Mapping Expert Uncertainties or Confidence Level in Mining Risk Prevention Plans

Maxime CAUVIN, 19th June 2006

< Geohazards - Technical, Economical and Social Risk Evaluation >
French mining background

Coal
Salt
Iron ore
Aluminium
Uranium
Others
French mining background

"POST-MINING" ISSUES
=> Surface instabilities
=> Emissions of gas
=> Hydrological problems

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MINING RISK PREVENTION PLAN

French edicts
n°95 1089 (1995) and
n°2000 57 (2000)

Coal
Salt
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Uranium
Others
Let’s do a Mining Risk Prevention Plan together…

**On surface**
- Houses, infrastructures, …

**Underground**
- Partial extraction method of mining => residual voids left
- Shallow depth (30 – 50 m)
Sinkholes
Sinkholes

In Bell & de Bryun, 1999
Sinkholes

US Geological Survey
How to work? A 3-step approach

1. Does it exist on a specific location of the area being studied a potential source of hazard?

2. Assuming the existence of this source of hazard, can it generate a disorder or a harmful effect on surface and what is the reliability of this result?

3. How to reduce or at least mitigate the risk?
What do we know about our mining area?

PROBLEM n°1

=> quality of the information:
reliability of mining maps,
informal nature of some data,
…
Solution 1) Index of Existence

=> express the probability that a source of hazard really exists in a given area, taking into account the source of information that allowed to identify it

<table>
<thead>
<tr>
<th>Mining map available</th>
<th>Partial extraction method</th>
<th>Total extraction method</th>
<th>Unknown extraction method</th>
<th>Archives</th>
<th>Total exploitation</th>
<th>Partial exploitation</th>
<th>Availability of data</th>
<th>Total exploitation</th>
<th>Partial exploitation</th>
<th>No data available</th>
</tr>
</thead>
<tbody>
<tr>
<td>No mining map available</td>
<td>Room-and-pillar</td>
<td>5</td>
<td>Good quality of pillar extraction (cf. extraction method)</td>
<td>1</td>
<td>Total exploitation</td>
<td>3</td>
<td>Extraction method of contemporary bordering workings</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gallery (or other small voids)</td>
<td>5</td>
<td>Bad quality of pillar extraction (cf. mining map quality, extraction method)</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total exploitation</td>
<td>3</td>
<td>Partial exploitation</td>
<td>4</td>
<td>Archives</td>
<td>Total exploitation</td>
<td>3</td>
<td>Availability of data</td>
<td>5</td>
<td>No data available</td>
</tr>
<tr>
<td></td>
<td>Partial exploitation</td>
<td>5</td>
<td>Archives</td>
<td>2</td>
<td>Archives</td>
<td>Total exploitation</td>
<td>3</td>
<td>Availability of data</td>
<td>5</td>
<td>No data available</td>
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<td>Archives</td>
<td>1</td>
<td>Archives</td>
<td>Total exploitation</td>
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<td>Availability of data</td>
<td>5</td>
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</table>
Hazard assessment phase

PROBLEM n°2

=> reliability of the methods:
experience rules, rules of thumb, strong hypotheses

...
Solution 2) Reliability of the hazard assessment

<table>
<thead>
<tr>
<th>Zone</th>
<th>Height of caving (Hf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>33,5m</td>
</tr>
<tr>
<td>Zone 2</td>
<td>33,5m</td>
</tr>
<tr>
<td>Zone 3</td>
<td>37,5m</td>
</tr>
<tr>
<td>Zone 4</td>
<td>33,5m</td>
</tr>
</tbody>
</table>
Solution 2) Reliability of the hazard assessment

<table>
<thead>
<tr>
<th>Zone</th>
<th>Height of caving (Hf)</th>
<th>P(A) Hf&gt;40m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>33.5m</td>
<td>48%</td>
</tr>
<tr>
<td>Zone 2</td>
<td>33.5m</td>
<td>14%</td>
</tr>
<tr>
<td>Zone 3</td>
<td>37.5m</td>
<td>37%</td>
</tr>
<tr>
<td>Zone 4</td>
<td>33.5m</td>
<td>0%</td>
</tr>
</tbody>
</table>

Monte Carlo simulations
Solution 2.bis) Spatial probability of occurrence

PROBLEM n°3
regulatory request for expressing the probability of occurrence of hazards

Spatial probability of occurrence of hazard =

Probability[existence of a source of hazard] ⇒ Index of existence x

Probability[damage will appear on surface / a source of hazard exists] ⇒ $P(A)$
Hazard assessment

<table>
<thead>
<tr>
<th>Zone</th>
<th>Height of caving (Hf)</th>
<th>I.E.</th>
<th>P(A) Hf&gt;40m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>33,5m</td>
<td>60 %</td>
<td>48%</td>
</tr>
<tr>
<td>Zone 2</td>
<td>33,5m</td>
<td>95 %</td>
<td>14%</td>
</tr>
<tr>
<td>Zone 3</td>
<td>37,5m</td>
<td>95 %</td>
<td>37%</td>
</tr>
<tr>
<td>Zone 4</td>
<td>33,5m</td>
<td>100 %</td>
<td>0%</td>
</tr>
</tbody>
</table>
Regulatory zoning plan

- **Index of Existence**
  => identification of areas where investigations have to be undertaken
  - Existing infrastructures => necessity of investigations
  - Future projects => prohibitions, restriction rules, monitoring, ...

- **Monte Carlo simulations**
  => identification of parameters whose uncertainties have the greatest impact on the hazard evaluation
  - Better accuracy of the hazard posting => mitigation measures
Perspectives

- ‘Hazard assessment’ phase of MRPP is currently undertaken in several French regions
- ‘Regulatory zoning’ phase is still under process
- PhD Thesis in progress
  « Uncertainties and Probabilities in Risk Management of Ground and Underground Problems »
- www.ineris.fr
- www.laego.org