Sustainability in Industrial Small Scale Mining (ISM)

J.B. Pateiro Fernández, P.N. Martens & S. Speer

Institute of Mining Engineering I

RWTH Aachen University

RWTH AACHEN UNIVERSITY

SDIMI 2007

Institute of Mining Engineering I

The project: Is Industrial Small Scale Mining a sustainable alternative? - Motivation

- Raw materials always have been acknowledged as crucial for any kind of development (paradigm):

  - Catch-up development (50s and 60s)
  - Eco-development (70s and 80s)
  - Sustainable development (80s to present)

  [- Globalisation (late 90s to present) ?]

- Still, non-renewable raw materials never have been included in these development paradigms, because:

  - non-renewable raw materials are not renewable
  - non-renewable raw materials are not substituable (to 100%)
  - non-renewable raw materials are provided only by nature
  - non-renewable raw materials' extraction means
    permanent impact on ecological systems

No strategy for the raw materials sector, only a problematization!

The project: Is Industrial Small Scale Mining a sustainable alternative? - Important existing Initiatives and Players

Raw Materials Industry:

MMSD:	The Mining, Minerals and Sustainable Development Project (since 1999)
EAA:	European Aluminium Association (since 1998)
CSI:	Cement Sustainability Initiative (since 1999)
GRI/ICMM:	Global Reporting Initiative/International Council Mining Metals (since 2003)

Politics:

Supranational:	EU	National:	Canada
	World Bank…		USA
			Australia ...

Product Stewardship: Green Lead™; MCEP: Mining Certification Evaluation Project, Kimberley Process

Eco-Concepts: Zero waste, MIPS, Ecological Rucksack, Factor 4, Factor 10, Factor X, Dematerialization…

Focus only on Large Scale Mining or Artisanal Small Scale Mining!

EXCURSUS: Sustainability according to "Brundtland"-Report

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

It contains within it two key concepts: the concept of needs, in particular the essential needs of the world's poor,to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."

WCED - World Commission on Environment and Development. (1987). Our Common Future. Oxford University Press, Great Britain.

The project: Is Industrial Small Scale Mining a sustainable alternative?
- R&D targets of the project

What about the Sustainability of Industrial Small Scale Mining (ISM)?

What is Industrial Small Scale Mining?

What is the actual or potential contribution of ISM to Sustainable Development?

Is ISM a viable and sustainable alternative to LSM and ASM?

Tasks:

- Definition of Industrial Small Scale Mining
- Assessment and Analysis of existing ISM operations
- Assessment and Analysis of reserves suitable for ISM
- Development of "the" sustainable ISM operations
- Development of Sustainability Indicators for ISM
- Development of a Sustainability Assessment System for ISM

} Initial Research on Gold mining

Definition of ISM vs Artisanal Small Scale Mining Operations

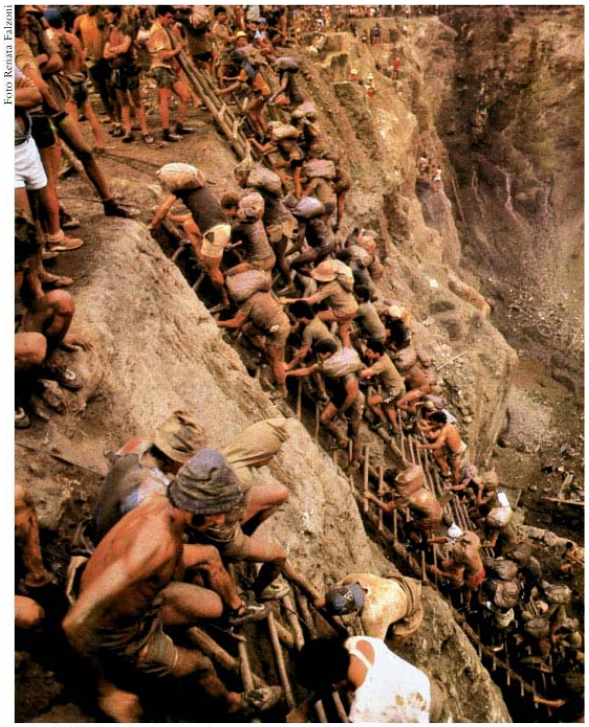
- Mostly Small Scale Mining is used conterminously with "Artisanal and Small-Scale Mining" (ASM)

- There is no acknowledged definition for ASM

- In „small scale mining" operations commonly less than 50 persons per operation are employed, in some uncommon cases also some thousand (e.g. the "Garimpeiros" in Brazil).

- "Operations without
  - license or official control
  - occupational safety
  - environmental standards." *(Hentschel, 2002; Wetzenstein, 2002)*

- Poorly mechanized and not using modern production technologies and methods



Trabalhadores na mina de ouro de Serra Pelada, Pará.

Source: www.scielo.br, 2007

Definition of ISM vs ASM, MSM and LSM

Medium-Scale Mining (MSM) is rarely used in literature.
It is describes “private” mining operations that are licensed by or at least declared to official authorities (e.g. in India). In Chile mining operations with a ROM (run of mine production) of up to 2.000 t per day are defined as “Medium-Scale Mining” operations.

Large-Scale Mining (LSM) is used as self-explaining term.

Initial working hypothesis/defintion for ISM:

Industrial Small Scale Mining refers to high technology or
highly mechanized/automated extraction
of small, high-grade deposits that due to their small size
– in combination with geological, depth and other constraints –
are not economically exploitable with large-scale mining operations.

Definition of ISM vs SME-Definitions

SME definition by EC (DG Enterprise, 2007)

Enterprise category	Head-count	Turnover or	Balance sheet total
medium-sized	< 250	≤ € 50 million	≤ € 43 million
small	< 50	≤ € 10 million	≤ € 10 million
micro	< 10	≤ € 2 million	≤ 2 million

Current project-result for ISM:

In-depth assessment of small and medium-sized gold mining companies showed that a maximum number of 200 employees for ISM operations is a characteristic figure.

Definition of ISM: Criteria

- Equipment Productivity (EP) defined as quotient of daily production and installed power, measured in t/kW
- Available Equipment (AE) defined as installed power per worker (WF), measured in kW/WF
- Absolute installed Power (P), measured in kW
- Run-of-Mine (ROM), measured in t/d oder t/a
- Feed, measured in t/d oder t/a
- Existing legal license [Yes/No-Criterion]
- Investment Volume (without beneficiation), measured in Euro
- Exploration and reserves calculation

Definition of ISM: Correlation between Productivity, Equipment and Power

$$WP = AE * EP$$

WP = Work Productivity, t/WF
EP = Equipment Productivity, in t/kW
AE = Available Equipment, in kW/WF

Work productivity correlates at least in principle with the available equipment.
Example: German lignite operations

Year	1888	2001
Installed Power of equipment used	3 kW per worker	300 kW per worker
Work productivity	3-4 t per manshift	200-300 t per manshift

Definition of ISM operations on Gold

	Delimitation ISM to ASM	Delimitation ISM to LSM	Necessary/ Sufficient
Exploration and reserves calculation	Yes	Not applicable	Necessary
Legal License [yes/no]	Yes	Not applicable	Necessary
Needed degree of performance in the following criteria	At least one of the following criteria accomplished	At least two of the following criteria accomplished	
Absolute installed Power	$\geq$ 1.000 kW	$\leq$ 7.000 kW	Sufficient
Available Equipment (AE)	$\geq$ 20 kW/WF	$\leq$ 65 kW/WF	Sufficient
Equipment Productivity (EP)	Not applicable	$\leq$ 0,65 t/kW	Sufficient
ROM or FEED	Not applicable	$\leq$ 2.000 t/d or 600.000 t/a	Sufficient
No. of Workers (WF)	Not applicable	$\leq$ 200	Sufficient
Investment Volume (without beneficiation)	Not applicable	UG: $\leq$ 25 Mio. € O/P: $\leq$ 4,6 Mio. €	Sufficient

Developing a sustainable ISM operation

Based on a large number of case studies 27 ISM operation models were developed, comprehending ROM figures from 200 t/d to 14.000 t/d.

Criteria for the selection of appropriate mining method:

- Easy to mechanise
- Low initial investment
- Short payback period
- Low operational costs
- Selective mining
- Flexible in mining operation
- Individual mining processes can be separated
- Suitable for low production rates
- Suitable for broad range of production rates
- High productivity
- Suitable for backfill to reduce risc of subsidiences…

Developing a sustainable ISM operation

Example: Block Caving

not suitable for low production rate
non-selective mining
high initial investment

Not suitable for ISM:

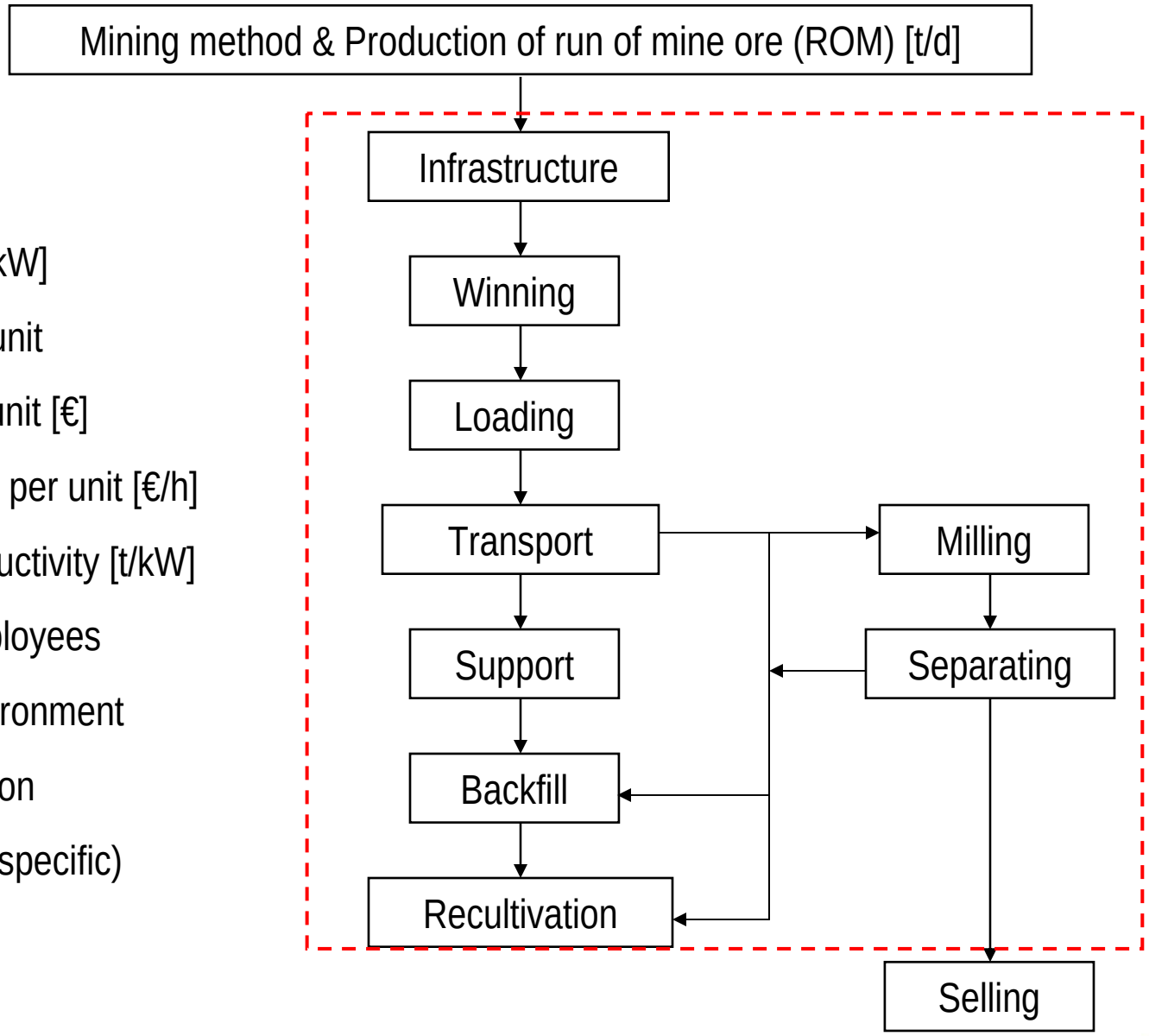
overhand stoping	difficult mechanisation
underhand stoping	difficult mechanisation
longwall mining	investment, flexibility
block caving	investment, selectivity, not for low production rate

Preferabe for ISM:

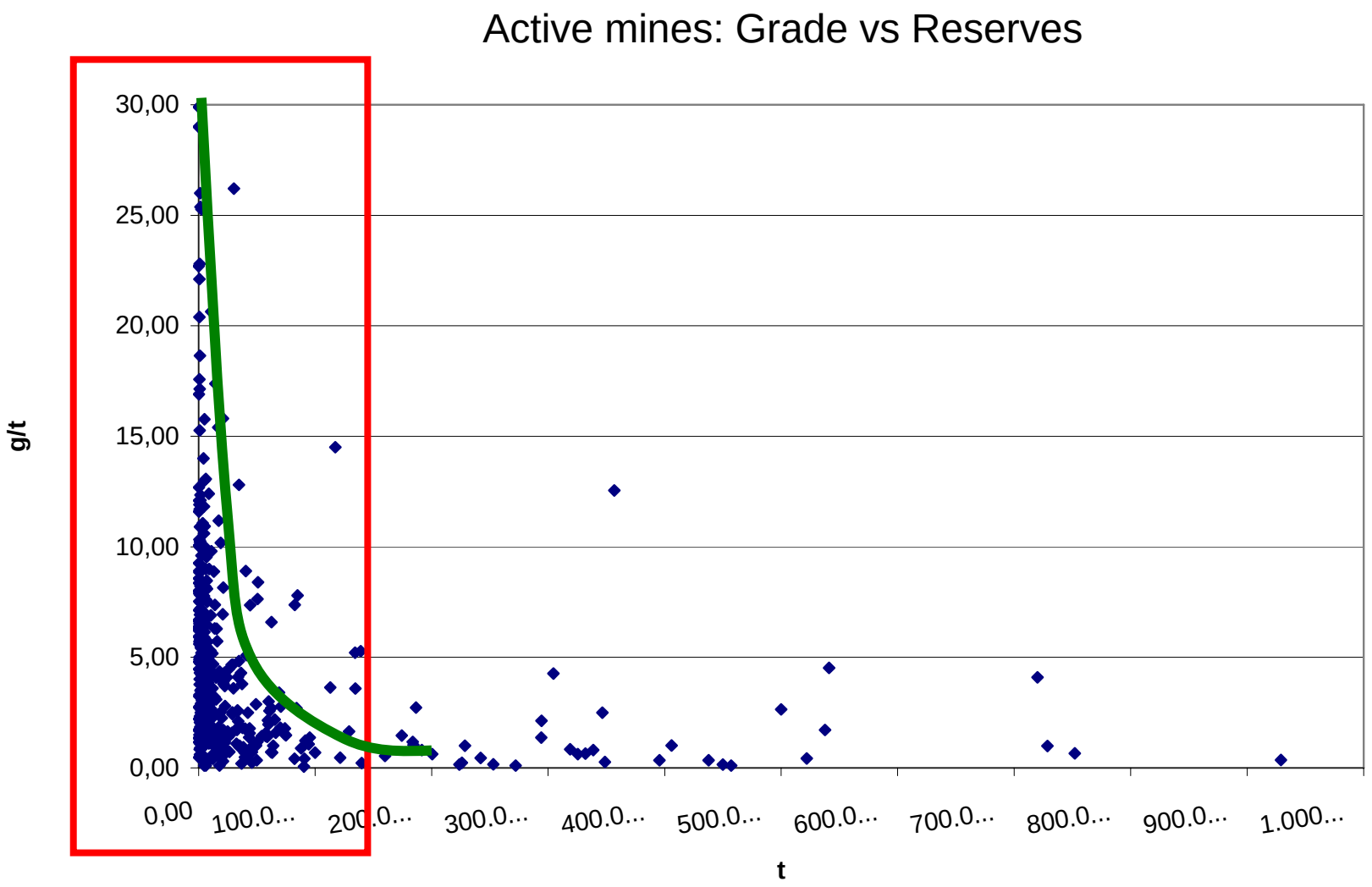
Vertical Crater Retreat Mining	scalability, efficiency
Cut & Fill	selectivity
Narrow-Vein-Mining	per se
Room/Stope & Pillar (adapted for backfill)	immediate cash flow

Developing a sustainable ISM operation: process chain analysis

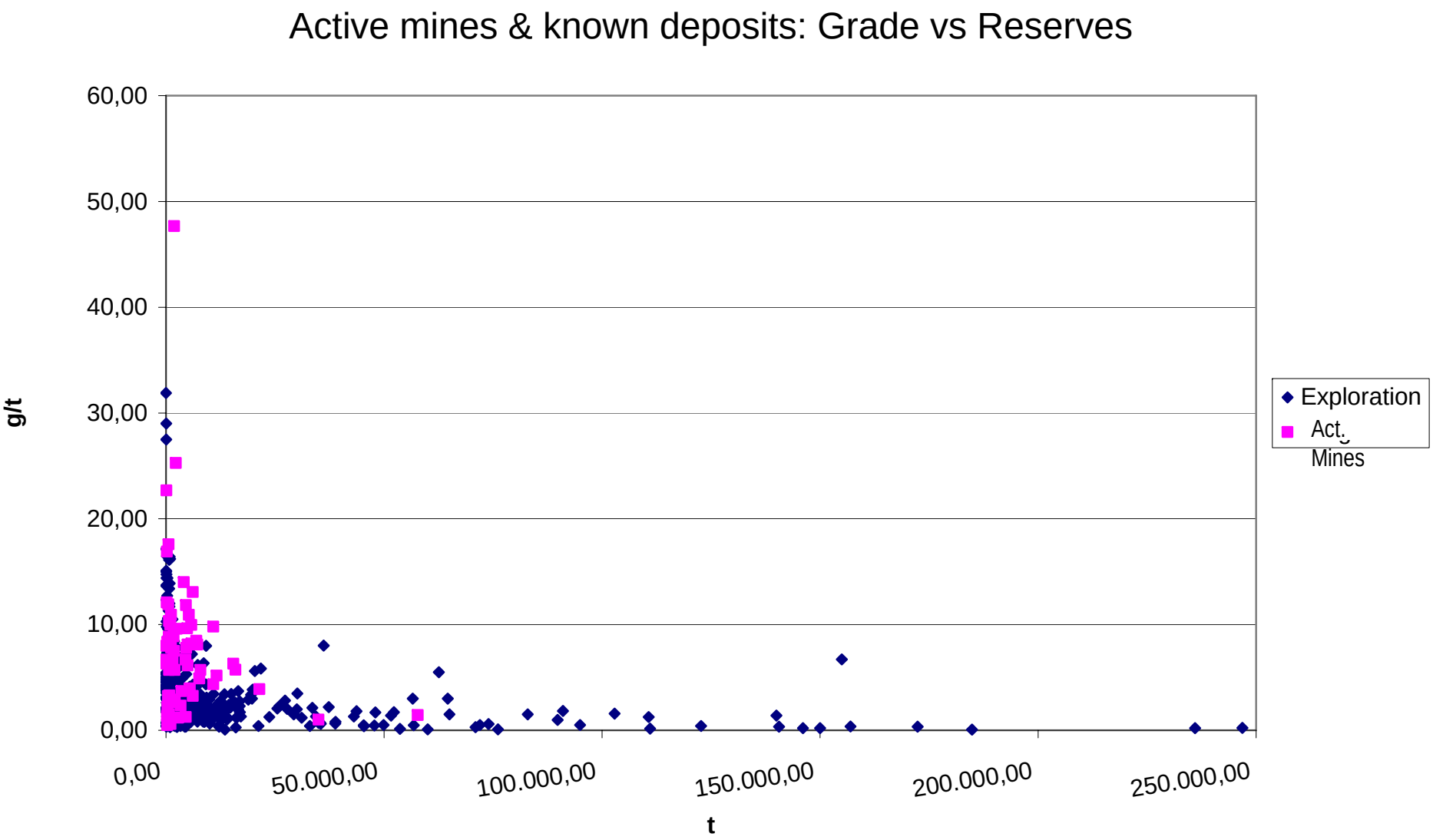
- Number of units
- Power per unit [kW]
- Employees per unit
- Investment per unit [€]
- Operational cost per unit [€/h]
- Equipment Productivity [t/kW]
- Hazards for employees
- Hazards for environment
- Waterconsumption
- and other (case specific)



Assessment and Analysis of reserves suitable for ISM operations



Assessment and Analysis of reserves suitable for ISM operations



Development of Sustainability Indicators for ISM operations

Environmental indicators

Land use
Water use
Percentage of recycled water
Energy use
Emission into air – Green House Gases
Emission into air – Non-Green House Gases
Emission into water – weighted
Voluntary investments into environmental projects
Reclamation and rehabilitation provision

Social indicators

Employment
Wages
Annual vacation
Working hours
Voluntary benefits for employees
Injuries
Occupational health, safety and environment
Resettled inhabitants
Child labour
Voluntary expenditures for social projects

Economical indicators

Production
Economic performance
Rate of return
Investment into assets
Investment into R&D and exploration
Taxes
Transport Distance (Extraction to Processing)
Annual level of damages to public infrastructure caused by mining
Percentage of infrastructure damages remunerated by the mining company
Provision for future infrastructure damages and for rehabilitation

Questions, Comments, Contact

German Reseach Foundation
of Economics and Labour
http://www.dfg.de

Institute of Mining Engineering I
RWTH Aachen University
http://www.rwth-aachen.de/bbk1

Institute for Processing of Mineral Raw Materials
RWTH Aachen University
http://www.amr.rwth-aachend.de

Further information at the Institute of Mining Engineering I under
http://www.rwth-aachen.de/bbk1

Or, just ask us:

José B. Pateiro Fernández
pateiro@bbk1.rwth-aachen.de

P.N. Martens
martens@bbk1.rwth-aachen.de