Management of the impact of mining on safety and the environment

Christophe.Didier@ineris.fr

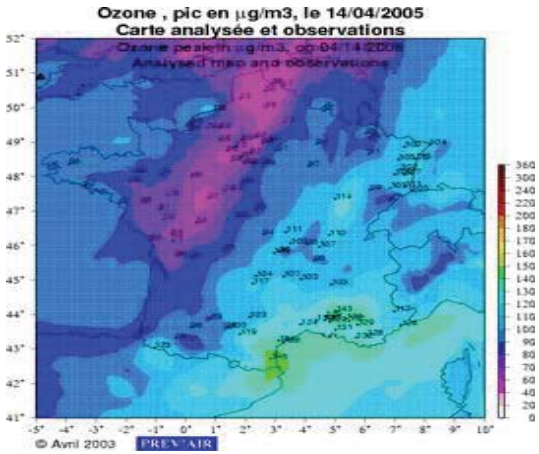
INERIS

maîtriser le risque
pour un développement durable

INERIS main mission: Environmental risk prevention

With a key objective : accompany innovation
to ensure it is safe and clean
for people & the environment

- **accidental risks** (industrial facilities) : products and processes, dangerous phenomena, system safety and probabilistic risk assessment, human factor and organisation, risk management



- **chronic risks** : health impact from toxic substances, (eco)-toxicology, modelling of diffuse air and water pollution, soil phytoremediation, monitoring of the environment, quantitative exposure evaluation

- **underground activities** : mining safety and post-mining management, underground coal gasification, Shale Gas & CBM/CSG environmental risk evaluation, natural hazards, underground storage (CO2, hydrocarbons, energy…)

Mining: a key industry that may suffer from a negative image

- **An essential activity**
  - Providing increasing request for Raw Material (incl. energy transition)
  - Offering a vector for social and economic development over a territory
- **A heritage that can sometime be burdensome**
  - In some areas, image of an outdated, hazardous and dirty activity
  - Largely publicized active mine accidents (tailings, firedamp…)
  - Some difficulties may develop after closure (surface impacts, unemployment)
- **Social License to Operate as a challenge … especially where mines**
  - are associated with “inevitable hazard sources” to people and the environment
  - are considered opposite (not complementary) to circular economy
- **It is critical to promote international Best Available Practices**
  - Identifying best management approaches to reduce impacts/risks
  - Enabling to differentiate “sustainable operators” from “others”

INERIS
maîtriser le risque
pour un développement durable

Towards a « sustainable mine »

- **A major challenge in more complex and dangerous contexts (depth)**
- **Reduction of the environmental mining footprint**
  - Reduction of impacts and risks on the environmental media (water, air, soil)
  - The earliest during the mine life cycle, the most efficient in terms of prevention
  - Development of innovative technologies to optimize the mining processes
- **Offering more attractive workplace**
  - Development of remote-automatic mining
  - Safety, temperature, dust, noise, traffic as important remaining challenges
- **Promoting “second life after mining” for territories**
  - More than rehabilitation, planning for redevelopment of the mining areas
  - Reconcile mining industry with circular economy principles (reuse, Ind. Ecol.)
- **Promoting a constructive dialogue with stakeholders**
  - Identifying key actors (and relative issues) civil society,
  - Developing communication tools and dialogue framework
  - Taking benefit of “sustainable mine labs” network to be built

INERIS
maîtriser le risque pour un développement durable

« An ounce of prevention is worth a pound of cure … »

Exploration

- Minor stage ⊙ impacts
- Major stage ⊙ acceptance

⇨ Initiate contact & dialogue, take questions/fears into account

Design and Planning

- Defining extraction/process methods
- Integrating mine project in local context
- Baseline elaboration
- Planning for closure & « second life »

⇨ Most important stage of the sustainable mining process

Building

- Implementing concepts
- Adapting project to reality

⇨ 1st image of the mine

Extraction

- Extracting ore and managing water, waste…
- Underground processing or backfilling more than building surface waste disposals
- Energy optimization
- Continuous monitoring, audits

⇨ Transparency as a challenge

Closure and post closure

- Minimize/mitigate impacts and risks
- Long term monitoring of the environment

⇨ Optimise reuse and redevelopment of territories. Transfer « positive heritage »

INERIS
maîtriser le risque pour un développement durable

Green mining: reducing environmental footprint

Promoting a set of methods to minimize mine interactions with surface through water and waste management, gas emissions, subsidence and impacts on ecosystems.

Water management

- Impacts on underground and surface water regimes (flooding, outlet, wet zones…)
- Impacts on water quality
- Sanitary aspects

Surface stability

- Disorders prevention
- Continuous subsidence
- Sinkholes or collapses
- Mine openings (shafts, adits)
- Associated land use planning

Waste Management

- Reduction of volume on surface
- Long term securing/monitoring
- Impacts on soil/sediments
- Sanitary aspects

Ecosystem & Sanitary Protection

- Baseline elaboration
- Ecosystem vulnerability
- Mitigation/monitoring techniques
- Contaminants reduction
- …

Gas & atmosphere

- O_2 deficit
- Noxious gases (CO, CO_2, H_2S…)
- Flammable gases (CH_4)
- Ionizing gas (radon)
- Dust

INERIS
maîtriser le risque pour un développement durable

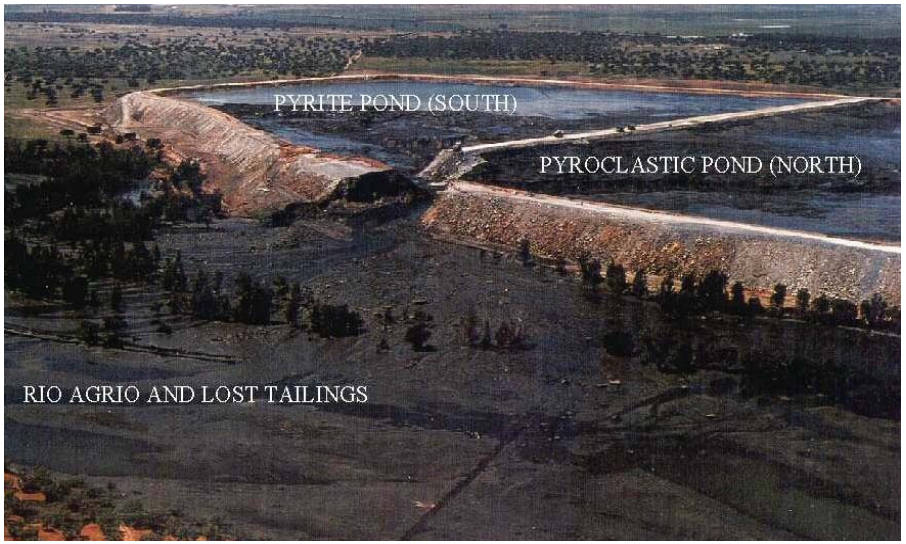
Few examples of environmental impacts

Water management

Surface stability

Few examples of environmental impacts

Waste management



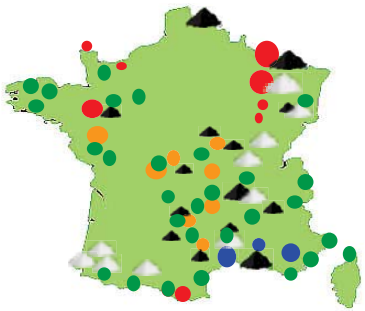
Gas & atmosphere

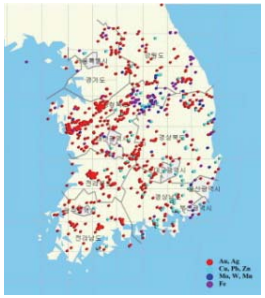
Sanitary aspects

Promoting international network on mine risk prevention

Presidency of ISRM « mine & mine closure » commission

- With members from all continents (Fr, SA, Can, Jap, S-Kor, UK, Ger, Pol...)
- To produce and diffuse knowledge
- To develop an international network
- To gather “successful case studies”





http://www.ineris.fr/centredoc/CDi__mineclosure_29_11_08-ang.pdf

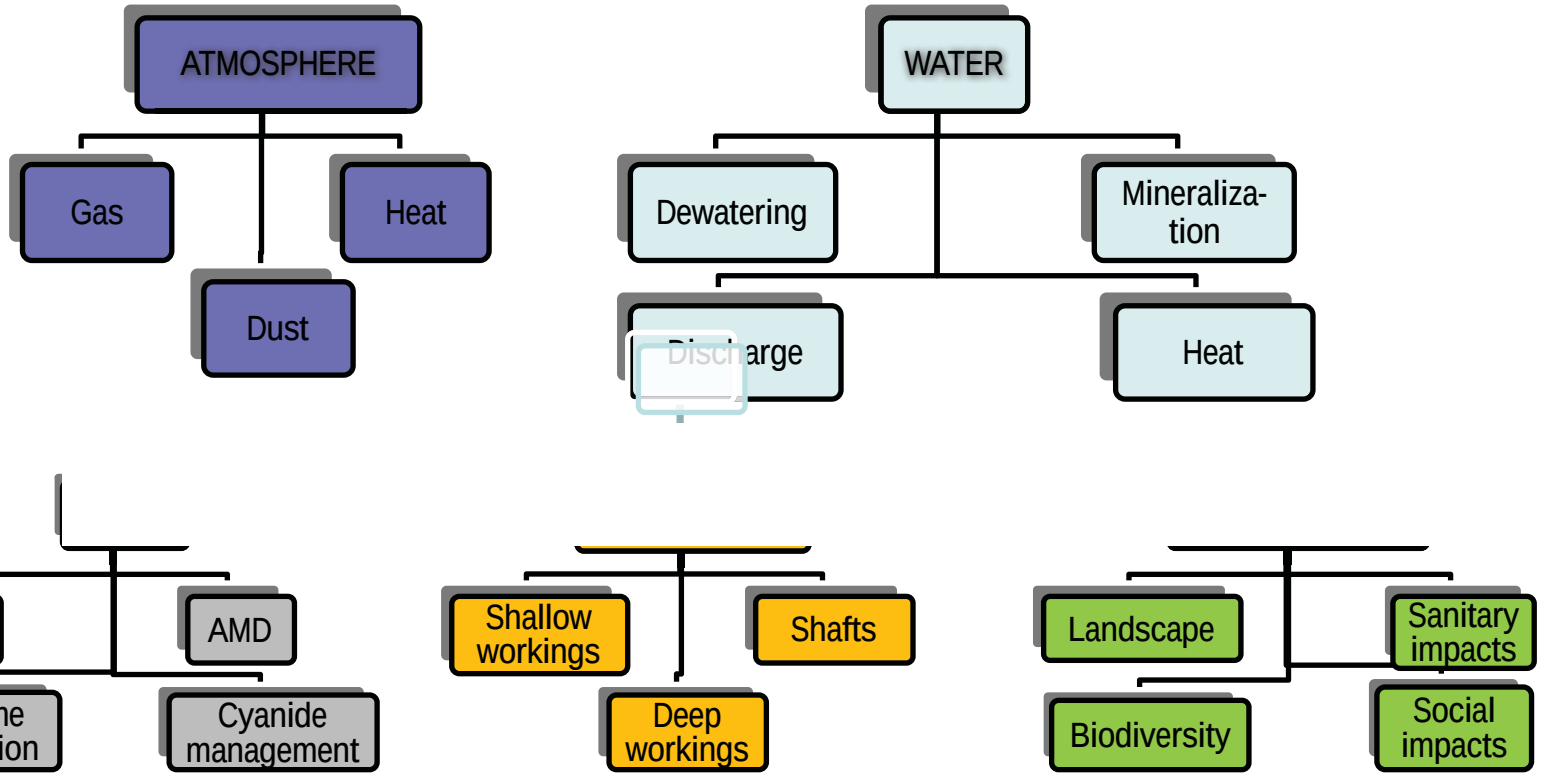
INERIS
maîtriser le risque pour un développement durable

A decision support website to promote green mining practises

5 main impacts ⇨ 18 technical topics ⇨ 52 synthetic forms ⇨ 123 cases studies

Access to website: http://green-mining.ineris.fr

18 topics related to the 5 main impacts



INERIS
maîtriser le risque
pour un développement durable

Synthetic forms presenting mitigation measures

Reference to main impacts

Reference to each topic

Reference to the mine life cycle

Reference of the form

Indication of the level of maturity

Main related impacts

Synthesis of described practies

Innovative Technologies and Concepts for the Intelligent Deep Mine of the Future

THEME	TOPIC	GREEN MINING ACTION
2. Mine water	2.1. Dewatering	2.1.1 Hydrogeological study

MINE LIFE PHASE ⇨	Exploration	Design	Development	Exploitation	Reclamation
		★★★		★★	★★

LEVEL OF REALISATION	Concept	Laboratory	Prototype	Realisation
				★★★

Awaited impacts	– Dewatering of adjacent aquifers – Drying of superficial waters : springs, swamps, rivers – Perturbation of regional hydrogeological cycle (potential impact on far downstream water production wells)
Principle of treatment or remediation	– Analyse precisely the groundwater inflow into the mine considering the climatic, hydrologic and hydrogeologic characteristics of the mine area (USA039, ZAM002); – Take into account both actual and future (climate change context); – Design the water control (for an underground mine) in the stages of pre-feasibility and feasibility studies (USA039) – Prefer grouting instead of dewatering (mine drainage) USA039

INERIS
maîtriser le risque pour un développement durable

Examples of forms available on the website

Innovative Technologies and Concepts for the Intelligent Deep Mine of the Future

THEME	TOPIC	FORM
3 – Solid wastes	3.1 – Geotechnical stability	3.1.1 Characterization phase

3.1.1.b. Co-disposal of waste-rocks and filter cake in the Narrabri coal Mine (Australia). Abstract of AUS0043 document.

Context

Narrabri is producing a high energy export thermal coal and a low ash, low sulphur, low phosphorus, mid volatile PCI coal . The mine is expected to produce about 850 kt of PCI coal in 2014.

(http://www.whitehavencoal.com.au/operations/narrabri_north_mine.cfm).

Challenge

Mixing the fine and coarse waste reduces the empty void space primarily associated with coarse waste streams whilst simultaneously increasing the strength of the co-disposal. The strength and rapid stabilisation of the co-disposal waste allows early access onto the tailings for rehabilitation and reduces the risk and consequences of static and dynamic loading.

By mixing some of waste rocks and tailings, it may be possible to compensate for the problems associated with each: waste rock is porous and prone to acid generation, while tailings are very fine and prone to instability. One idea is that the co-disposal of these two wastes could create storage facilities that are both chemically and physically more stable..

This method improves geotechnical and geochemical stabilities. However, this kind of 'co-disposal' also carries risks. If the proportion of tailings is too high, the deposit will be physically unstable; if it is too low, air and water can penetrate more easily, leading to increased dangers of acid rock drainage.

Solution

In the Narrabri coal Mine (AUS0043), waste-rocks and filter cake (the fine and ultra-fine wet rejects, generate by the coal washing, are dewatered to produce a filter cake) will be disposed in combination.

The International Network for Acid Prevention (INAP) has embarked on sponsored research to investigate various aspects of co-disposal. These include constructing facilities for the co-disposal of waste rock and tailings and the use of co-disposal to construct covers for waste rock retention facilities (INT001)

View of Narrabri coal Mine site, Australia (http://www.urs.com/uki/projects/whitehaven-coal-narrabri-coal-mine/)

To go further: http://www.tailings.info/disposal/codisposal.htm

Innovative Technologies and Concepts for the Intelligent Deep Mine of the Future

THEME	TOPIC	FORM
4 - Subsidence	4.1 - Shaft treatment	4.1.1 - Plug

4.1.1.a - Securing of the shaft "Meys" in Sainte-Foy-l'Argentière (France). Abstract of FRA007 document.

Context

On the old coal exploitation of Sainte Foy l'Argentière (France), some shafts present risk for humans and surface activities. The government decided to realize specific works to secure them.

A special focus is done to Shaft "Meys". This shaft was defined with a high level of risk because no treatment has ever been done since the end of exploitation.

This shaft, located near a national road, presents the following characteristics :

- Depth: 400 m
- Diameter: 3.2 m

View of "Meys" shaft

Challenge

Secure shaft with self supporting plug techniques. This plug with a minimum slenderness (height / diameter ratio) of 2 must be located on a portion of land with good geotechnical characteristics, like resistance.

Solution

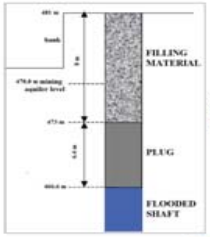
If we consider a vertical concrete plug with a height h pouring the head of the shaft with a perimeter p and a section s. The lateral concrete-lining contact has shear strength qs. In addition to its own weight (determined by its specific gravity), the cap may be subjected to an overload surface P1 and to a stress P2 resulting from the unramming of filling material. The calculation of the various static forces exerted on the cap is expressed as:

$$(P_1 S + P_2 S + \gamma S h) = p\ h\ q_s$$

We deduce the value of the height of the required plug:

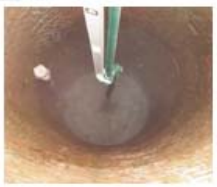
$$h = \frac{S(P_1 + P_2)}{pq_s - \gamma S}$$

Considering the shaft diameter (3.2 m) and shear strength about 200 kPa (feedback value), the height of the plug is evaluated to 8 m. the encoring depth is defined depending thicknesses of poor quality grounds.



Self-supporting plug implantation

Concrete injection



Int standardisation: a key approach to promote best available practices

- **At international level**
  - Within ISO TC82 (Mining) “revitalized” few years ago
  - Including major mining countries as active members (Ger., US, Canada, Aus., S.Africa, Sweden, Chile, Poland, China, Russia, France…)
- **A dedicated SC dedicated to “sustainable mining” focus on “Mine Closure and Reclamation Management and Planning”**
  - Mining countries strongly involved (Can., US, SA, Chile, Aus., S-Kor., France…)
  - Covering the whole mine life-circle : “the earliest planned… the better!”
  - Covering all aspects of closure with a risk-based approach
- **Major objectives of ISO/TC 82/SC 7**
  - Production of international “non prescriptive” standards
  - Promoting best available practices to reduce impacts on the environment
  - Providing references to “emerging actors” in mining risk prevention
  - Enabling mining operators to refer to international standards

INERIS
maîtriser le risque pour un développement durable

Standardisation: a key approach to promote best available practices

- **On-going initiatives**
  - "Mine Closure and Rehabilitation Terminology" (leader S-Korea)
    - Soon ready for external consulting
  - "Mine Closure and Reclamation Management Planning" (leader Canada)
    - Focusing mainly on "future mines"
    - Being presently elaborated. Cover a very large scope
- **Possible future initiatives**
  - "Abandoned Mines Reclamation Planning"
    - Complementary to Canadian initiative that could be launched rapidly
  - "Waste disposal long term management"
  - "Mine water management during and after closure"
- **All expertise welcome**
  - Through national "mirror committee" of standardization agencies
  - Contribution to active and proposal of future initiatives

INERIS
maîtriser le risque
pour un développement durable

Thank you for your attention

Merci de votre attention

Any questions… or requests ?

Christophe.Didier@ineris.fr

INERIS
maîtriser le risque
pour un développement durable