HELMHOLTZ-INSTITUT FREIBERG
FÜR RESSOURCENTECHNOLOGIE

Innovative resource technologies "Made in Germany", building bridges from research to industry'- Helmholtz Institute Freiberg for Resource Technologies

Sandra Birtel

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Helmholtz Institute Freiberg for Resource Technology

HELMHOLTZ INSTITUTE FREIBERG FOR RESOURCE TECHNOLOGY

HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG
Die Ressourcenuniversität. Seit 1765.

- Nationally-funded research institute
- Founded in 2011
- Integrated into the Helmholtz-Zentrum Dresden-Rossendorf (HZDR)
- In close cooperation with the TU Bergakademie Freiberg (TUBAF)
- Location: Freiberg/ Germany
- Staff: Over 145 employees from 29 different countries, of which 35 PhD students

Infrastructure Development

Metallurgy Pilot Plant

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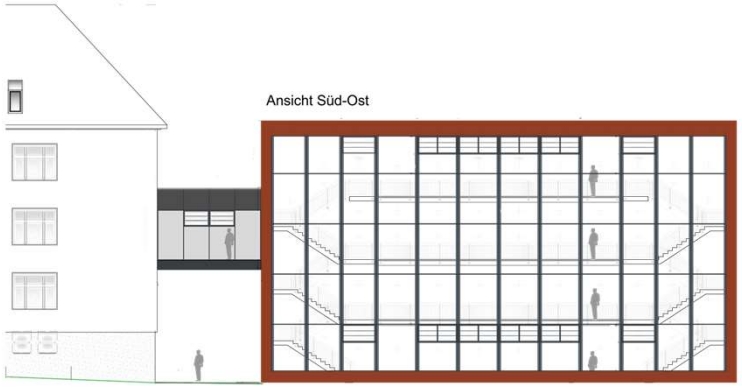
- Digitally linked pyro- and hydrometallurgy methods
- Testing and optimization of developed simulation models
- Budget: 10.2 Mio. €
- EFRE funding
- Construction commenced: Q2 2018
- Construction completed: Q2 2020

Europäische Union

Europa fördert Sachsen.
EFRE
Europäischer Fonds für regionale Entwicklung



Visualization: BBF Baubüro Freiberg GmbH

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Next steps: Freiberg Sustainability Campus

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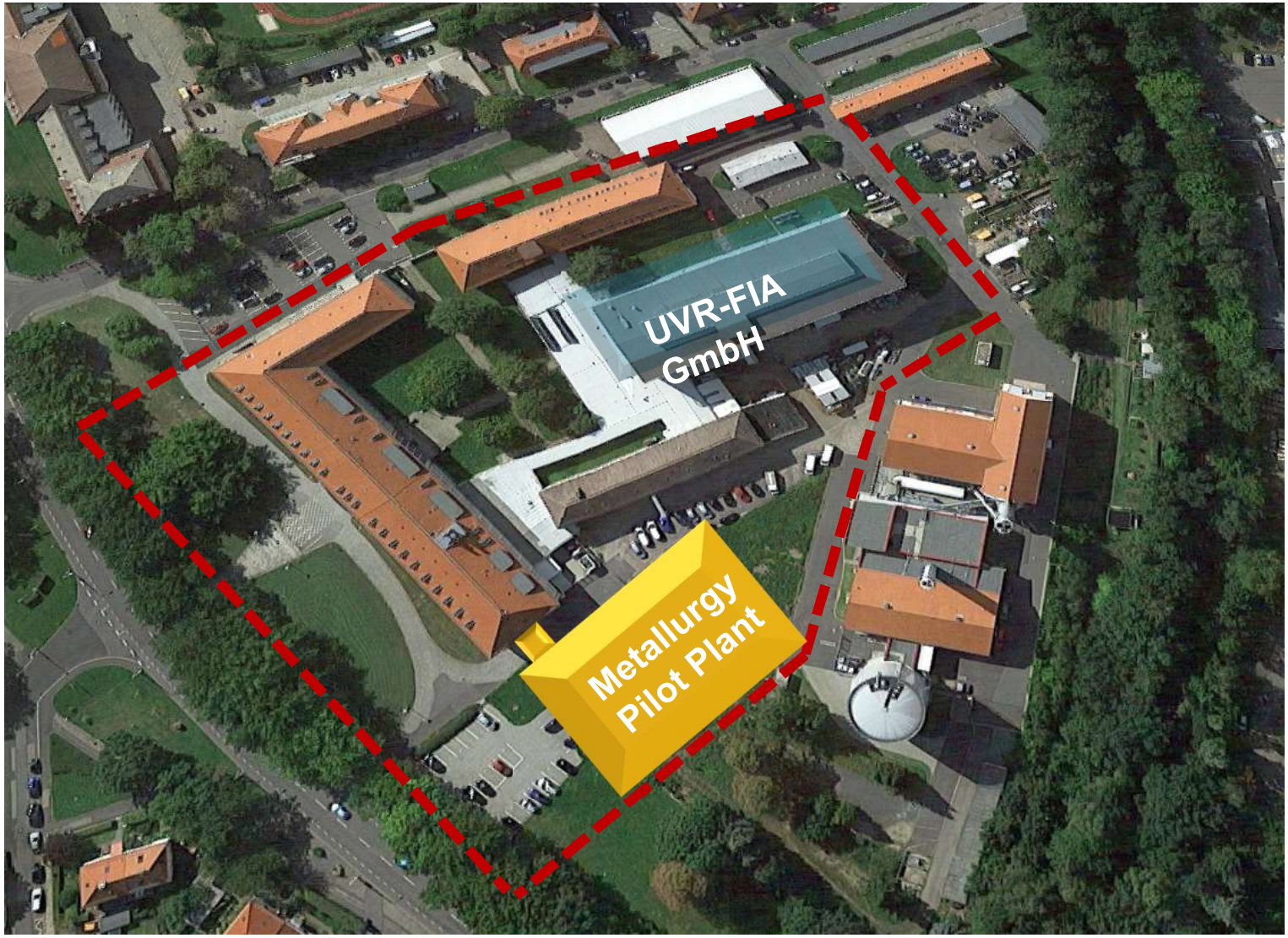

© Googlemaps

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HiF
HELMHOLTZ INSTITUTE FREIBERG
FOR RESOURCE TECHNOLOGY


Source: HZDR

Our Mission

National center for researching & developing technologies.

Assure the steady supply of mineral & metalliferous raw materials for the German and European economy.


Source: HZDR

Our Goals

- Developing new resource technologies
- Contributing to sustainability & industry growth
- Training a new generation of resource industry professionals

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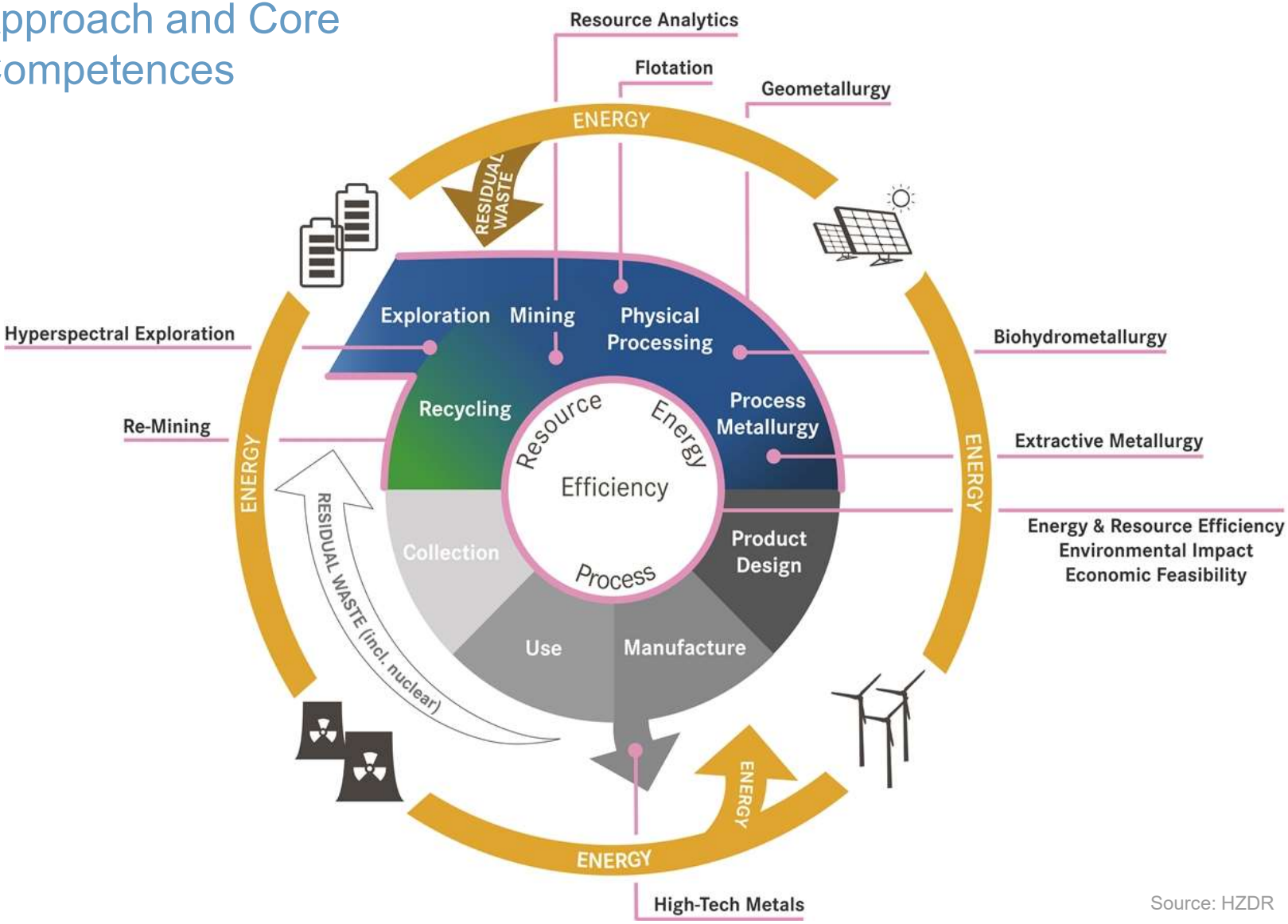
Approach and Core Competences



Source: HZDR

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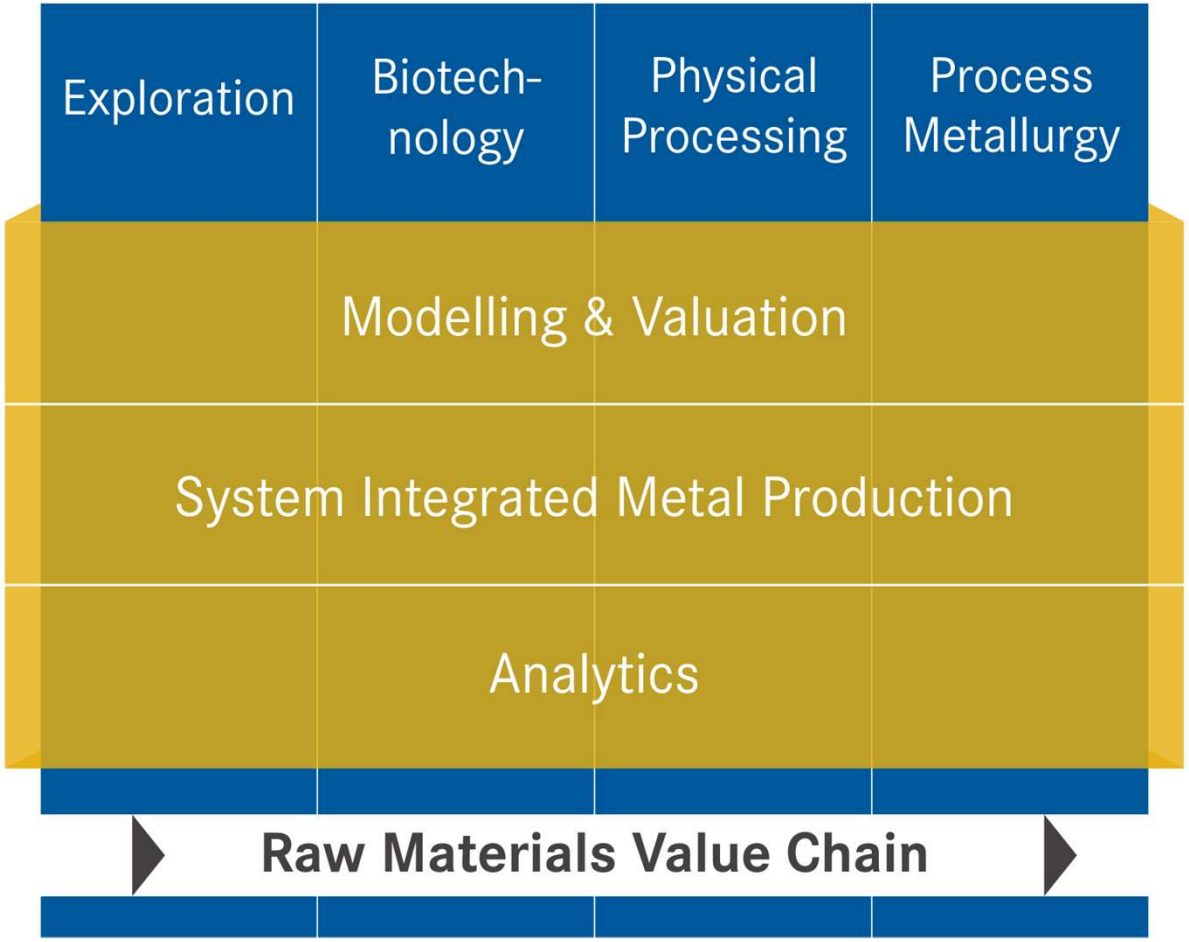
Departments



Resource Analytics:

- Sample Preparation
- Mineralogical Analysis
  - 3x Mineral Liberation Analyzer
  - Electron Microprobe
  - LA-ICPMS
  - Ion Microprobe
  - X-ray Powder Diffractometer
  - X-ray Tomography
- Chemical Analysis
  - X-ray Fluorescence Spectrometry
  - Wet chemistry assay lab

Spin off

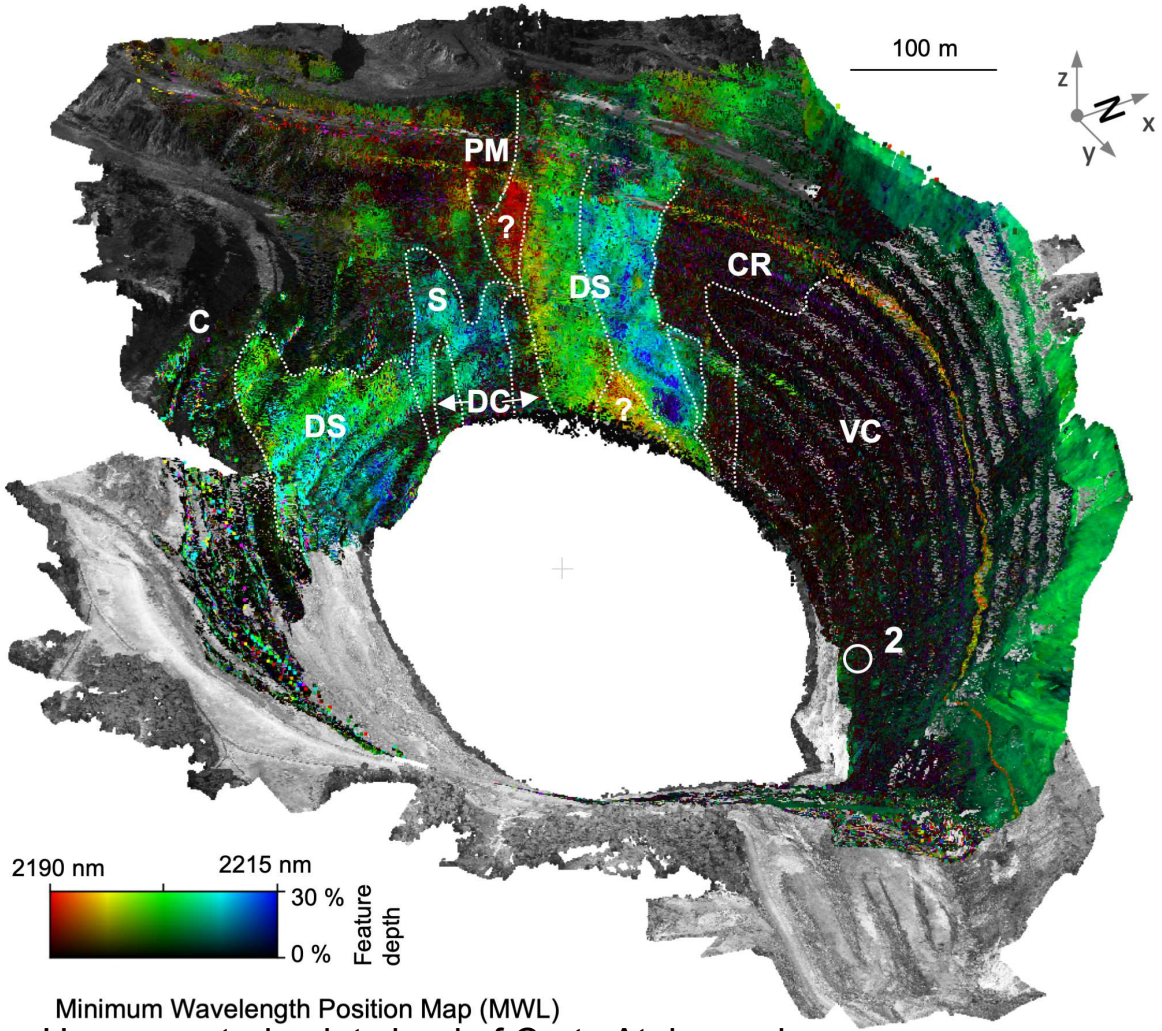
ERZLABOR

prepare | analyze | embrace

https://www.erzlabor.com/en.html

Analytic group:
https://www.hzdr.de/db/Cms?pNid=2943
Jens Gutzmer: j.gutzmer@hzdr.de
Axel Renno: a.renno@hzdr.de

Exploration: Outcrop and subsurface modelling

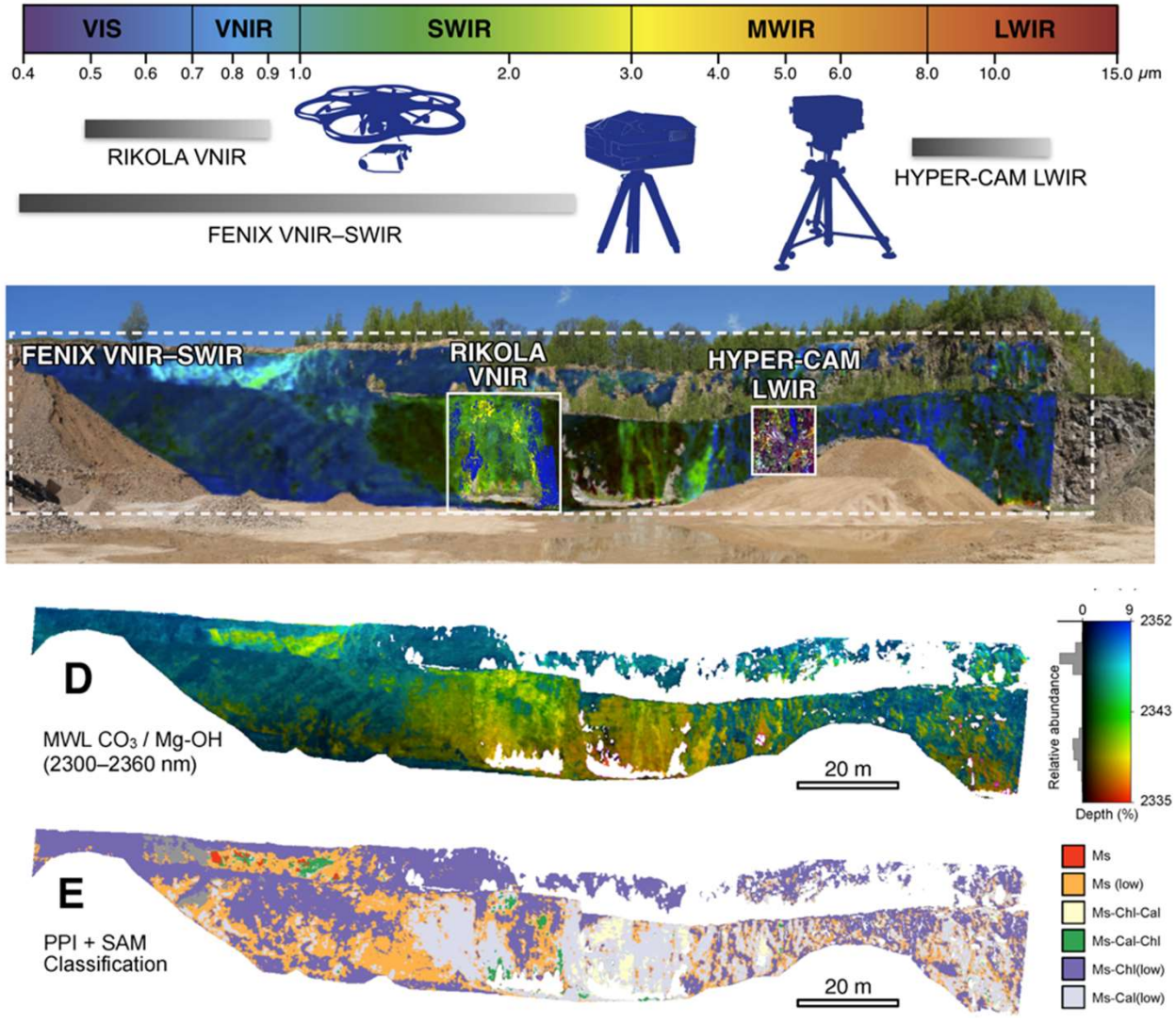


Hyperspectral point cloud of Corta Atalaya mine, Iberian Pyrite Belt (Lorenz et al., 2018)

- Ground-based, multi-sensor remote sensing to support geological activities in exploration and mining
- Integrated 3D geological and geophysical modeling for mineral resource assessment

Explo group:
https://www.hzdr.de/db/Cms?pNid=3055
Dr. Richard Gloaguen:
r.gloaguen@hzdr.de

Exploration: Combining Sensors & Image Processing



Kirsch, M. et al. (2018): Remote Sensing, 10, 1366

- First 3D calibrated, validated, integrated hyperspectral outcrop mapping with in-situ and drones sensors
- Machine Learning, Analytics, Remote Sensing
- Fast, cost-efficient and safe mapping and monitoring of mines

Classes correspond to lithological zones (minerals identified from VNIR to SWIR)

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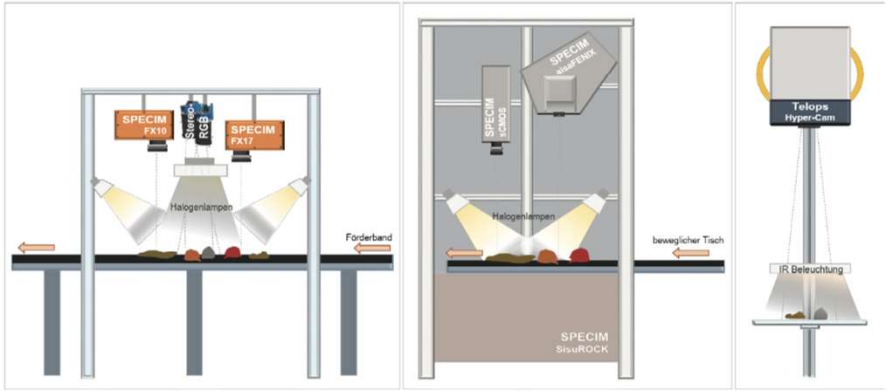
Exploration: Near Field Sensing

Sensor Integration

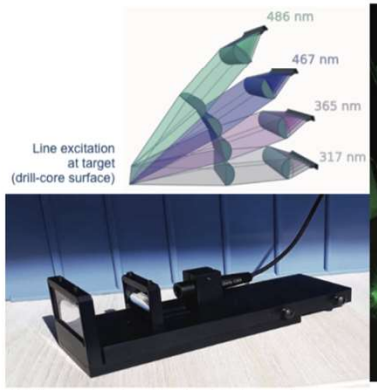
- multi-source hyperspectral imaging
- online material stream characterisation
- primary and secondary resources

Sensor & method development

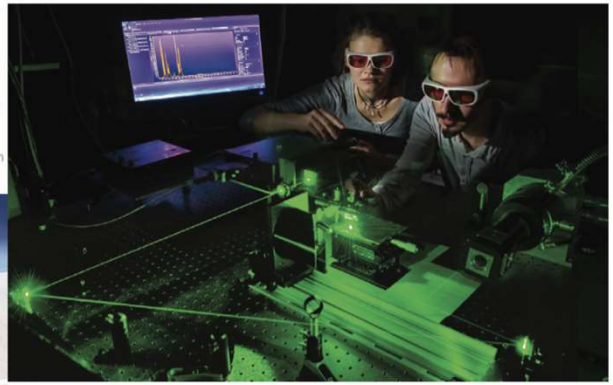
- Laser-induced fluorescence (LiF) for exploration
- advanced data processing for upscaling & fusion



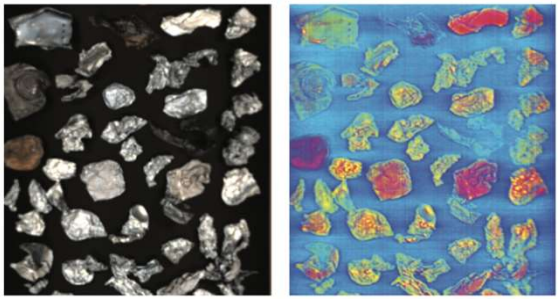
Multi-sensor systems at HIF (Lorenz 2019)



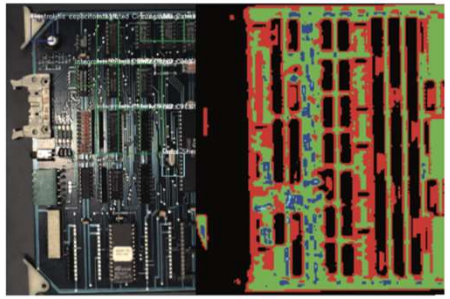
LiF line-excitation (design & photo: Abend 2019)



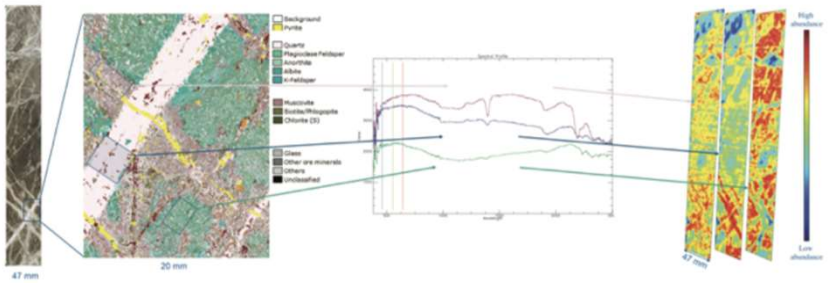
IAP optical lab at TUBAF (photo: Mueller 2017)



Car shred (FX17, MNF; Seidel 2019)



PCB feature extraction (Sudharshan 2019)



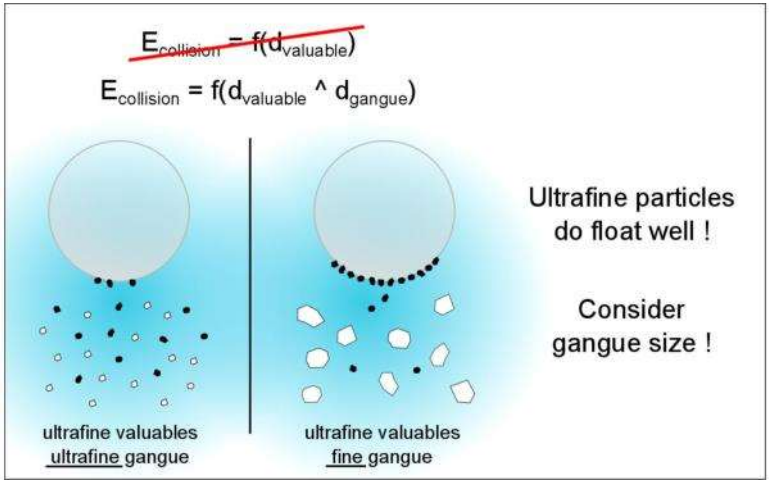
Upscaling of high-resolution mineralogical data using HSI data from drill-cores (Tusa 2018)

Mineral Processing: Fine Particle Processing

Efficiency through Understanding

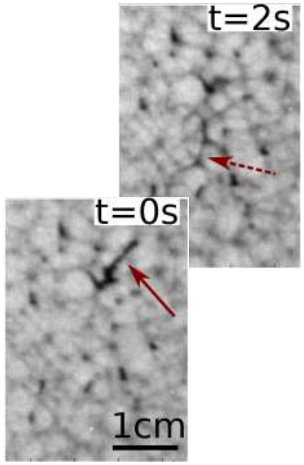
- **Impact of Fine Gangue**

  Impact of ultrafine hydrophilic particle on flotation of hydrophobic fines leads to new concepts for ultrafine particle processing

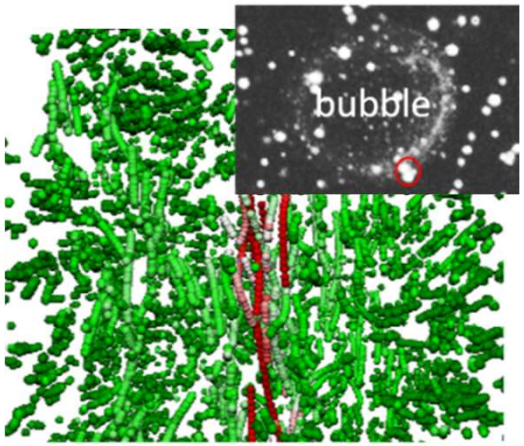


- **Fluid Dynamics of Interfaces**

  Institute of Fluid Dynamics multiphase flows in the flotation pulp phase and in the froth phase



Neutron imaging of particle flow in froth



4D particle image velocimetry in a single rising bubbble column

Key Papers

Leistner et al. (2017) Min. Eng., 109, 1-9

Heitkam et al. (2018) Min. Eng., 119, 126-129

Mineral processing group:

https://www.hzdr.de/db/Cms?pNid=2945

Martin Rudolph: m.rudolph@hzdr.de

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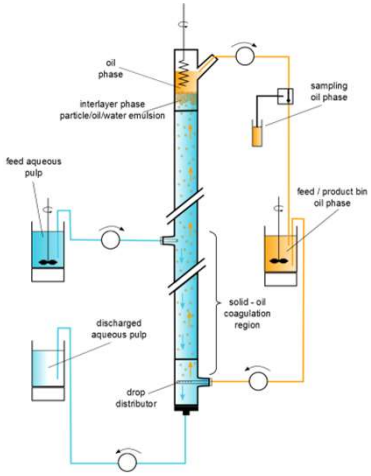
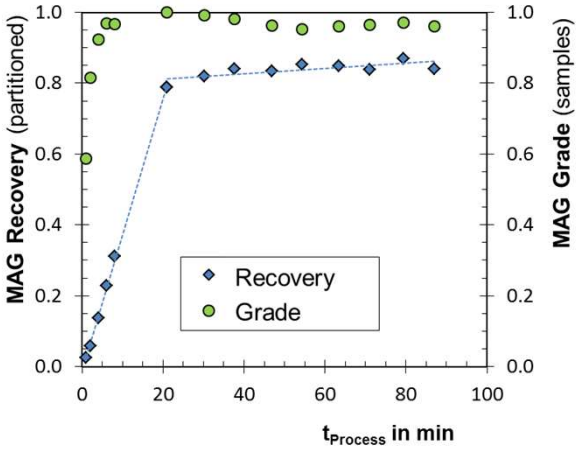
Mineral Processing: Fine Particle Processing

Efficiency through Innovation

- **Oil Assisted Techniques**

  Two liquid flotation and oil agglo-meration flotation for the improved recovery of ultra-fine particles

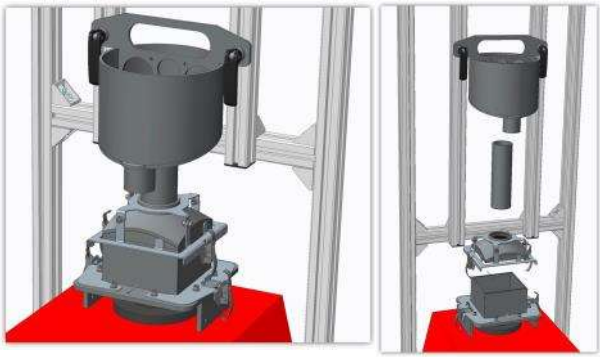




Two-liquid flotation results of sub-micrometer magnetite separated from ultrafine quartz

- **MultiDimFlot – a new concept**

  Development and study of a new flotation cell design for ultrafine particles within the DFG SPP 2045



MultiDimFlot flotation cell

Key Papers

Erler et al. (2014) Adv. Chem. Eng. Sci., 4, 149-160

Leistner et al. (2016) Min. Eng., 96-97, 94-98

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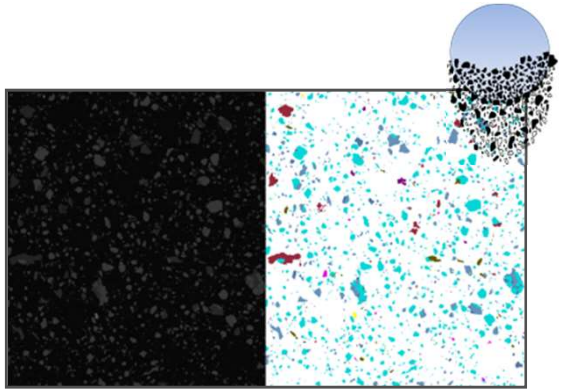
Mineral Processing Fine Particle Processing

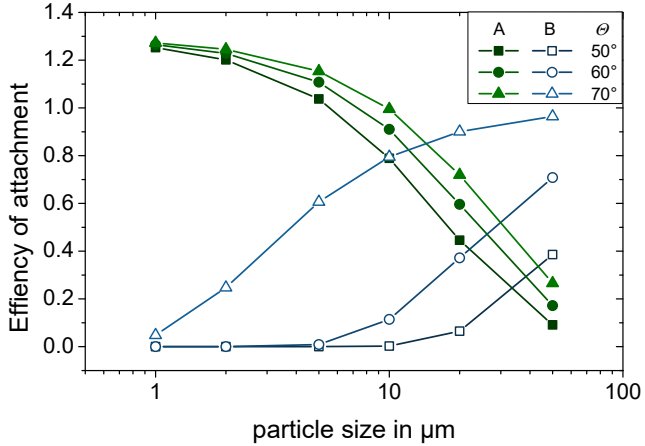
Efficiency through Optimisation (an Outlook)

Geometallurgy – Advances through Automated Mineralogy and System Intergration

- Complex characterization of particle composition, shape, liberation, …
- Improved process understanding and enabled complex modelling
- Incorporation of energy balance, water streams and economic considerations



Automated mineralogy of particles in flotation



Discrepancies in particle-bubble attachment as a function of size and contact angle needs improved process understanding

Procemin-Geomet 2018, 28.-30.11.2018, Santiago, Chile
Schach, E.; Buchmann, M.; Tolosana Delgado, R.; Kern, M; Leißner, T.; Möckel, R.; van den Boogaart, K. G.; Rudolph, M.; Peuker, U. A.
Uncertainty assessment in particle tracking processing models of cassiterite in complex skarn ores

Procemin-Geomet 2018, 20.-22.11.2019, Santiago, Chile
Hassanzadeh, A; Godinho, J.R.A.; Heinig, T.; Möckel , R.; Ebert, D.; Rudolph, M.
A Quantitative and Comparative Analyses of X- ray Computes Tomography and Mineral Liberation Analyzer

Biotechnology
Innovative Bioleaching

International state of the art

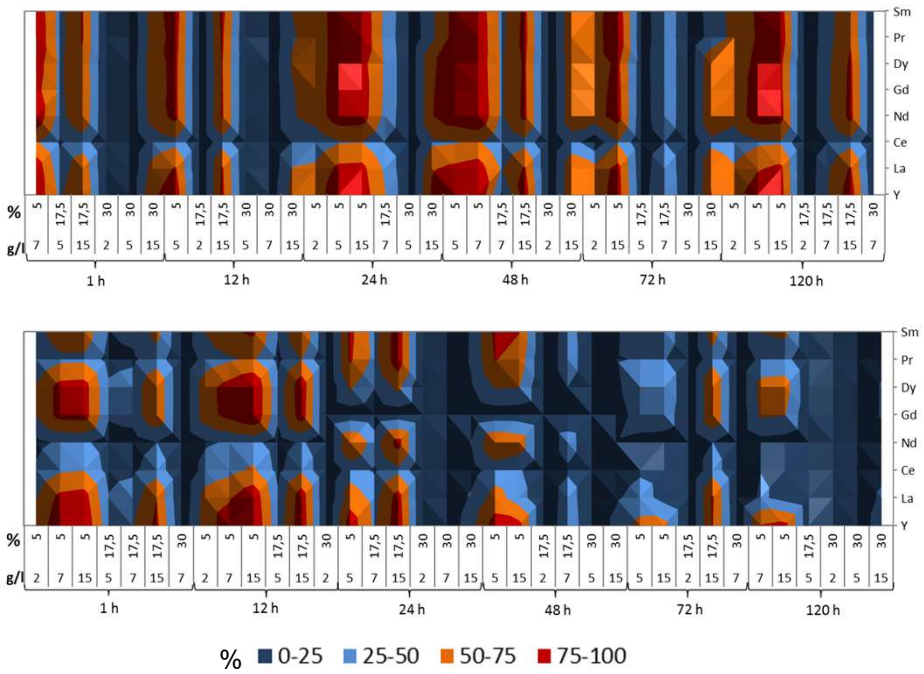
- Bioleaching of sulfidic ores using sulfur and/or iron oxidizing bacteria at acidic conditions, biooxidation; industrial scale

Research at HIF

- Bioleaching at neutral to alkaline conditions
- Complex and non-sulfidic ores
- Secondary resources: Mining residues and technical wastes (e.g. fluorescent phosphors)

Achievements:

- Bioleaching of complex ores and ion adsorption clays at pH 7
- Monitoring $^{64}Cu^{2+}$ mobility using GeoPET (IRE)



Rare earth extraction from ion adsorption clays with polyglutamic acid at 22 ºC and 40 ºC

Key Papers:

Hopfe et al. (2017) Waste Management, 62, 211-221

Karimzadeh et al. (2017) Chemosphere, 178, 277-281 (IRE)

Biotechnology group:

https://www.hzdr.de/db/Cms?pNid=659

Katrin Pollmann: k.pollmann@hzdr,de

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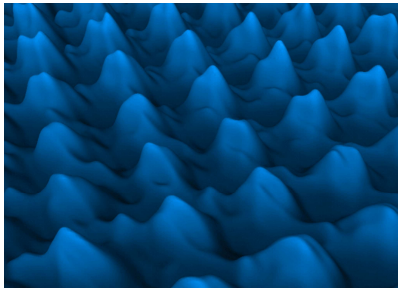
Biotechnology
Innovative Biosorption

International state of the art

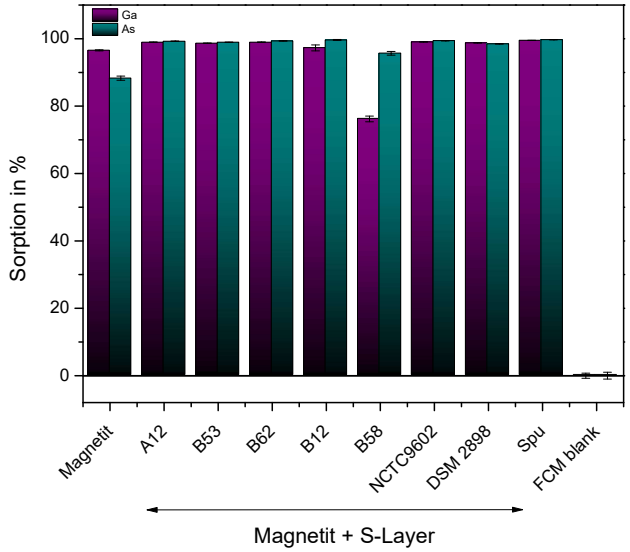
- Mostly used for removal of toxic metals
- Most applications use biomass (e.g. bacteria, seaweed, crab shells) with low selectivity

Bacterial
S-layer proteins



Research at HIF

- Design of metal binding biomolecules (e.g. peptides)
- Use of natural chelating agents (e.g. siderophores)
- Development of metal binding biocomposites



Binding of Ga and As from industrial waste waters by S-layer/magnetite composites

Achievements:

- REE and Ga binding with bacterial surface layer proteins and composites

Patent

DE102016208110 (pending)

Spin-off in 2015:

biconex

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Biotechnology: Innovative Bioflotation

International state of the art

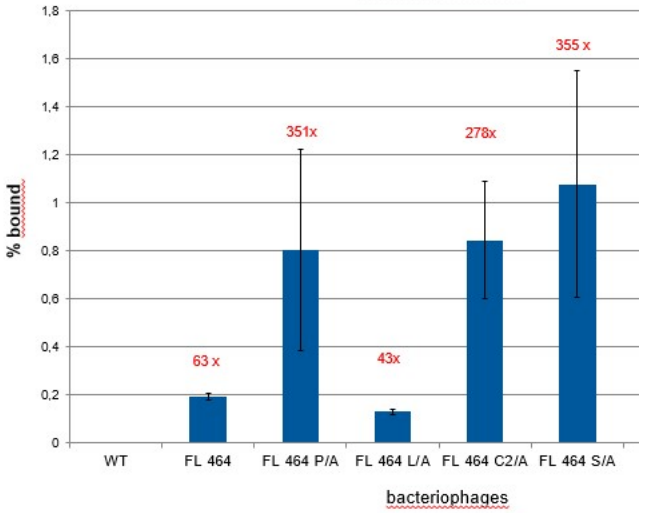
- Only few publications mostly using bacterial cells or extracellular polysaccharides (EPS) and concentrating on sulfidic minerals

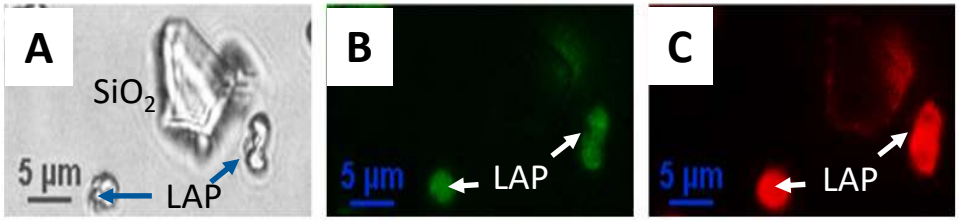
Research at HIF

- Microbial compounds and metabolites as flotation reagents
- Design of peptide based biocollectors
- Investigation of mechanisms and bio/particle interactions

Achievements:

- Development of a technology platform for surface binding peptides: identification of REE mineral specific peptides





Selective binding of bacteriophages to $LaPO_4$:Ce^{3+}, Tb^{3+} (LAP) particles

Key Paper

Lederer et al. (2017) Biotechnology and Bioengineering, 114, 5, 1016-1024

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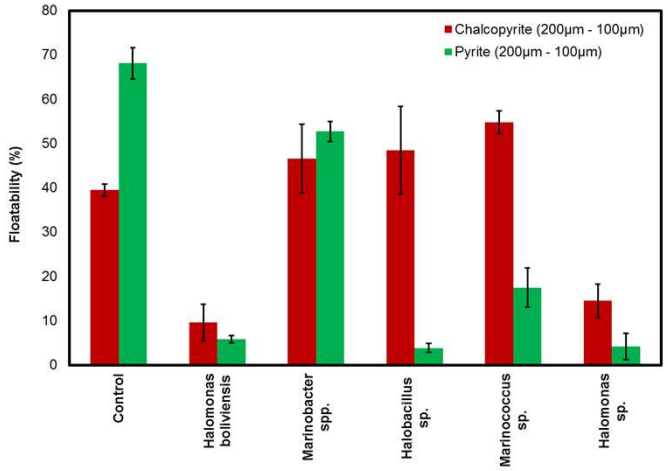
Biotechnology: Bioflotation- represented here by Project 'BS2': Bioflotation of sulfides in seawater

WTZ project with AMTC Chile (Willy Kracht)

Aim of project: Development of processes for flotation of sulfide minerals using seawater as aqueous medium and utilising bacteria as biodepressants of pyrite mineral

Background

- Only few publications mostly using bacterial cells or extracellular polysaccharides (EPS) and concentrating on sulfidic minerals
- Replacement/avoiding of toxic chemicals in flotation processes by using biodegradable biocompounds
- Development of flotation processes using seawater, saving of water and energy



Bioflotation experiments with 5 different strains (Minerals engineering, submitted)

Current state of the project (HIF):

✓Selection and screening of 5 different halophilic bacteria in microflotation conditions

✓Depression of pyrite without pH modification (no addition of lime) using halophilic bacteria as biodepressants

✓Ongoing work towards understanding of mechanisms by which biodepression is achieved by halophilic bacteria using various chemical techniques

Funding: BMBF funding: 240 k€,
Duration: 2016-2019

GEFÖRDERT VOM Bundesministerium für Bildung und Forschung

CONICYT Ministerio de Educación Gobierno de Chile

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Our 1st Chile project:
Optimization of Molybdenum Recovery from Porphyry Copper Ores in Chile 'Opti-Moly'

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TU BERGAKADEMIE FREIBERG

AHK

Chile 2013

Germany 2014

Chile 2015

Challenge: Mo production as a by-product is inefficient

Aims of the project

1) Identification of the reason for low recoveries of Mo
2) Develop a method in lab scale to optimize recovery of molybdenite, taking the economically dominating copper production into account
3) Assess the possibility of recovering Mo from slags

Results

1) Aims fullfilled, (confidential)
2) Mutual knowledge transfer
3) Positive feedback on present results by mine sites, 2 derived further project ideas
4) Onset of relation of trust and cooperation between IM2/ mine sites and HIF - several mutual research visits during the project (2 visits per year)-
5) Development of a consciousness for problems and sensitivity of large scale technical challenges in the modern mining industry (*for German partner*)

Funding: BMBF funding: 290 k€, IM2 contribution: 150 k€ + HR
Duration: March 2013- Dec 2015

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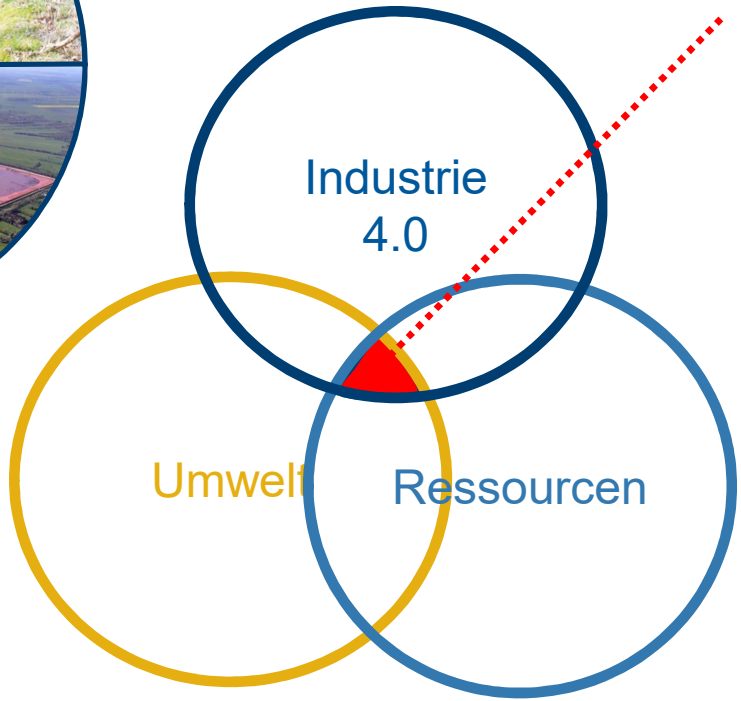
Wandel durch Innovation - Know How in der Region nutzen

GEFÖRDERT VOM

Bundesministerium
für Bildung
und Forschung



+
Gesellschaft

http://www.recomine.net/

Contact: Philipp Büttner
p.buettner@hzdr.de

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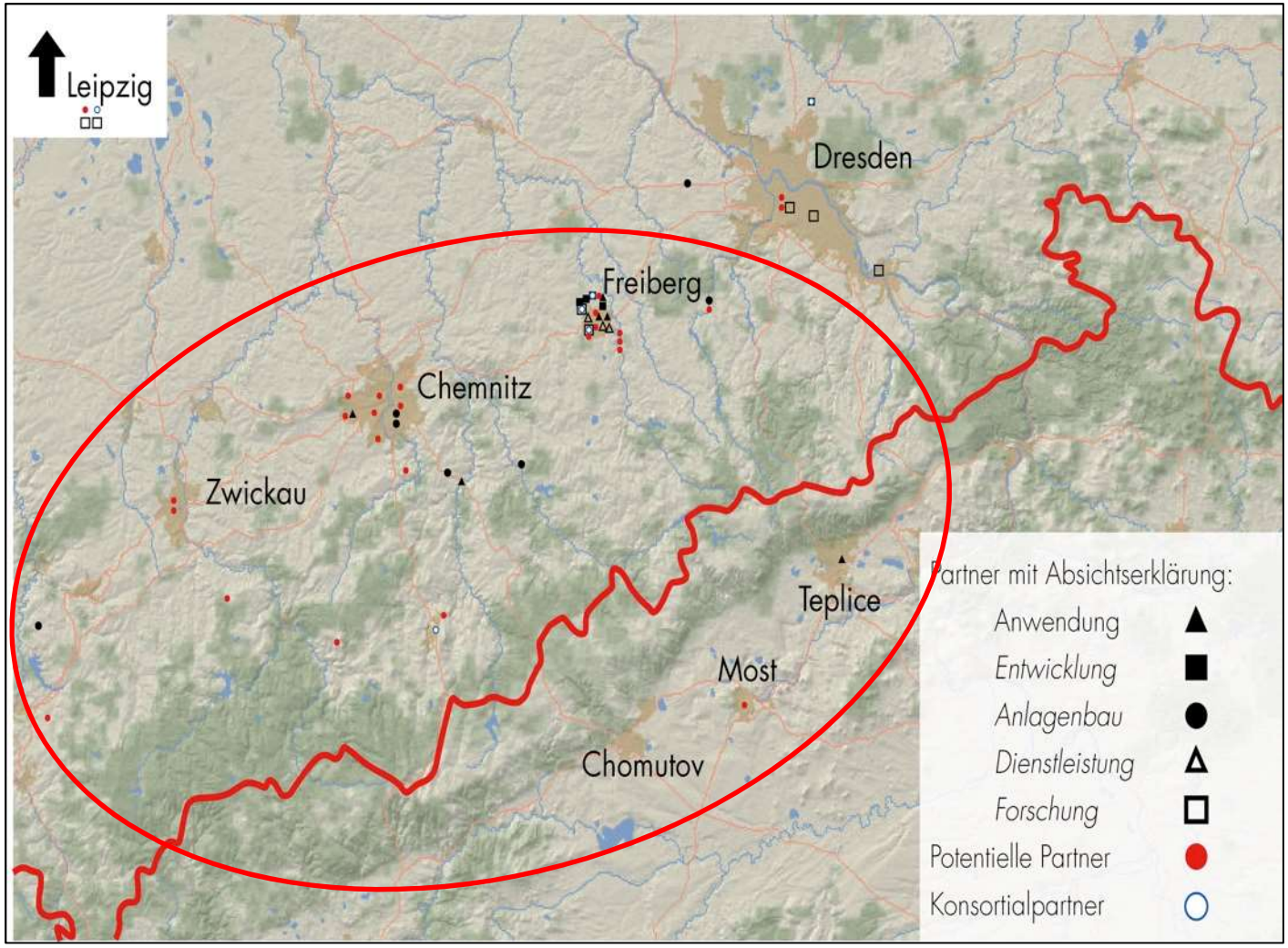

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rECOmine

Koordinator: HZDR

Partner: > 60 regional, national

Förderzeitraum: 2019-2023

Fördervolumen: ca. 15 Mio €

Fokus: Kombination von Nutzung disperser Rohstoffquellen und Rehabilitation der Umwelt

	Belastete Wässer	Aufbereitungsrück-stände	Schlacken, Asche, Stäube
Regionale Anwendung	WISMUT, Ústecký kraj, mittelsachsen	SAXONIA Standortentwicklungs- und -verwaltungsgesellschaft mbH, Ústecký kraj, ETH Erdbau Thalheim GmbH	BEFESA, Nickelhütte Aue GmbH
Entwicklung	Freiberg Instruments, UMWELTLEISTUNGEN Umwelt- und Ingenieurtechnik GmbH Dresden, IBZ - Salzchemie GmbH & Co. KG	UMWELTLEISTUNGEN, Freiberg Instruments, JAHNIG, IBZ - Salzchemie GmbH & Co. KG, G.E.O.S. Ingenieur-Gesellschaft mbH	IBZ - Salzchemie GmbH & Co. KG, Freiberg Instruments, G.E.O.S. Ingenieur-Gesellschaft mbH, UMWELTLEISTUNGEN
Anlagenbau & Zulieferung	KUNSTSTOFF TECHNIK Weißbach GmbH, KTW, STEP, OSTEC Oberflächen- und Schichttechnologie GmbH, LEHMANN UMT	KUNSTSTOFF TECHNIK Weißbach GmbH, KTW, LEHMANN UMT, JAHNIG, Corant, OSTEC Oberflächen- und Schichttechnologie GmbH	stfi Sächsisches Textil Forschungs Institut e.V., VFA Verfahrenstechnik für Rohstoffe
Dienstleistung	WISMUT, beak CONSULTANTS, G.E.O.S. Ingenieur-Gesellschaft mbH	VFA Verfahrenstechnik für Rohstoffe, beak CONSULTANTS, SAXONIA Standortentwicklungs- und -verwaltungsgesellschaft mbH	VFA Verfahrenstechnik für Rohstoffe, beak CONSULTANTS, BEFESA
Forschung	HTW Hochschule für Technik und Wirtschaft Dresden University of Applied Sciences, Technische Universität Bergakademie Freiberg, Technische Universität Dresden	HZDR, Technische Universität Bergakademie Freiberg, Helmholtz Zentrum für Umweltforschung UFZ	Institut für Abfall- und Kreislaufwirtschaft, Technische Universität Bergakademie Freiberg, HZDR
Wirtschaft & Gesellschaft	IMPACT HUB, georado, CLEANTECH Initiative Ostdeutschland, WFE Wirtschaftsförderung Erzgebirge, PNO, IHK Industrie- und Handelskammer Chemnitz, Wirtschaftsförderung Sachsen		

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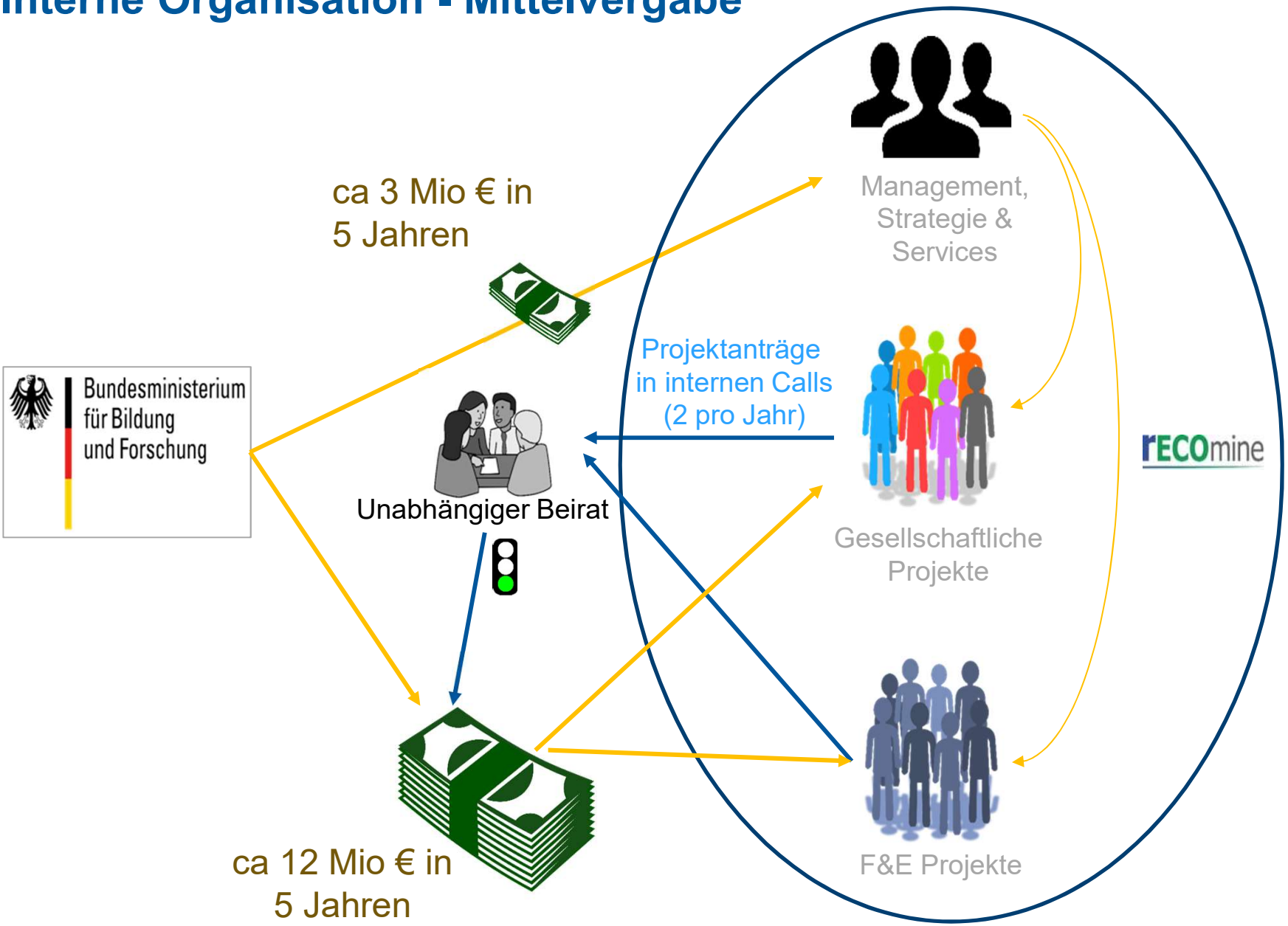
Interne Organisation - Mittelvergabe



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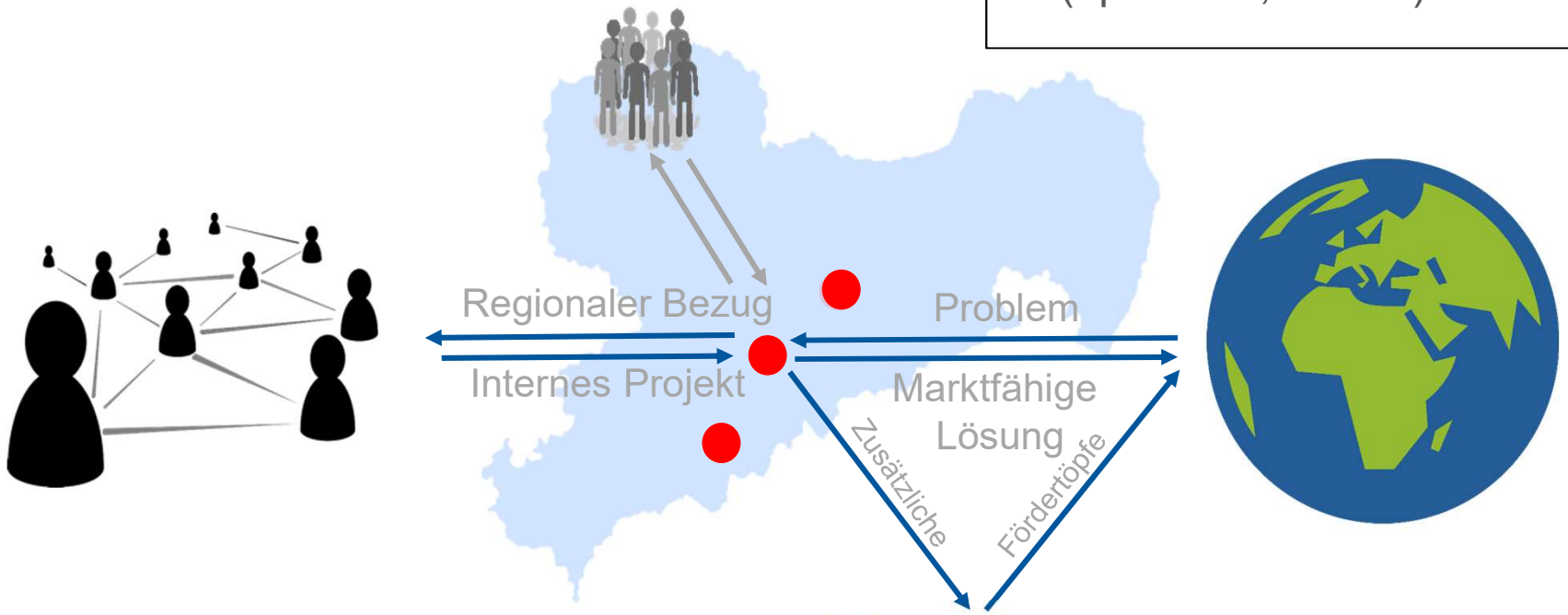
Verbindung zum EIT Raw Materials

Entwicklungsstandorte:

- Bad Schlema (Wasser)
- Ehrenfriedersdorf (Spülhalden, Wasser)
- Freiberg, Davidschachthalde (Spülsande, Wasser)



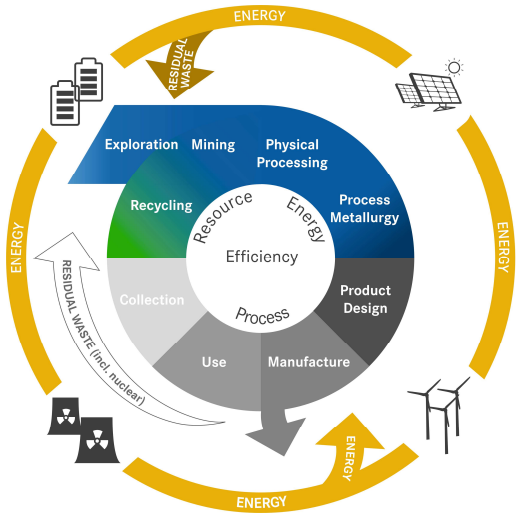
Entwicklungsstandort

Gesellschaftliche Fragestellungen

Dr. Sandra Birtel
Helmholtz Institute Freiberg for Resource Technology

Cooperation opportunities with HIF

- **Short term projects < 1 yrs**
  - Project assessment (geological, technical, economical)
  - Value stream analysis of economically critical raw materials
  - Identification of technical deficiencies
  - Identification of relevant R&D topics



- **Medium term projects < 3 yrs**
  - Joint R&D in the field of Innovative Technologies
  - Increase in material efficiency
  - Substitution possibilities
  - Recycling / recovery optimisation
  - Improved recovery rates by means of environmental protection

- **Long term projects < 5 yrs**
  - Strategic partnerships (e.g. radical changes in innovation)
  - Technical consulting by leading HIF scientists (e.g. raw material alliances)

Danke für Ihre Aufmerksamkeit!
¡ Gracias por su atención !

https://www.hzdr.de/db/Cms?pNid=2423&pOid=32948

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