

EXECUTIVE SUMMARY

The objective of this investigation was to gain a qualitative understanding of the mineralogy of the coal measures occurring in the Highveld coalfield of South Africa. The project focused on the identification of minerals occurring in coal and the understanding of the distribution of these minerals among the various coal seams. Furthermore, the lateral distribution patterns of minerals in coal were researched. In addition, an effort was made to establish the relationship between the mineralogy of the coal and the associated water quality.

The different depositional environments that have been recognized by other workers in the coal-bearing strata of the Ecca Group are associated with characteristic physicochemical conditions. Such characteristic physicochemical conditions dictate the precipitation of typical mineral assemblages. Thus, based on theoretical considerations, there should be a direct link between the depositional environment and the modal proportion of minerals and mineral assemblages.

Samples were collected from the No. 1, No. 2, No. 4 and No. 5 coal seams, as well as their roof and floor lithologies in both the Witbank and Highveld coalfields.

Low-temperature ashing (LTA) and X-ray diffraction (XRD) carried out on selected samples accentuated the need and practicality of integrating other analytical techniques with XRD. XRD on LTA coal proved to be more accurate in identifying minerals that occur as rare constituents, i.e. < 5 modal percent, especially since the organic material in coal tends to obscure interpretations from raw coal XRD;

There are numerous variables influencing the results from X-ray fluorescence (XRF) analyses on coal. Differences were observed, firstly, between whole coal and fusion disk XRF, and secondly, between whole coal results of mixed proportions of two samples. The calcination and fusion of coal samples introduces some difficulties concerning the loss of important constituents in coal, such as sulphur and possibly phosphorus. The conditions during preparation of XRF disks, such as temperature, need to be kept constant if similar results are to be obtained each time. A disadvantage of using whole coal briquettes refers to the "infinite thickness" issue. X-rays are often absorbed into coal briquettes resulting in lower count rates, while mass absorption is accounted for in fusion disks by the addition of La_2O_3 during preparation. The differences between whole coal results of mixed proportions of two samples could also be attributed mass absorption effects. Elements such as iron have a higher mass absorption resulting in lower count rates than is to be expected. The possibility of segregation of heavy minerals in samples during mixing and storage has been considered, and was minimized by correct sample handling and thorough mixing. The standard XRF technique is recognized as precise and reliable, but in this case whole coal analysis was more suitable.

The mineral components in coal were expressed as a percentage of the inorganic constituents. Minerals detected in the XRD patterns were semi-quantitatively evaluated in terms of dominant (>40% of the mineral fraction), major (10-40%), minor (2-10%), accessory (1-2%) and rare (<1%) constituents. The inorganic fraction consisted primarily of dominant quartz and kaolinite, and sometimes even dominant

pyrite, calcite and dolomite. The latter three were almost ubiquitous in the coal. The Ca-phosphate mineral, crandallite was detected in the western region of the Witbank and Highveld coalfields. Although only present in low concentrations, fluorapatite was detected throughout in the Witbank coal except in the extreme northeastern region. Fluorapatite was not detected in samples from the Highveld coal.

Chemical analyses confirmed the mineralogical interpretations. The inorganic components make up approximately 8 to 35 wt% of a coal sample. SiO_2 concentrations varied between and 35 wt% of a sample, Al_2O_3 between 0.5 and 16 wt%, Fe_2O_3 between 0.03 and 10 wt%, and S between 0.15 and 8 wt%. Minor concentrations of CaO (0 to 8 wt%) and MgO (0 to 1 wt%) were present. P_2O_5 occurred in concentrations of 0 to 3.5 wt% and K_2O was in the order of 0 to 1.3 wt%. Na_2O values were the lowest varying between 0 and 0.45 wt%. The only difference in chemistry between Witbank and Highveld coal was a slight increase in Na_2O (0 to 0.51 wt%) in the Highveld coal.

Acid-base accounting (ABA) results for the collected samples show that the lithological units in the coalfields have the ability to contribute to deterioration in ground and surface water quality. A positive correlation was recognized between the types of minerals, i.e. modal proportion of sulphide, carbonate and clay minerals, present in the coal and the associated water quality, i.e. the severity of the AMD problem.

Two types of screening criteria was used to determine whether acid or alkaline conditions will prevail once all acid consuming and acid producing minerals has been oxidized. From the NNP, or net neutralizing potential, it can be predicted that the No. 5 coal Seam, the No. 4 coal Seam and the unit between No. 2 and No. 4 coal seams will be predominantly acidic. The NNP of the other units vary between -20 kg/t and 20 kg/t, therefore these stratigraphic units could become either acidic or alkaline. The unit between No. 1 and No. 2 coal seams is the only unit possessing enough neutralizing potential to buffer the acid produced, but could still become acid since the NNP is less than 20 kg/t.

The NPR or NP: AP ratios, for all stratigraphic units (except between No. 1 and No. 2 coal seams) are less than 1:1 suggesting that acid conditions will dominate. The NPR ratio between No. 1 and No. 2 coal seams is at least 3:1 implying that enough buffering capacity is available to counteract the acid. The AP and NP are largely dependant on the presence of pyrite and calcite, respectively. Good correlations were obtained between the NP and CaO% and the AP and S%. Therefore it is possible to use the mineralogy to predict these factors. It should also be remembered that these predictions do not take time and weathering rates into consideration, thus such conditions will only be obtained once ideal situations are reached.

Finally, the study has contributed by recognizing regional distribution patterns of mineral matter in the No. 2 seam coal in the Witbank and Highveld coalfields.

A significant amount of useful mineralogical information has been compiled during the course of this study. However, the interpretation of the available data has not yet been optimized. We recommend that the

interpretation of available information should be completed and that additional information should be gathered where required.