# INVENTORY AND RISK ASSESSMENT USING A PC DURING CLOSURE PROCEDURE OF ABANDONED MINES

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**ABSTRACT**

*In this paper, it is presented two software's called ABANDMIN and RISKMIN which serve to make a database and the evaluation of human and environmental risk induced by closure and abandonment of mining works.*
*This methodology represents an advance in the selection of the most convenient closure method for each mining work. Therefore, climate, geology and chemical, physical and environmental conditions of the site are considered as well as viability and total costs involved.*
*So, once the mine or work cycle life cycle, it should be started a plan of abandonment and closure. It begins with the dismantlement and demolition of facilities that are not in use. Then, a sort of treatment and closure of mining works should be done and, finally, terrain reclamation and recovery will be needed to get new uses from it.*
*Several aspects are considered to conduct the evaluation and to estimate the risk, such as the mining layout, nature and location of the mine, ground characteristics, presence of water and ventilation nets, state, size and depth of the mining works, security of accesses, measures adopted for mine closure and future uses of the ground.*
*Once this evaluation has been made, one can choose the most appropriate method to close any mining work or installation.*

## INVENTORY AND LOCATION OF ABANDONED MINING WORKS

First phase comprises the elaboration of an abandonment and closure plan and it is corresponded with the inventory of mining works.

If the mine is still in activity, these labors are simple because you can have at one's disposal archives full of projects, reports and maps in which they are described location and dimensions of each labor and former and latter year of activity.

When it is a mine or an abandoned mining area, it is necessary to carry out a mining work location and identification. It is sometimes very difficult because these mining works are usually hidden by vegetation, half destroyed or even completely sunk.

### Abandoned mining works inventory. Software ABANDMIN

The software ABANDMIN serves to make an inventory of abandoned or in closure procedures mining works. It contains information about the state of the mining works (with photographs), it allows presenting mining works location inside the mine (location map) and it reveals data from each labor to be closed, such as name and mining layout, former and latter year

of mining activity, height, latitude and longitude, accessibility, risk level for living beings, labor description and proposed or used type of closure method.

The inventory database owns a list in alphabetical order of every catalogued works. Each labor is identified by its name and a photograph which shows its state (Figure 1).


Figure 1. Catalogue for selection of inventoried labor.

Once the labor is chosen, ABANDMIN displays a data filing card of each selected labor. The software permits updating and creating new ones to incorporate them to the mining works inventory.

ABANDMIN has three options, data, photo and location map (Figure 2), that are related among them. One can choose the desired option from each of them.

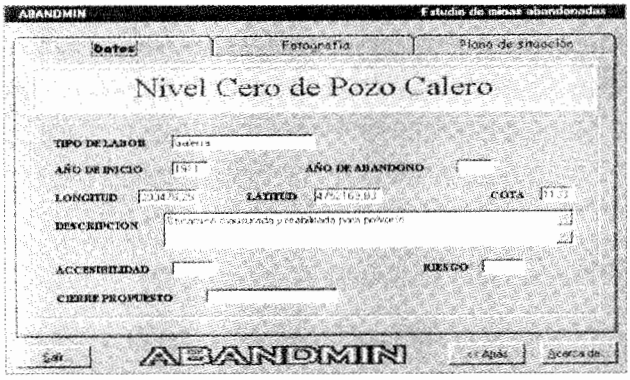


Figure 2. Data filing card of an inventoried labor.

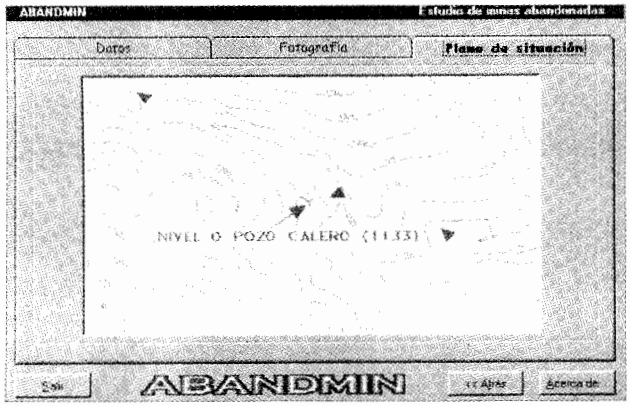


Figure 3. Labor to be closed in the location map.

Software ABANDMIN also serves as a supporting tool for mining companies which must carry out a closure of their mining works partially or totally, temporarily or permanently.

## RISK ASSESSMENT FROM ABANDONED MINES. SOFWARE RISKMIN

The methodology developed to the risk assessment from abandoned mines is divided into three groups. The former estimates chemical risk from human and environmental aspects while the second and the third group make the risk assessment from aspects of people with or without access to the abandoned mining works.

In Figure 4 it is presented the process RISKMIN follows to the risk assessment.

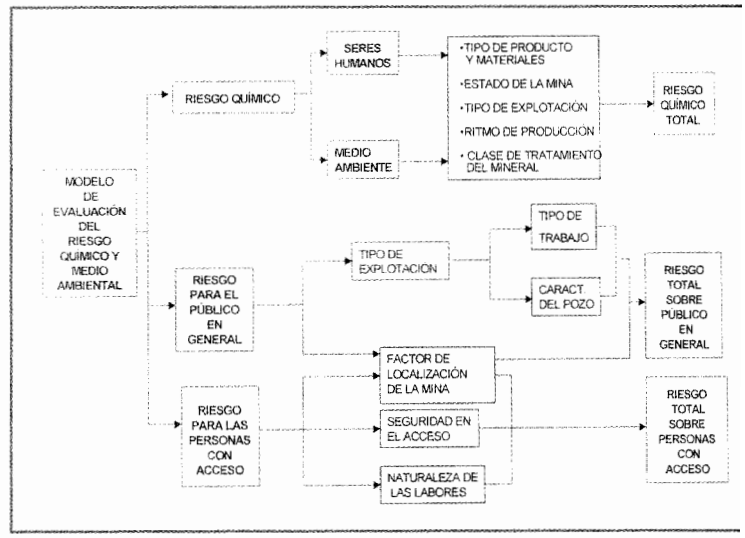


Figure 4. Risk assessment model from RISKMIN.

### Chemical risk produced by abandoned mines and its influence on human beings and environment

Under environmental aspects there are two types of risk: physical and chemical risk. The methodology is designed to identify and value the chemical risk which comes from old mining works. This sort of risk is divided into two categories: human and environmental so chemical conditions play different risks to human beings, flora and fauna.

The valuation of this risk is carried out assigning numerical factors to every feature and location of the area which is being evaluated. Software RISKMIN disposes of several lists with its factors to make the risk assessment (Table 1).

In the process of calculation to appraise the chemical risk factors, five main fields are considered; the same that will be used as information or data base to predict and mitigate the potential environmental impact: kind of products and materials, mine condition, kind of exploitation, production rhythm and type ore treatment.

| Production (t/year) | | Factor of risk |
|---|---|---|
| Very small | < 1.000 | 1 |
| Small | 1.000 a 10.000 | 1.2 |
| Small – medium | >10.000 a 250.000 | 1,4 |
| Medium | > 250.000 a 500.000 | 1,6 |
| Medium – large | >500.000 a 1 million | 1,8 |
| Large | > 1 million | 2 |
| No data | | 1 |

Table 1. Chemical risk factors owed to production rate.

## Environmental risk for people associated to the abandonment of mines

In this section, the risk is evaluated from the point of view of the environmental security associated to the general public and to people with access to the works of abandoned mines, since the majority of these works can represent a danger for human beings and for the local ecosystem.

As in the case of chemical risk, this part also incorporates lists with weighted factors.

*Risk associated to the public in general*

This part of the model is composed by two principal factors: one is related with the location of it mine, while the other is associated to the kind of exploitation. The later, depends on two components, a concerning to the characteristics of the works and it other related with the properties of the shafts.

*General public total risk evaluation*

The total rating for general public risk is obtained by multiplying the addition of the factors that define the type of mine work, by the factor which characterises the shaft by the factor of location of the mine. The result is an index for general public total risk that comes expressed in percentage.

$$RTPG = Fl \times (Ft + Fp) =$$
$$Fl \times ( P + Ev + Me + Fe + Dp + Cr + Ci)$$

where:

RTPG = Total general public risk
Ft = Factor for kind of work
Fp = Factor for the kind of shaft
Fl = Factor for location of the mine
P = Depth
Ev = Vertical thickness of the work
Me = Exploitation method
Fe = Factors for stability
Dp = Surface density of shafts
Cr = Quality of the closure /fill
Ci = Inventory quality

*Risk associated to people with access to abandoned mines*

Mines always attracts the attention of adventurous people; danger is small if the person is experienced and well equipped but, whatever the case, abandoned mines always represent potential danger for both people and animals. This part of the risk model is designed in order to get an estimate of the danger that mines involve in this context.

In the appraisal of this kind of risk, the location, the grade of safety at the entrance and the nature of the works have been considered.

*Total risk associated to people with access*

This value is obtained by multiplying the safety factor of the access by the factor of location of the mine and by the addition of the factors according to the nature of the works.

$$RTPA = Fs \times Fl \times Fnt$$

where:

RTPA = Total risk associated to people with access
Fl = Factor of location of the mine
Fs = Factor of safety at the entrance
Fnt = Factor of nature of the work (type of sinking, fallings into shafts, stability, presence of water and gases, and works connected)

In the Figure 5 shows a view of the computer screen where the output of the evaluation carried out is included (evaluation of the chemical risk, for people with access and for general public)

Figure 5. Presentation of results of the risk evaluation. Program Riskmin.

Once the punctuation for each type of risk (chemical, general public and people with access) has been obtained and according to its value, a corrective action and the most appropriate closure method in each work will be selected in order to reduce the risk.

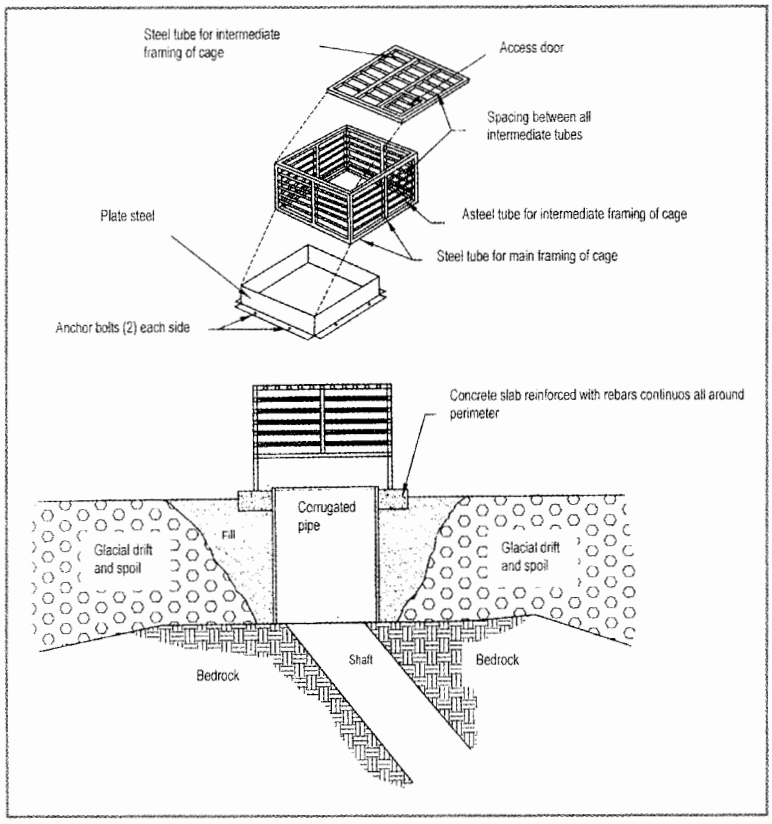


Figure 6. Closure of the shaft with tubing and metallic cage.

A wide range of closing techniques can be used in abandoned mines; all of them introduces certain advantages and disadvantages, according to their design, their costs and their application to the different alternatives. Every mining work (horizontal or vertical) to be closed requires the particular application of one method of closure.

As an example, Figure 6 shows a type of permanent closure for an dip mining abandoned work. It is designed to control gases and unauthorised access into the mine.

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