ARC AGRICOLA RESEARCH CENTRE

Interactions in Multi-Component Mineral Systems

LULEÅ TEKNISKA UNIVERSITET

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Anna-Carin Larsson[1], Sven Öberg[3],
Jonas Hedlund[1], Johanne Mouzon[1], Iftekhar Uddin Bhuiyan[1],
Seija Forsmo[5]

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Agricola Research Center - Multicomponent Mineral Systems **ARC-MMS** (2008 - 2012)

7.3 Mkr	2.8 Mkr (20.7 %)	2.5 Mkr (18.5 %)	0.920 Mkr (6.8 %)	Total: 13.52 Mkr
VINNOVA FORSKNING OCH INNOVATION FöR HÅLLBAR TILLVÄXT	BOLIDEN	LKAB	lundin mining	

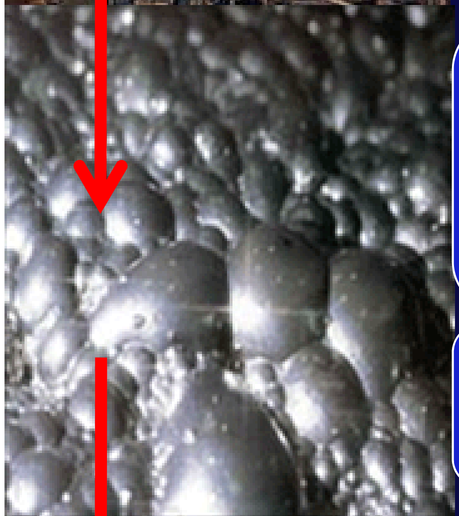
Bergforskdagarna, 4-5 May 2010, Luleå

Interactions in Multi-Component Mineral Systems

Justification: Understanding on these interactions is important for optimizing processes and quality of products. Knowledge of surface speciation and chemistry of interfaces is

MODELS FOR SPECIATION OF/ON SURFACES ARE NEEDED!

Ores: ZnS, PbS, $CuFeS_2$, FeS_2, gang minerals



FROTH FLOTATION (for separation of minerals)

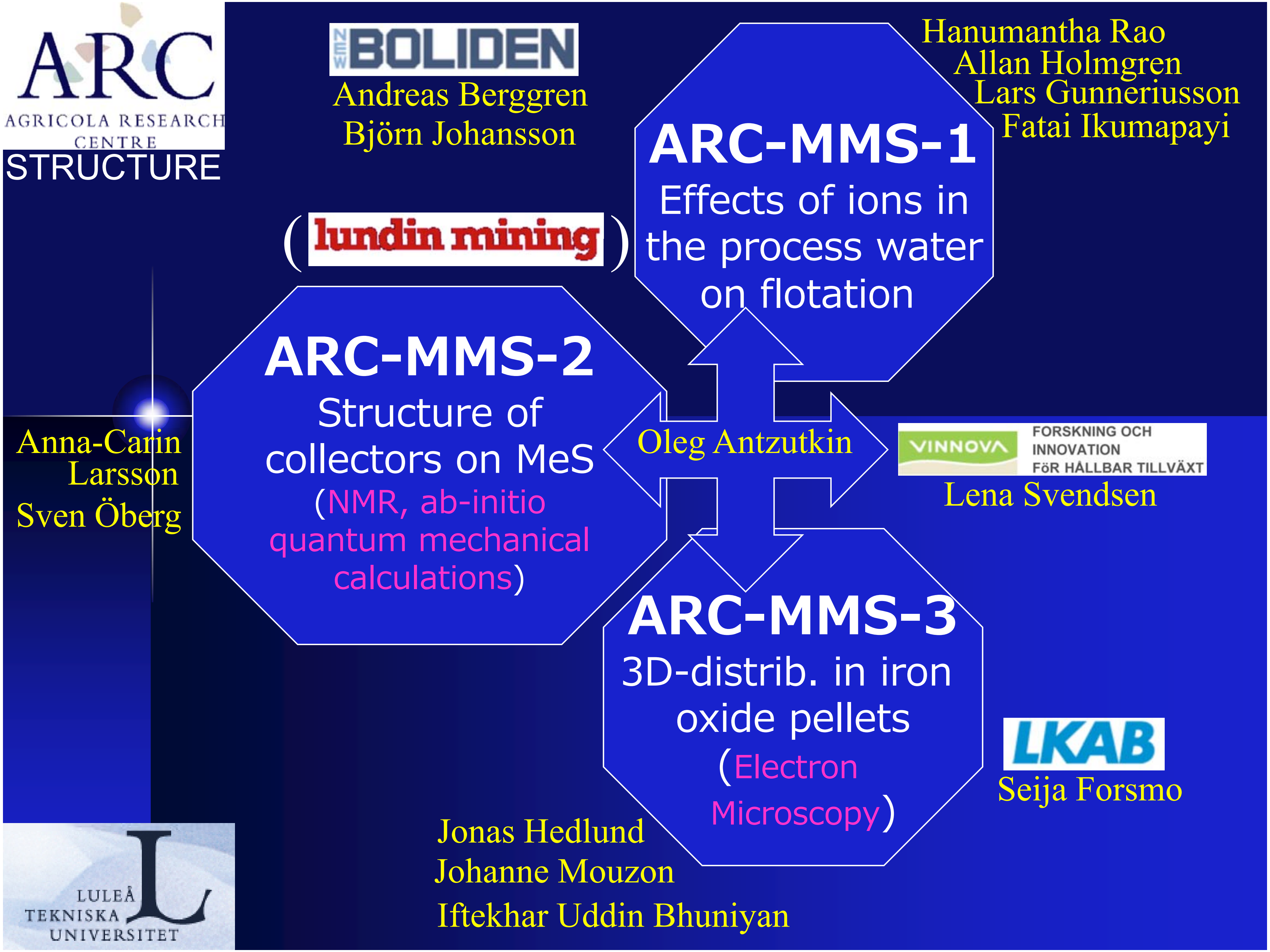
Reagents: collectors, frothers, depressants

AGGLOMERATION

- -magnetite
- -olivine
- -dolomite
- -bentonite (binder)

Recycled process water with Ca^{2+}, SO_x^{2-}, reagents, etc

recycled process water with Ca^{2+}, Na_2SiO_3, flotation reagent (ATRAC)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STRUCTURE
BOLIDEN
Andreas Berggren
Björn Johansson
Hanumantha Rao
Allan Holmgren
Lars Gunneriusson
Fatai Ikumapayi
ARC-MMS-1
Effects of ions in the process water on flotation
(lundin mining)
ARC-MMS-2
Structure of collectors on MeS
(NMR, ab-initio quantum mechanical calculations)
Oleg Antzutkin
Anna-Carin Larsson
Sven Öberg
VINNOVA
FORSKNING OCH INNOVATION FöR HÅLLBAR TILLVÄXT
Lena Svendsen
ARC-MMS-3
3D-distrib. in iron oxide pellets
(Electron Microscopy)
LKAB
Seija Forsmo
Jonas Hedlund
Johanne Mouzon
Iftekhar Uddin Bhuniyan
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OBJECTIVES

BOLIDEN

Andreas Berggren

Björn Johansson

(lundin mining)

Hanumantha Rao

Allan Holmgren

Lars Gunneriusson

Fatai Ikumapayi

Objective 1: *To provide remedies to selectively regulate surface properties of sulphides, which are affected by recycled process water*

Anna-Carin Larsson

Sven Öberg

Objective 2: *To utilize understanding of adsorption mechanisms of collectors in improving selectivity and recovery of the valuable sulphide minerals*

Oleg Antzutkin

VINNOVA FORSKNING OCH INNOVATION FöR HÅLLBAR TILLVÄXT

Lena Svendsen

Objective 3: *To supply a new type of 3-D data for water, air bubbles, flotation reagents and particles in wet iron ore pellets. To create remedies for controlling of air-bubble inclusions in iron oxide pellets, which affect their mechanical strength*

LKAB

Seija Forsmo

Jonas Hedlund

Johanne Mouzon

Iftekhar Uddin Bhuniyan

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ARC-MMS SUBPROJECT 1

Flotation chemistry of complex sulphide ores- Recycling of process water

Ikumapayi Fatai Kolawole (Ph.D student)
Prof. Kota Hanumantha Rao (coordinator)

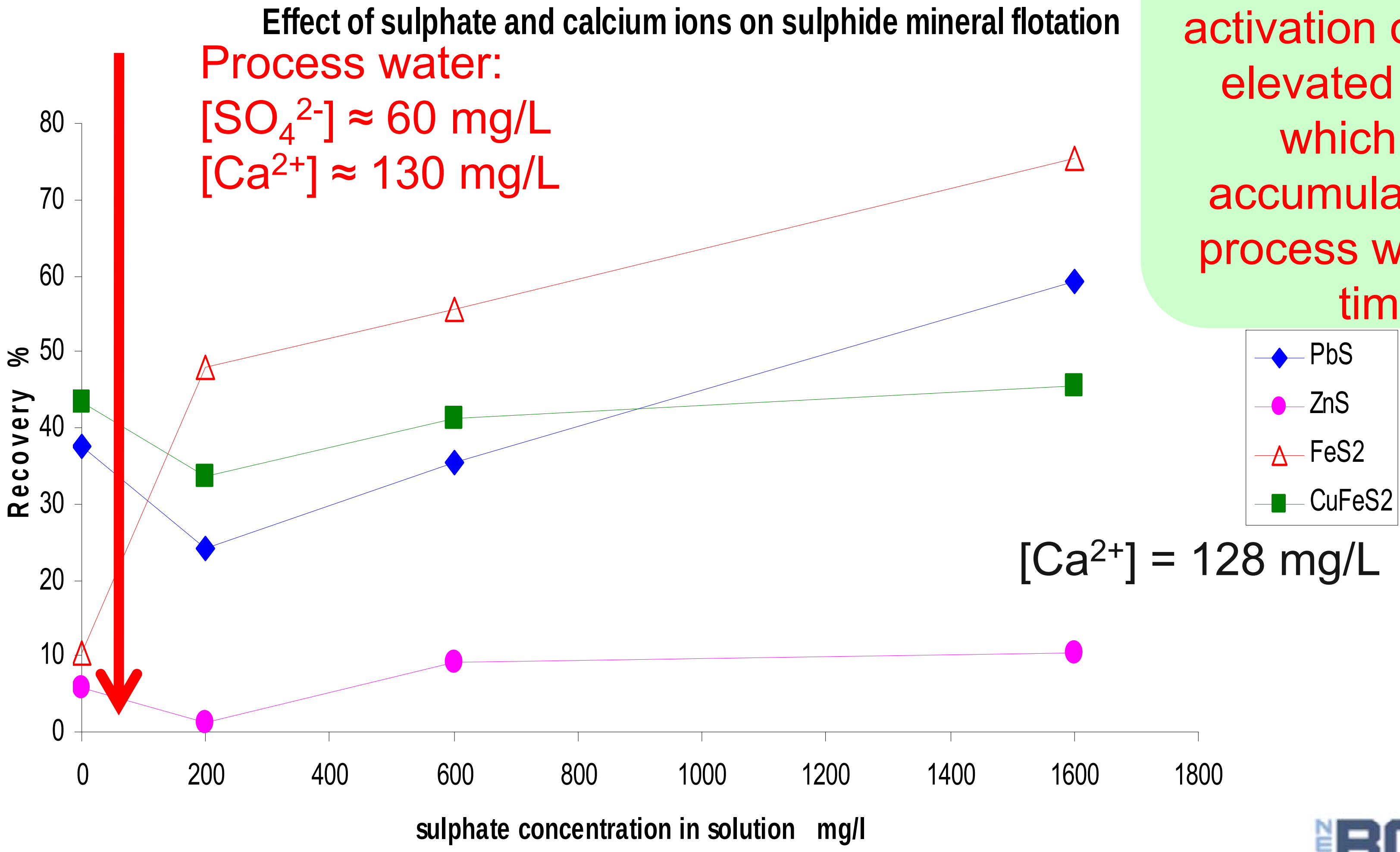
The effects of major components of calcium (Ca^{2+}) and sulphate (SO_4^{2-}) ions in process water on sulphide mineral flotation have been investigated through:

1. Hallimond flotation of single pure sulphide minerals using tapwater and water containing SO_4^{2-} and Ca^{2+}

2. Bench scale flotation of complex sulphide ores using tapwater and process water and with tapwater in the presence of Ca^{2+} and SO_4^{2-}

3. Zeta-potential measurements

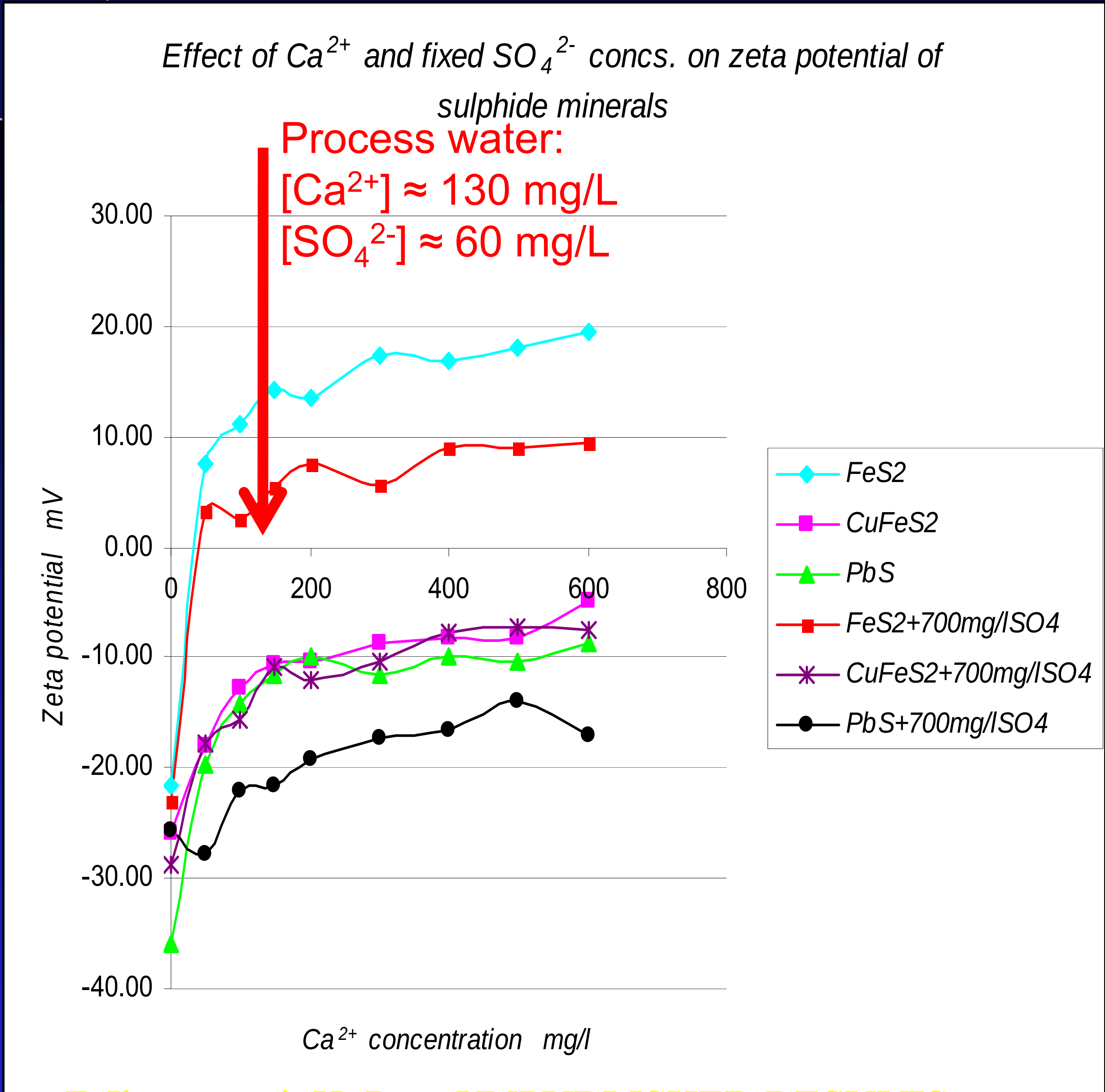
Influence of Ca^{2+} and SO_4^{2-} ions in solution on recovery of PbS, ZnS and $CuFeS_2$

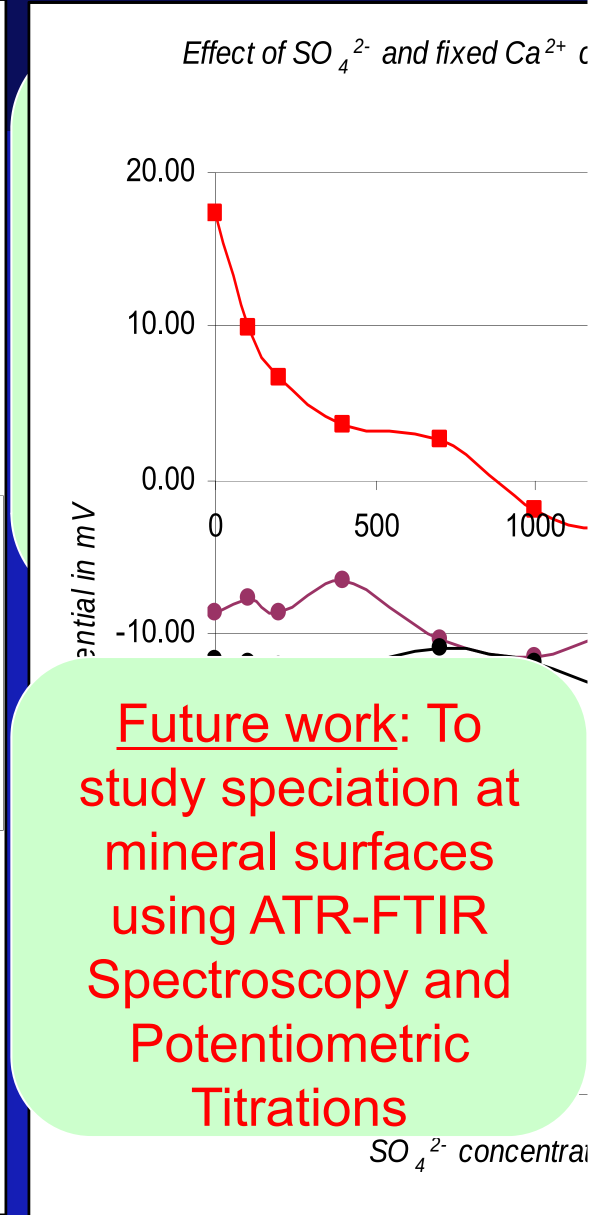


Risks of undesired activation of FeS_2 at elevated [SO_4^{2-}], which may accumulate in the process water with time!

F. Ikumapayi, B. Johansson, H. Rao, Recycling of Process Water: Effect of calcium and sulphate ions in sulphide flotation. *Conference, Mineral Engineering*, Luleå, 2-3 February 2010 & POSTER

Zeta-potential measurements





Future work: To study speciation at mineral surfaces using ATR-FTIR Spectroscopy and Potentiometric Titrations

F. Ikumapayi, H. Rao, UNPUBLISHED RESULTS

ARC-MMS SUBPROJECT 2

Molecular scale approach towards behaviour of collectors on sulphide surfaces

Dr Anna-Carin Larsson (coordinator)
Prof. Sven Öberg

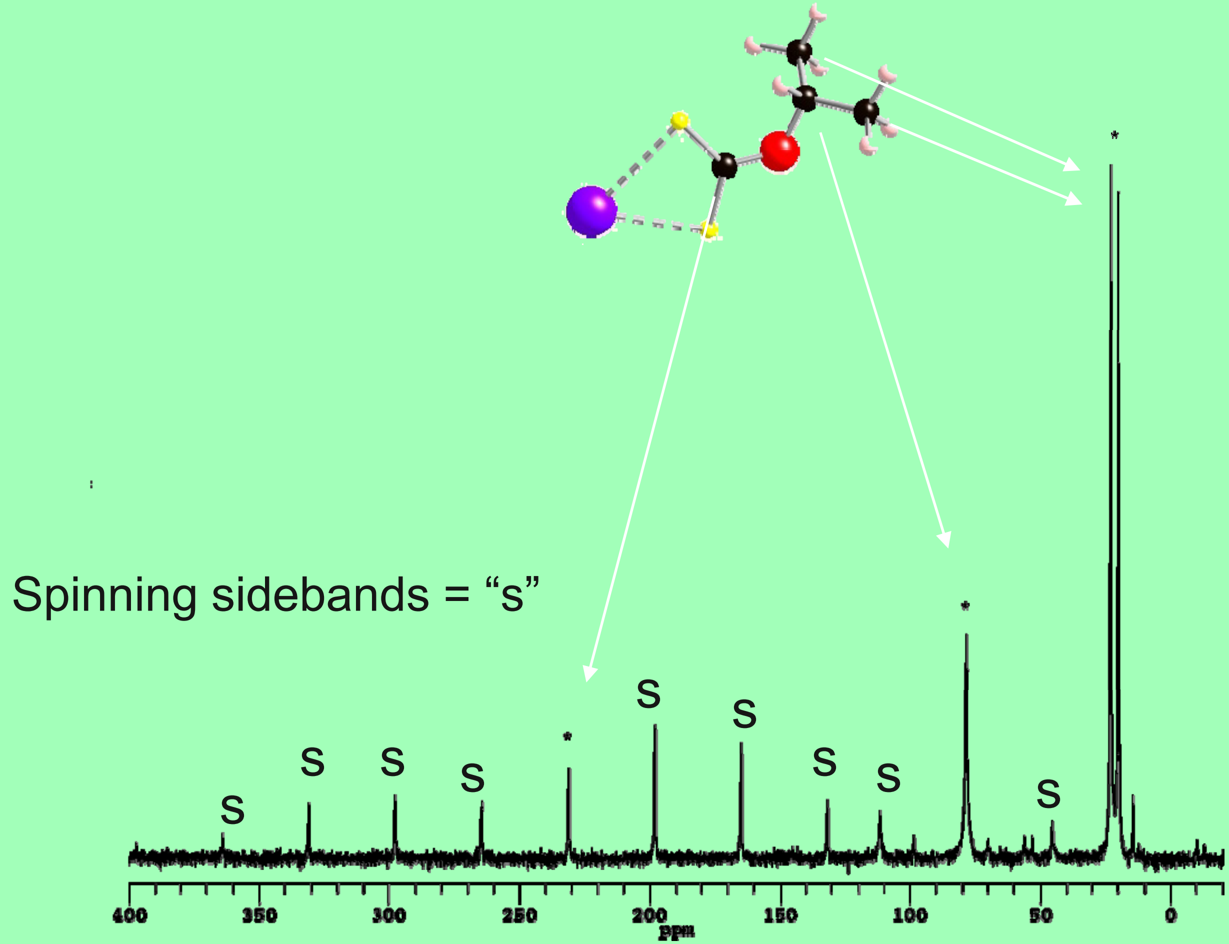
What happens to a collector when it adsorbs to a mineral surface?

^{13}C CP/MAS NMR combined with Quantum Mechanical DFT calculations can provide an answer on a molecular level

Different carbons give signals in different positions depending on the electronic environment (chemical shifts)

Potassium *iso*-propylxanthate

Shape of spinning sidebands give additional information which can be used to identify different species on a mineral surface



$\delta_{iso} = (\delta_{xx} + \delta_{yy} + \delta_{zz})/3$

$\delta_{aniso} = \delta_{zz} - \delta_{iso}$

$\eta = (\delta_{yy} - \delta_{xx}) / \delta_{aniso}$

$\Omega = |\delta_{zz} - \delta_{xx}|$

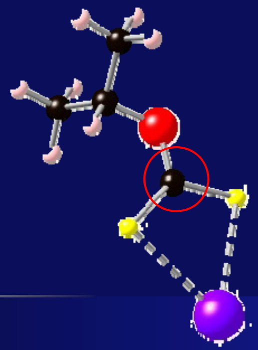
$|\delta_{zz} - \delta_{iso}| \geq |\delta_{xx} - \delta_{iso}| \geq |\delta_{yy} - \delta_{iso}|$

Data for relevant xanthate species and products of their decomposition, which can form in a flotation pulp or on a mineral surface

A few examples of data for the most interesting carbon $-CS_2$

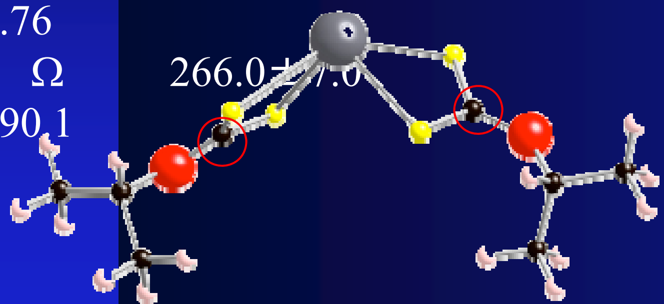
K *iso*-propylxanthate

	exp	DFT
δ_{iso}	231.6	231.6
δ_{aniso}	154.4±4.6	164.3
η	0.60±0.05	0.60
Ω	278.2±8.2	295.7



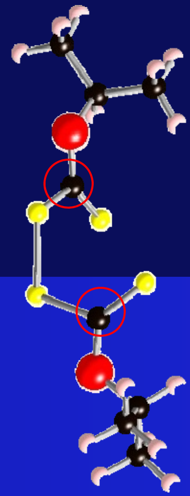
Pb *iso*-propylxanthate

	exp	DFT
δ_{iso}	226.4	224.7
δ_{aniso}	142.8±4.1	154.4
η	0.73±0.04	0.76
Ω	266.0±7.0	290.1



Dixanthogen

	exp	DFT
δ_{iso}	206.8	205.3
δ_{aniso}	140.6±4.2	161.8
η	0.15±0.15	0.06
Ω	222±12	237.4



There is a good agreement between experimental and calculated data

Substitution K → Pb/Cu/Zn decreases δ_{iso}

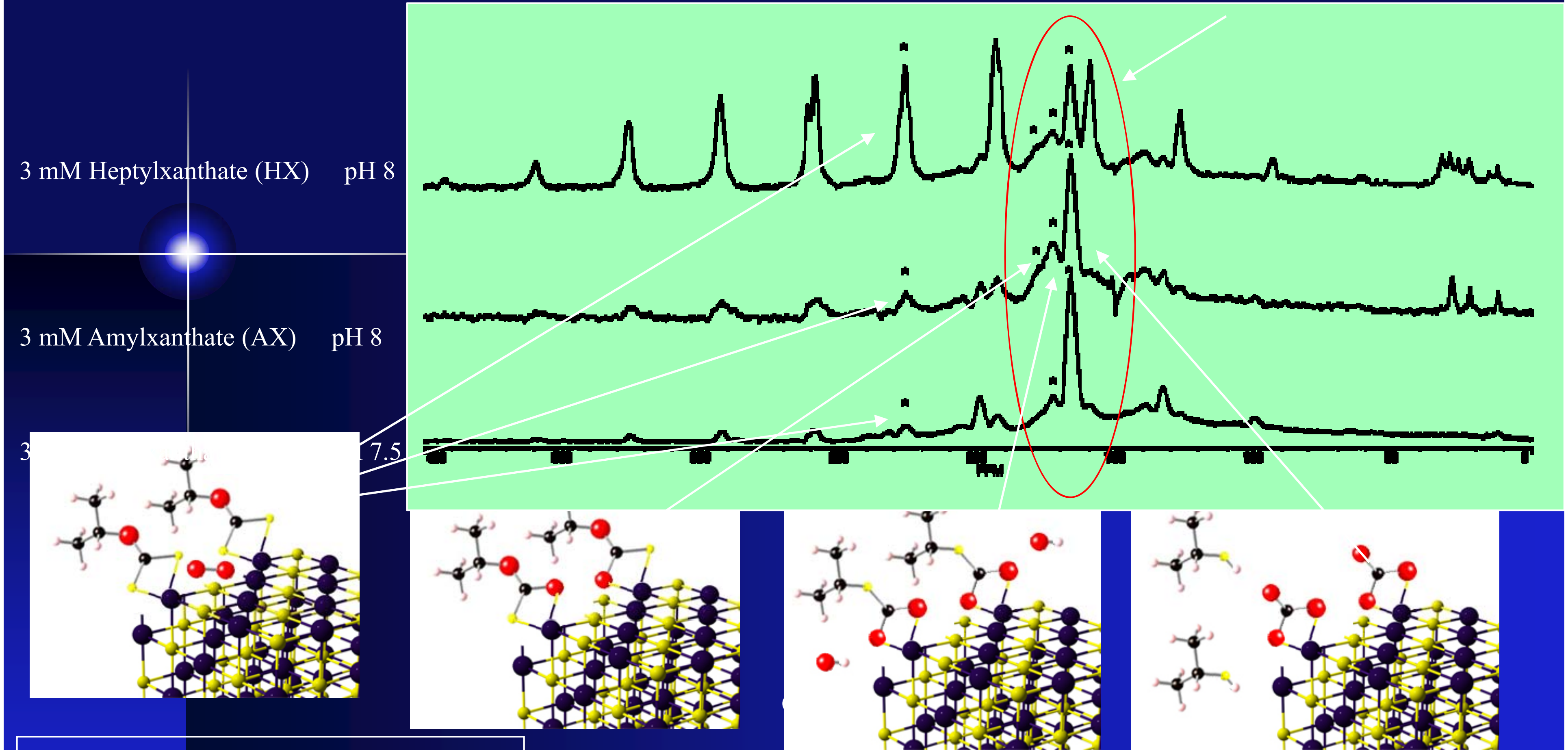
It is possible to distinguish different surface species using ^{13}C CP/MAS NMR!

Xanthate adsorption/decomposition on PbS

(Larsson, Öberg, Lindberg, Sun, unpublished)

CS_2-carbon ^{13}C-enriched to provide stronger NMR signals

Decomposition products



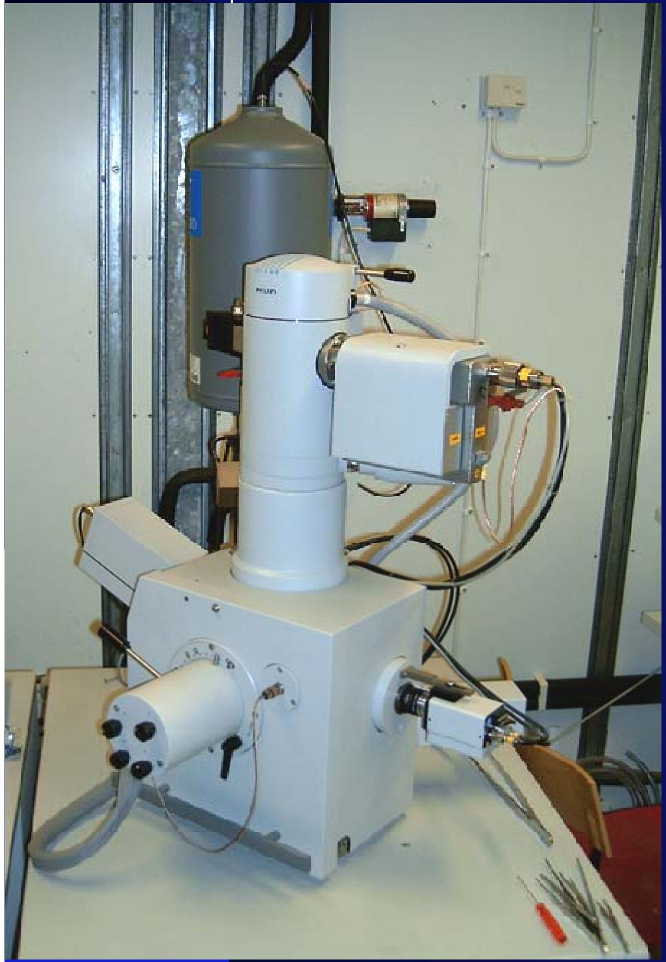
Surface adsorbed xanthate stays more stable the longer the alkyl chain is

Eventually, the alkyl chain decomposes into hydrophilic $PbCO_3$ through intermediate steps

ARC-MMS SUBPROJECT 3

3D Data for Iron Ore Pellets

Iftekhar Uddin Bhuiyan (PhD student)
Dr Johanne Mouzon
Prof. Jonas Hedlund (coordinator)



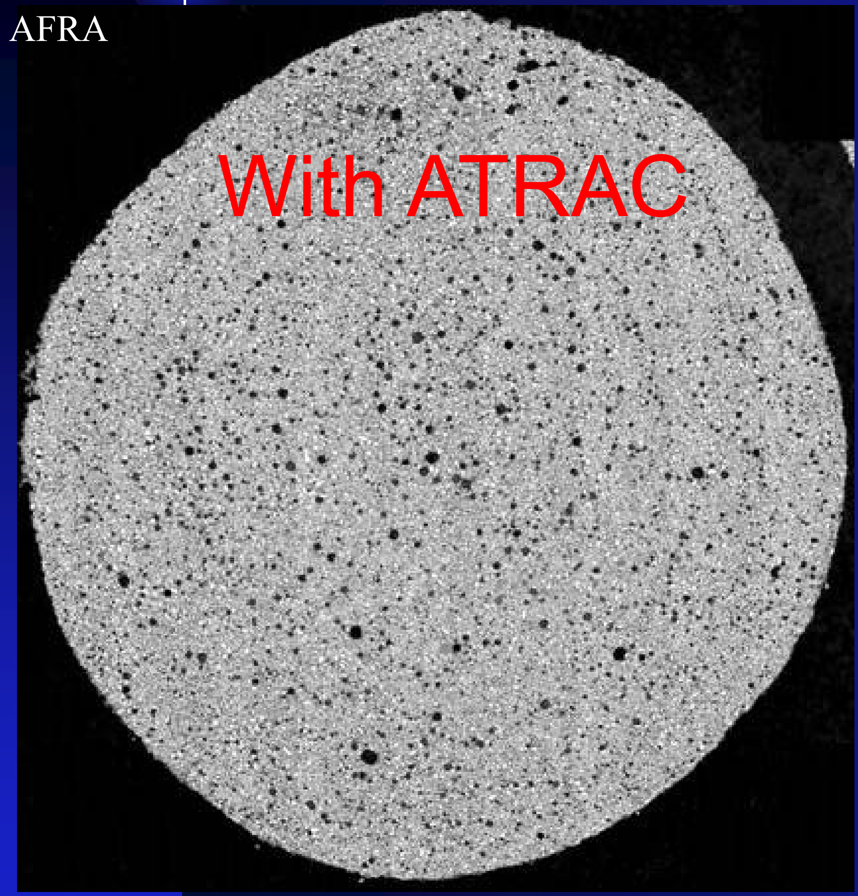
LKAB's green pellets are complex arrangements of:

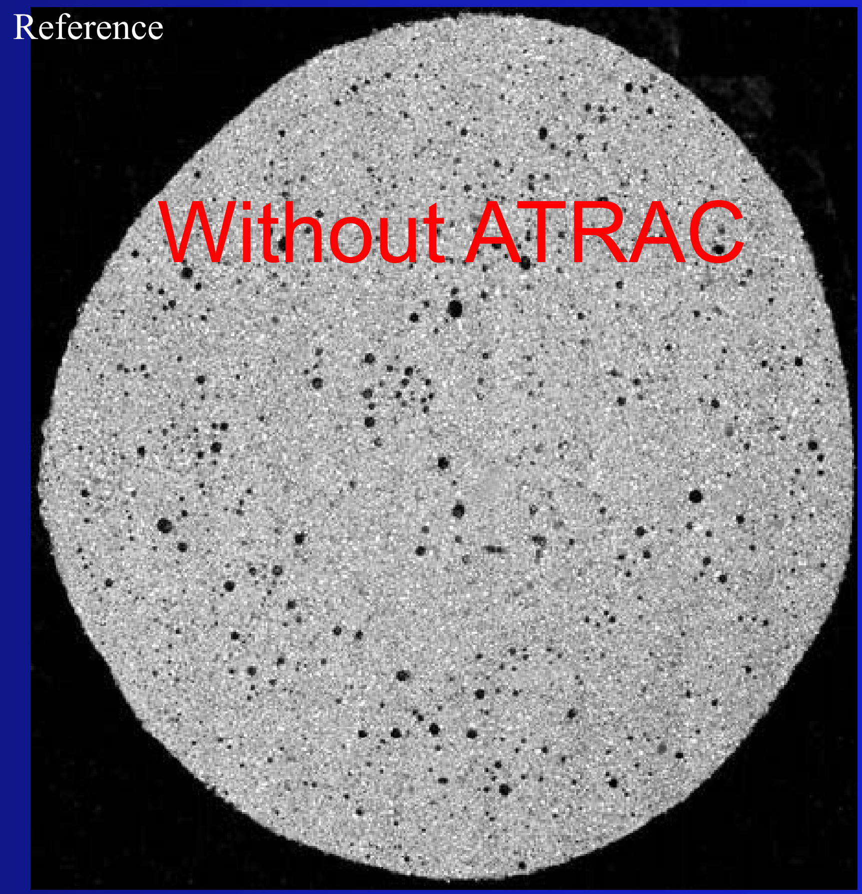
- iron ore particles with a broad size distribution
- a binder (e.g. bentonite)
- additives (e.g. olivine)
- water
- porosity

It is this complex arrangement and interactions between different components that determine the wet and dry strengths of the pellets and subsequently the final porosity for oxidization and reaction in blast furnaces ⇒ 3D data are valuable!

Extreme High Resolution Scanning electron microscope (XHR-SEM) Magellan 400 (installed at Division of Chemical Engineering, LTU, Oct 2009)

Cryogenic-SEM Images of Green Iron Ore Pellets (with and without flotation reagent ATRAC)





Correlations? 3D Porosity ⇔ Mechanical strength of pellets?

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Image analysis
Spherical Porosity Distribution

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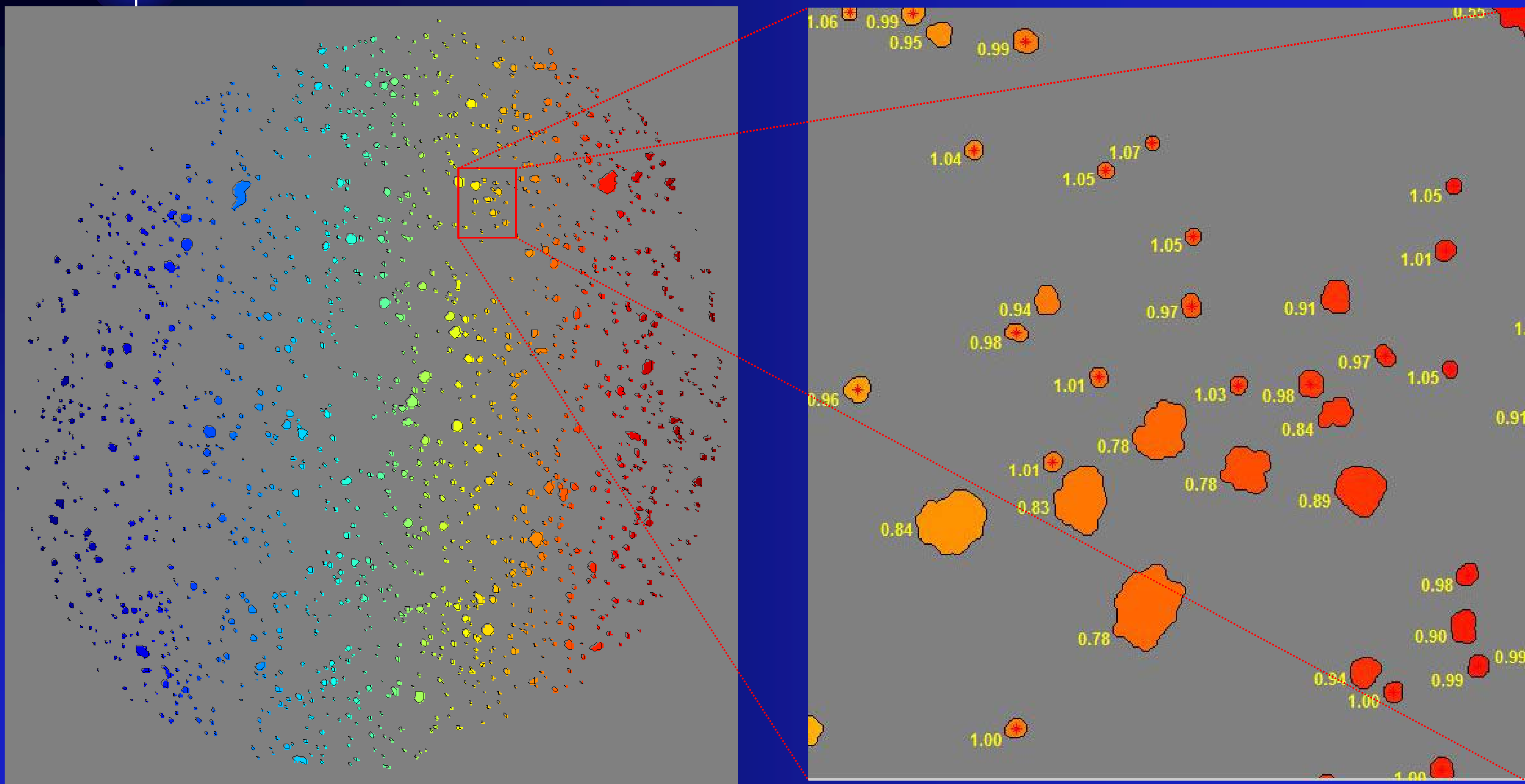

LKAB

Correlations? 3D Porosity ⇔ Mechanical strength of pellets?

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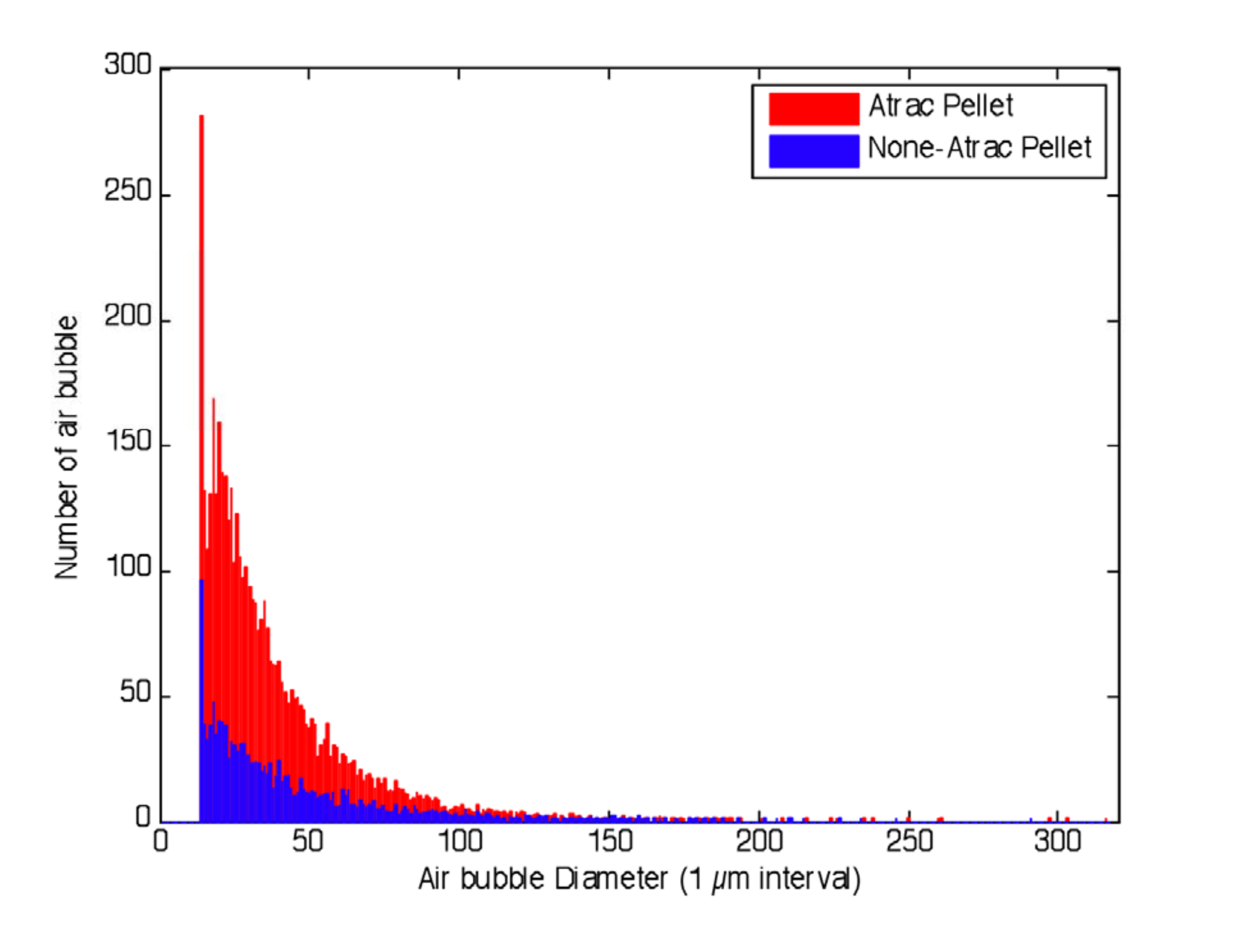
Spherical Porosity Distribution



According to analysis of SEM images flotation reagent (Atrac) entrapped more air bubbles and the size fraction between10 and 150 μm is increased by the flotation reagent.

This method is a useful tool for quality tests of green pellets

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Effects of ions in the process water on flotation

(lundin mining)

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ARC-MMS-2
Structure of collectors on MeS
(NMR, ab-initio calculations)

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Lena Svendsen

Sven Öberg

NEW

FORMAS (applied 2010, 3.95 Mkr) “Novel titanium-phosphate ion-exchangers for water treatment”

?

BOLIDEN “in-kind” + 0.4 Mkr

ARC-MMS-3
3D-distrib. in iron oxide pellets
(Electron Microscopy)

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ACKNOWLEDGEMENTS

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VINNOVA
FORSKNING OCH INNOVATION FöR HÅLLBAR TILLVÄXT

NEW BOLIDEN

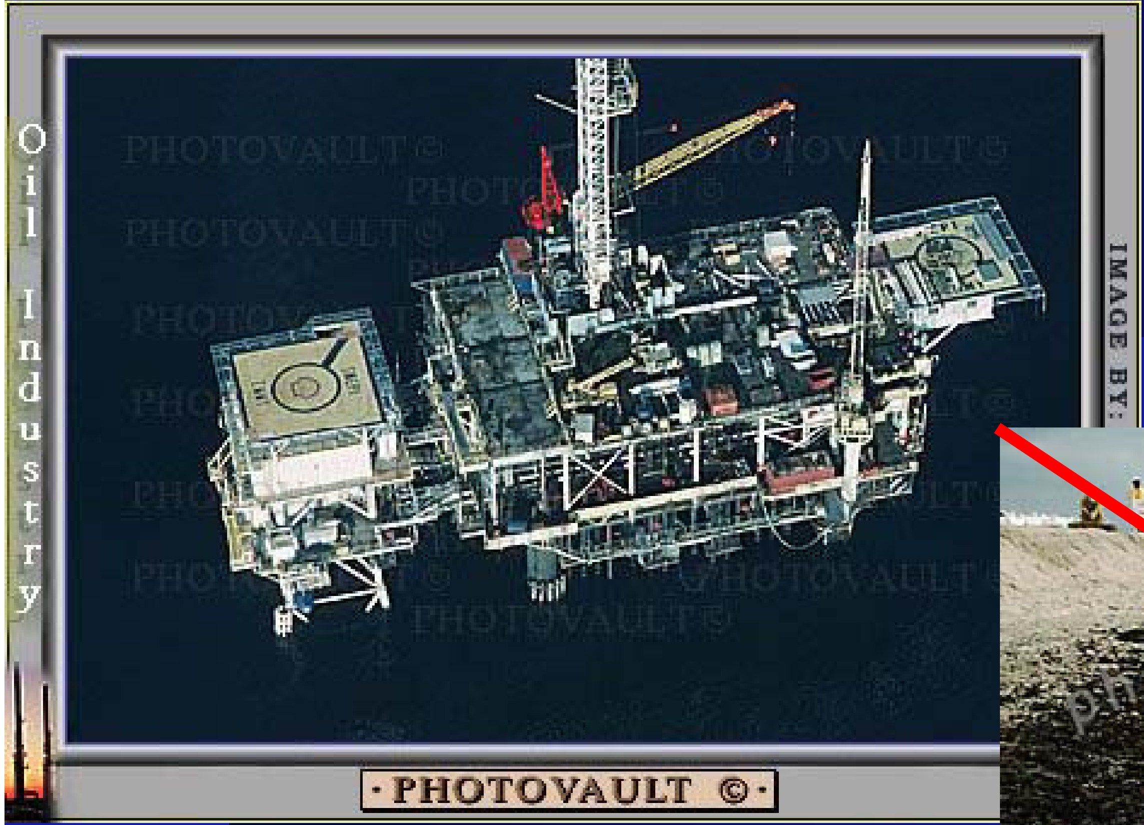
LKAB

lundin mining

ALL FELLOWS AND SPONSORS OF ARC-MMS:
Prof. Hanumantha Rao; Fatai Ikumapaiy; Björn Johansson; Andreas Berggren; Assoc. Prof. Allan Holmgren; Assoc. Prof. Lars Gunneriusson; Dr Anna-Carin Larsson; Prof. Sven Öberg; Prof. Jonas Hedlund; Dr Johanne Mouzon; Dr Seija Forsmo; Iftekhar Uddin Bhuiyan; Lena Svendsen

SUSTAINABLE USE OF NATURAL RESOURCES

THINK ABOUT FUTURE GENERATIONS!



Bergforskdagarna,
4-5 May 2010, Luleå