Mineral Dusts

A valuable resource or only dust in the wind?

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The Helmholtz-Zentrum Dresden-Rossendorf

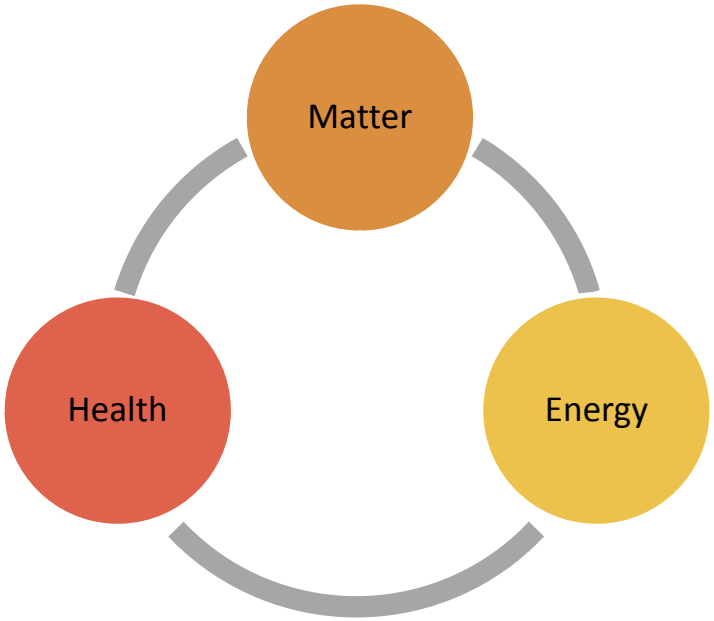
Member of the **Helmholtz Association of German Research Centers** (since 01/2011)

Foundation 01.01.1992 (e.V.)

Employees ca. **800** from **40 nations**

Research at seven institutes, in three research fields, and with five large-scale facilities

- Radiation Source ELBE with **F**ree-**E**lectron-**L**aser and the High-Intensity Laser Draco
- Dresden High Magnetic Field Laboratory (HLD)
- Ion Beam Center
- PET Center
- TOPFLOW Facility



Research Sites **Dresden**, Freiberg, Leipzig, Grenoble

Helmholtz Institute Freiberg for Resource Technology

Helmholtz Institute Freiberg for Resource Technology

HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

BERGAKADEMIE FREIBERG TECHNISCHE UNIVERSITÄT

Objectives

- New technologies for utilization of mineral and metal containing resources from complex domestic and foreign deposits
- Contribution to global environmental protection by means of material and energy efficient extraction and use of raw materials
- Economic networks between Germany and resource countries based on sustainable technologies provided to German industry by the Helmholtz Institute (technology in exchange for access to raw materials)
- Training of new generation of highly qualified academic and technical staff for German industry and academia

DRESDEN concept

HZDR

Research along the supply chain

engineering

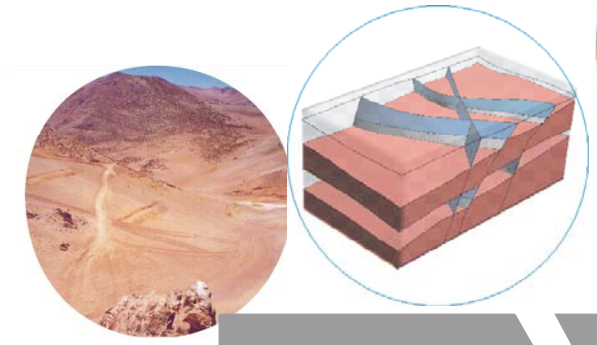
environmental sciences

metallurgy

processing

mining

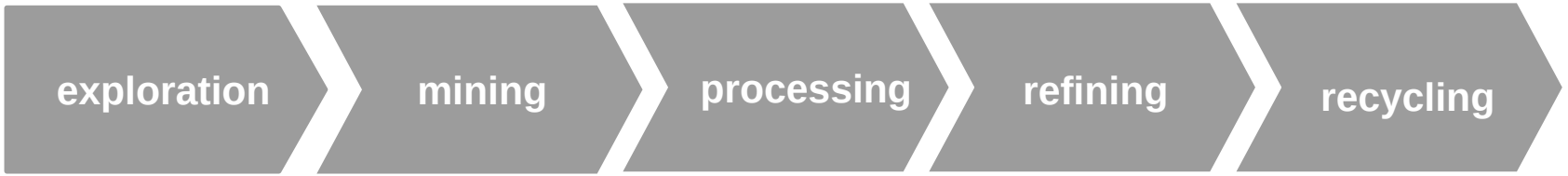
Earth sciences



Applied natural/ Earth sciences

exploration → mining → processing → refinement → recycling

structure



Head of institute

departments	**exploration**	**mining**	**processing**	**metallurgy & recycling**	**modeling & assessment**	**Analytics**
projects	**Remote sensing**	**robotics/ automation**	**geobio-technology**	**pyro-/ hydro-metallurgy**	**mineral economics**	**Ion Beam Analytics (IBA)**

Mineral Dusts

Mineral and rock dusts are a by-product in every branch, related to mining and processing of mineral and metallic raw materials.

The total mass of such fine-grained material may reach over **90 wt.-%** of the mined material in mines and quarries.

The variation limit of the mineralogical and geochemical features is extremly broad and exceeds the range of the natural rocks and ores.

Mineral Dusts

Many dust types are defined as injurious to health and harmful to the environment and are subject to formalities, recommanded practice, and statutory rules.

The degree of utilization differs from case to case. It depends on mineralogical and geochemical features, but more important are economic, logistical, and technological conditions as well as the density of regulation.

Unused dust must deposited in landfills or repositories, this deposition is limited by obligations.

From the point of view of resource efficieny deposition is no sustainable, satisfactory solution.

Mineral dusts

In many cases the dusts "concentrate" the better part of the energy consumed during processing and refinement by the '*dust-producing enterprise*'.

Considering the landscape consumption related to mining of raw materials the demand for utilization of all by-products is inevitable.

“strategic-dust

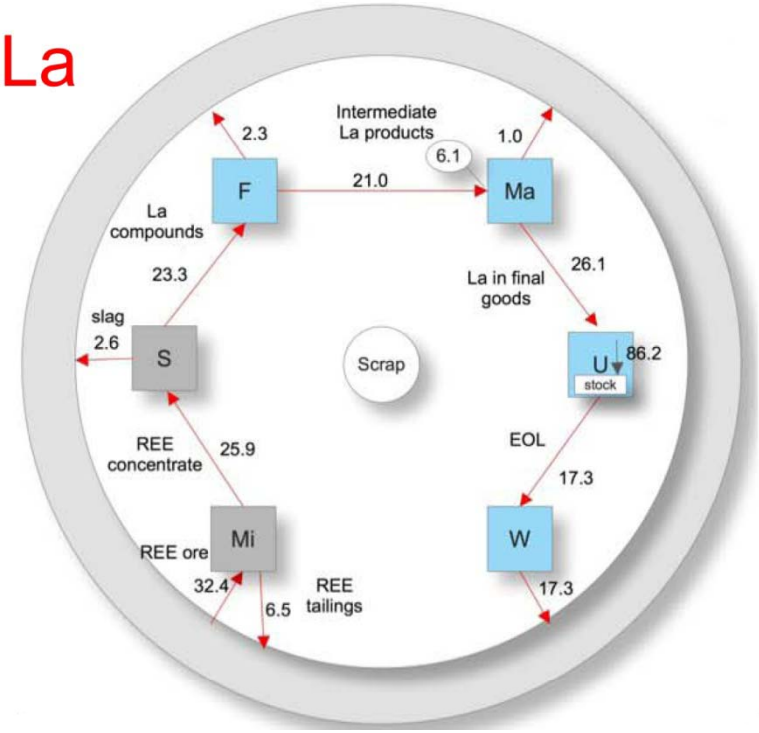
OPEN

SUBJECT AREAS:
SUSTAINABILITY

Uncovering the Global Life Cycles of the Rare Earth Elements

Xiaoyue Du & T. E. Graedel

La



Example of La.

Of the 32.4 Gg La that was mined in 2007, 20% was lost to tailings at the mining stage. A 10% loss of the ongoing flow occurred during separation as slag, another 10% was lost during the fabrication of intermediate products, and another 5% was lost during the manufacture of most final products.

1 Gg = 1000 t

SCIENTIFIC REPORTS | 1 : 145 | DOI: 10.1038/srep00145

DRESDEN concept HZDR

“strategic-dust

OPEN

SUBJECT AREAS:
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Uncovering the Global Life Cycles of the Rare Earth Elements

Xiaoyue Du & T. E. Graedel

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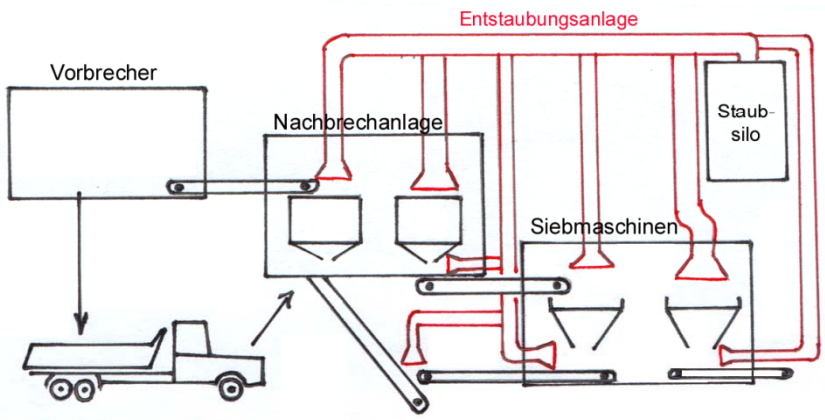
Bayan Obo - China

Mineral dusts - outline

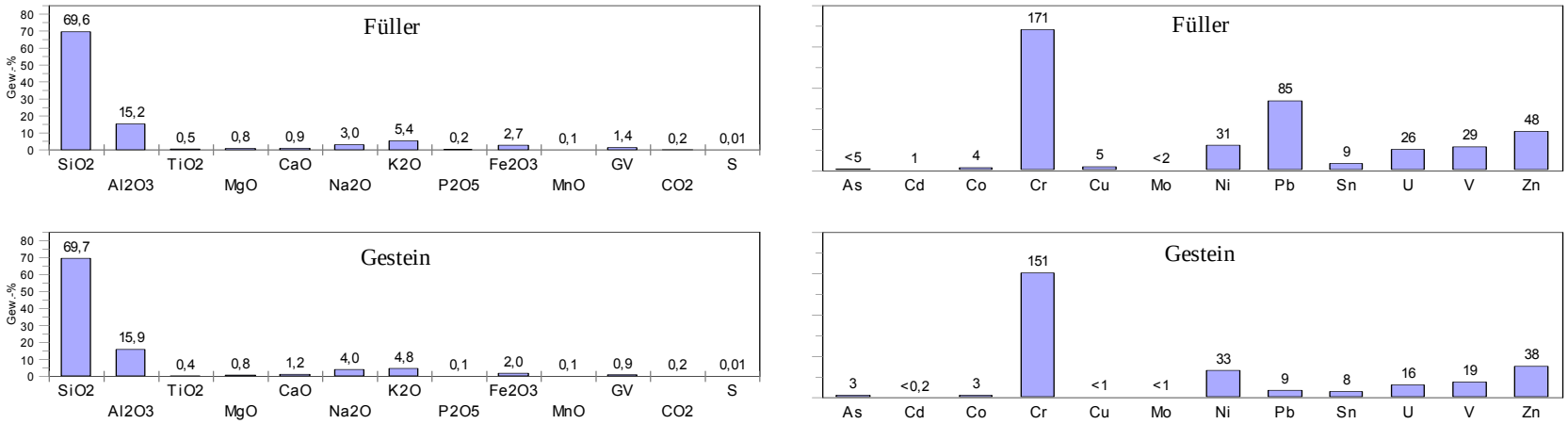
- **Methods of mineralogical and geochemical characterization**
- **Applications and methods of process engineering characterization**
- **Where we are today – booster and inhibitors of dust utilization**

Rock dust from quarries

The technology of dedusting (dust separation) in quarries demands exhausting and filter equipment in all technological steps (blasting, crushing, milling and transport).



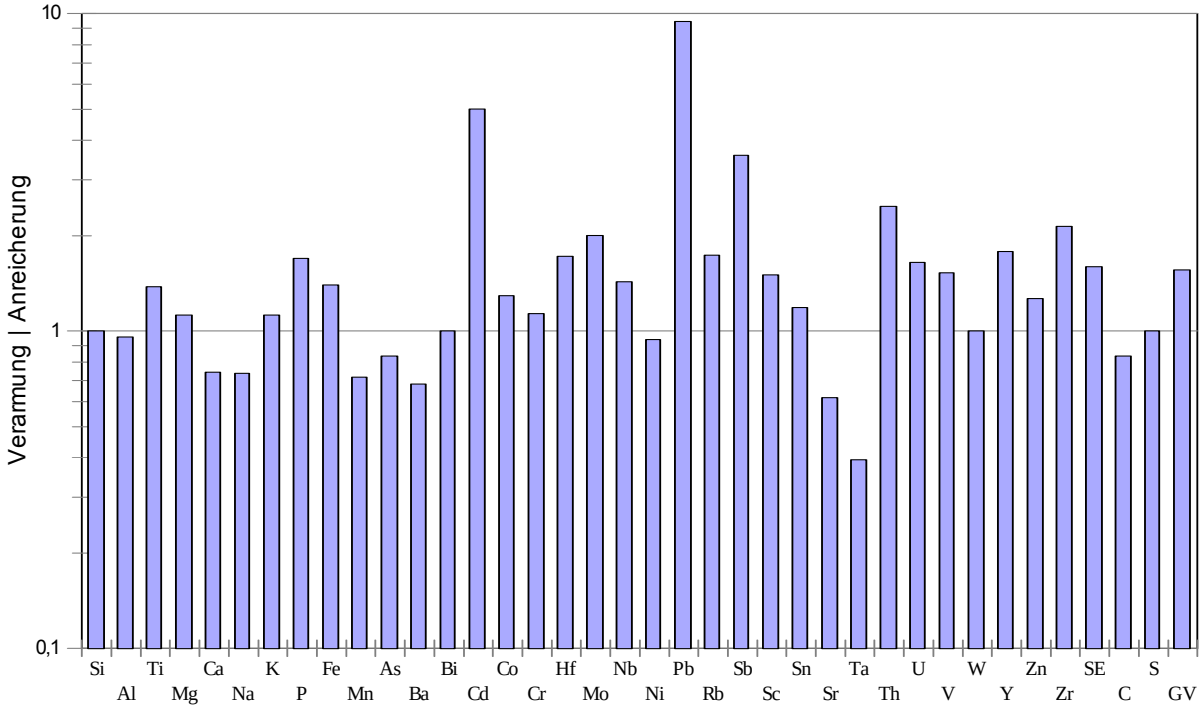
Geochemical characterization



Major and Trace element content of quarried rock and the associated rock dust (granodiorite)

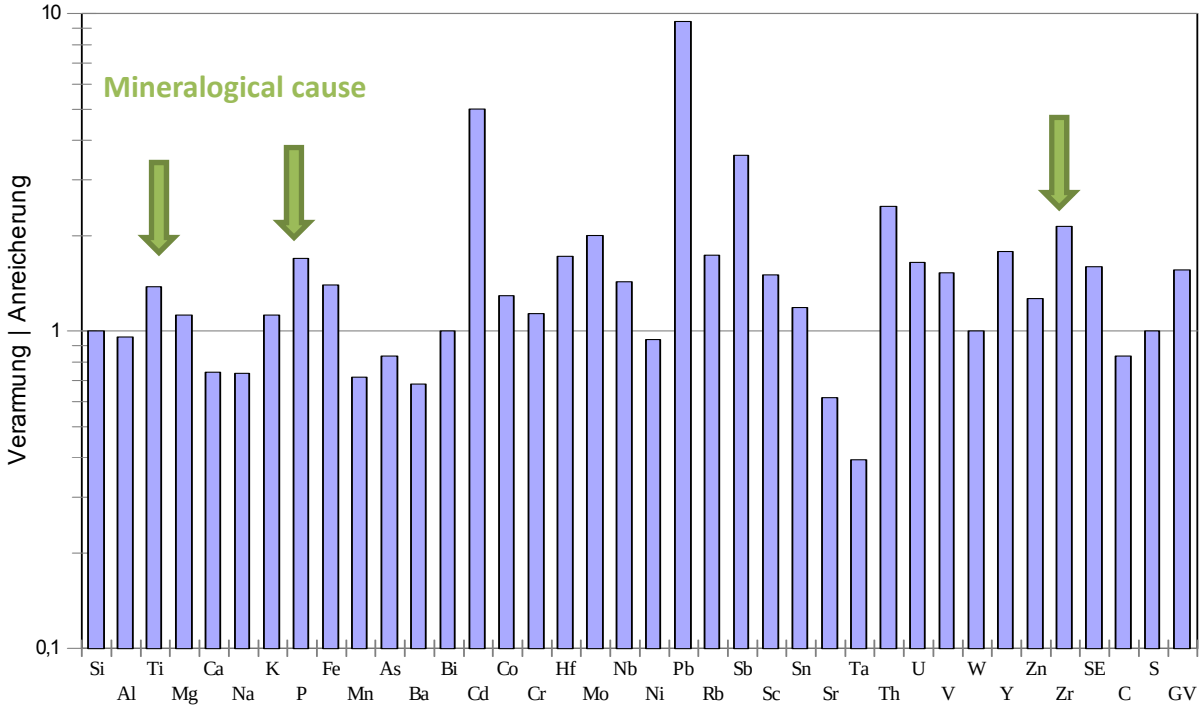
The simultaneous characterization of rock and rock dust is an essential quality assurance measure.

Geochemical characterization – element fractionation



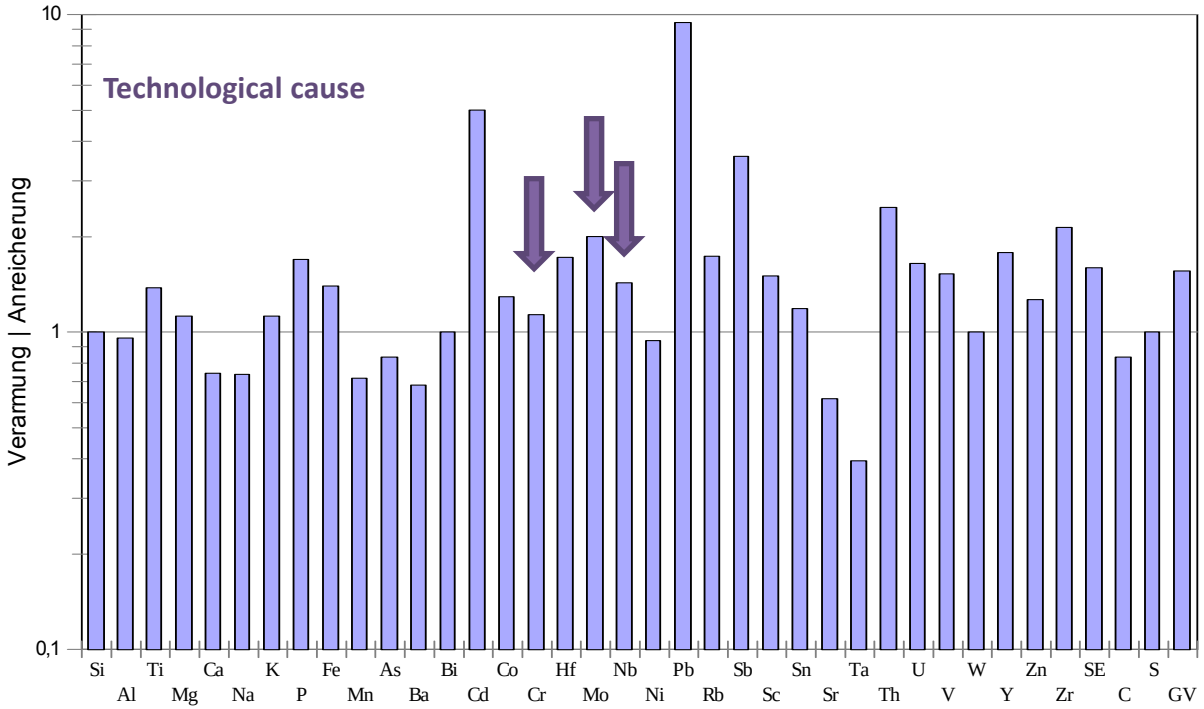
Characterization of element fractionation due to grain size related mineralogical and technological causes.

Geochemical characterization – element fractionation



Characterization of element fractionation due to grain size related **mineralogical** or technological causes.

Geochemical characterization – element fractionation



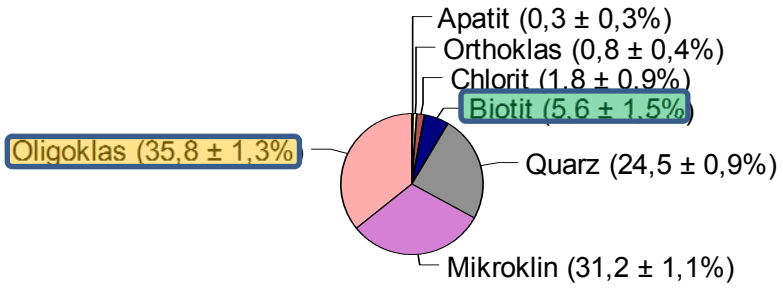
Characterization of element fractionation due to grain size related mineralogical or **technological causes**.

Mineralogical characterization

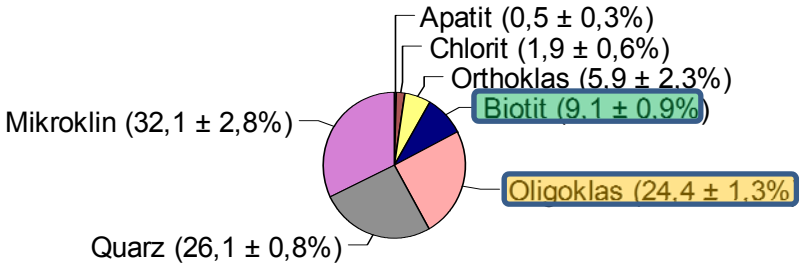
- Optical microscopy (thin sections) of the rocks
- Quantitative X-Ray diffraction of rock and dust
- Characterization of mineral intergrowth in the rocks and the dusts
- Grain size distribution
- Grain forms
- Specific surface
- ……..

Quantitative X-ray diffraction analysis

Rock



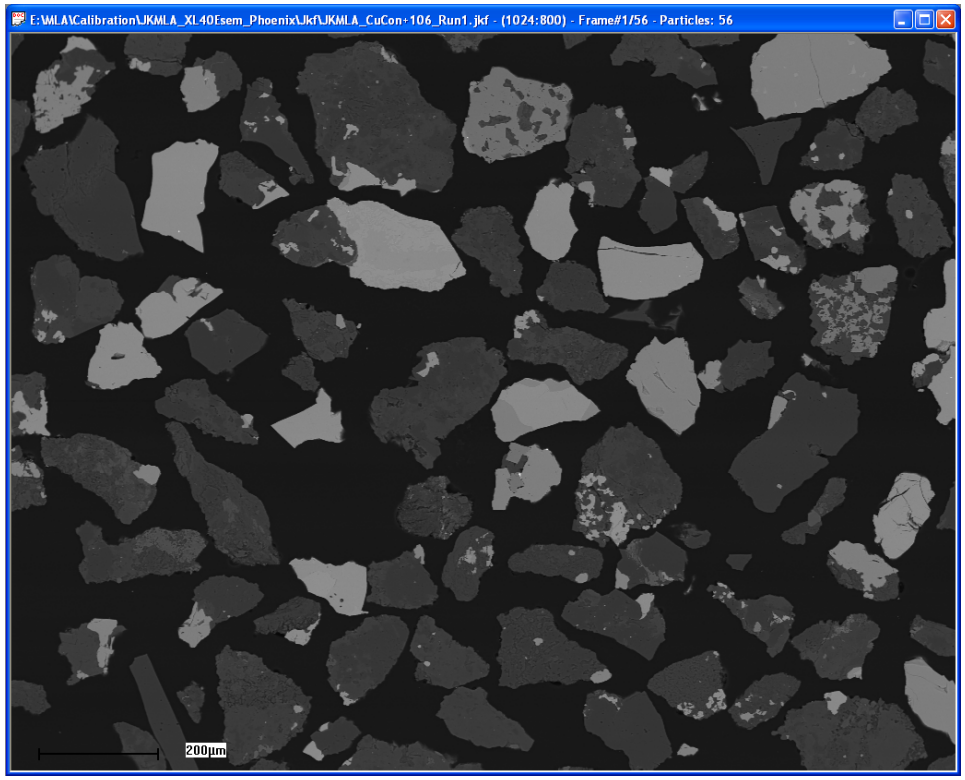
Rock Dust



Quantitative XRD is based on the Rietveld method (software: BGMN/AUTOQUAN).

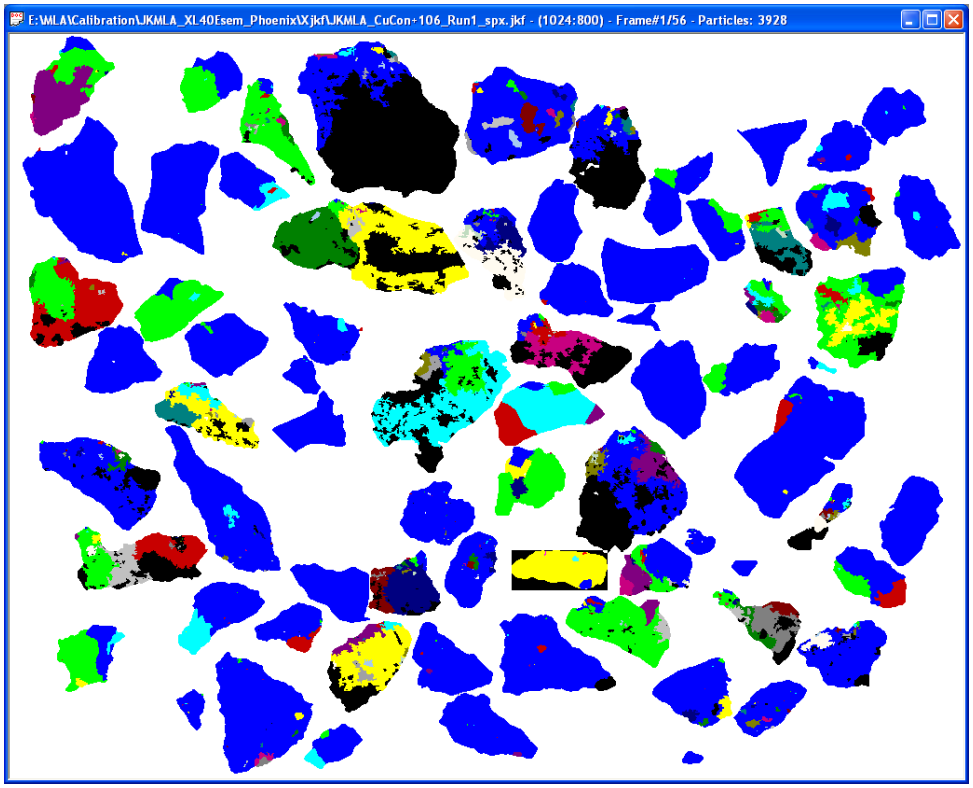
Grain size related fractionation in mineralogical composition are easy visible (biotite and oligoclase).

Intergrowth relationships in mineral dust



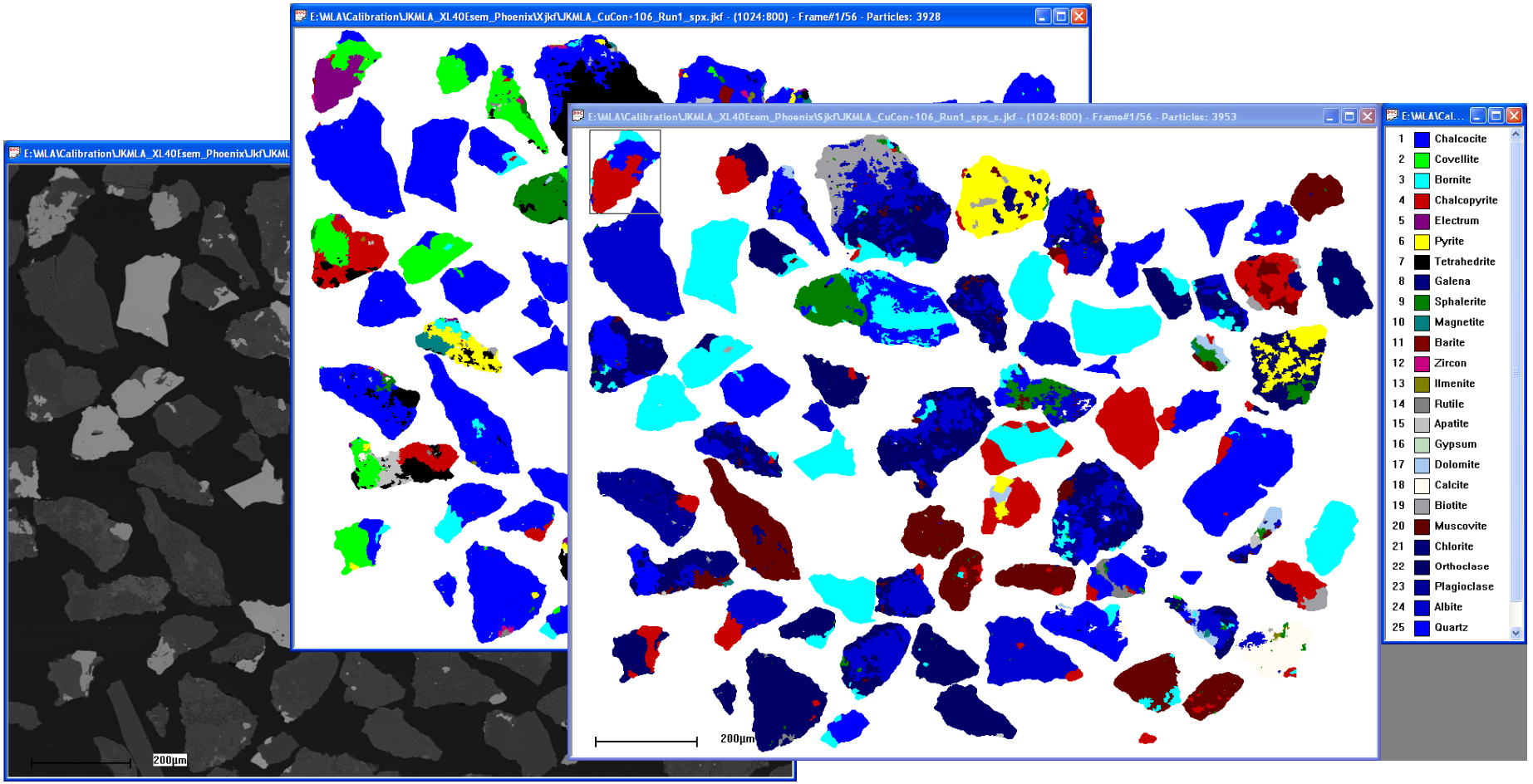
Backscattered electron image of a processed (crushed) ore sample

Intergrowth relationships in mineral dust



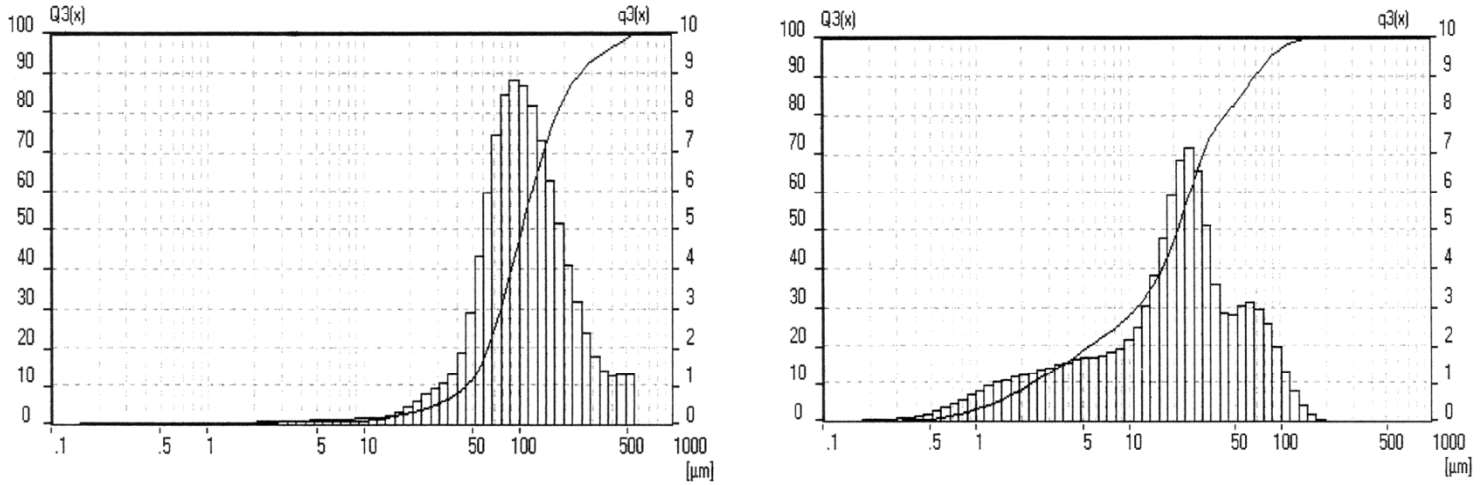
Element distribution map – SEM-EDX - image of a processed (crushed) ore sample

Intergrowth relationships in mineral dust



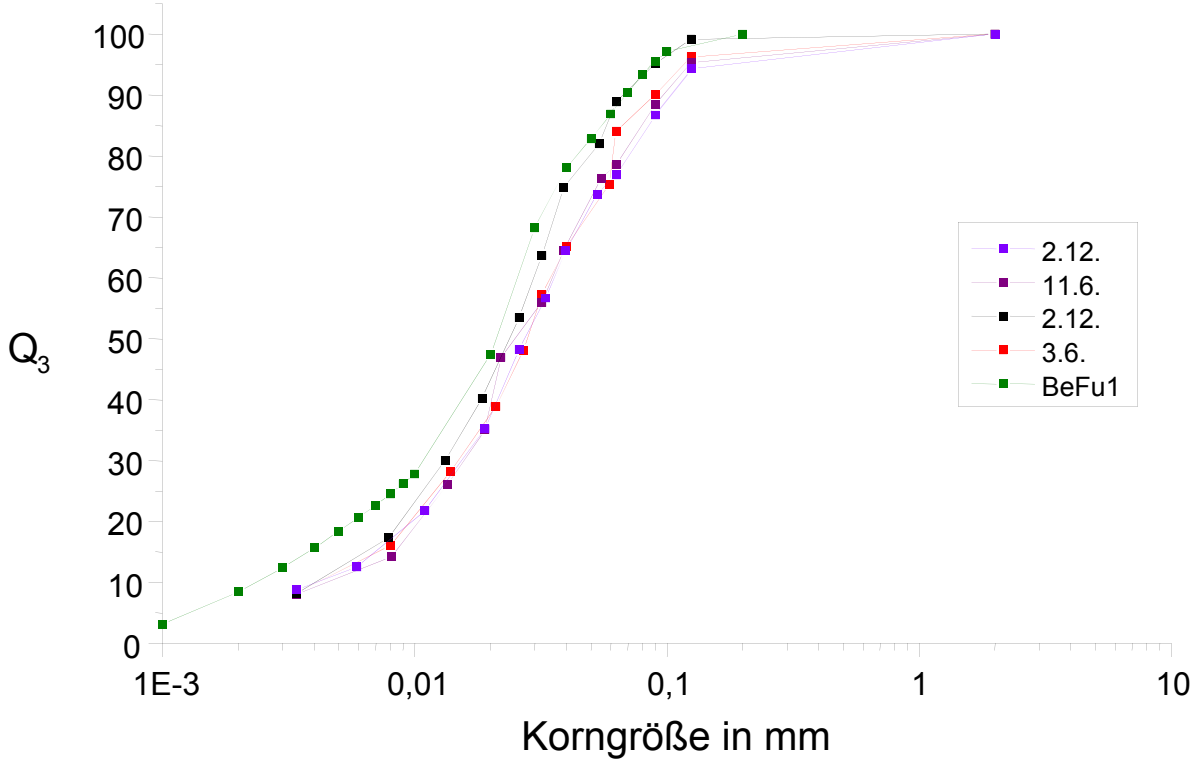
Quantitative determination of the mineralogical composition of the processed sample by combining the information of the SEM-BSE and the SEM-EDX.

Grain size distribution



Grain size distribution of rock dust determined by laser diffraction in aqueous suspension. The dust is prone to agglomeration, as shown by the measurement of the same sample ultrasonically treated for dispersion (right).

Grain size distribution



Temporal fluctuations of the grain size distribution demand continous quality assurance.

utilization

The possible range of utilization is very broad:

- soil amendment („fertilizer“)
- feed additive
- pesticide
- deodorant
- grog (nonplastic materials) and flux (ceramic industry)
- Enamel and glaze raw material
- construction materials industry
  - Calcium-Silicate blocks („Kalksandstein“)
  - Autoclaved aerated concrete („Porenbeton“)
  - concrete
  - bitumen
  - Thermal insulating material
- filler for plastics
- Geochemical barriers
- neutralization agents
- water treatment

soil amendment

Intensive agriculture and forestry induces a depletion of plant nutrients in the soil. Mineral fertilizers are the usual solution since Liebig. The good plant availability of mineral fertilizers causes the risk of element washout.

Rock dust is used as a long-acting soil supplement, a very effective soil conditioner and growth stimulant in organic and conventional agriculture.

Rock dust will not substitute mineral fertilizers in every situation.

soil amendment

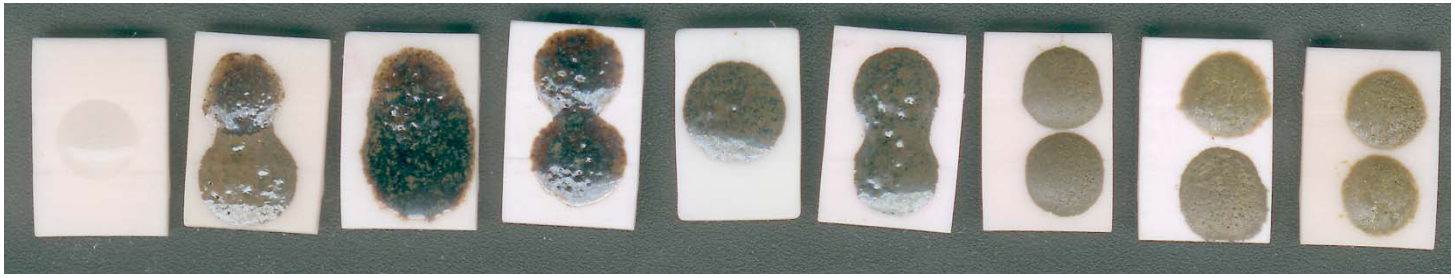
Before using a rock dust as soil amendment you must run many tests, according to environmental, agricultural and water legislation:

- **Limiting values**
- **Plant availability of nutrients and contaminants**
- **Cation exchange capacability**
- **Puffer capacities**
- **Kinetics of nutrient release**

Grogs and fluxes for the ceramic industry

Additional tests to the mineralogical and geochemical charcterization are necessary:

- **Differential thermal analysis**
- **Melting**
- **Sintering**
- **Inflating**



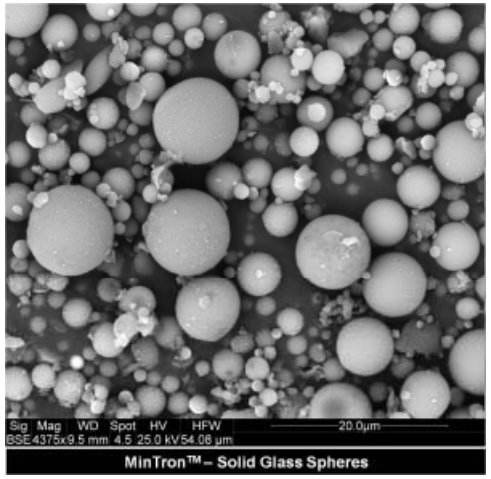
Grogs and fluxes for the ceramic industry

			Anforderungen der Ziegelhersteller														
			Rohstoff							Brennverhalten							
			Korngröße	Gleichmäßigkeit	Gehalt an SiO_2 >60 % | >60 % | <60 %			spez. Oberfläche	Gehalt an freiem Quarz	Schmelzpunkt (HKP)		Brennfarbe	Schmelzverhalten				Bewertung
			(mm)		$RO+R_2O$ <11,7% | <11,7% | >17,5%			(m^2/cm^3)		(°C)			Blähen		Schwinden		
					Fe_2O_3 <2,3 % | >2,3 % | >4,0 %					K <1100	H >1300		K	H	K 5-10 %	H	
			<1	groß	<2,3 %		>4,0 %		niedrig								
	v		x	x	x		x	1,0	26		1400	braun			✛	✛	
Granit	g	F	●	●		●●					●●●				●	●	M
		M	●	●		●●											
	v		x	x	x		x	0,8	0,7		1225	oliv			✛	✛	
Nephelinit	g	F	●	●			●								●	●	F
		M	●	●													

x ... requirements fulfilled ✛ ... positive v ... existing property - ... negative
● ... demand fulfilled
Applicable as **F** ... flux **M** ... grog for **K** ... brick/clinker; **H** ... backing brick

Test report for different types of rock dust (granite and nephelinite) for usage as grog or flux in brick production.

Filler



Filler are particles added to materials like plastics to lower the consumption of more expensive binder material or to better some properties of the mixtured material. Highly specialized fillers like nano particles, conductive, surface modified, abrasion resistant particles, fillers with defined morphologies are are in high demand.

Filler

According to the grain size distribution rock dust can used as filler after removement of oversized particles. Prospective applications shwo the following effects on the platic:

- Improvement of Ultimate tensile strength
- Improvement of Compressive strength
- Improvement of Young's modulus
- Improvement of impact strength
- Reduced thermal dilatation
- Reduced shrinkage
- Improved Thermal conductivity
- Improved temperature stability
- Increased electrical resistance
- Improved chemical resistance
- Improved abrasion resistance
- Improved extrusion speed
- Price-reduction

Filler - example

A metallocene-catalyzed Polyethylene (PE-Me), a soft and flexible thermoplastic, which is used as packing foil, cable coating, tube, flexible container, bottles and garbage can was added 10 – 70 weight percent gneis and amphibolite dust.

All experiments ran at the Research Institute of Leather and Plastic Sheeting (FILK), Freiberg/Sa.

The plastics were extrudable at all filling stages. We produced foild of a thickness between 500 – 600 µm.

All material properties All material proportions remained stabel. The experiments showed the basic versatility at high filling stages of these rock dusts for different circumstances..

Where we are today? – Boosters and inhibitors of dust utilization

Boosters

- Economic incentives
- Reduction of environemental impact
- Common sense

Inhibitors

- Business as usual
- Missing mineralogical, geochemical, and technological knowledge
- Slow return on investment
- Growing patent coverage (India, South Korea and China) with poorly defined petrographic and mineralogical characterization and classification
- Pseudo-science

Conclusions

- **Mineral- and rock dust demands utilization for economic and ethic rationales.**
- **The base of utilization is an exhaustive estimation of the mineralogical, and geochemical features.**
- **We know nearly infinite utilization possibilities, but every single usage demands mineralogical, technological and legal analysis.**
- **The demand for raw materials with constant characteristics necessitate that technologists and engineers pay the same attention to the by-products like to the commodity.**
- **Using mineral and rock dust implicates a radical rethink of companies, public authorities, consumers and local residential communities.**