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Beneficiation of an ilmenite waste stream containing undesirable levels of chromite

by

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in the Faculty of Engineering, Built Environment and Information Technology,
University of Pretoria, Pretoria

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Role and responsibility of the author

Because this thesis relies on inputs of testwork done by others, the role and responsibilities of the author are discussed in detail below.

This work started when one of the managers from IHM Heavy Minerals asked me to compare the roasting behaviour of LSR with that of crude ilmenite (which was the material which IHM were familiar with). I conducted a brief literature survey and designed the test programme based on work conducted by Nell and Den Hoed on behalf of IHM Heavy Minerals in 1996 (as presented at the 1997 Heavy Minerals Conference). As the IHM Heavy Minerals plant was in the detail design phase and the industry was extremely secretive sourcing of material for test work was difficult. I had to share the small amount of material that was available with other projects that utilised the material for detail plant design test work.

Since I worked for IHM Heavy Minerals and was based in Pretoria the equipment available to me at Kumba R&D included the fluidised bed roaster (that could roast ilmenite samples of 40g or less); the Linn-type furnace that could roast larger samples; the Frantz barrier magnetic separator; a Readings laboratory scale magnetic separator and a Carpco laboratory scale magnetic separator. To familiarise myself with the operation of the fluidised bed reactor and the Frantz separator I conducted tests on crude ilmenite myself (under the conditions reported). I physically preheated the reactor, placed samples in the glass tube, put the glass tube in the reactor, introduced the fluidising gas, observed during roasting, timed the process, removed the reactor from the furnace, cooled the sample, weighed it before and after roasting, logged the data into a log sheet, bagged, labelled and numbered the samples. I did not operate the Linn furnace myself but use of the furnace was demonstrated to me. I used the Frantz separator myself, splitting samples into fractions at different amperages.

Kumba R&D employed a technician (Jonathan Skosana) who was well trained on the operation of the equipment and he conducted the bulk of the remaining test work on the fluidised bed reactor and the Frantz. Although I was working on the Heavy Minerals Project at that stage (working on the detail design and pre-commissioning activities) I also had an office at the pilot plant where I spent several days a week whilst Jonathan did the test work. Jonathan borrowed the magnetic susceptibility meter from Geotron for the LSR test work. I did not use this specific meter myself but used the meter that was purchased by Kumba R&D at a later stage whilst conducting shift work (engineer on shift) during a roasting pilot plant campaign at Mintek at a later stage (not part of this thesis).

To conduct XRF, XRD and QEMSEM analyses specialised equipment were utilised and although I am familiar with XRF machines (as utilised by laboratories providing a service to steel and heavy minerals plants) I only interpreted the results from the datasets received from the various laboratories.

I wrote the paper and presented the results of this study at the Heavy Minerals Conference in 2001 (Gouws and Van Dyk 2001). At that stage I still assumed that nothing happened to the chromite during roasting. One of the conference attendees commented on the graph for roasted LSR and challenged that assumption. That was the origin of the second hypothesis. I contacted the University of Pretoria and discussed the matter with Prof Pistorius who was quite keen to investigate the matter with me. Both the professor and I investigated possible sources for clean chromite. The best option would have been to separate the chromite in the LSR from the ilmenite. Due to the low chromite concentrations in the LSR this option was impractical. I discussed the matter with the refractory supplier as well as the geologist on site. Prof Pistorius discussed the matter with the Geology Department at the University and they sourced the chromite rock from the UG1 deposit.

The roasting and magnetic separation test work was once again conducted by Jonathan Skosana. By this time it was easy to manage the execution of the test work even from a distance as I had established a relationship with the personnel at Kumba R&D. I updated the literature review over the whole period with an extensive survey in the last 12 months of the project while I was writing the thesis and trying to make sense of the test results. I performed all of the data analysis and interpretation. The conclusions and recommendations were my own.

From the above statements it is clear that I not only contributed to the work but was fully responsible for the research idea, development and execution of the experimental plan, data analysis and interpretation and recommendations made for application of the results and further studies.

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List of abbreviations

Abbreviation	**Description**
AC	Alternating current
CPC	Central processing complex
CSTR	Continuous stirred tank reactor
DC	Direct current
DIC	Dry ilmenite circuit
DMDS	Dry magnetic drum separation
EDX	Energy-dispersive X-ray analysis
HCP	Hexagonal closed packed
HGMS	High gauss magnetic separators
HIWMS	High intensity wet magnetic separators – also called WHIMS
HMC	Heavy mineral concentrate
HSR	High susceptibility fraction
IA	Image analyzer
LIMS	Low intensity magnetic separators
LIWMS	Low intensity wet magnetic separators
LSR	Low susceptibility fraction
PFR	Plug flow reactor
PWP	Primary wet plant
QEM*SEM	Quantitative Evaluation of Materials by Scanning Electron Microscopy
URIC	Unroasted ilmenite circuit
R&D	Research and Development
ROM	Run-of-mine product
SEM	Scanning electron microscope
VHM	Valuable heavy mineral
WDS	Wavelength dispersive spectrometry
WHIMS	Wet high intensity magnetic separators – also called HIWMS
XRD	X-ray diffraction
XRF	X-ray fluorescence