



Quantitative Mineralogy

Workshop - May 23rd 2013



IMA-CAM Commission for Applied Mineralogy

with support from the European Research Fund for Coal and Steel



Quantitative Mineralogy

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▶ Program



- ▶ 14⁰⁰ Welcome address
 - 14¹⁰ Reinventing Docimasy
Eric Pirard (ULg), President of IMA-CAM (Commission for Applied Mineralogy)
 - 14³⁰ Semi-Quantitative Mineralogy in exploration using VNIR-SWIR and Raman spectroscopy
Erick Ramanaidou (CSIRO Perth), Research leader Fe-Ni Geometallurgy
 - 15⁰⁰ Quantitative Mineralogy from XRay diffraction spectra
Gilles Mertens(QMineral) Director
- ▶ 15³⁰ Question time & Coffee Break
 - 16⁰⁰ Quantitative mineralogy and petrography using automated SEM-EDS technology
Alan Butcher (FEI), Principal Petrologist at FEI Natural Resources
 - 16³⁰ Quantitative texture analysis and multispectral microscopy
Laura Perez Barnuevo (UPM Madrid), Researcher
- ▶ 17⁰⁰ Question & Discussion time
- ▶ 17¹⁰ Happy Hour





Reinventing Docimasy

Essential tools for Geometallurgists

Eric PIRARD

Pioneers in Applied Mineralogy

Pierre Berthier (1782-1861)

- ▶ δοκιμασία : « Proof, Test »
 - ▶ Examination that public officers had to pass in Ancient Greece

 - ▶ Analysis of ores consisting in the determination of the **quality and quantity of metal** contained therein.
 - « Les Romains et les métallurgistes du moyen âge étaient si ignorants en **docimasie** que, nécessairement, ces scories doivent contenir encore une grande quantité d'argent. » BALZAC, *Lettres à l'Étrangère*, t. 1, 1850, p. 474

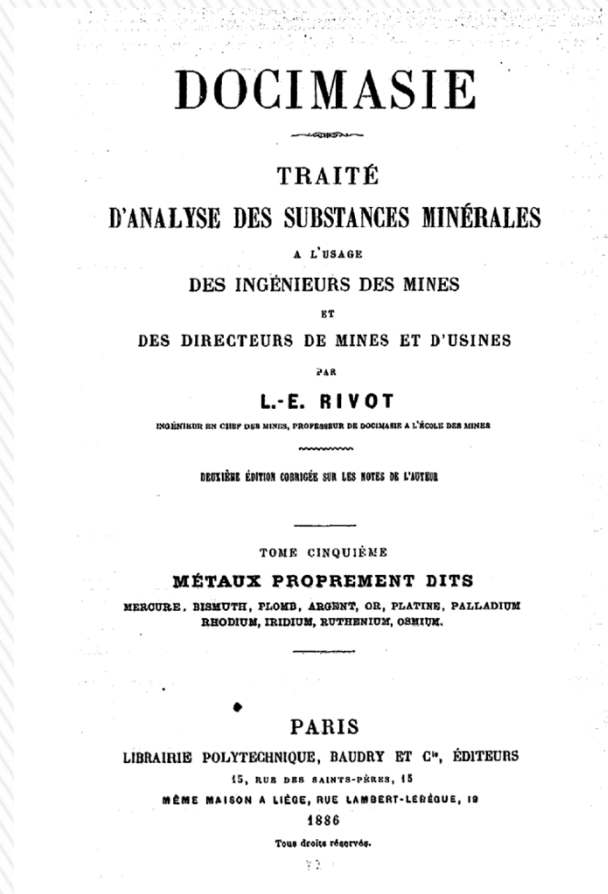
- ▶ Pierre Berthier
 - ▶ Professor of Docimasy (1816-1845)
 - ▶ Head of the Laboratory of the Paris School of Mines
 - Discovered Bauxite
 - Made a detailed analysis of French Iron Ores to improve their processing and metallurgy



Pioneers in Applied Mineralogy

Louis-Edouard RIVOT (1820-1869)

- ▶ RIVOT, L-E, 1886, Docimasia, Traité d'Analyse des Substances Minérales à l'Usage des Ingénieurs des Mines, Baudry Eds, Paris & Liège.



Pioneers in Quantitative Microscopy

Henry Clifton SORBY, 1826-1908

...geologists said that it was not a proper thing to examine mountains with microscopes, and ridiculed my action in every way. Most luckily I took no notice of them.

1849 - foundation of microscopical petrography

"In those early days, if a railway accident had occurred and I had suggested that the company should take up a rail and have it examined with the microscope, I should have been looked upon as a fit man to send to an asylum"



Sorby (1866)

1864 - foundation of metallography

"In the case of nearly all branches of science a great advance was made when accurate quantitative methods were used instead of merely qualitative."

Henry Clifton SORBY, 1858, Quarterly J. Geol. Soc., "On the Application of Quantitative Methods to the Study of the Structure and History of Rocks"



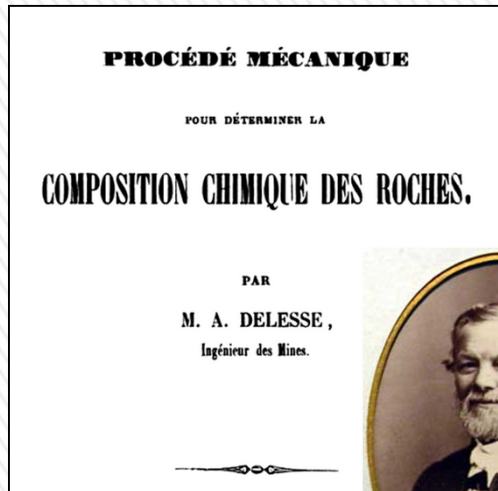
Pioneers in Quantitative Microscopy

Achille DELESSE (1817-1881)

- ▶ DELESSE, A, 1848, Procédé Mécanique pour déterminer la composition Chimique des roches, C.R. Acad. Sc, Paris.

- ▶ **1st Principle of Stereology**

- Volume phase ratios V_V can be estimated unbiasedly from Area phase ratios A_A obtained from a series of random sections



$$V_V^\alpha = A_A^\alpha = L_L^\alpha = P_P^\alpha$$



Join the
International Society for Stereology!





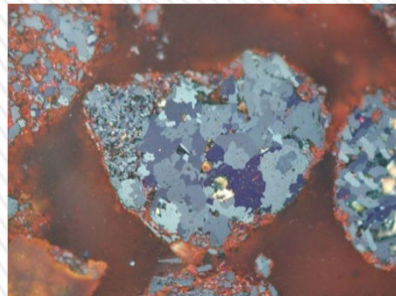
Génie Minéral, Matériaux & Environnement

Geometallurgy

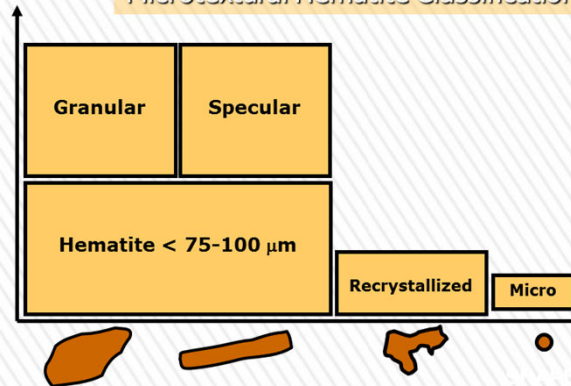
Geometallurgy

From orebody to concentrate

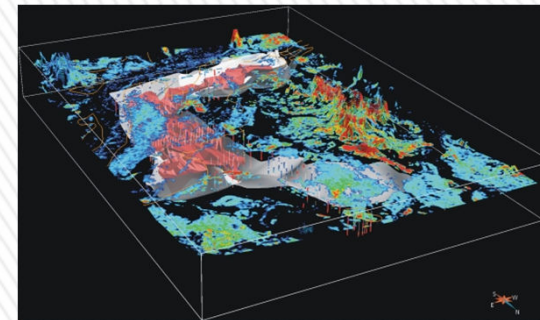
- ▶ Predictive mineralogy
 - ▶ Breakability, Leachability, Sintering,...
- ▶ 3D Orebody modelling
 - ▶ Non-additive geostatistics



Microtextural Hematite Classification



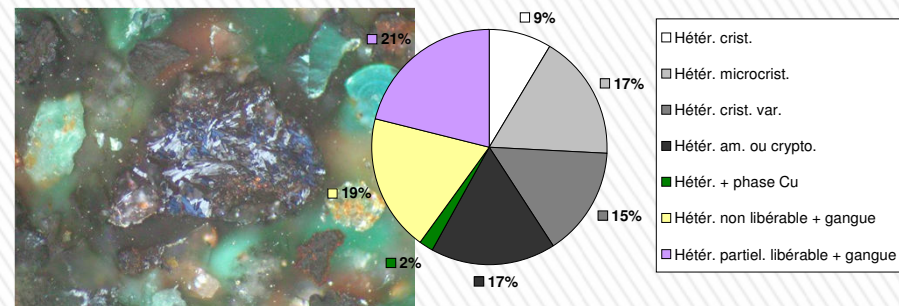
3D Mineral Mapping



© CSIRO

- ▶ Process mineralogy

- ▶ Particle Tracking,...

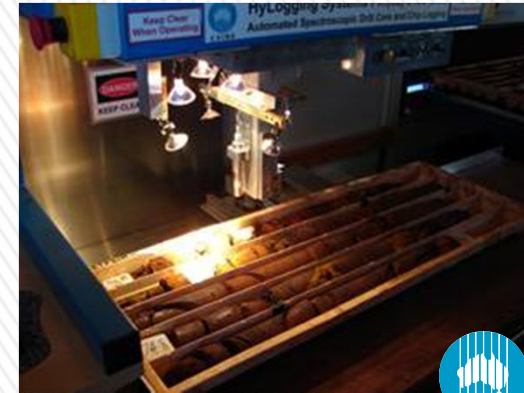


Sensors for Geometallurgy

In exploration

▶ Quantitative data to feed the 3D model

▶ Core scanning



▶ Lithological Mapping
from Optical & Mechanical Measurements

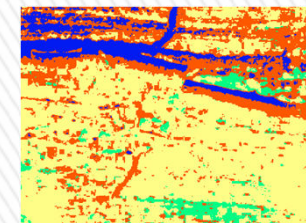
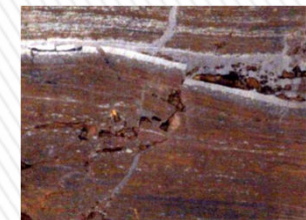
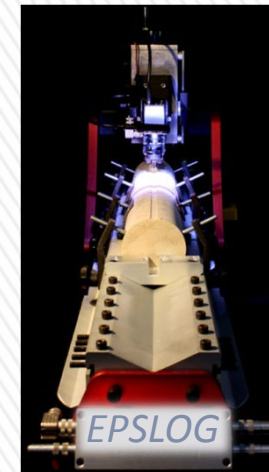
- Hyperspectral imaging and 3D sensing



RÉGION WALLONNE

RELATE

First Int - 300k€

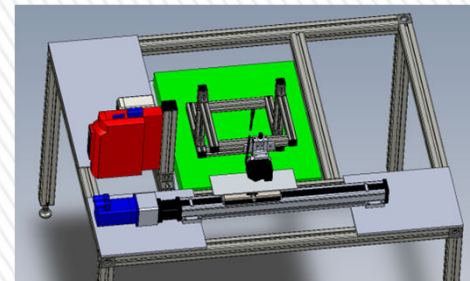


Sensors for Geometallurgy

In exploration

► Chips Scanning

► 3D size and shape analysis (POW3D)



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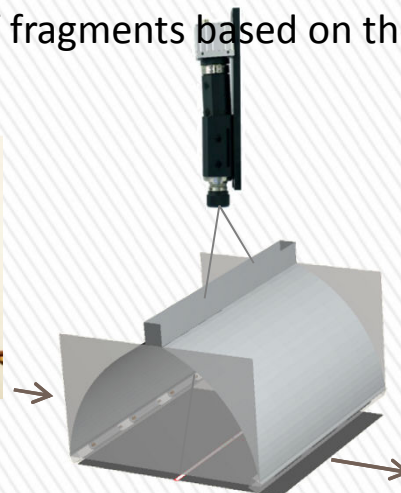
POW3D

First - 300k€



► Integrated Laser and Image Analysis for Alloys Detection (ILIADE)

- Characterization of fragments based on their reflectance (400-2500nm) / shape.



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ILIADE

WBGreen - 800k€

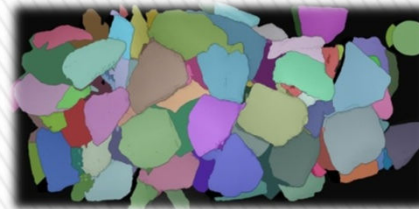


Sensors for Geometallurgy

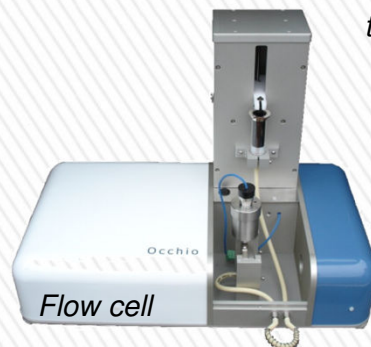
Online Particle Tracking

- ▶ On conveyor belts
 - ▶ Optical Control of Aggregates for Online Process Optimisation (COGOLIN)

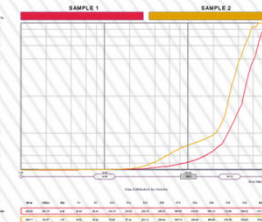
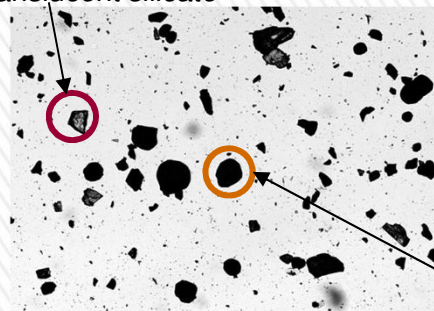

RÉGION WALLONNE
C.O.G.O.L.I.N
WIST3 - 600k€



- ▶ On pulps
 - ▶ Online particle tracking for size, shape and mineralogy



translucent silicate



opaque chromite

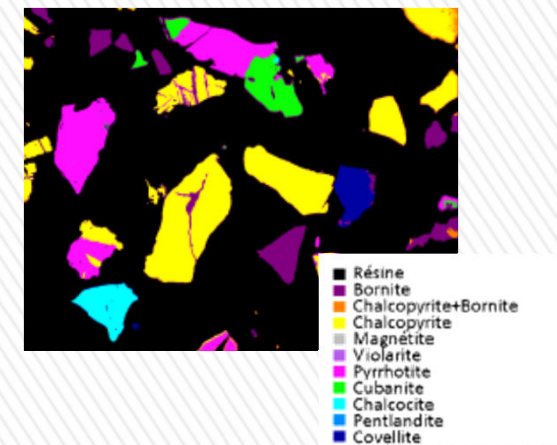
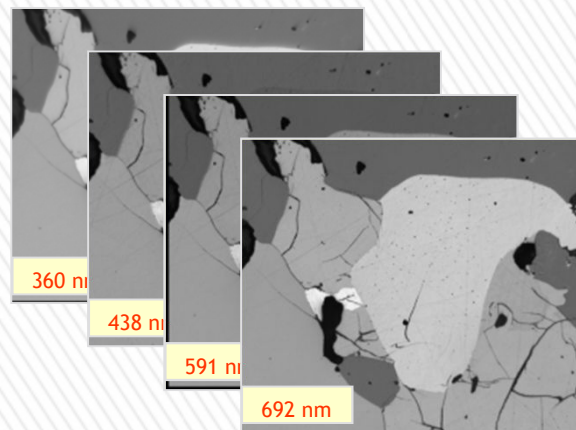


Sensors for Geometallurgy

Quantitative Microscopy

► Photonic Microscopy

► Remote Sensing Techniques in Materials Image Analysis (TSUNAMI)



► Caracterización y cuantificación automatizadas de menas metálicas mediante visión artificial (CAMEVA)

- International Cooperation with
 - Univ. Politecnica Madrid
 - Univ. Quebec, Univ Bochum



Congresses

See you soon

- ▶ 1 ICTMS, Gent, July 1-5, 2013
 - ▶ 1st International Conference on Tomography of Materials and Structures
- ▶ 11 ECS, Kaiserslautern, July 8-12, 2013
 - ▶ 11th European Congress of Stereology and Image Analysis
- ▶ IMA 2014
 - ▶ Remote Mineral Mapping
 - ▶ Computerized Tomography in Mineralogy
 - ▶ Archeometallurgy
- ▶ 50th SGA Anniversary Meeting, Nancy Aug 24-27, 2015
 - *Mineral Resources in a Sustainable World*
 - ▶ RWTH Aachen; KULeuven; ULg Liège; UL Lorraine



Thank You



Liège, Belgium

Innovative Education in Geometallurgy



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