ABSTRACT

This thesis evaluates the entire coal value chain in order to understand the economic and environmental impacts of the various beneficiation pathways, including modern coal processing techniques required to produce different specifications of local and export quality thermal coal products. Three South African coals, one from the Witbank coalfield No 4 seam, a second from the Waterberg Upper Ecca group and, to a lesser extent for comparative purposes, a third from the Free State (Vereeniging) coalfield were evaluated. The ultimate objective was to determine whether it would be advantageous from the techno-economic and environmental viewpoint, to produce low grade thermal coal for export from any of these coalfields. Against this background, this thesis serves to explain the extended value chain in the production of export coal with a view to technically and economically evaluating the advantages and disadvantages of low grade export versus domestic coal production.

Detailed experimental work was undertaken on samples from the Witbank No 4 seam and Waterberg Upper Ecca coals. Apart from conventional analyses, detailed petrographic and mineral liberation analyses (using QEMSCAN and XRD) were performed on a series of washability density fractions for each coal. Trace element analysis (for the environmental studies) was also undertaken using ICP-MS on the same washability fractions. These data were combined in the thesis (i) to produce liberation models for the macerals and the minerals using M-curves, and (ii) to determine the association of sulphur and trace elements with the macerals and minerals using Principal Component Analysis.

The thesis applied coal process modelling to a wide range of coal preparation options in order to produce various thermal coal products from the three South African coals under investigation. The impacts of the different beneficiation process options on the rejection of specific ash-forming minerals were evaluated at various separation densities. Costing of the various processing options was conducted. This was combined with the projected income expected from each thermal coal product. The economic analysis was subsequently evaluated in conjunction with the power required to produce each product as well as the carbon footprint and emission

rates of carbon and sulphur dioxide for each processing option. The multifaceted outcome then produces a series of results from which conclusions can be drawn as to what product is best produced from which coal field technically and feasibly.

Key words: Coal preparation, beneficiation, process modelling, mineralogy, liberation analysis, trace elements, coal petrography, energy utilisation, techno-economic modelling, low grade thermal coal export, carbon footprint