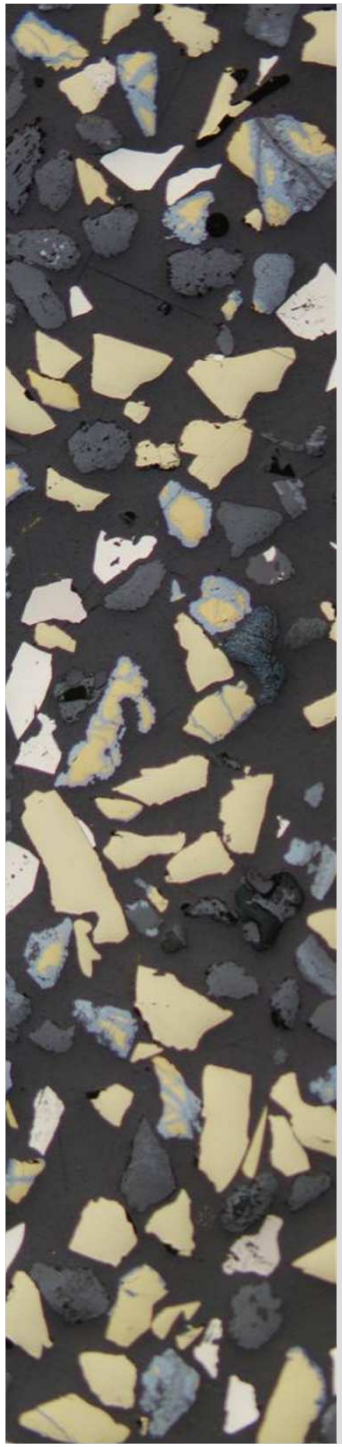

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POLITÉCNICA
"Ingeniamos el futuro"

TEXTURAL DESCRIPTORS

FOR MULTIPHASIC ORE PARTICLES

Laura PEREZ-BARNUEVO
Eric PIRARD

Synopsis

- Introduction
  - Complex ores
  - Liberation theory
  - Predicting Particle Behaviour
- Methods
  - Notations
  - Review of indices
  - Intercept distributions
- Simulated Materials
  - Rim/Emulsion
  - Veins
- Results
  - Performance evaluation
- Perspectives

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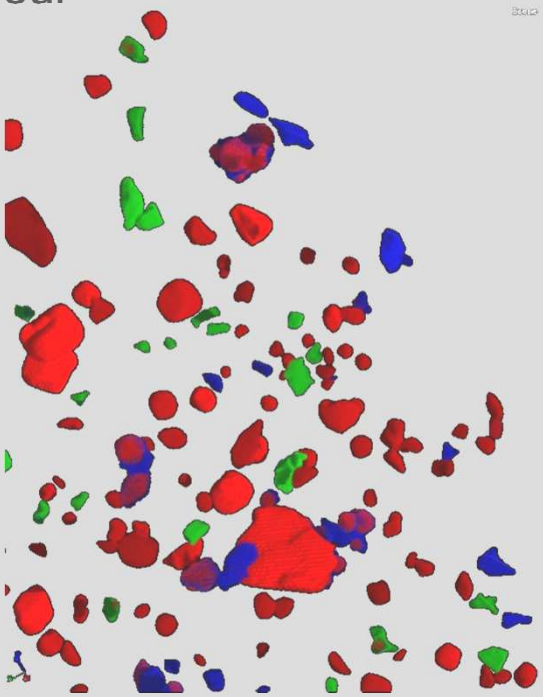
Introduction

- Complex Ores
- Liberation Theory
- Predicting Particle Behaviour



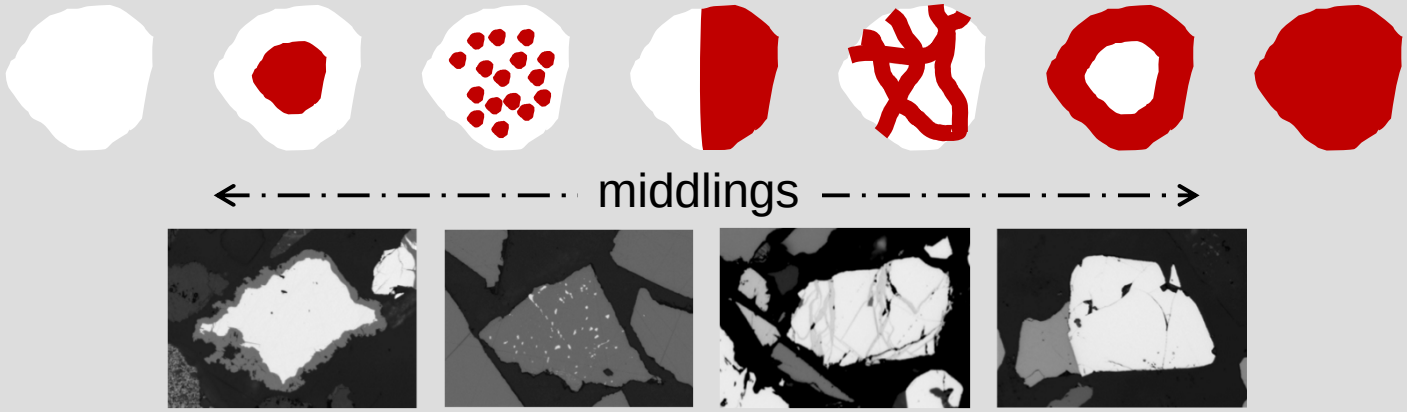
Introduction

- Mineral Processing & Recycling
  - Aim : Separate valuable material from « gangue »
    - e.g. Copper ore
      - » Typically 1%-2% of Cu bearing minerals !

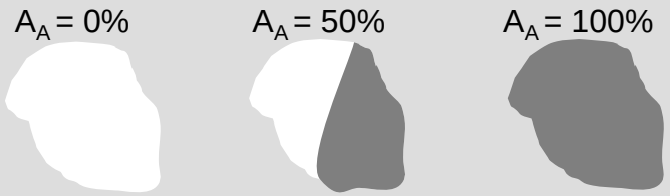
    - e.g. Waste Electrical Electronic Equipment (WEEE)
      - » Cu wires in Printed Circuit Boards

Introduction

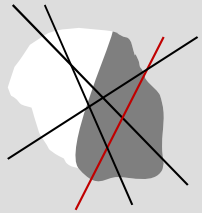
- Grinding
  - Aim: Produce particles with a **predictable** behaviour

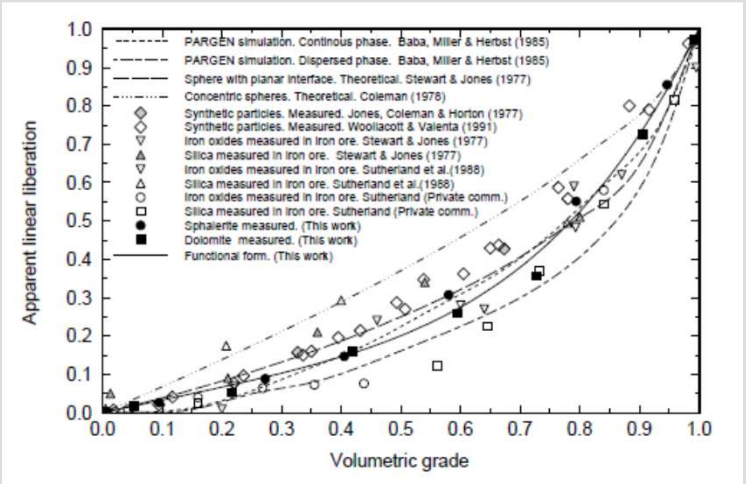


- Gravimetry
  - » Separation based on DENSITY
- Flotation
  - » Separation based on HYDROPHOBICITY
- Leaching
  - » Selective dissolution based on ACCESSIBILITY



- Liberation Analysis
  - Standard
    - Area fraction of valuable phase (A_A)
    - Systematic overestimation
  - Stereologic
    - Apparent Lineal Liberation
      - » Nb fraction of fully liberated random intercepts
    - Theory of Liberation (King, Schneider, Barbery,…)
      - » Homogeneous texture hypothesis





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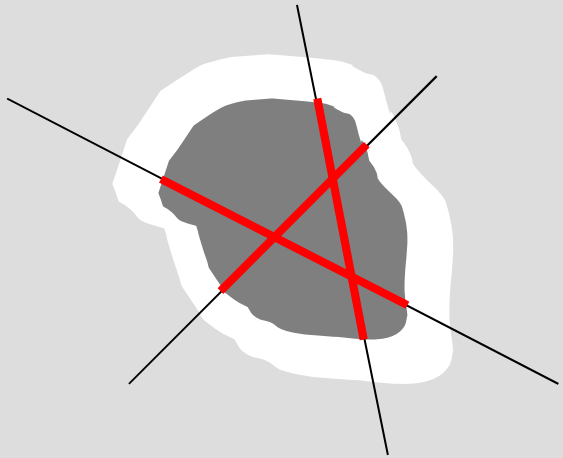
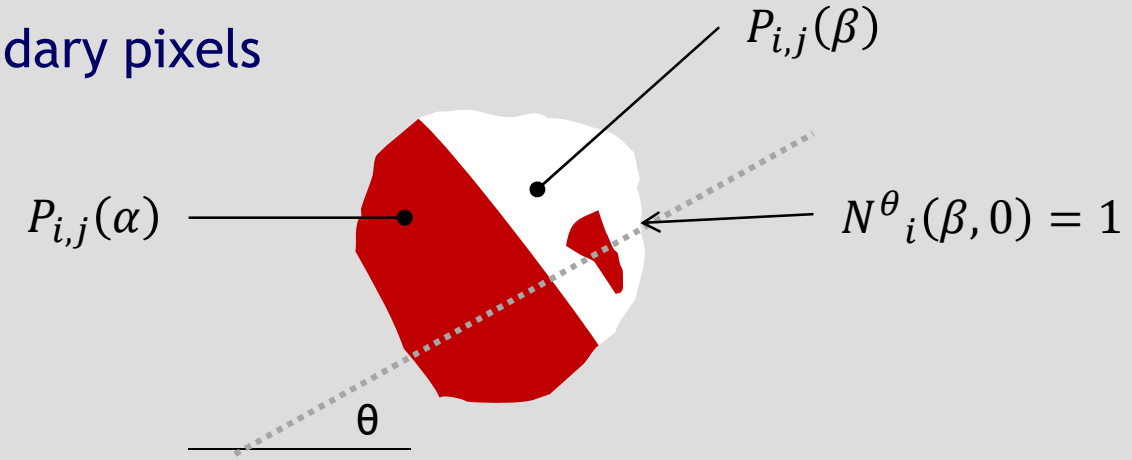
Methods

- Notations
- Review of indices
- Intercept distributions



Methods

- Plain vs Boundary pixels



Phases α,β,γ,….
φ : all phases
0 : background
· : phase or background

- Area Fraction of phase α:

$$A_A^{\alpha} = A_A(\alpha) = \frac{\sum_i \sum_j P_{i,j}(\alpha)}{\sum_i \sum_j P_{i,j}(\varphi)}$$

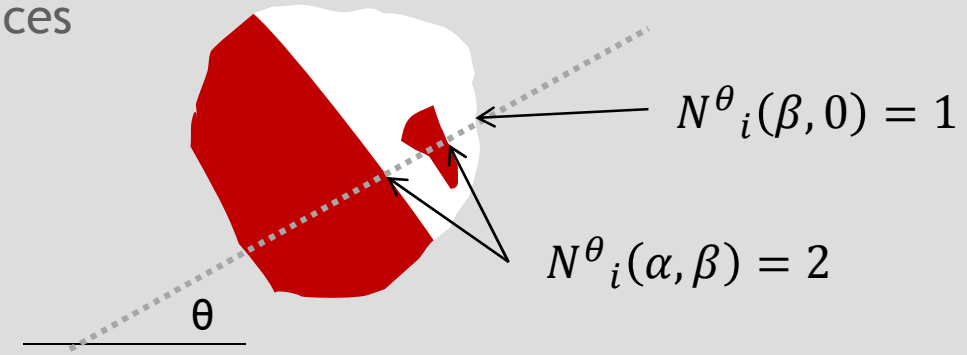
- Boundary Ratio of phase α:

$$B_B(\alpha) = \frac{\sum_j N_j^{\theta}(\alpha, o)}{\sum_j N_j^{\theta}(\varphi, o)}$$

Methods

- Contiguous pixels
  - Phase contact indices

Phases α,β,γ,….
φ : all phases
0 : background
· : phase or background



- C1
  a/B interface relative to boundary:

$$I_{C1}(\alpha,\beta)=\frac{\sum_j N_j^{\theta}(\alpha,\beta)}{\sum_j N_j^{\theta}(\varphi,o)}$$

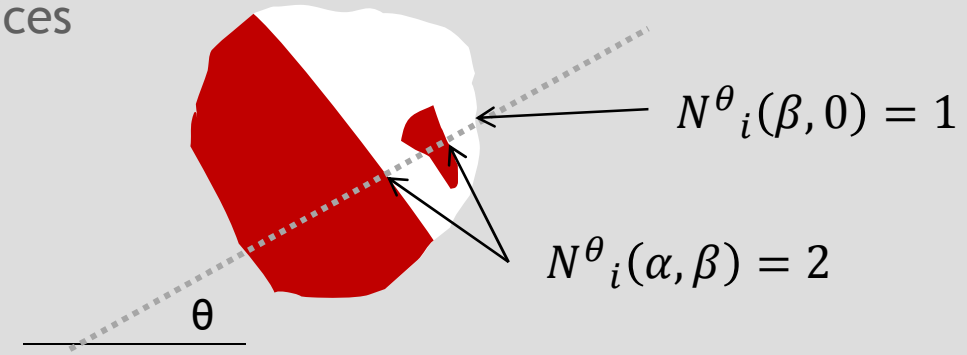
- C2
  a/B interface relative to a-boundary:

$$I_{C2}(\alpha,\beta)/\alpha=\frac{\sum_j N_j^{\theta}(\alpha,\beta)}{\sum_j N_j^{\theta}(\alpha,o)}$$

Methods

- Contiguous pixels
  - Phase contact indices

Phases α,β,γ,….
φ : all phases
0 : background
• : phase or background



- Amstutz-Giger:

$$I_{A-G}(\alpha,\beta)=\frac{\sum_{j}N_{j}^{\theta}(\alpha,\beta)}{\sum_{j}N_{j}^{\theta}(\varphi,\bullet)}$$

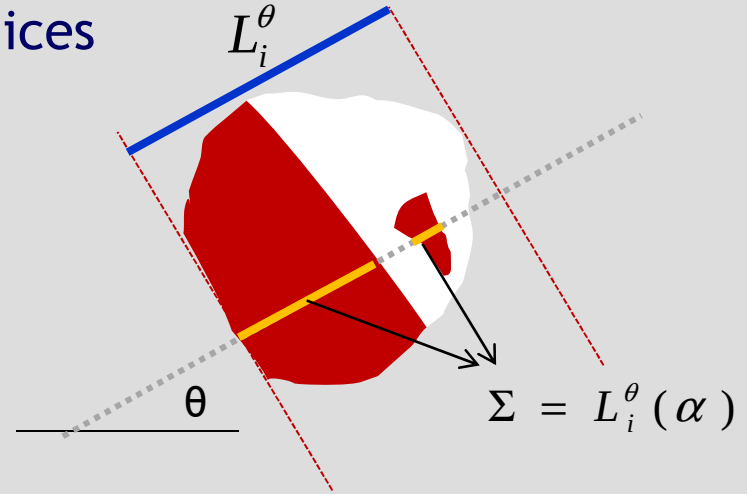
- Jeulin:

$$I_{J}(\alpha,\beta)=\frac{\sum_{j}N_{j}^{\theta}(\alpha,\beta)\times\sum_{j}N_{j}^{\theta}(\varphi,\bullet)}{\sum_{j}N_{j}^{\theta}(\alpha,\bullet)\times\sum_{j}N_{j}^{\theta}(\beta,\bullet)}$$

- NAB:

$$N_{\alpha\beta}=\frac{\sum_{j}N_{j}^{\theta}(\alpha\beta)}{N(I^{\theta})_{NonLiberated}}$$

- Intercepts based indices



- L_L
  Mean of lineal liberation by number

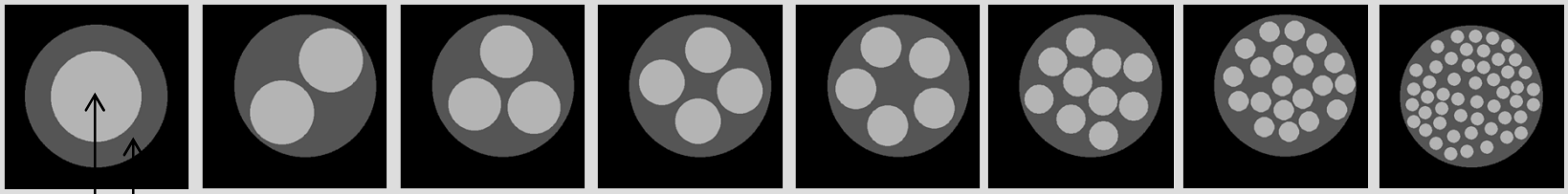
$$\overline{L_L}(\alpha) = \frac{1}{N(I^\theta)} \sum_\theta L_{Li}^\theta(\alpha)$$

- L_{LA}
  Apparent liberation index by length

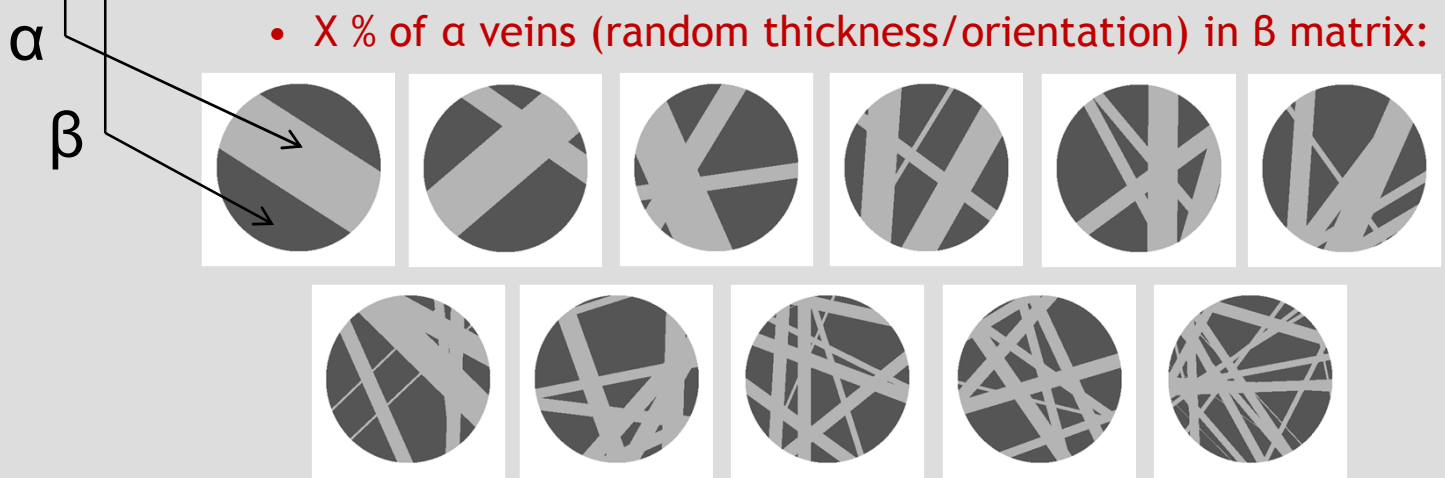
$$L_{LA}(\alpha) = \frac{\sum_i \sum_j P_{i,j}(\alpha)}{A} \text{ iff } L_{Li}^\theta(\alpha) = 100\%$$

Methods

- Simulated Particles
  - Emulsion series
    - X % of α inclusions (hard balls) in ß matrix:



  - Poisonian Veins series
    - X % of α veins (random thickness/orientation) in ß matrix:



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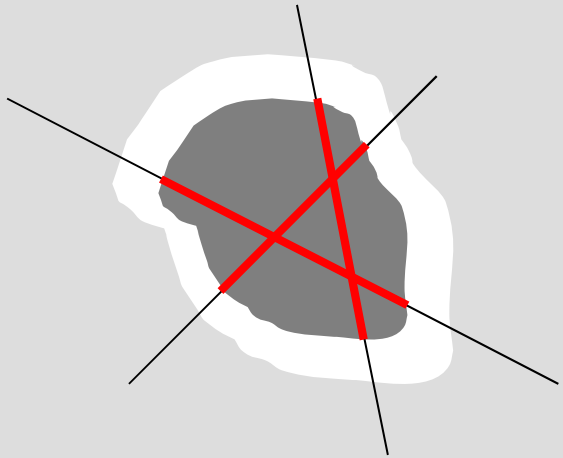
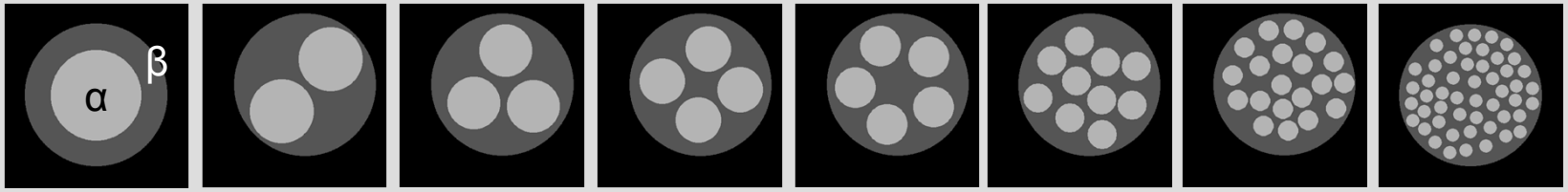
Results

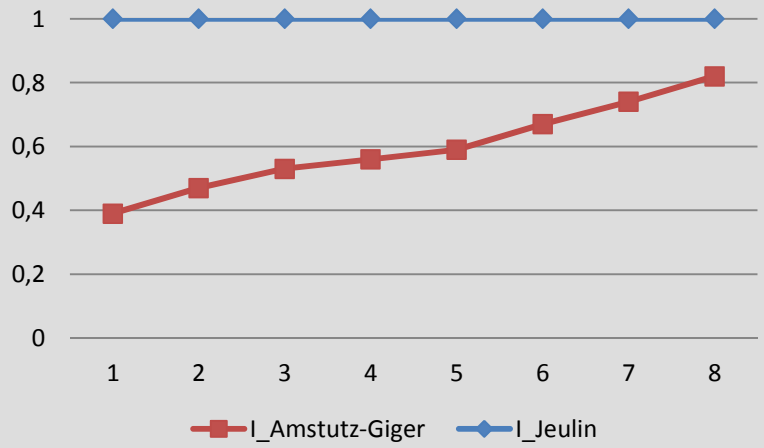
- Performance evaluation

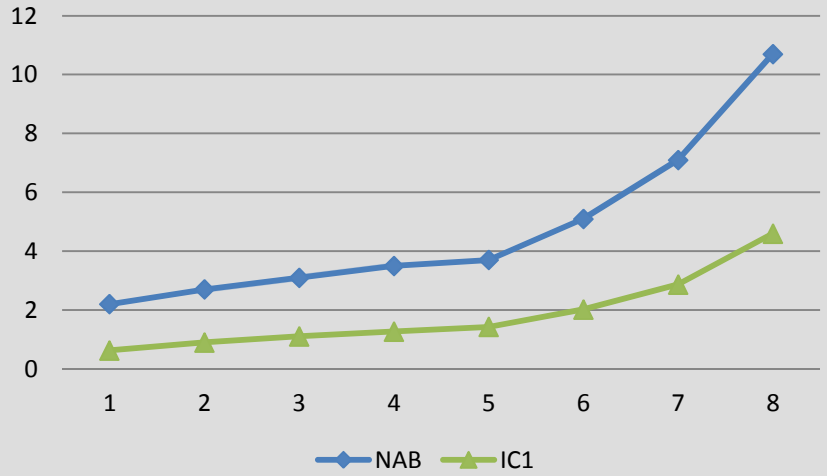


Results

- Emulsion Series
  - Area fraction ($A_A(\alpha)=0,4$)
  - Boundary ratio ($B_B(\alpha)=0$)

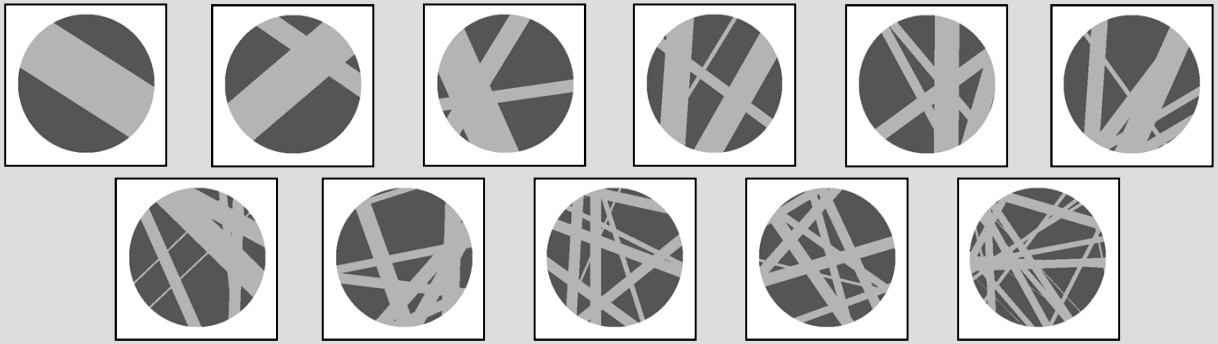


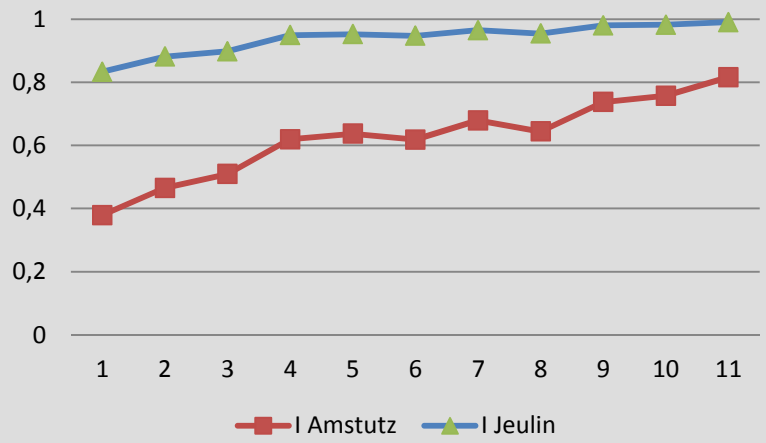


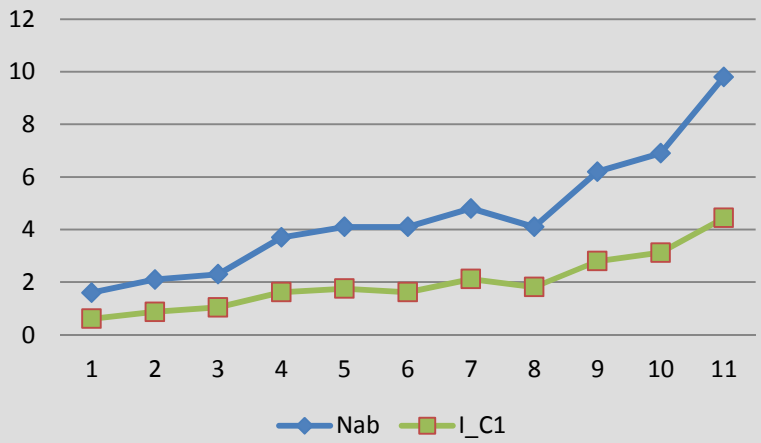


Results

- Poisson Veins Particles
  - Area fraction ($A_A(\alpha)$= 0,5)
  - Boundary ratio ($B_B(\alpha)$= 0,27 to 0,42)

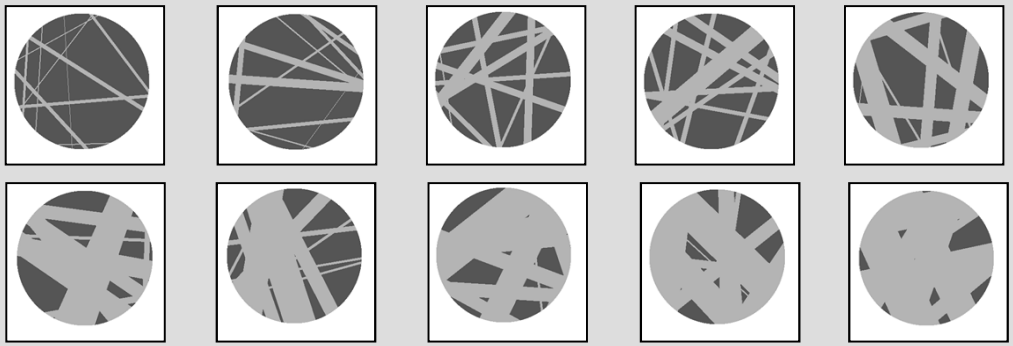


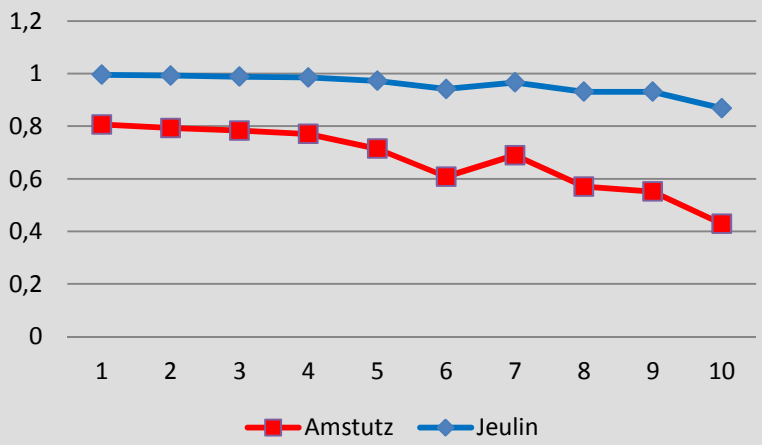


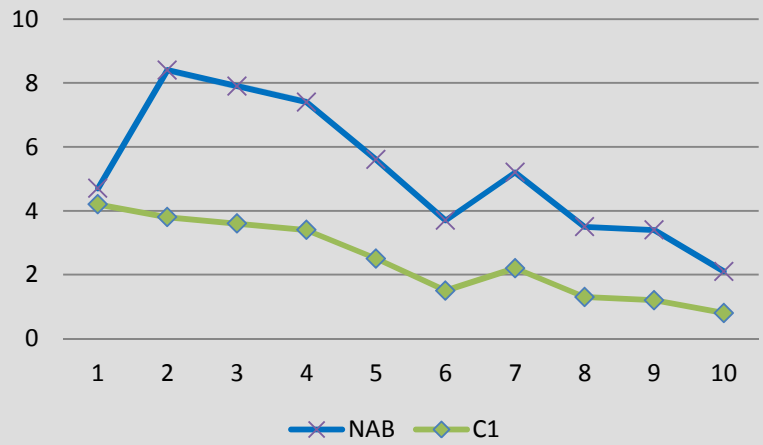


Results

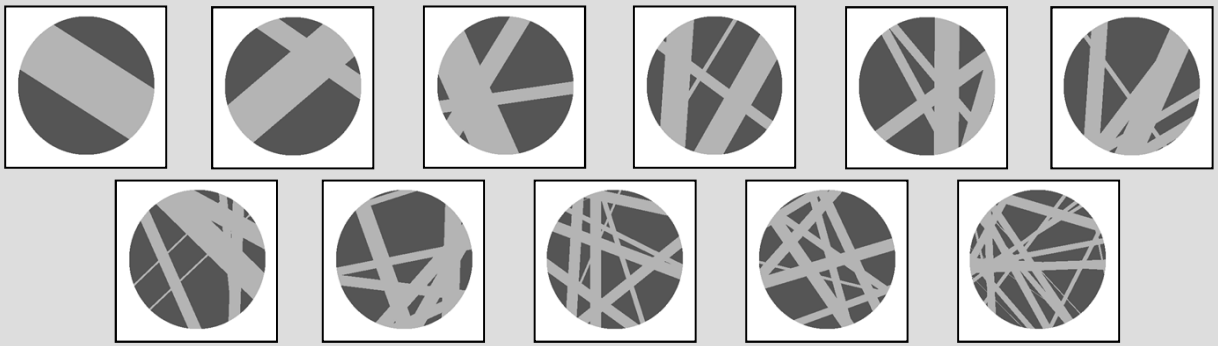
- Poisson Veins Particles
  - Area fraction ($A_A(\alpha)$= 0,14 to 0,9)
  - Boundary ratio ($B_B(\alpha)$= 0,12 to 0,72)



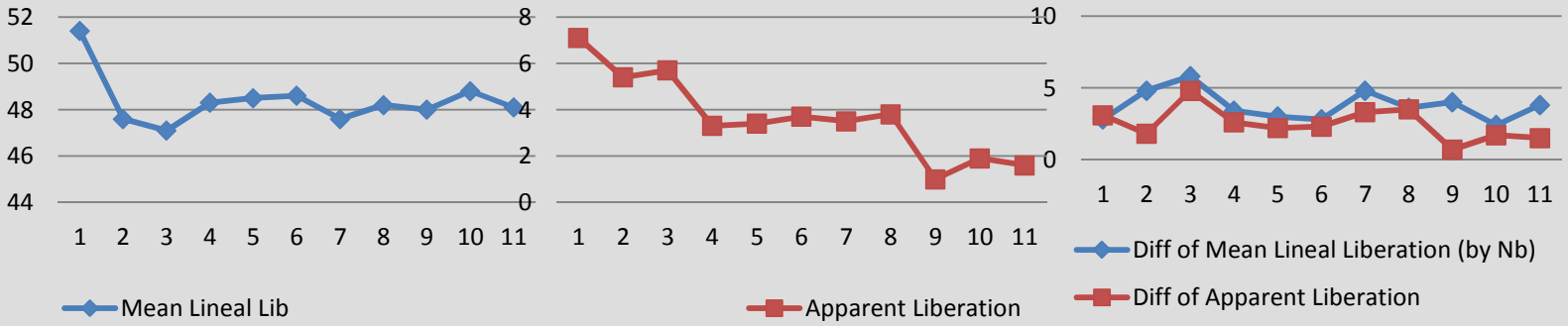




- Poisson Veins Particles
  - Area fraction ($A_A(\alpha)$= 0,5)
  - Boundary ratio ($B_B(\alpha)$= 0,27 to 0,42)



» Mean and apparent liberation indices (for matrix)



Conclusions

- From Indicator to Predictor
  - What is pertinent for Flotation ? etc.
  - Multivariate problem (A_A, B_B, $N_{\alpha\beta}$,…)
- Performance Evaluation of Indices
  - Sensitivity (Nab, IC1)
  - Non-normalized indices [0,1]
  - Threshold value ?
- Statistics on distributions of intercepts
  - Length-weighted intercepts
  - Percentiles of intercept length: P_{95} ($L_L(\alpha)$)
- Work on real particles
  - Binary mix
  - Mutliple phases (α,ß,γ,…,φ)