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Stress and Seismic Monitoring in an active deep mine

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INERIS – National Institute for Industrial Environment and Risks





maîtriser le risque pour un développement durable

I2Mine objectives

FP7 UE project 2012–2015

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

= activities designed to realize the concept of an invisible, zero-impact mine



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INERIS at French and European level

National centre for Industrial Safety and Environmental Protection (French Government, 1990)

expertise in the areas of chronic and hazardous risks preventing the risks brought about by economic activities on health, safety of persons and property, and on the environment

Emmanuel Macron (Minister of Economy, Industry and Digital Affairs), press release (March 2015); « Responsible mine » = revitalizing sustainable acceptable mining in Europe -> administrations, BRGM, INERIS

I2Mine – WP1 & WP3

Geophysics & geomechanics for safe mining



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Gouvernement

Administrations

Universités

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Mine-induced seismicity Seismic hazard and rockburst phenomena

1. pre-mining stresses may vary significantly with geological disturbances and structures (faults, folds, ...)

2. mine-induced stress field vary considerably around the advancing working faces

3. seismic events perturb locally quasi-static stress field adding complexity in stress prediction

4. dynamic stresses induced by seismic ground motion may be amplified locally around mining voids

But it fits hard to rock mechanic considerations.

Despite geophysical models, seismic events reveal to be difficult to handle as a quantitative input into numerical geomodels to enhance near to real-time stress field prediction.

High-risk mine hazards assessment = f(mining production) + g(stress changes) + h(induced seismicity)

the most relevant components to be monitored and quantified on a continous basis

from good quality seismic data, elastodynamic considerations and rupture models



INERIS digital infrastructure **Production data Ground control data** (seismic & stress (mining scheme & monitoring) process) Etherne 220 V ī Ethernet Mine 1 local network Z **Real Time Data Processing** (accounting for the dynamic Cloud Mine 2 monitoring development of the mine) Etherne 220 V local network Ţ Mine managers, Ground Engineers, Distant Specialists **Real Time quantitative &** Ethernet probabilistic hazard **Assessment of induced** Ethernet seismicity risk þ. **INE-RIS** maîtriser le risque pour un développement durable Alice TONNELLIER DRS-15-127366-03408A 5/11

Garpenberg mine

I2Mine WP1 – 1.4 Development of innovative technologies for ground monitoring





Integration to a mine network featuring operational seamless interface with the mine databases related to:

- mining progress,
- refreshed mine layout,
- blast and production data.



I2Mine WP3 – 3.4 Experimental implementation and calibration of the technologies Tests in real field conditions in collaboration with a mining company.







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Garpenberg mine INERIS processing software package

example on velocity model



SYTMISview: picking, polarisation





From 5 calibration blasts $v_{\rm P} \simeq 6320 \text{ m/s}, v_{\rm S} \simeq 3770 \text{ m/s}$ $v_{s}/v_{p} \approx 0.59$

- Locate exploitation blasts with velocity model
- Look for seismic events close to the monitored area
- Improve the localisation parameters (grid search)



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e.cenaris for data sharing INERIS cloud monitoring tool

Improvements of numerical routines to process and analyze simultaneously seismic data & stress measurements vs production data:

 a web help desk to map and service hardware related to the monitoring system

 a 3D visualizer of seismic foci and mine layout through the web to offer fast and shared easy-to-read mapping of the seismic activity in a given mining area







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Microseismic - global overview Stress measurement - close to seismic sources



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Conclusions, next steps

How to design more productive and safer and cleaner deep mines at the same time?

I2Mine: European objectives to secure raw materials in Europe

INERIS develops a cutting edge integrated solution to the mine data flow to monitor the host rock response versus mine progress to provide a better insight and enhance prevention on a routine basis

- Integration of microseismic and stress monitoring results with mine data flow
- Data sharing through cloud monitoring tool
- Overview and modeling in space and time
- Next steps...



Toward I2Mine-2??





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pour un développement durable

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