up to 0.1% higher than that of the telocollinite in the same samples; this is consistent with the results obtained by Benedict et al. (1968) and Koch (1970). The reflectance within individual layers of either telocollinite or pseudovitrinite, however, remains essentially constant both vertically and laterally across the individual respective bands.

The reflectance of collotelinite (ICCP, 1994) is used widely as an index of the rank of coal, and also of organic matter in sediments. According to the ICCP (1994), related terms for *collotelinite* include:

> 'Vitrinite A' (Brown et al., 1964), and
> Pseudovitrinite (Benedict et al., 1968).

This implies that "so-called pseudovitrinite" (if present) should be included in routine vitrinite reflectance determinations. Work on the Gunnedah Basin suggests that, if followed, this will result in abnormally high reflectance values in coals where the pseudovitrinite material is abundant.

IMPLICATIONS FOR THERMAL MATURITY ASSESSMENT

Variations of any sort in the composition and properties of isorank vitrinites have far-reaching implications. The Permian bituminous coals in the Gunnedah Basin indicate a previously unsuspected variability in vitrinite character, ranging from a perhydrous, low-reflecting vitrinite on the one hand to a subhydrous, higher-reflecting (pseudo)vitrinite on the other.

It is very well known that vitrinite deposited under anaerobic conditions tends to have a depressed reflectance. Newman and Newman (1982), for example, indicate that vitrinite reflectance data from marine and marginal marine sediments should be interpreted with particular caution. Vitrinite from non-marine strata is also not completely free from reflectance anomalies (Newman and Newman, 1982). This is demonstrated by some of the Gunnedah Basin coals. The assessment of thermal maturity in such cases could pose problems, particularly in interpretation of maturation profiles from reflectance data. Price and Barker (1985) have stated that the maturity of the sediment could be miscalculated if either hydrogen-rich or oxygen-rich kerogen was used without reference to the overall kerogen type.

CHEMISTRY

Vitrinite group macerals have less hydrogen than liptinite and show higher reflectance (Stach et al., 1982). Within the vitrinite group reflectance also increases with decreasing hydrogen content, from desmocollinite towards telocollinite. Pseudovitrinite is defined by Stach et al. (1982) as band vitrinite with less hydrogen and volatile matter and lower swelling properties than ordinary telocollinite.

Preliminary electron microprobe analyses carried out on some high volatile bituminous coals from the Gunnedah Basin, following the methods of Bustin et al. (1993) and Mastalerz and Bustin (1993), indicate that between semifusinite, pseudovitrinite, telocollinite and desmocollinite, pseudovitrinite has the lowest carbon and the highest oxygen content. This indicates its subhydrous character. This study, however, is still in progress, and more samples are required to be analysed.

ETCHING AND OTHER PROPERTIES

Etching tests carried out on the Gunnedah Basin coals have shown that pseudovitrinite possesses a cryptotelinitic structure. Examination of thin sections of Gunnedah Basin coals also shows a cell structure in pseudovitrinite material.

Johnson et al. (1985), using photoacoustic microscopy, indicate that, up to a rank equivalent to 92% carbon, vitrinite and pseudovitrinite have a significantly different photoacoustic response. This is thought to reflect a different chemical composition and molecular structure in the respective macerals. At higher rank levels vitrinite and pseudovitrinite are indistinguishable.

ORIGIN

This “so-called pseudovitrinite” is thought to have formed by primary oxidation (probably by slow low-temperature oxidation), drying or desiccation during periods of low water table in early peat-forming times (Benedict et al., 1968). The presence of pseudovitrinite suggests that conditions were relatively dry during the accumulation of the respective seams (Newman and Newman, 1982). However, Kaegi (1985) suggests that slitted pseudovitrinite present in ‘fresh’ coal may also have been produced by post-coalification oxidation. In any event the presence of pseudovitrinite is generally taken to indicate some form of in situ oxidation.

Goodarzi (1985) studied subbituminous coals in Western Canada. The pseudovitrinite found in these coals may have been formed by heat-treatment of fossil oxidised vitrinite fragments. Koch (1970), however, suggests that the difference in reflectance can be partly attributed to differences in the vegetable source material.

It is still not clear whether the relatively strongly reflecting pseudovitrinite results from ulminite and/or densinite, i.e. from huminites that are already biochemically gelified (Stach et al., 1982).

Debate still exists over the origin and nature of this so-called pseudovitrinite, including that of its slit pattern. The origin of pseudovitrinite has has not yet been established with certainty, and additional chemical and geological studies, including studies of its distribution, are clearly required. Although some sort of oxidation process is commonly assumed to be involved, Koch (1970) suggests that the difference in reflectance is partly attributed to the differences in the vegetable source material.

3. COMMENTS

Considerable further study on so-called pseudovitrinite should be undertaken, with a particular emphasis on high volatile bituminous coals. Attention should be paid to:

- relevance to coal properties (chemistry)
- significance in rank studies and relevance to hydrocarbon generation
- relevance to coal utilisation
- origin of the material, including its slit pattern.

It would appear that work should be done by ICCP on:

1. The features which are of primary importance in the recognition (identification) of pseudovitrinite. It should be pointed out that no single property is sufficient to identify this material. The above-mentioned optical features are adequate for high-volatile coals. However, as Benedict et al. (1968) have shown, the spread between the average reflectance of normal vitrinite and that of pseudovitrinite diminishes rapidly in low-volatile bituminous coals. Hower and Wild (1981), on the other hand have indicated that material identified as 'pseudovitrinite' is not always as distinctive as that originally defined by Benedict et al. (1968).

2. The name of the material is also a factor for consideration. If chemical and petrographic studies suggest that it is in fact vitrinite, then the name *pseudovitrinite*, implying that it resembles but is not vitrinite, is clearly inappropriate.

3. The implications to rank studies and hydrocarbon generation of the presence of such so-called pseudovitrinite. If pseudovitrinite represents altered vitrinite, should this material be included as part of the determination of coal rank by reflectance? The best way to determine the rank and the technological properties of a coal, where pseudovitrinite is present, might therefore possibly involve some consideration of the different vitrinite types and the relative amounts of each.

4. Doubts remain about differences in carbonizing properties between normal vitrinite and pseudovitrinite. Studies of pseudovitrinite from Carboniferous coals have suggested that this material is considerably less reactive than other associated vitrinite, and that, depending on its degree of alteration, it reacts as do the semi-inert, or even inert, macerals during coking. ICCP (1994) suggests that higher proportions of pseudovitrinite may diminish a coal's thermoplastic properties. The proprotion of pseudovitrinite, if present in a coking coal, should therefore be determined separately to that of other vitrinites, because it could explain any anomalies in the overall coking properties. However, Smith (1980) has reported some carbonisation tests that failed to demonstrate the inert character of material with comma-like fissures (pseudovitrinite). In spite of this it has assumed that any material having a distinctly higher reflectance than normal vitrinite would behave as an inert component. Tests carried out by Goodarzi and Murchison (1976), have shown that although a mosaic texture is produced in pseudovitrinite during coking, the mosaic is much reduced in size. Cook and Edwards (1971) studied differences in the coking behaviour of the Bulli seam, New South Wales, in relation to a number of other coals, and note specifically that pseudovitrinite is not present.

5. Analyses of physical/chemical properties of pseudovitrinite material. Current studies using the electron microprobe (based on discussions with Dr Maria Mastalerz) have shown that pseudovitrinite resembles the chemistry of vitrinite more than it does of (say) semifusinite. This work, however, is so far based on a limited number of samples from one location (the Gunnedah Basin). Similar work on other coals needs to be incorporated, perhaps under an exchange or collaborative arrangement.

6. Debate still exists over the origin and nature of this so-called pseudovitrinite, including that of its slit pattern. The origin of pseudovitrinite has not yet been established with certainty, and additional chemical and geological studies, including studies of its distribution, are clearly required. Although some sort of oxidation process is commonly assumed to be involved, Koch (1970) suggests that the difference in reflectance is partly attributed to the differences in the vegetable source material.

7. The material from the Gunnedah Basin commonly contains small pyrite crystals in the individual slit fractures. Similar pyrite was found by Falcon and Snyman (1986) in pseudovitrinite from African coal samples. The distribution and origin of this material is also worthy of consideration.

It is likely that critical assessment of vitrinite reflectance in other sedimentary basins which are of HVB rank will show that the elevated reflectance anomalies due to so-called pseudovitrinite detected in the Gunnedah Basin are far from unique.

Everyone is welcome to join the discussion on this material.

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