Physical property changes of Fe-Ti oxides along their alteration:

A geometallurgical study to improve the yield of a mineralurgical plant.

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I. Introduction

PhD thesis in partnership between Eramet Ideas, TiZir Limited and Université de Franche Comté (Besançon)

→ Current objective of the thesis: To improve the understanding of Fe-Ti oxides to enhance the metallurgical processes.

Grande Côte mineral sands Operation (GCO) in Senegal,
A mineral processing plant design to separate ilmenite, leucoxene, rutile and zircon.
I. Introduction

➢ The Fe-Ti oxides products

**ILMENITE 1**
- 54% TiO₂
- 325 000 t/y
- Low Value
- Less strict chemical specification

**ILMENITE 2**
- 58% TiO₂
- 125 000 t/y
- Medium Value
- Very strict chemical specification: Cr, P, Al, S, U+Th

**LEUCOXENE**
- >85% TiO₂
- 6 000 t/y
- Medium Value

**RUTILE**
- >95% TiO₂
- 3 000 t/y
- High Value
- Very strict chemical specification: P, Cr, Fe, Al, Si

Data: GCO Dec 2016

Stricts chemicals specifications constrain the production of high-value products
• I. Introduction

➢ Problematic

➢ Difficulty in reaching chemical specifications for each commercial product

➢ Obligation to continuously change processing parameters

➢ Complex forecasting, loss of yield, tight workflow work

Probable causes:
• Poor understanding of the physical properties of minerals including Fe-Ti oxides

➢ Objective of the PhD: To improve the understanding of Fe-Ti oxides to enhance metallurgical processes
➢ A geometallurgical approach
## I. Introduction

### Problematic

**State of the art**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Formula</th>
<th>Stoichiometric TiO₂-content (possible range)</th>
<th>Avg Density</th>
<th>Electro/Magnetic Susceptibility</th>
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<tbody>
<tr>
<td>Ilmenite</td>
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<td>60.0% TiO₂ (57 - 65 % TiO₂)</td>
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<td>Ferropseudobrookite</td>
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Knowing the real mineralogy in order to well adjust the processing parameters
II.

Characterization step: Qemscan, XRD, SEM and Microprobe analysis
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- Automated Mineralogical mapping using Qemscan

- XRD, phase identification
- Microprobe
- SEM (High resolution image)
- Qemscan process simulation

Qemscan mapping of a Leucoxene product sample

- Ilmenite
- Pseudorutile
- Anatase
- Rutile
- Other Ti Oxides
- Zircon
- Quartz
- Epidote
- Other Silicates
- Other Oxides
- Other Minerals
- Unidentified
II. Characterization step

Qemscan results

Only few ilmenite in the « ilmenite product »
Ilmenite/Pseudorutile = Not only a nomenclature, physical and chemical properties are different: Fe/Ti, Fe²⁺/Fe³⁺, Density, Magnetic, Impurities (Cr, P, Al, Si, etc...)
Leucoxene product: mainly composed of rutile minerals (>97 % TiO$_2$)
Chemical specification of Rutile product: >95% TiO$_2$
Possibility to recover the rutile minerals from the Leucoxene product by working on the process parameters
II. Characterization step: Microprobe analysis

Ilmenite, Pseudorutile, Anatase et Rutile

% Fe2O3 vs TiO2

Grains resulting from the progressive alteration of ilmenite into pseudorutile.

Ilménite

Pseudorutile

Anatase

Rutile

Leucoxene product

Pure theoretical pole
III.

Leucoxene product: Chemical and mineralogical composition
III. Simulation of chemical distributions by Qemscan

Leucoxene Product, Elemental impurities deportment:

Removing the chemical impurities in order to recover the rutiles of the Leucoxene product

Main phases bearing impurities: Pseudorutiles, Phosphates and Anatases
• III. Leucoxene: mineralogical composition

→ High intensity magnetic separation tests in order to remove the low sensitive grains
IV.
Mineral separation tests
IV. Mineral separation tests

**Goal:**
- Isolate rutile from anatase and pseudorutile
- Reducing the impurities contents, especially P and Cr

3 Separation steps:
1. MAG RER
2. MAG RER Cleaning
3. MAG IRMS

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**LEUCOXENE**

1. MAG RER
2. MAG RER Cleaning
3. MAG IRMS

**Goal:**
- Isolate rutile from anatase and pseudorutile
- Reducing the impurities contents, especially P and Cr
• IV. Mineral separation tests

➢ Chemical and mineralogical results:

Final rutile concentrate with:
- Yield = 40%
- Cr$_2$O$_3$ & P$_2$O$_5$ under Rutile commercial specifications

Capacity to create a rutile concentrate with impurities content under the commercial specifications
• IV. Mineral separation tests

Chemical and mineralogical follow up of the output during the separation tests

More a mineral separation than a chemical separation!
V. Conclusion

- Adjust the processing parameters from the mineralogy allowed us to create a rutile concentrate with impurities content under the commercial specifications.
- Cr, P, Al, Fe, Si bearers isolated: pseudorutile and anatase.
- Industrial adaptation of these process parameters.
- Electrostatic separation test to collect the remaining zircons.
- Same research work with Ilmenite product.
THANKS FOR THE ATTENTION

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