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SINTERING AND SLAGGING OF MINERAL MATTER IN SOUTH AFRICAN  
COALS DURING THE COAL GASIFICATION PROCESS

By

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## ABSTRACT

### SINTERING AND SLAGGING OF MINERAL MATTER IN SOUTH AFRICAN COALS DURING THE COAL GASIFICATION PROCESS

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#### **Key words:**

Coal analysis, Petrology, Mineral matter, Macerals, Coal ash analysis, Lurgi gasification, Glass analysis, Coal sintering and slagging, Pyrometallurgy, Density separation, Screening, Pyrolysis, Sequential leaching, Low temperature ashing, Particle morphology, X-ray diffraction, Electron microprobe, Computer controlled scanning electron microscopy, Quantitative evaluation of materials by scanning electron microscopy, Scanning electron microscope with a light element energy dispersive spectrometer, FactSage modeling.

Coals, from mines in the Highveld coalfield, as well as gasification ash samples were characterised, in order to understand the mineralogical and chemical properties of the individual components in the gasification feedstocks.

X-ray diffraction of low temperature oxygen-plasma ash indicates that the coals contain significant proportions of kaolinite, quartz and a fluxing elements-bearing mineral (dolomite), plus minor concentrations of illite and other fluxing elements-bearing minerals namely calcite, pyrite and siderite.

Of the feed coal, the -75+53 mm size fraction has a high pyrite, and to a lesser extent a high calcite and dolomite content. However, the small proportion of iron-bearing phases (from the reaction between kaolinite and pyrite) in samples taken from the gasifier implies that pyrite contributes minimally to sintering or slagging in this case.



Calcite is mainly present in the  $>1.8 \text{ g/cm}^3$  density fraction of the feed coal, whereas dolomite is mainly present in the  $1.5\text{-}1.8 \text{ g/cm}^3$  density fraction, as inclusions or fine cleats in the coal matrix.

Electron microprobe analyses of coals from the six different South African mines confirmed that some Ca, Mg, Al, Si, Na, K, Ti and Fe are present in the organic matrix in the coal samples tested in this study, but the amounts of these are small compared with the fluxing elements in minerals.

XRD and microprobe analyses indicate that the ash clinker samples taken from the gasifiers contain a number of crystalline high temperature phases, including anorthite, mullite, cristobalite, quartz and diopside. FactSage confirmed that anorthite and mullite are equilibrium phases at elevated temperatures in the ash clinkers and heated rock fragments. Limited reaction takes place between the included coal minerals and the extraneous rock fragments.



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## LIST OF ABBREVIATIONS

AAL	Ammonium Acetate Leaching
AAS	Atomic Absorption Spectroscopy
AFT	Ash Fusion Temperature
ASTM	American Society for Testing and Materials
AXRD	Ambient X-ray Diffraction
B/A	Base/Acid ratio
BSE	Backscattered Electron
CHF	Chemical Fractionation
CCSEM	Computer Controlled Scanning Electron Microscopy
CMT	Coal and Mineral Technologies
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CQP	Coal Quality Predictor
daf	Dry Ash Free
DC	Dust Collector
DME	Department of Mineral and Energy
DTF	Drop Tube Furnace
EMP	Electron MicroProbe
FBDB	Sasol-Lurgi Fixed Bed Dry Bottom
FC	Fixed Carbon
FT	Fluid Temperature



GL	Gas Liquor
HCIL	Hydrochloric Acid Leaching
HLC2	Highveld Leached Coal Two
HLC1	Highveld Leached Coal One
HT	Hemispherical Temperature
HTA	High Temperature Ash
HT-XRD	High Temperature X-ray Diffraction
HUC	Highveld Unleached Coals
IC	Ion Chromatography
ICP	Inductively Coupled Plasma
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectroscopy
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
IDT	Initial Deformation Temperature
IM	Inherent Moisture
KMC	King-Maries-Crossley
LTA	Low Temperature Ash
MM	Mineral Matter
OES	Optical Emission Spectroscopy
PM <sub>1</sub>	Particulate Matter less than 1 $\mu\text{m}$
PSD	Particle Size Distribution



QEM*SEM	Quantitative Evaluation of Materials by Scanning Electron
ROM	Run of Mine
SABS	South African Bureau of Standards
SAMB	South African Low-grade Medium Rank C Bituminous
SCS	Sasol Coal Supplier
SEM-EDS	Scanning Electron Microscope with a light element Energy Dispersive Spectrometer
ST	Softening Temperature (spherical),
Tot	Total
TS	Total Sulphur
TSI	Technology Service International
UC1	Unleached coal 1
UC2	Unleached coal 2
UJ	University of Johannesburg
PC	Personal Computer
WDS	Wavelength Dispersive Spectrometer
WL	Water leaching
XAFS	X-ray Absorption Fine Structure Spectroscopy
XRF	X-ray Fluorescence Spectroscopy
$\eta$	Apparent Viscosity
$\gamma$	Surface Tension



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