

Wissensforum Metals in bottom ash and how they can be recycled

International VDI Conference 2013

ENERGY AND MATERIALS FROM WASTE

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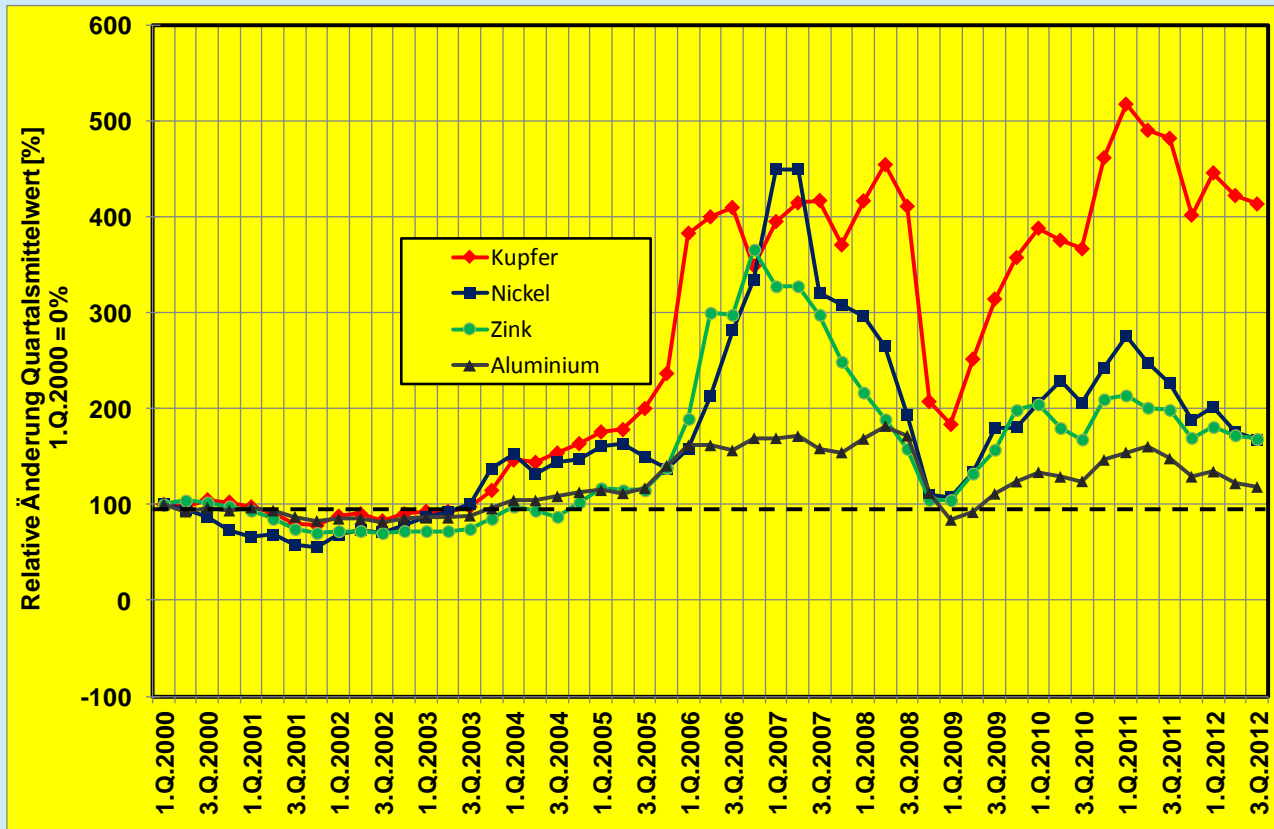
³C.C. Reststoff-Aufbereitung GmbH, Würzburg

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- 1. Changing raw material marketes**
- 2. Residues from Waste to Energy plants and how they are used**
- 3. Metal contents in bottom ash depending on the particle size fraction**
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- 5. Possible recycling processes for different metals**

1. CHANGING RAW MATERIAL MARKETS

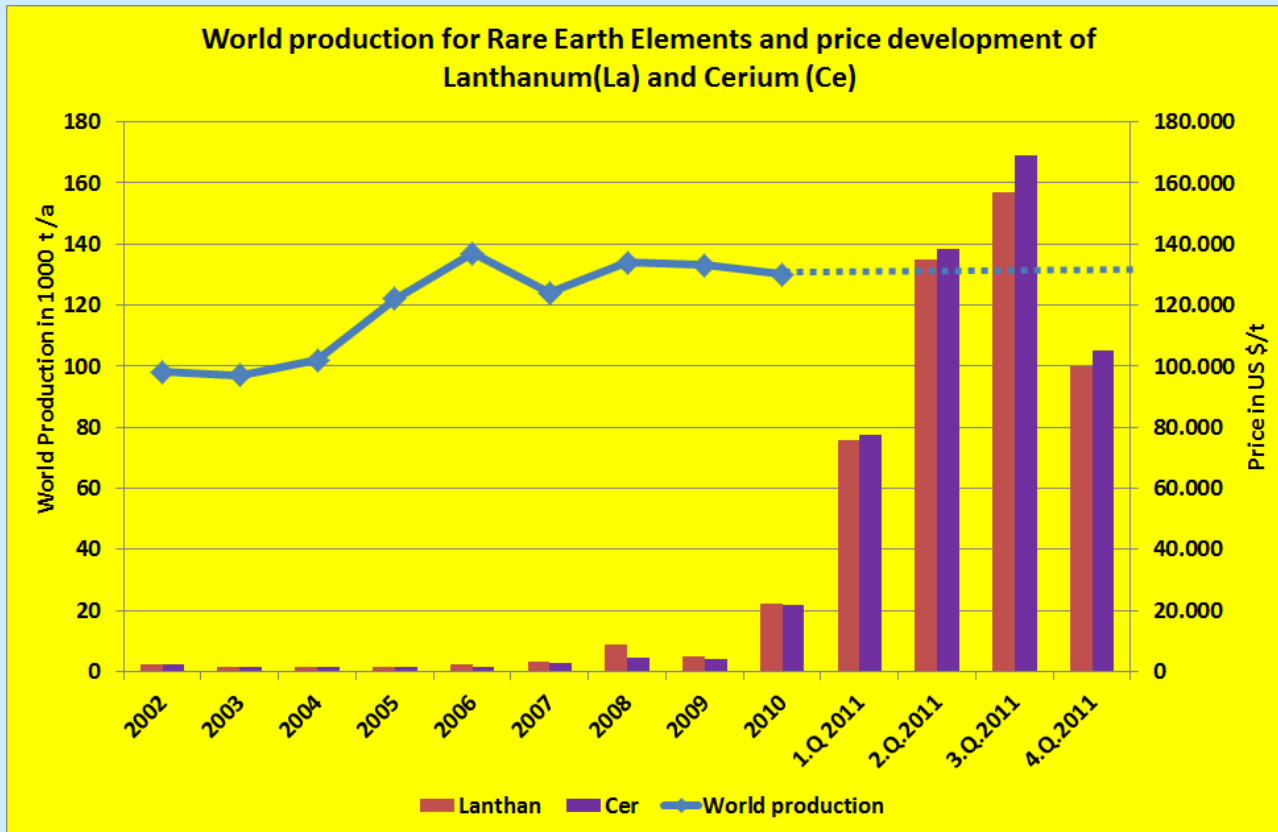
Development of different metal prices on the basis of quaterly data (1. Q. 2000 = 100%)



Data of LME

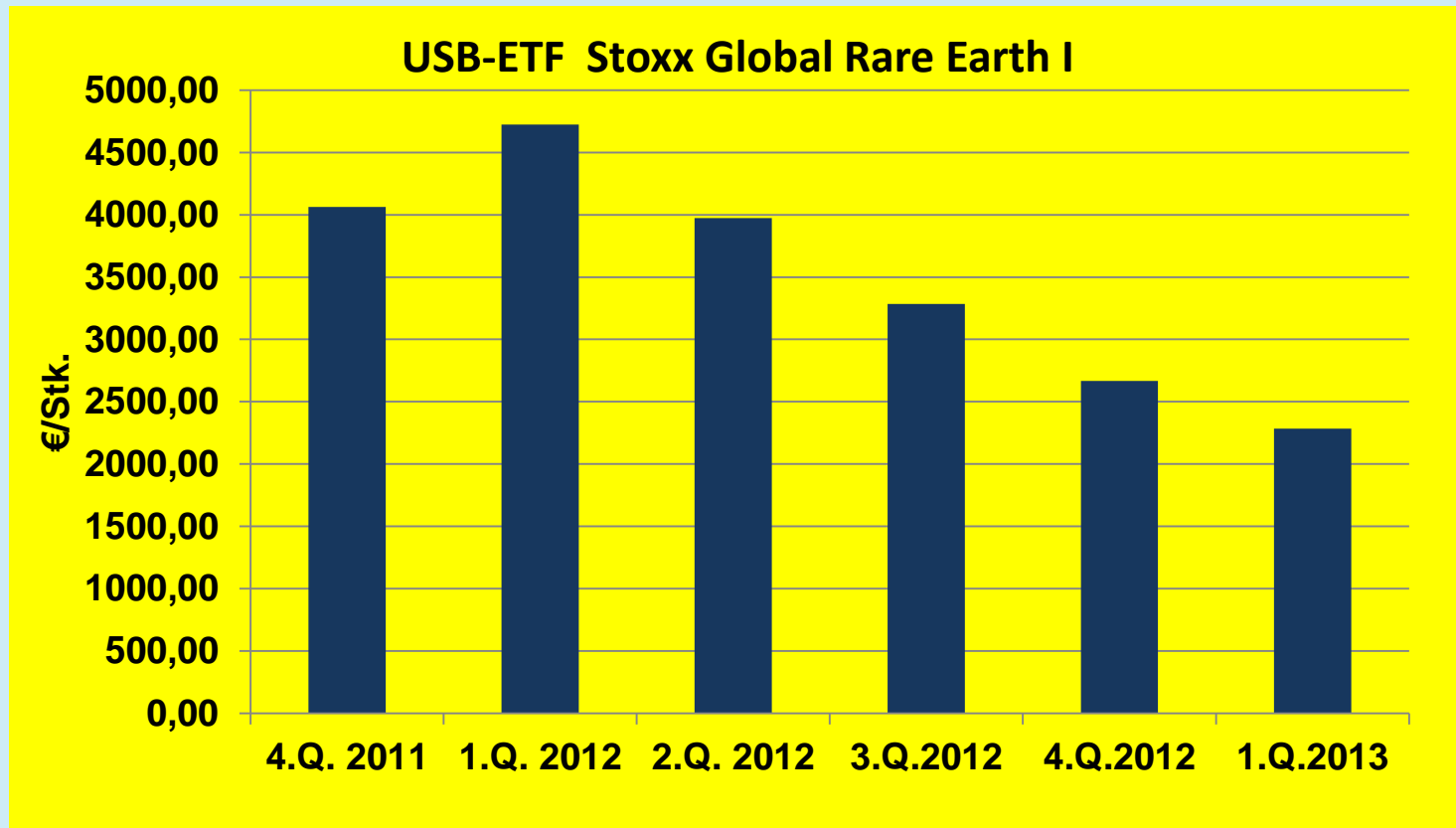
Deike, R.: CastTec 2012, Krefeld, 08.11.2012

Global production of rare earth and prices for La and Ce between 2002 and 2011



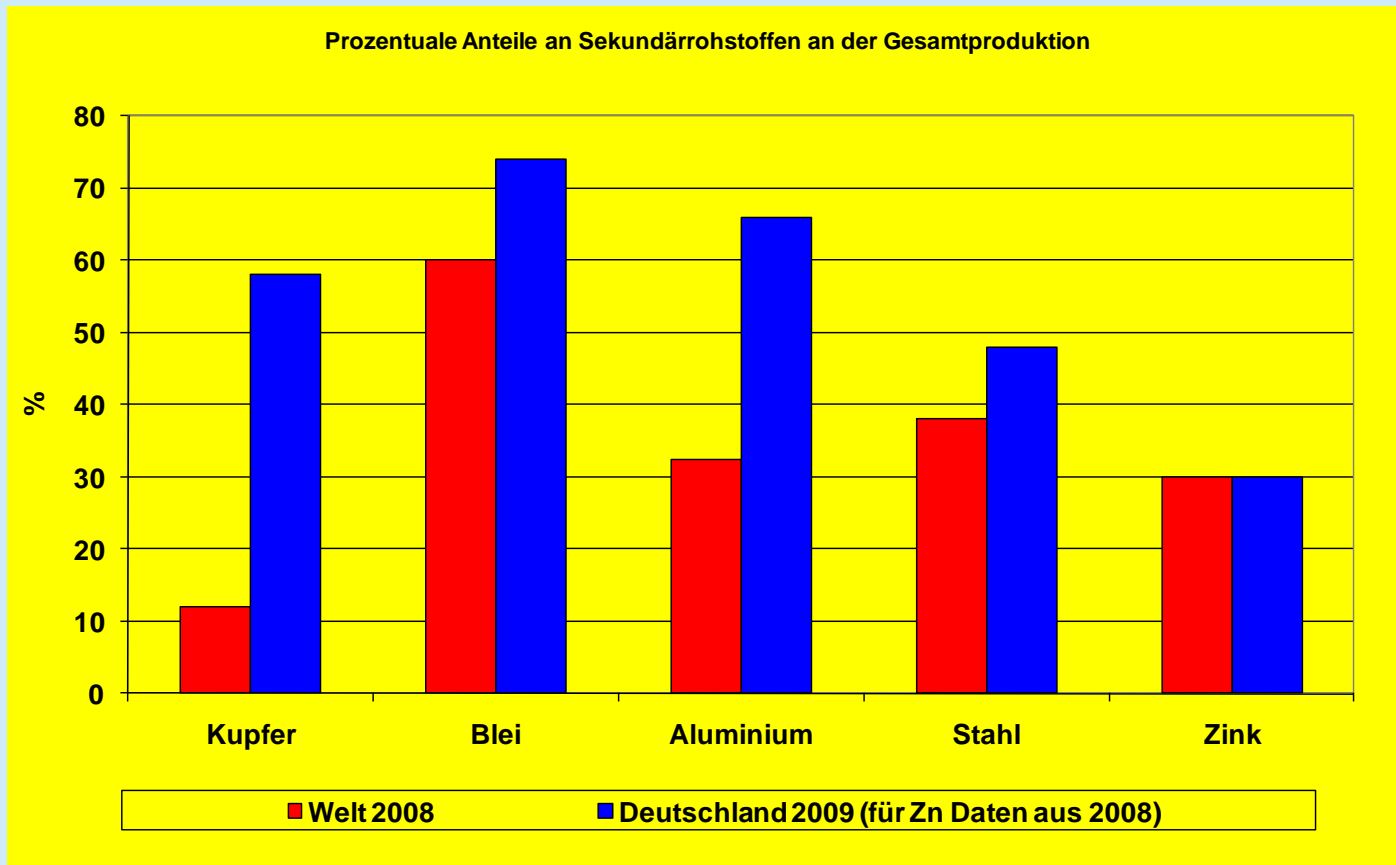
Data of United States Geological Survey, www.usgs.gov; British Geological Survey, www.bgs.ac.uk, www.seltenerdmetalle24.com,

Share price index of global companies in rare earth business



Data of www.boerse-frankfurt.de

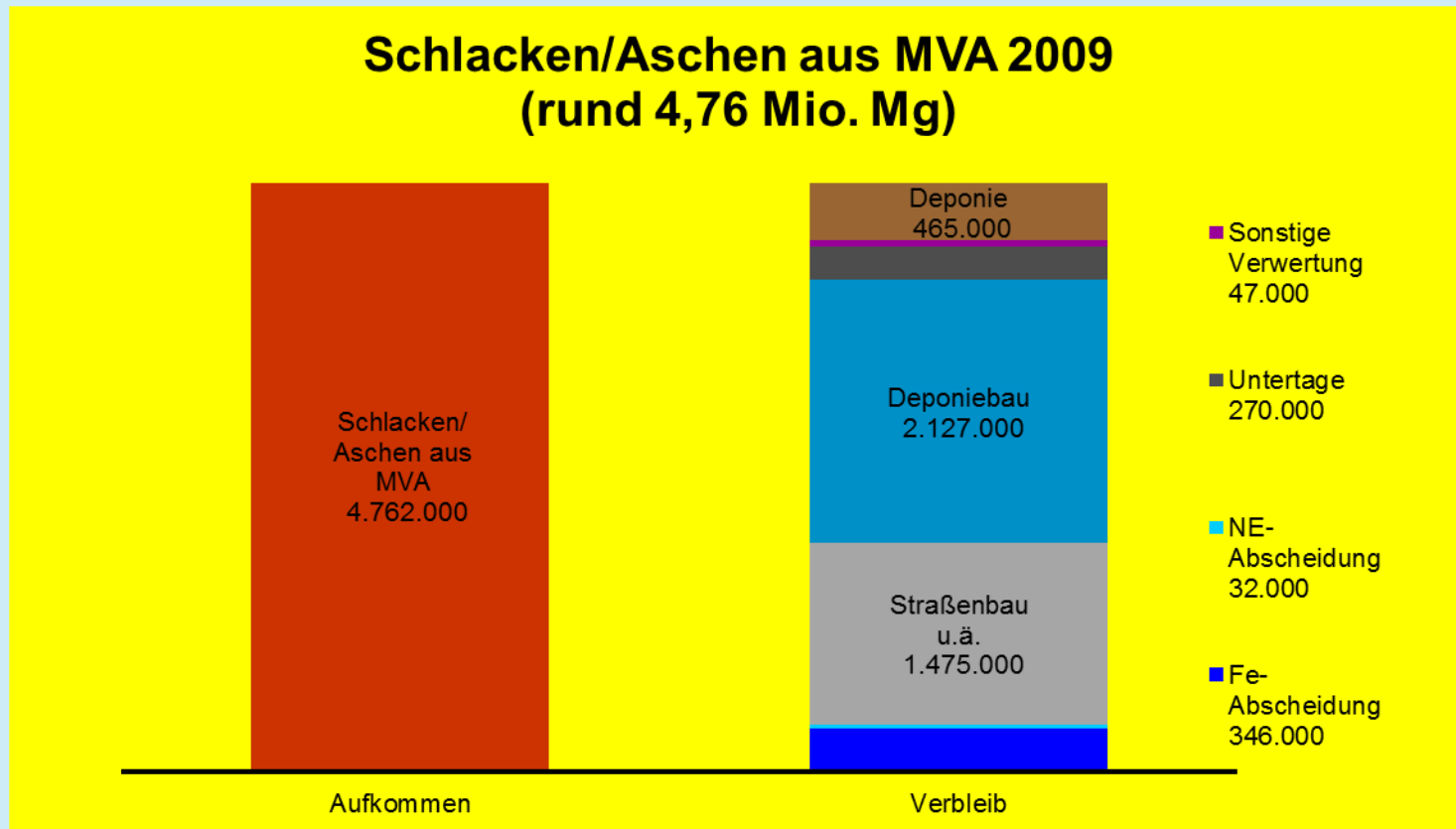
Percentage of secondary raw materials of total productions in Germany in 2009



Deike, R.: Symposium Rohstoffeffizienz und Rohstoffinnovationen, Nürnberg, 10-11.02.2011

2.RESIDUES FROM WASTE TO ENERGY PLANTS AND HOW THEY ARE USED

Total amount of bottom ash from WtE-plants and how the bottom ash is used in Germany in 2009



Data of Umweltbundesamt; Verbesserung der umweltrelevanten Qualitäten von Schlacken aus Abfallverbrennungsanlagen

As the result of the incineration process we do get due to the decarbonization of the waste, concentrates of minerals and metals in the flue ash and the bottom ash.

The recycling potentials of the metals depend on following issues:

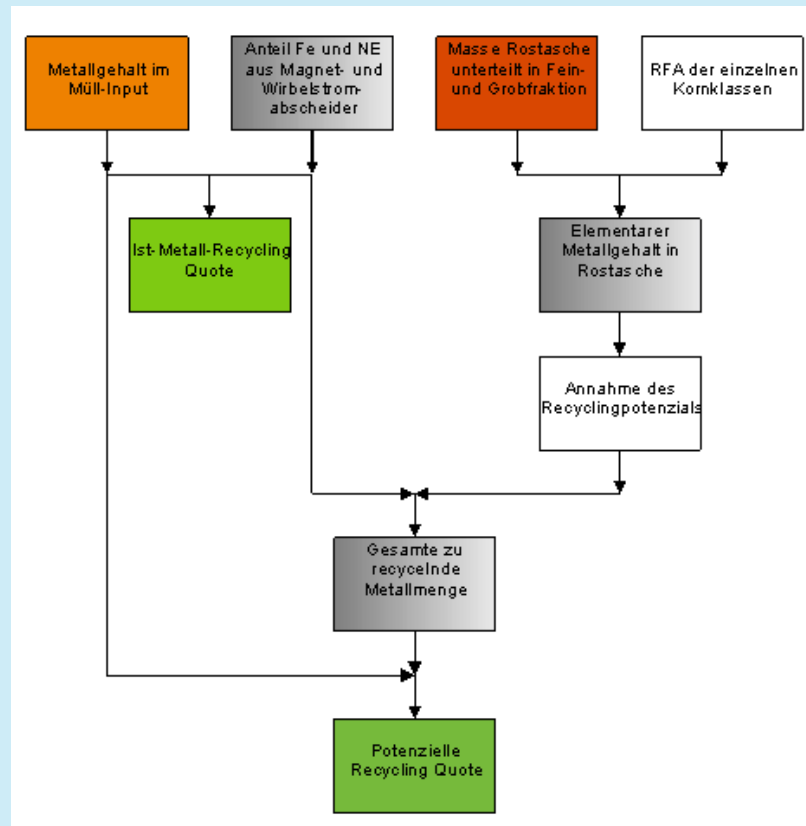
1. What differences in compositions do we have in different particle size fractions?
2. In which compositions do we have the metals in different particle size fractions?
 - Metals and alloys
 - Oxides
 - Sulfides
 - Chlorides

Average waste input composition in the catchment area of the Gemeinschaftskraftwerk Schweinfurt GmbH

	Fraktionen:	Massenanteile
		[Mas.-%, f.]
1	Feinfraktion (bis 8 mm)	10,84
2	Mittelfraktion (8 - 40 mm)	16,31
3	Organik	25,20
4	Papier, Pappe, Kartonagen	4,93
5	Hygieneprodukte	13,21
6	Kunststoffe	7,03
7	Textilien	4,13
8	Verbunde	6,41
9	Holz	0,75
10	Sonstige Abfallarten	1,94
11	Problemabfall	0,22
12	Sperrmüll	0,00
13	Glas	4,04
14	Metalle	2,34
15	Inertes	2,64
	Gesamt	100,00

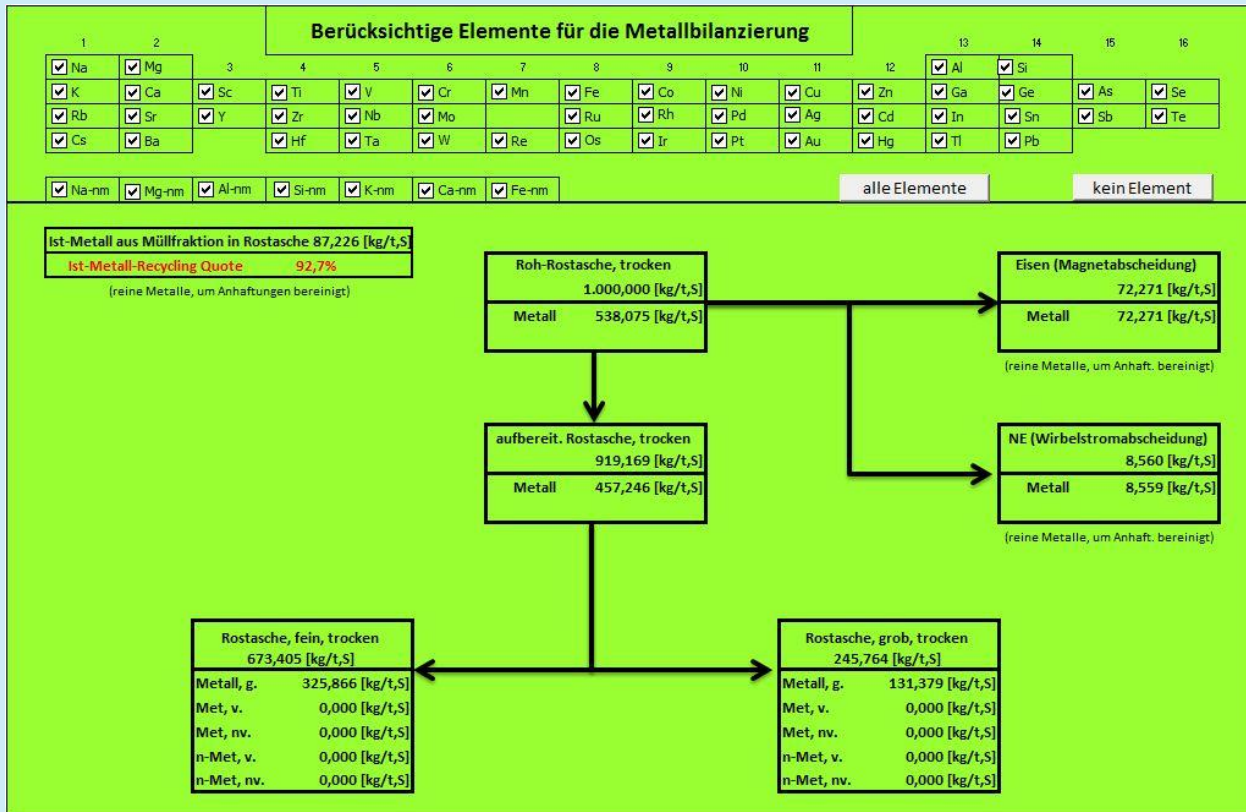
Warnecke, R.; Deike, R.; Ebert, D.; Vogell, M.: 17. Internationaler Erfahrungsaustausch für Betreiber thermischer Abfallbehandlungsanlagen „Dreiländertreffen“, Linz, 14.-16.10.12

Process to calculate actual and potential metal recycling rates from bottom ash



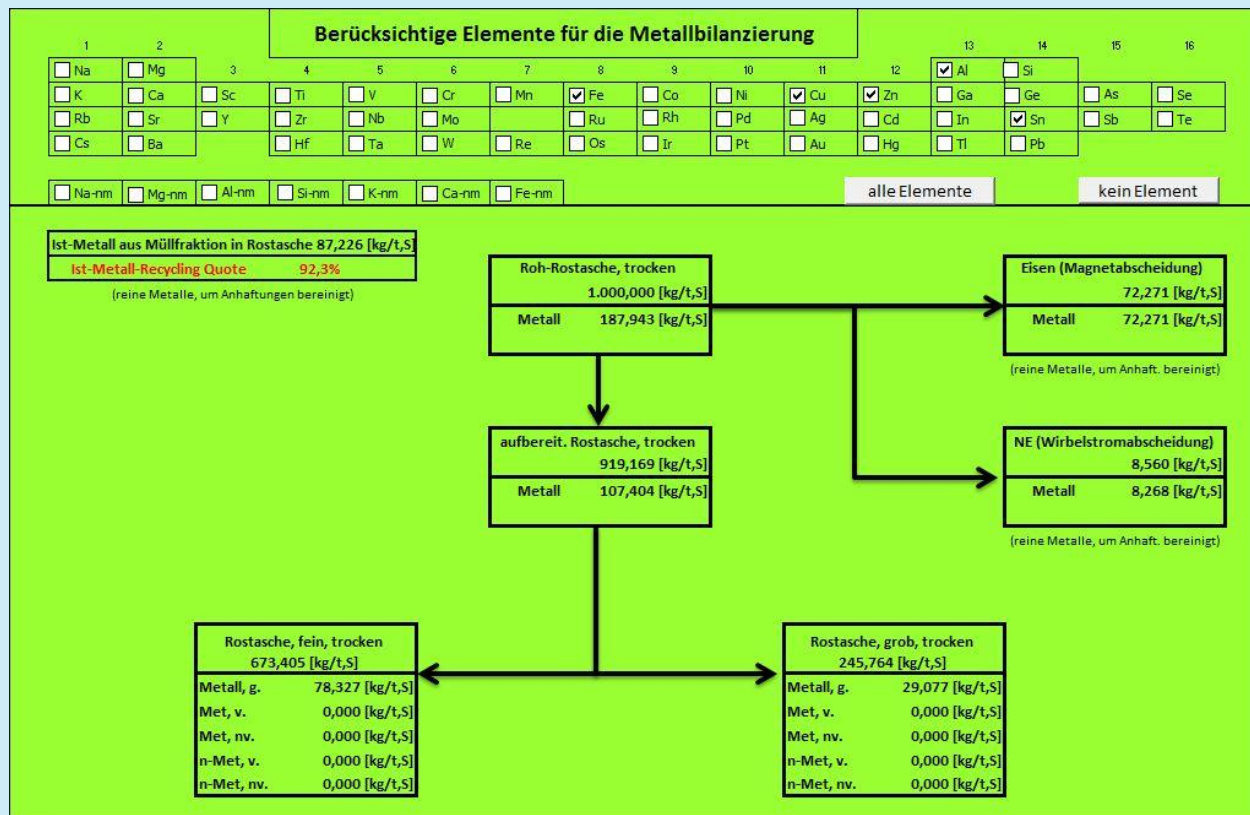
Deike, R.; Ebert, D.; Warnecke, R.; Vogell, M.: ProcessNet-Fachgruppe Jahrestagung 2012, DECHEMA-Haus, Frankfurt 20.02.2013

Metal content of bottom ash from WtE-plants and recycling rates realized with current technologies



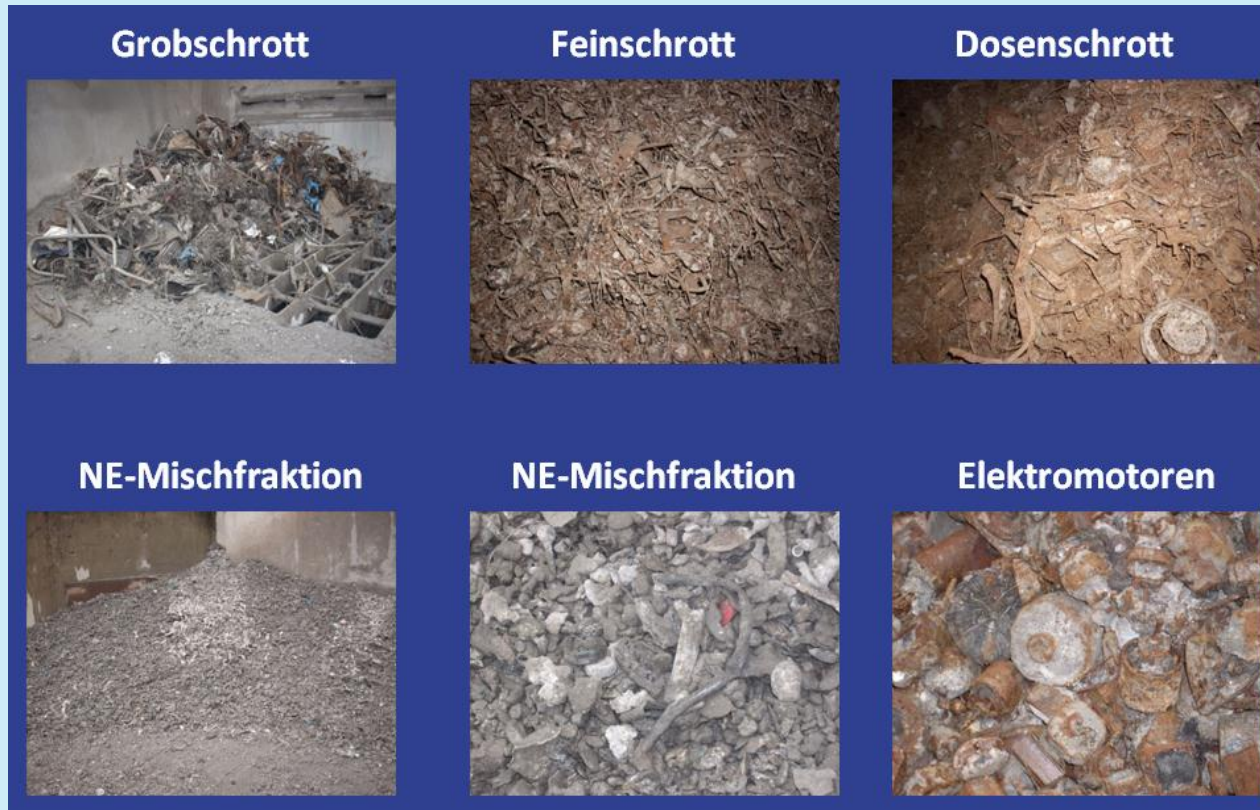
Deike, R.; Ebert, D.; Warnecke, R.; Vogell, M.: 24. VDI Fachkonferenz Thermische Abfallbehandlung, Würzburg 11.-12.10.2013

Content of five selected metals in bottom ash from WtE-plants and recycling rates realized with current technologies



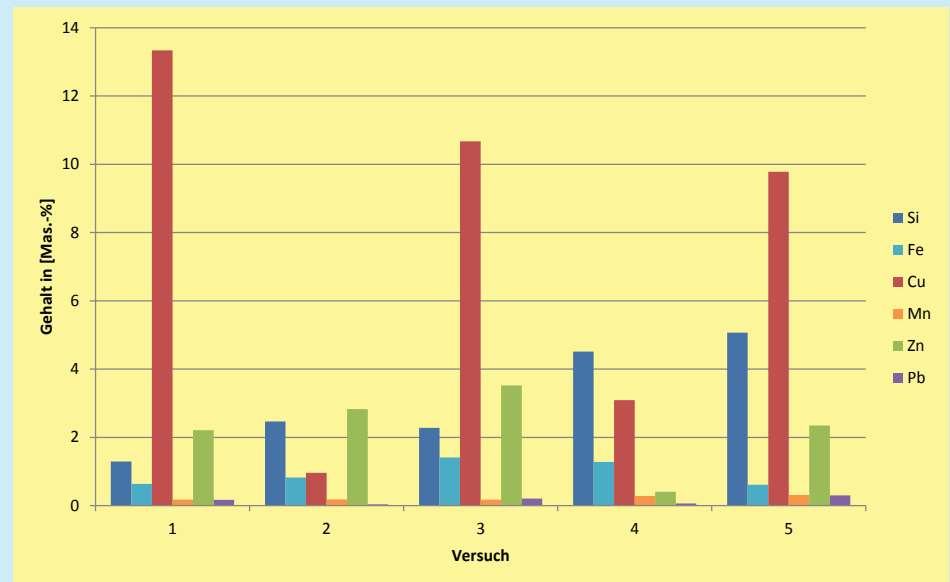
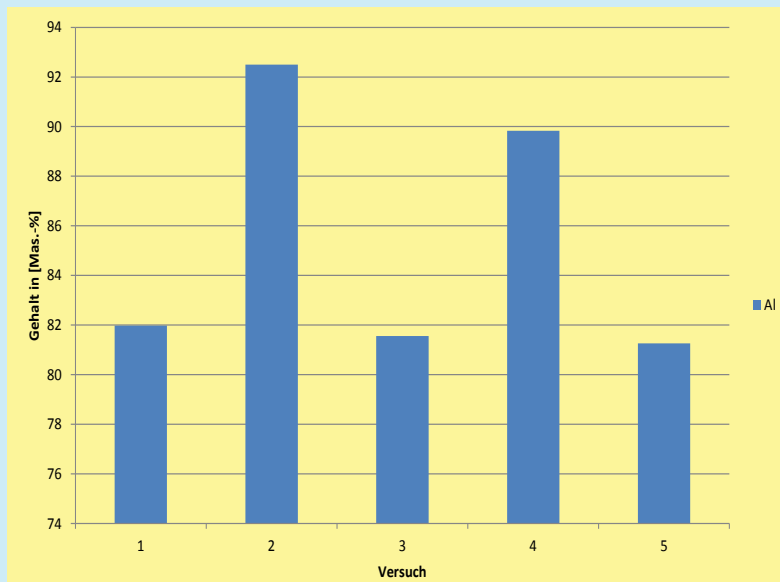
Deike, R.; Ebert, D.; Warnecke, R.; Vogell, M.: 24. VDI Fachkonferenz Thermische Abfallbehandlung, Würzburg 11.-12.10.2013

Different ferrous and non-ferrous scrap qualities already recycled from bottom ash with conventional technologies today



Deike, R.; Ebert, D.; Warnecke, R.; Vogell, M.: ProcessNet-Fachgruppe Jahrestagung 2012, DECHEMA-Haus, Frankfurt 20.02.2013

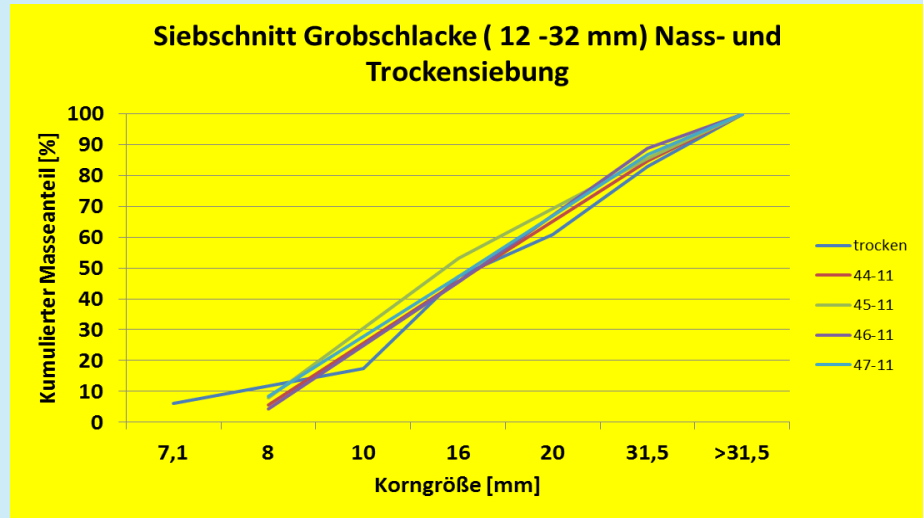
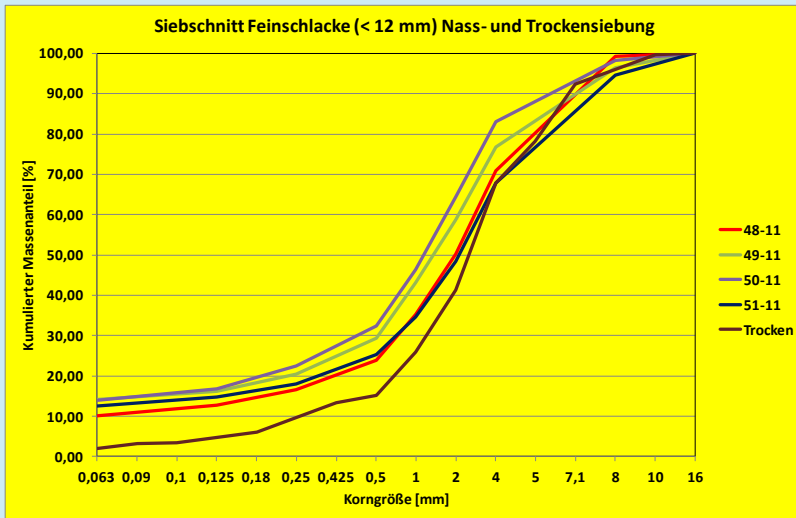
Metal contents of different ferrous and non-ferrous scrap qualities already recycled from bottom ash



Deike, R.; Ebert, D.; Warnecke, R.; Vogell, M.: ProcessNet-Fachgruppe Jahrestagung 2012, DECHEMA-Haus, Frankfurt 20.02.2013

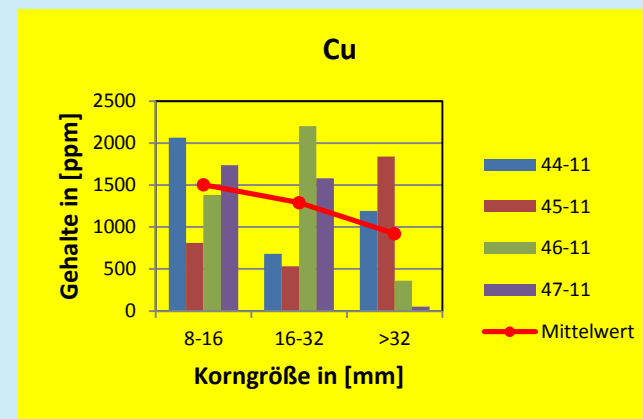
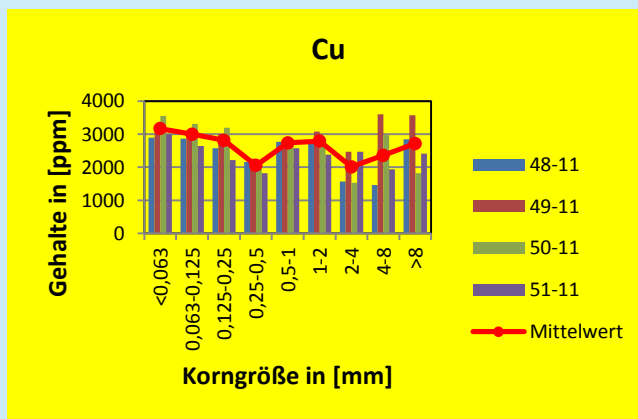
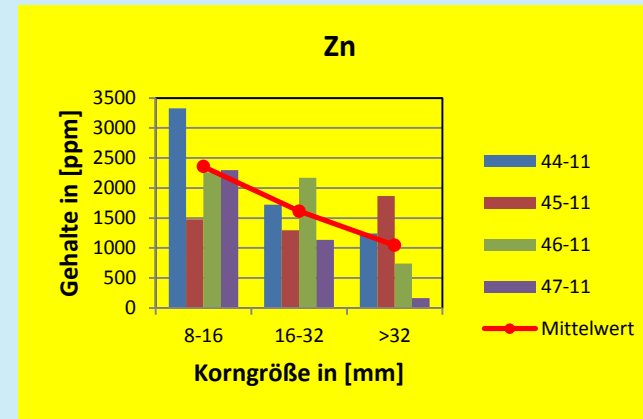
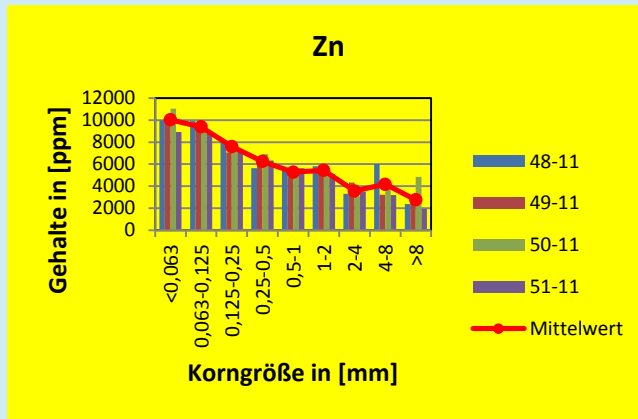
3. METAL CONTENTS IN BOTTOM ASH DEPENDING ON THE PARTICLE SIZE FRACTION

Particle size distribution curves of wet and dry sieved fine and coarse bottom ash



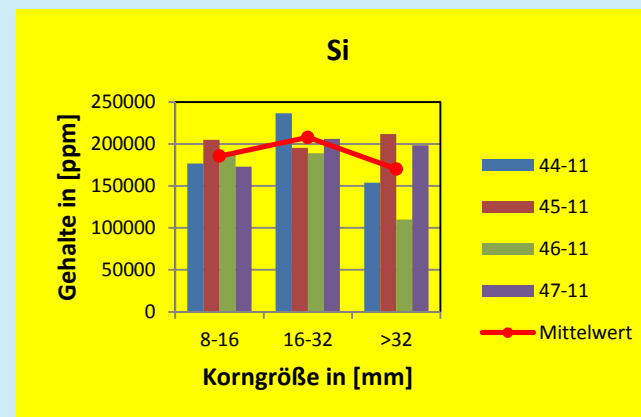
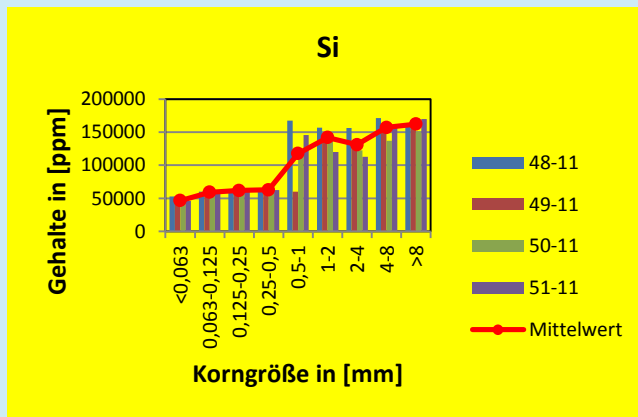
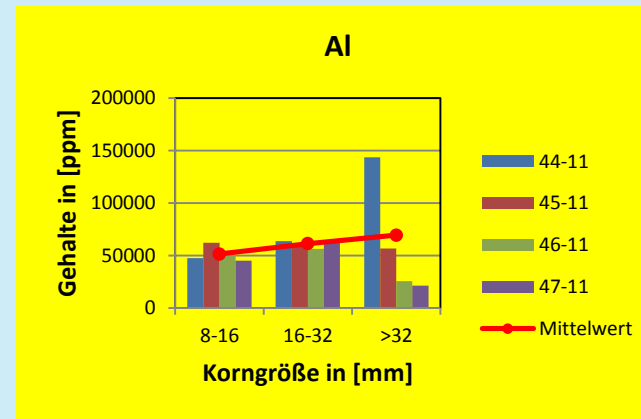
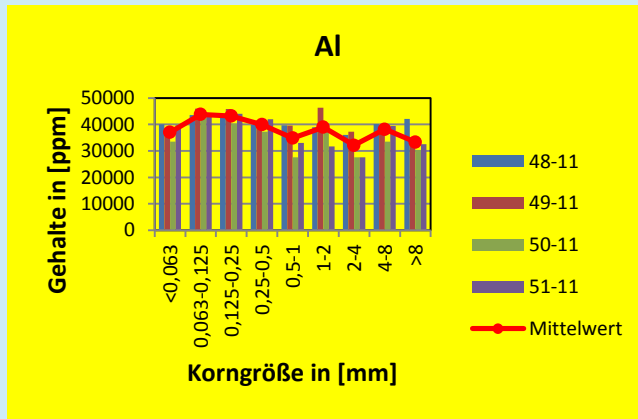
Deike, R., Ebert, D.: VGB Workshop Produkte aus der thermischen Abfallverwertung, Bleicherode, 18.04.2012

Zn- und Cu-contents according to particle size fraction



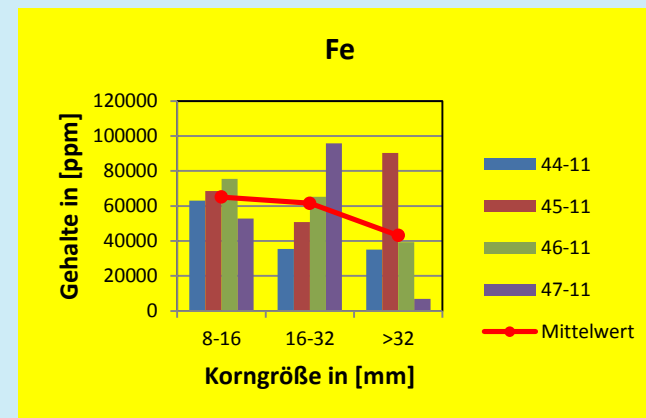
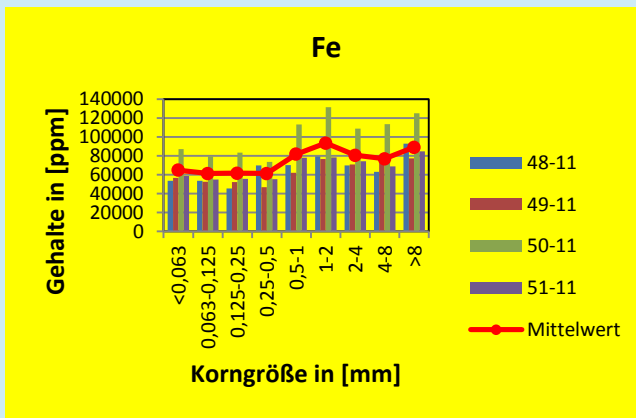
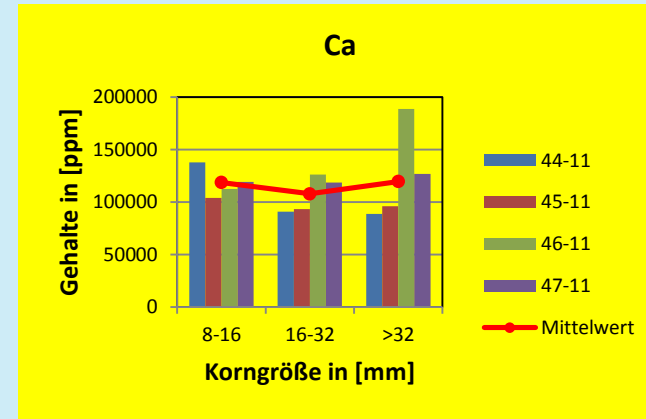
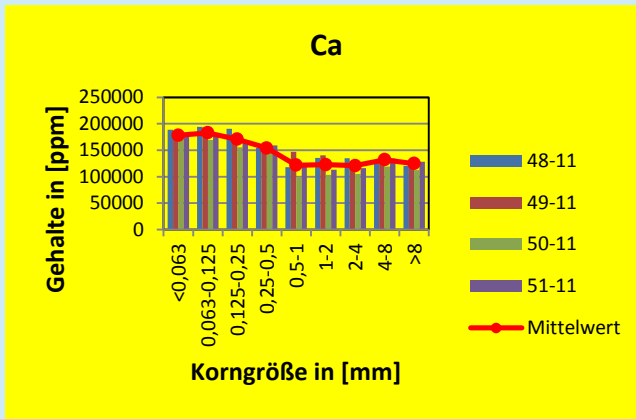
Deike, R., Ebert, D.: VGB Workshop Produkte aus der thermischen Abfallverwertung, Bleicherode, 18.04.2012

Al- and Si-contents according to particle size fraction



Deike, R., Ebert, D.: VGB Workshop Produkte aus der thermischen Abfallverwertung, Bleicherode, 18.04.2012

Ca- and Fe-contents according to particle size fraction



Deike, R., Ebert, D.: VGB Workshop Produkte aus der thermischen Abfallverwertung, Bleicherode, 18.04.2012

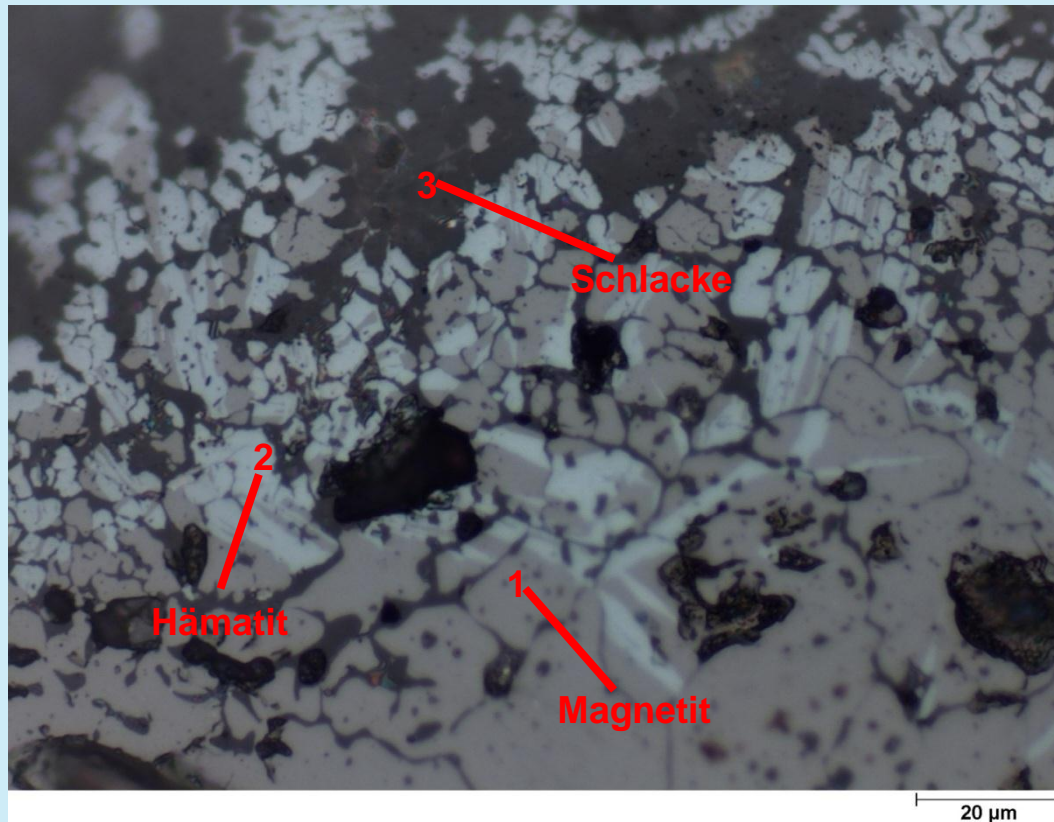
4. PHASE ANALYSIS OF DIFFERENT METAL PARTICLES IN BOTTOM ASH

3D-LM micrograph of a particle covered with an iron oxide layer



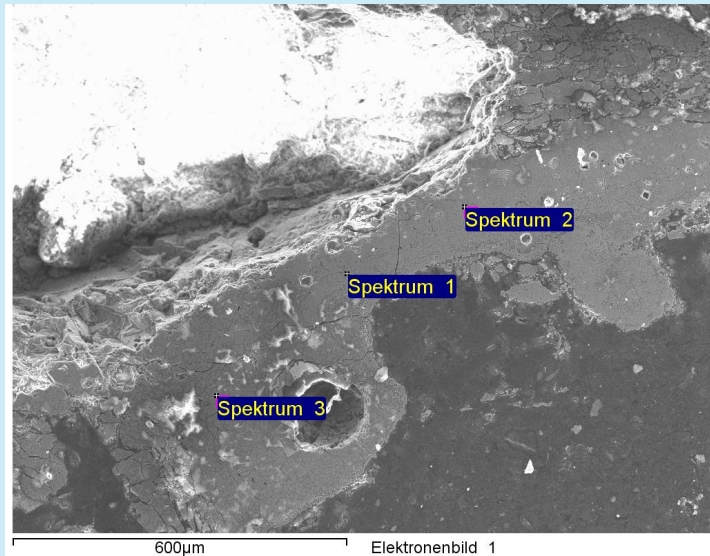
Deike, R., Ebert, D.: VGB Workshop Produkte aus der thermischen Abfallverwertung, Bleicherode, 18.04.2012

LM-micrograph with areas of hematite, magnetite and slag



Deike, R., Ebert, D.: VGB Workshop Produkte aus der thermischen Abfallverwertung, Bleicherode, 18.04.2012

SEM-micrograph with EDX-analysis in different areas of the oxide layer

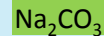
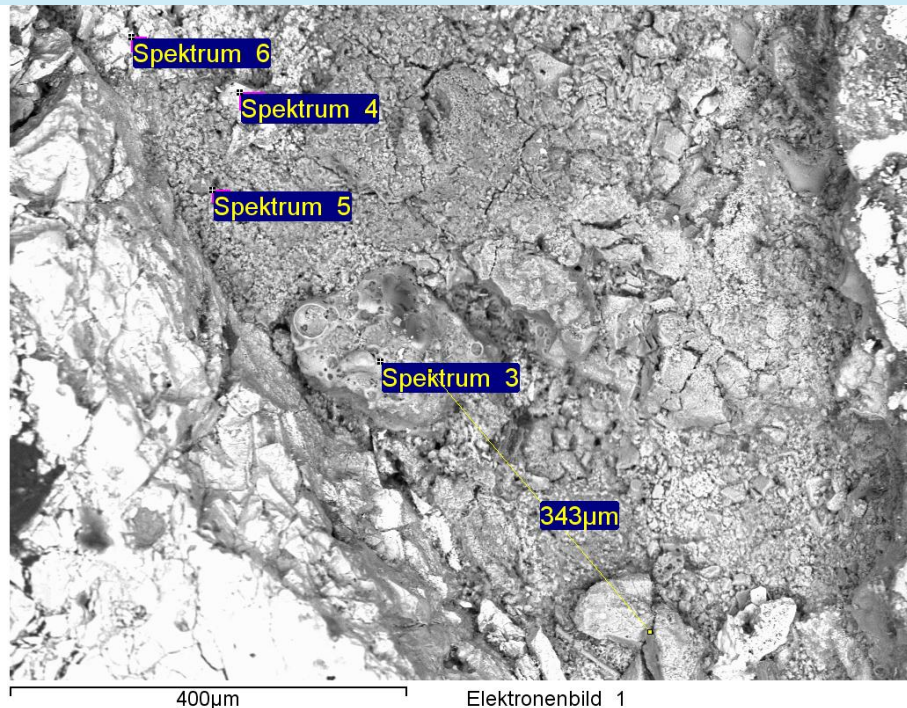


- Fe₃O₄
- Al₂O₃
- SiO₂
- CaO
- MnO
- BaO
- MgO
- ZnO
- K₂O
- Na₂O

Spektrum	C	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Mn	Fe	Ba	O theoretisch
Spektrum 1	8	35	0,5		4,2	9,7	0,3	0,4	0,3	0,5	7,4		0,6	30,8	2,4	30
Spektrum 2	2,6	35,4		0,4	1,3	7,1					4,8	0,2		48,1		29,5
Spektrum 3	8,8	34,3		0,3	1,3	6,1					4,5			44,8		27

Deike, R.; Ebert, D.; Warnecke, R.; Vogell, M.: 24. VDI Fachkonferenz, Thermische Abfallbehandlung, Würzburg, 11.-12.10. 2012

SEM-micrograph with EDX-analysis in different areas of the mineral part in the core of the particle



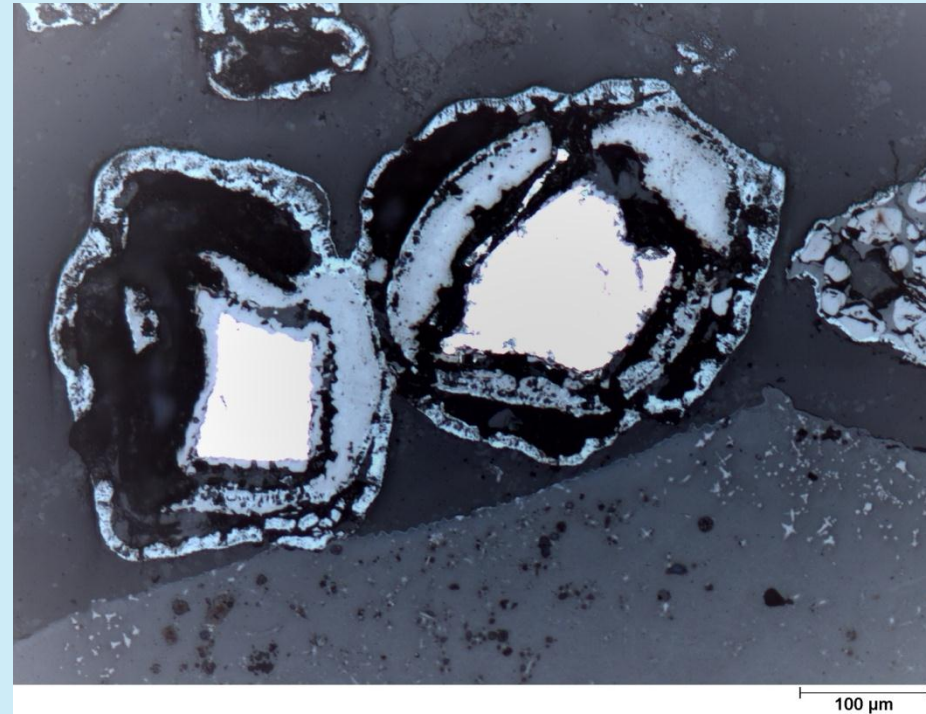
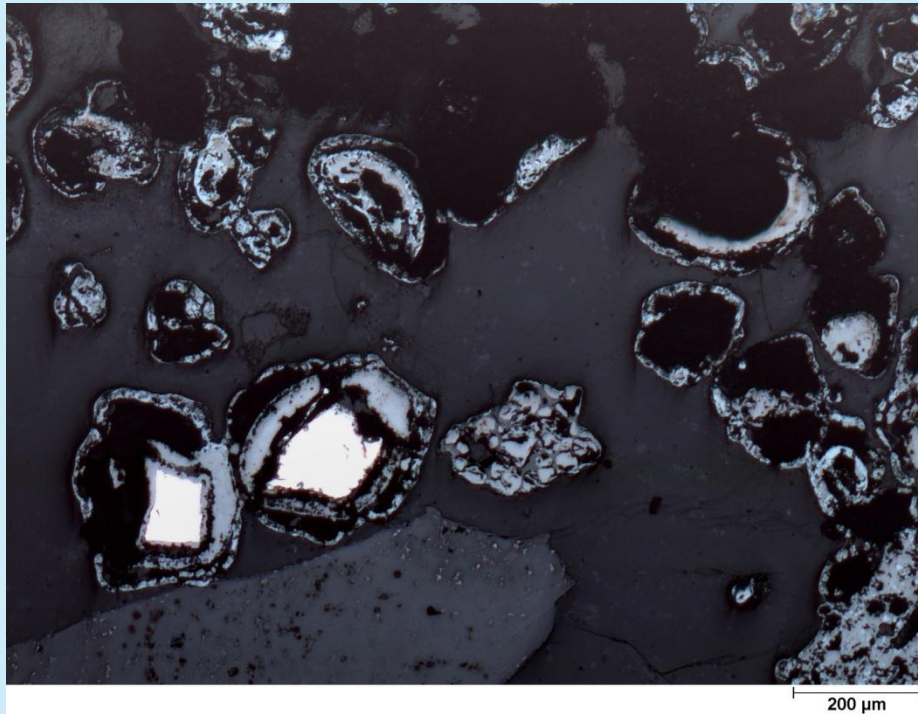
Spektrum Nr.	Sauerstoff	
	Gew.% stöchiometrisch	Gew.% gemessen
3	40,2	49
5	42,8	56,1
4	44,4	45,5
6	40,1	42,6

Spektrum Nr.	Kohlenstoff	
	Gew.% stöchiometrisch	Gew. % gemessen
3	6,3	9,2
5	9,6	5,3
4	5,5	5,6
6	7,0	4,1

Spektrum	C	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Fe	Cu	Zn	Re
Spektrum 3	9,2	49	1,2	1,3	2,4	11	1,1	3,2	0,7	0,7	16	0,5	0,3	2,19		0,66	0,11
Spektrum 5	5,3	56,1		9,1	3,1	1,1		1,6	2,2	0,2	15	2,8		2	0,7	1,72	-0,33
Spektrum 4	5,6	45,5	1,3	1,2	5,5	14		1,1	0,3	2,3	4,4	0,2		13,7		5,18	
Spektrum 6	4,1	42,6		0,5	3,5	5,1		0,5	0,2	1	2,5			27,4		12,55	

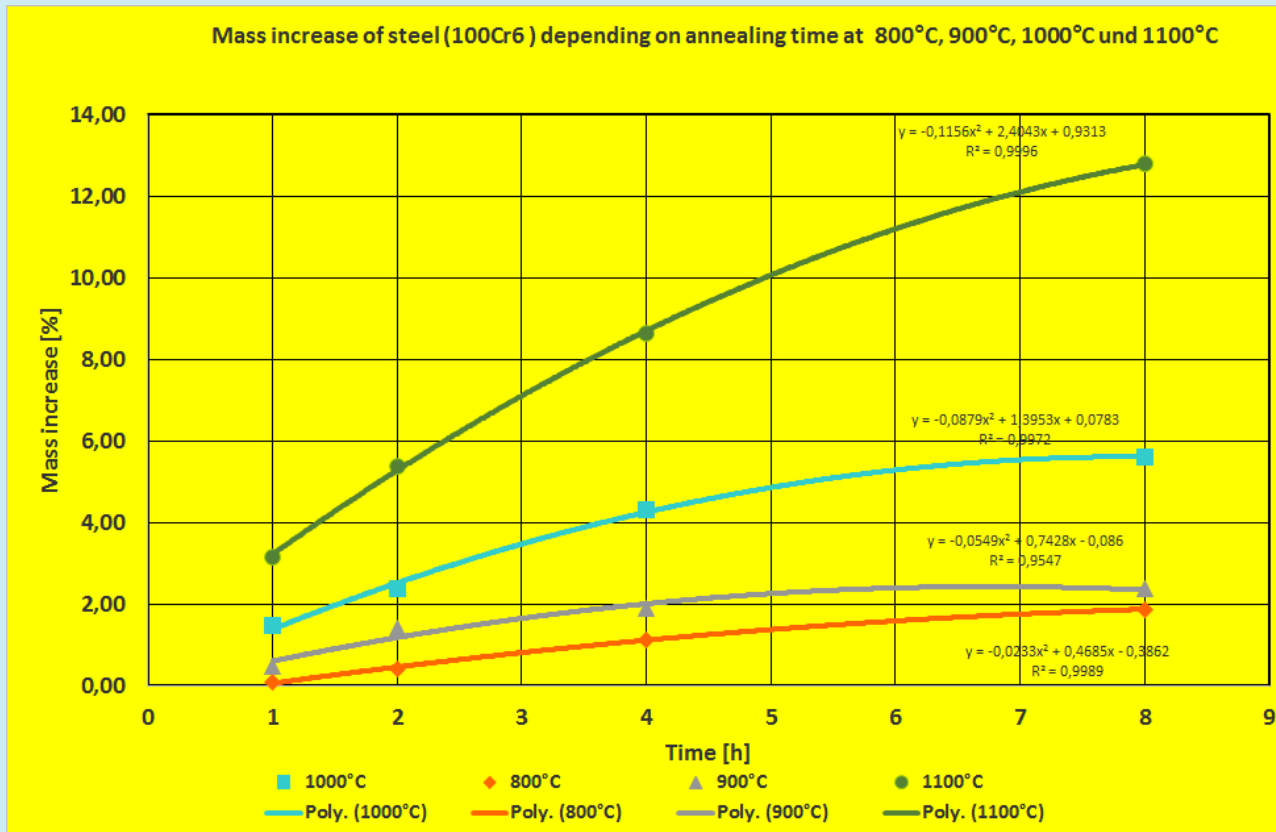
Deike, R.; Ebert, D.; Warnecke, R.; Vogell, M.: 24. VDI Fachkonferenz, Thermische Abfallbehandlung, Würzburg, 11.-12.10. 2012

LM-micrographs of oxidised iron particles at 850°C

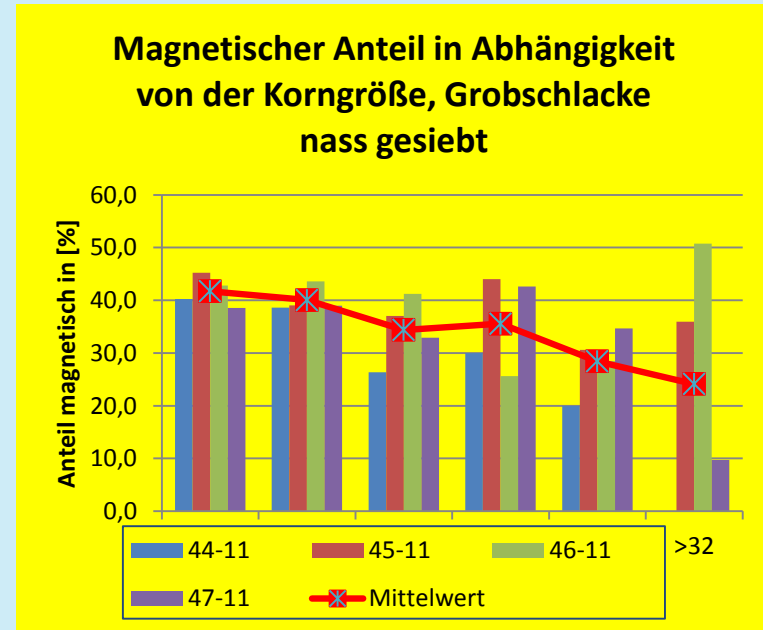
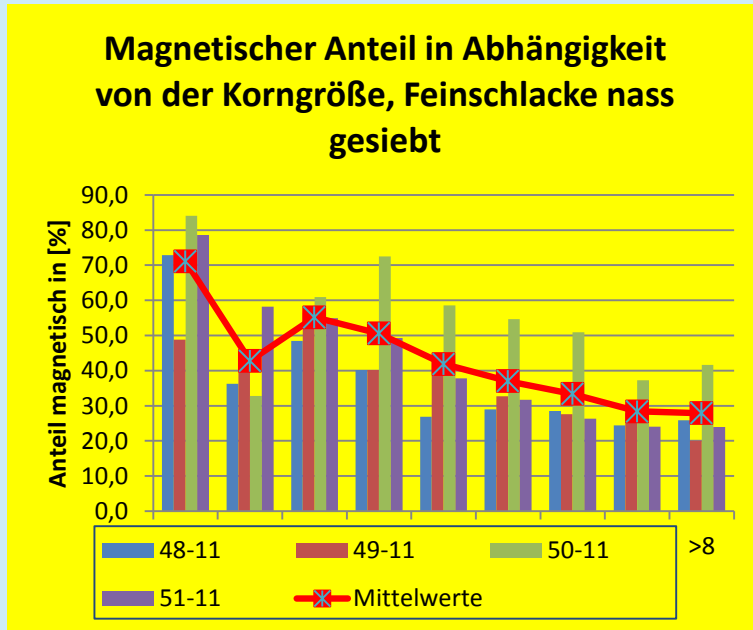


Deike, R.; Ebert, D.; Warnecke, R.; Vogell, M.: 6th CEWEP Congress 2012, Würzburg, 06.-07.0. 2012

Mass increase of steel due to oxidation at different temperatures

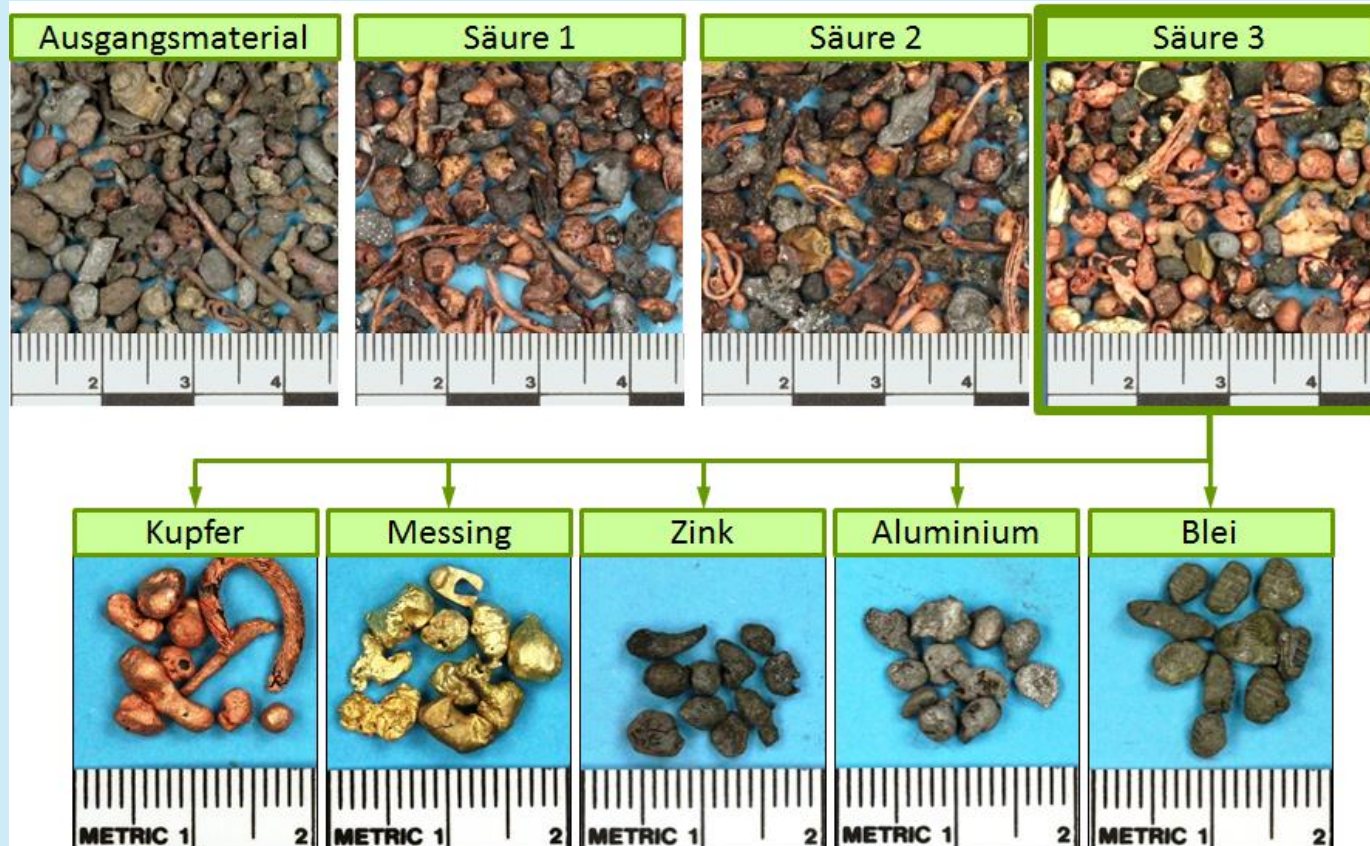


Percentages of magnetic fractions according to particle size fraction



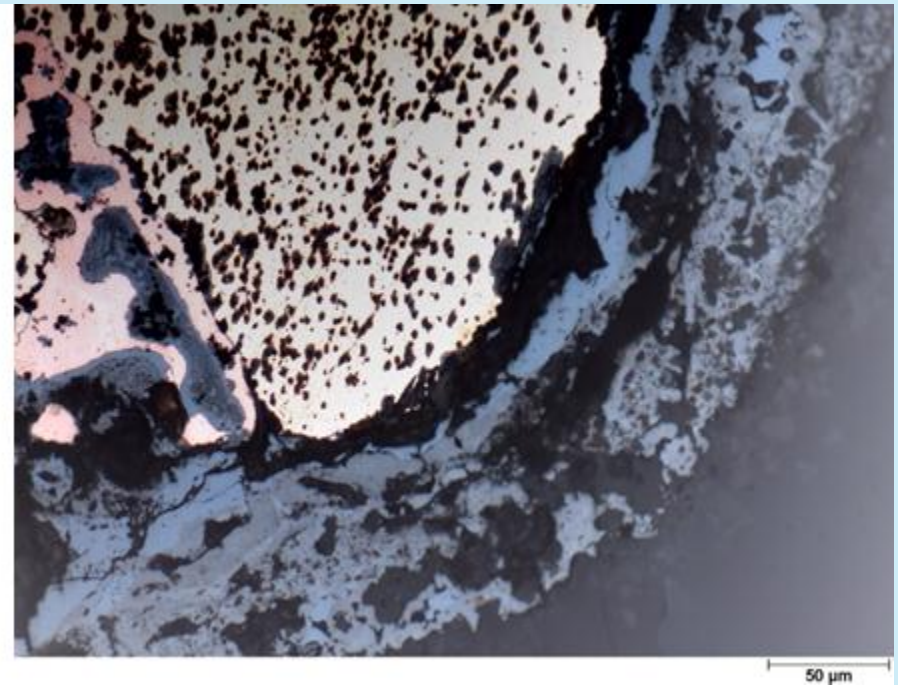
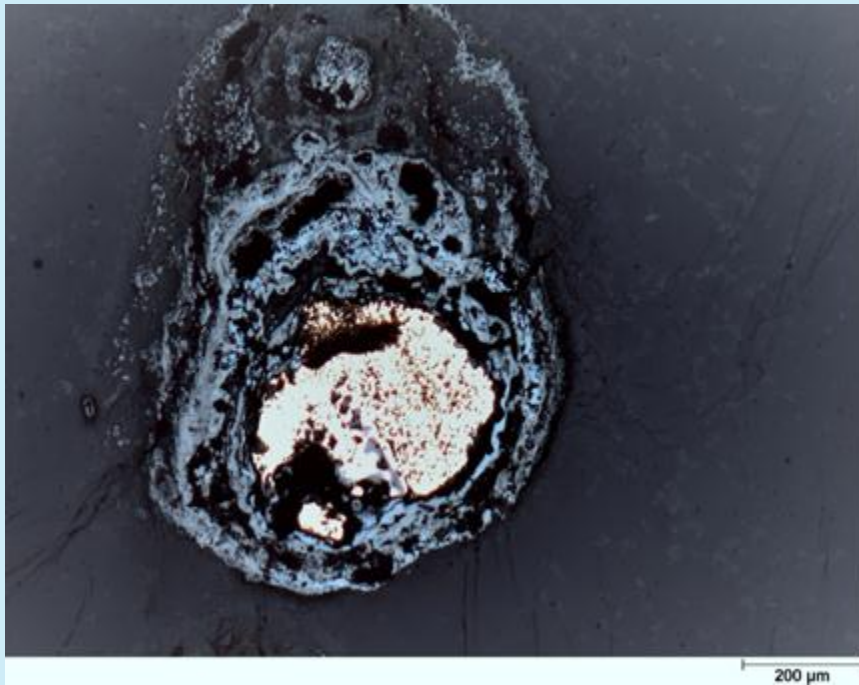
Deike, R.; Ebert, D.; Warnecke, R.; Vogell, M.: 6th CEWEP Congress 2012, Würzburg, 06.-07.0. 2012

Metal particles from dry bottom ash process



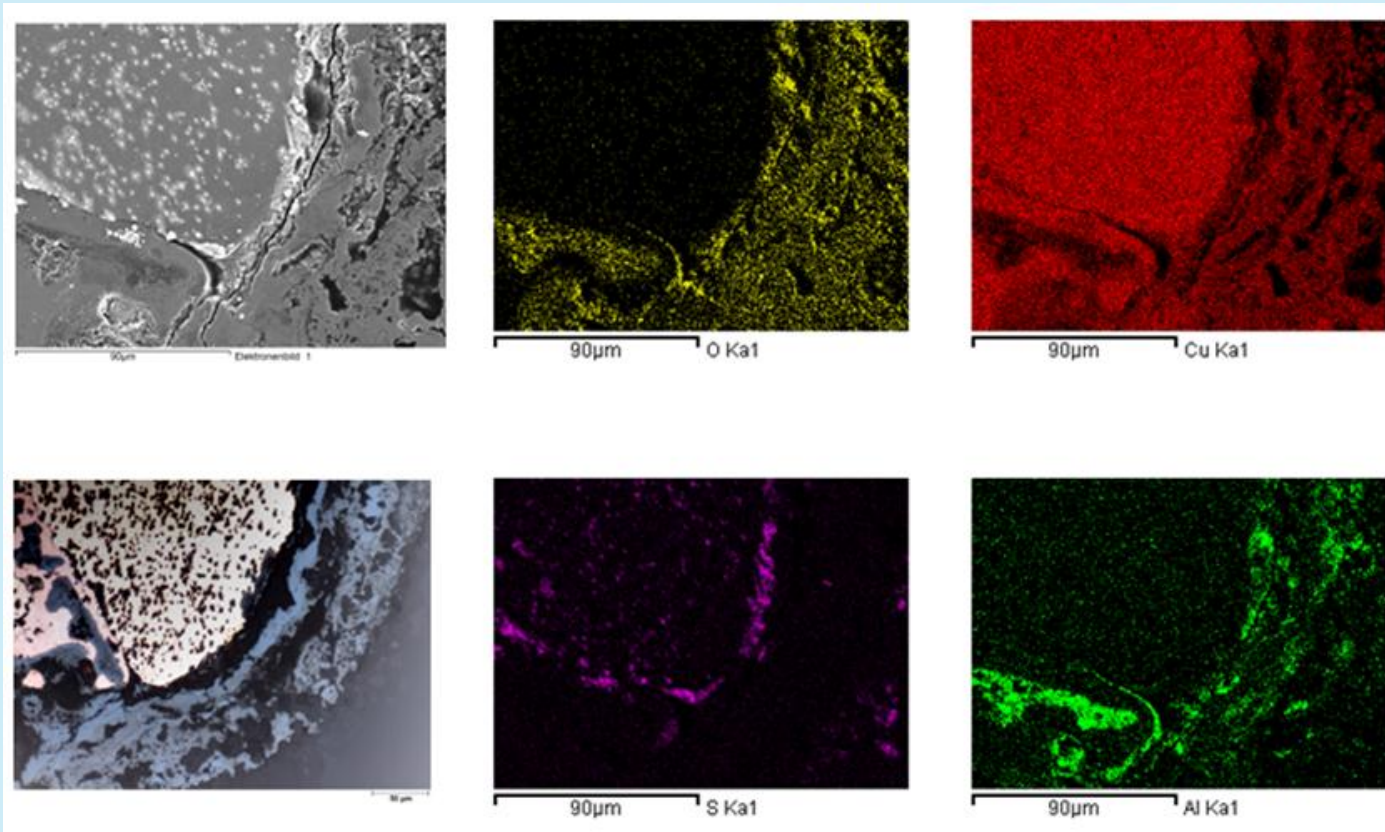
Deike, R., Brümmer, A.: *Qualitätssicherung bei der Schlackenaufbereitung – neue Herausforderung*, ZAR –Stiftung Zentrum für Nachhaltige Abfall- und Ressourcennutzung, Hinwil, 21.03.2012

Copper particle from bottom ash coated with oxide layers



Deike, R.; Ebert, D.; Warnecke, R.; Vogell, M.: 6th CEWEP Congress 2012, Würzburg, 06.-07.0. 2012

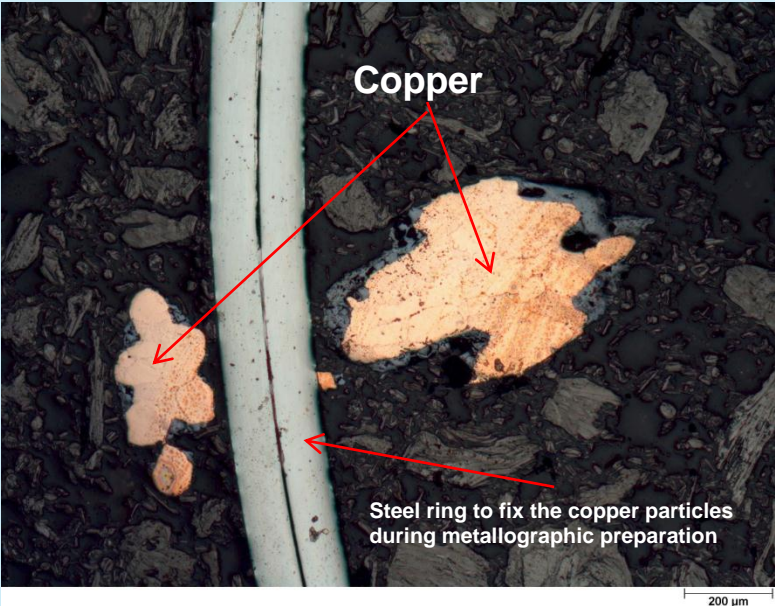
EDX-mapping of a copper particle from bottom ash coated with oxide layers



Deike, R.; Ebert, D.; Warnecke, R.; Vogell, M.: 6th CEWEP Congress 2012, Würzburg, 06.-07.0. 2012

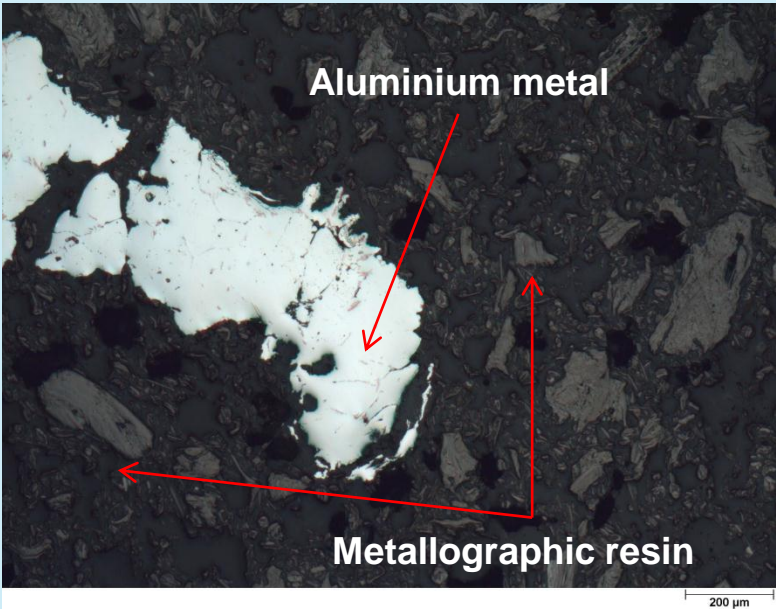
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Oxide layer structure on the surface of a small copper particle



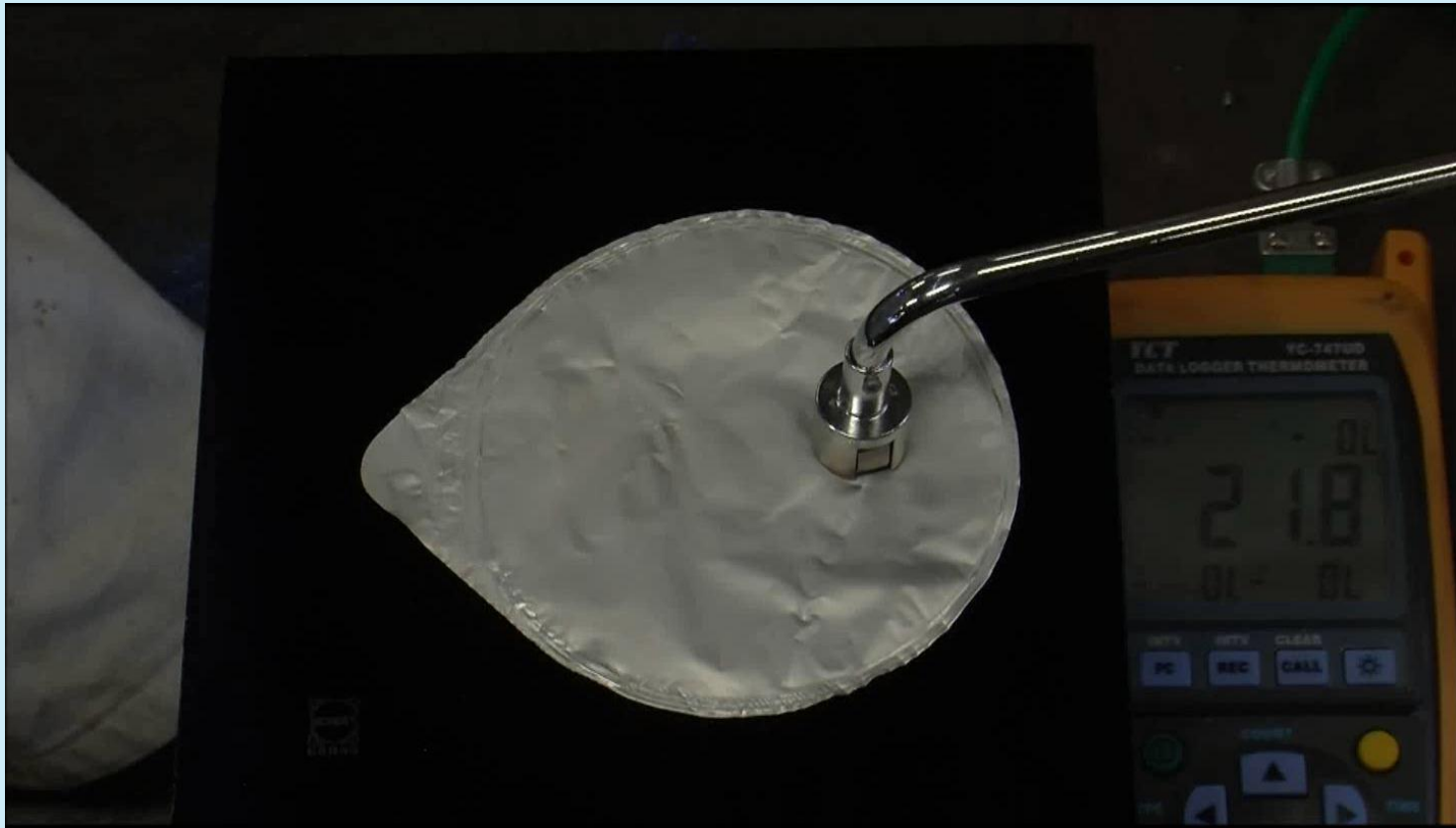
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Small aluminium particles partly coated with a slag layer and with slag inclusions

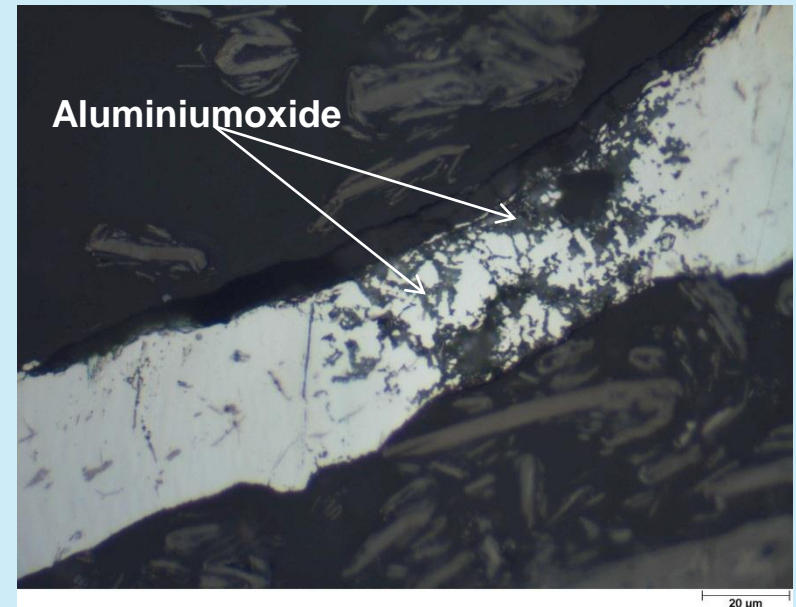
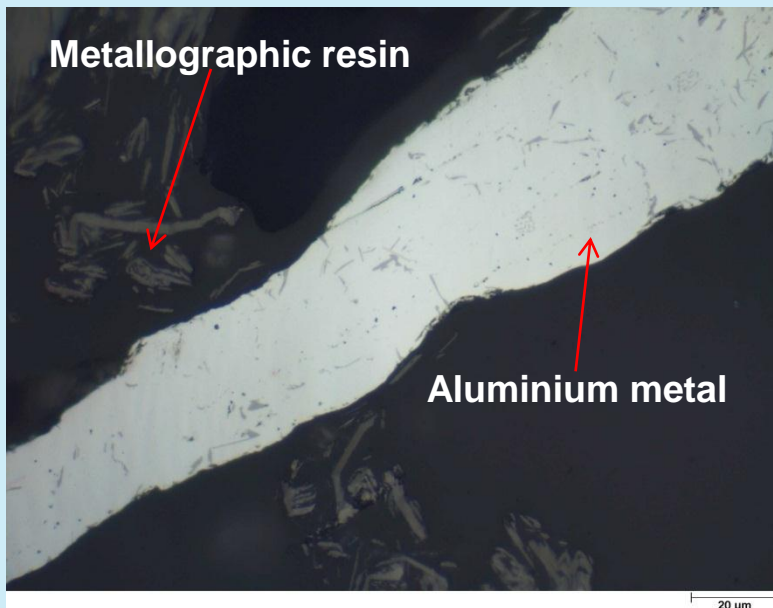


Mass increase of copper and aluminium due to oxidation at higher temperatures

The behaviour of a thin aluminium foil at temperatures beyond the melting point of aluminium (660°C)

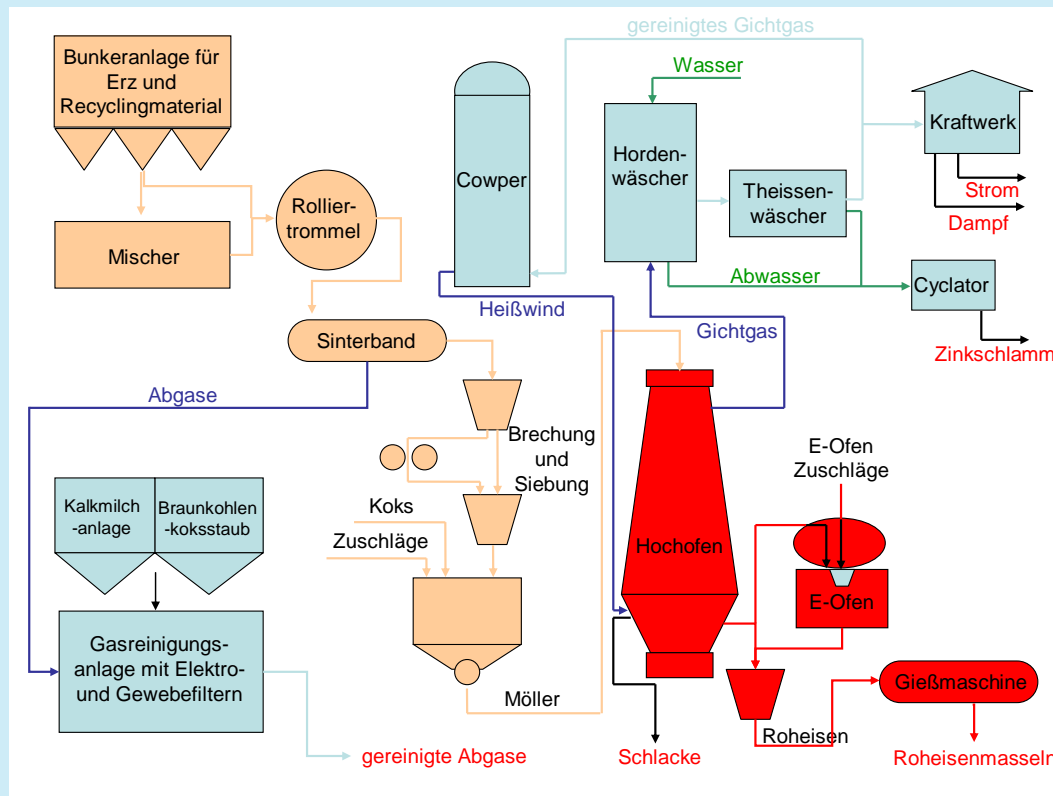


LM-micrograph of the heat treated aluminium foil with aluminiumoxide inclusions (2072°C melting point) in the destroyed area



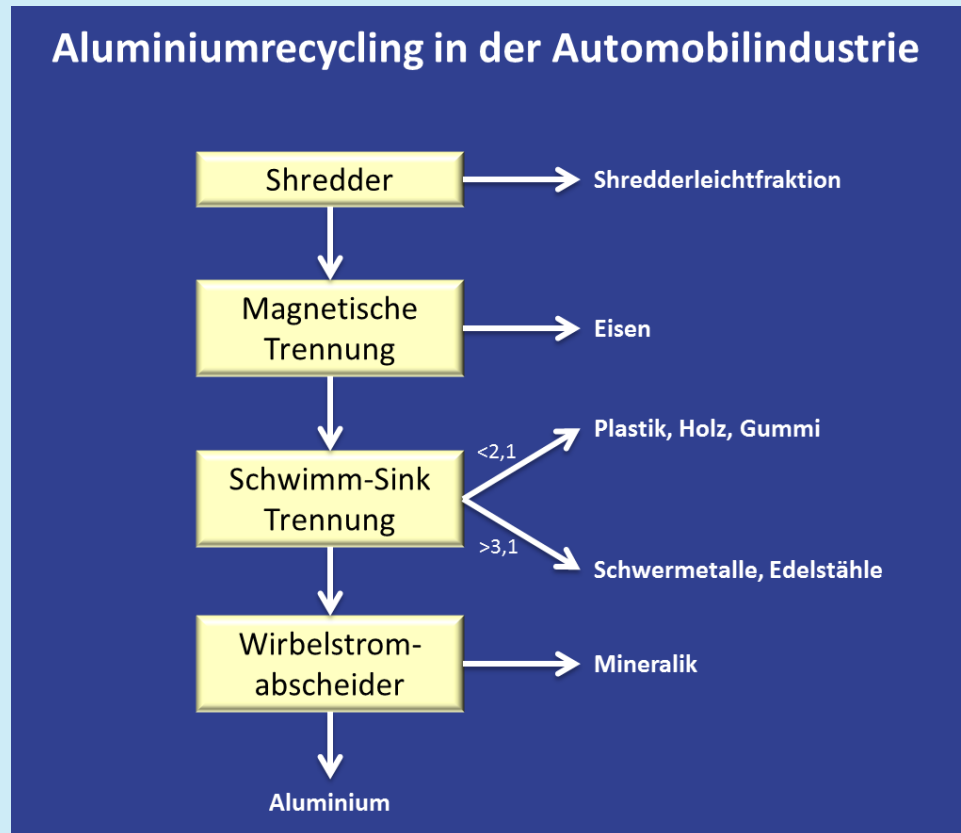
5. POSSIBLE RECYCLING PROCESSES FOR DIFFERENT METALS

Flow process chart of pig iron production from iron rich filter dusts



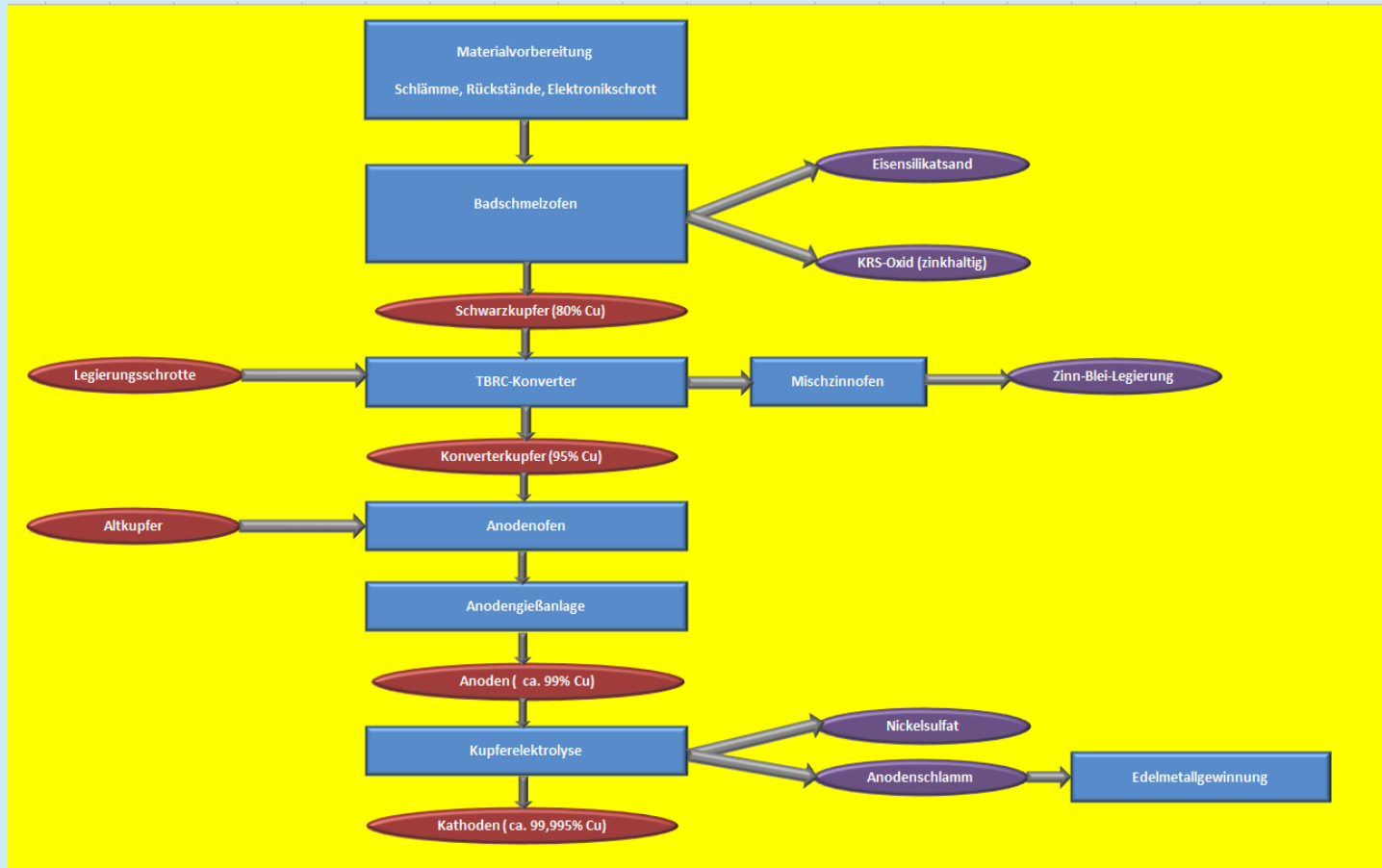
Deike, R., Dings, J.: Giesserei, vol. 94-06, pp. 198-205, 2007

Flow process chart of aluminium recycling from automotive industry



According to: Cui, J.; Roven, H.J.: Trans. Nonferrous Met. Soc. China 20 (2010) 2057-2063

Flow process chart of copper recycling



According to: Aktualisierte Umwelterklärung 2012, AURUBIS AG, Lünen, www.aurubis.com

Thank you for your attention!