

# CONSIDERATIONS UPON MINE VOIDS BASED ON DUMP RECOVERING EXPERIENCE. PUENTES MINE CASE

Francisco Aréchaga Rodríguez and Aníbal Gil Bueno

Puentes Mine - ENDESA  
Tesouro, s/n. Apartado 17  
15320 As Pontes de García Rodríguez, A Coruña, Spain  
Phone: + 34 981 451600, Fax: + 34 981 450002  
e-mail: dmapsecretaria@endesa.es

## ABSTRACT

*Mining layout as well as unfavourable rock mechanic conditions together with digging operations at our Puentes Mine, has not allowed us to undertake transfer mining operations until now. All the aforesaid means that most part of the waste, about 750 million cubic meters have to be unloaded on an outside dump on the Southwest of the Mine.*

*The specific features of this deposit born within a sulphur area which makes waste very acid, implies that land recovering operations are done under very difficult conditions, more so when taking into consideration that top cover is very scarce.*

*Water run-off is strongly affected by sulphur oxidation process of those materials excavated lowering the pH of waters and increasing their solids content.*

*On the other hand, the high pluviometry of this area represents a big problem of surface erosion and filtrations. Base on this, it is imperative to act accordingly as to the final dump area and manage rainfall runoff to cut down digging problems and ease our land recovering goal which is to get an stable and permanent green cover. The paper informs about the shortcomings to overcome and tells about the method employed to recover 1300 Hectares of dumpland.*

*Moreover, it presents the most important topics to study on facing the final void of the Mine, based on the experience gathered along a period of 15 years of dump recovering operations.*

## FOREWORD

The brown lignite deposit of As Pontes de García Rodríguez, is located on the NW of Spain, specifically on the east border of the province of A Corunna.

The deposit is a Tertiary sediment series basin where shales and lignite alternate together with interbedded sands. Enclosing rock is formed by Palaeozoic phyllites and quartz phyllites.

Its length is 8,5 Km striking NW-SE. It is splitted into two basins (named under West and East fields) reaching maximum widths of 2 and 3 Km on the West and East borders. In the

middle it narrows and reaches 1 Km, which serves as a division to both basins.

The final excavating front will be about 11,8 Km<sup>2</sup>, part of which, that is 3 km<sup>2</sup> belong to phyllites on the borders and the remaining 8 km<sup>2</sup> to the basin. Out of the 3 km<sup>2</sup> of phyllites which shall be exposed, the ones named under F2 have to be especially noted due to their high concentration on iron sulphur (pyrites) which bring serious problems by lowering water pH. Phyllites named under F1 also present high concentrations on iron sulphur but only on certain points. Both rocks outcrop on the NW area of the West field.

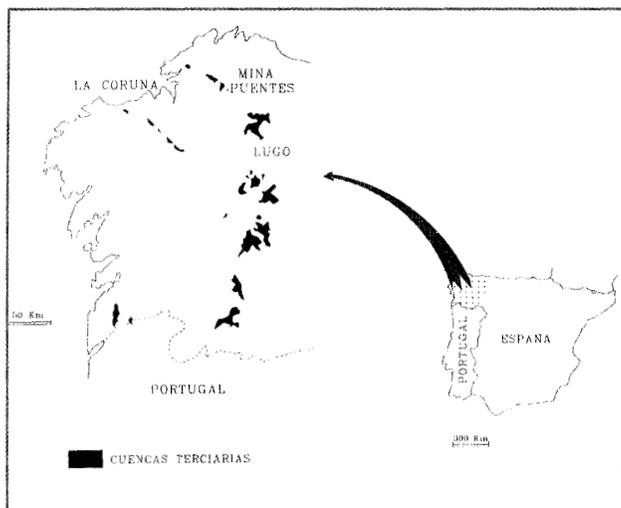


Figure 1. Location map.

Palaeozoic materials outcropping on the Southern area of the West field are similar to the Northern area ones, but offer a different texture and composition. This is because the Southern area was the passive side of the Tertiary basin, so these materials have been subject to a highly chemical weathering caused by continuous changes between water/air on the basin.

Regarding depth, the West field will reach a 140 m level and East field a 170 m level. Whereas threshold level between fields will be 240 m.

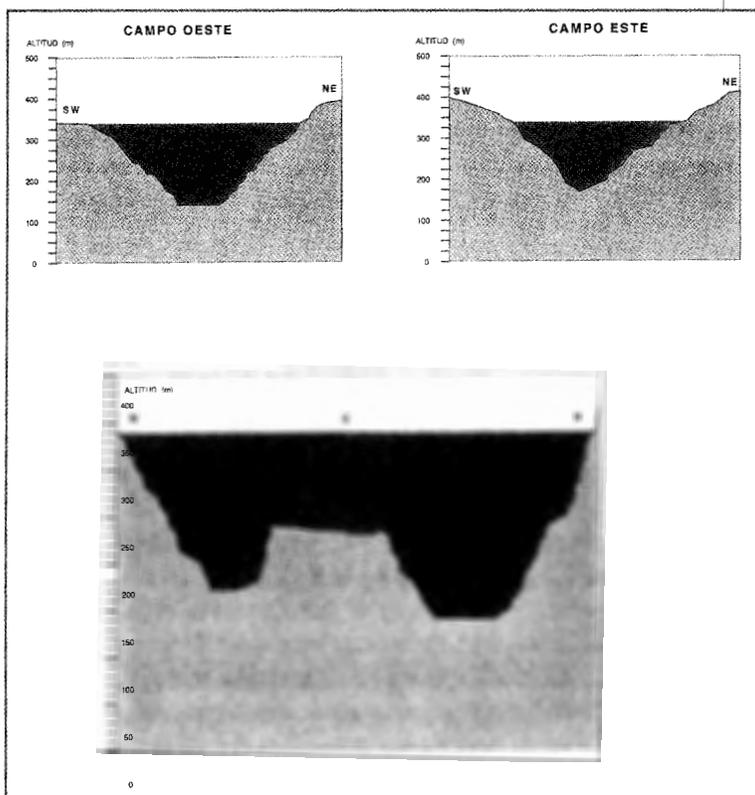


Figure 2. Survey profiles of final mine void.  
Top: West and East fields' profiles. Down: Maximum profile of final void.

The excavating front together with the unfavourable rock mechanic conditions as well as regular mining operations on both fields, do not allow inside dumping until a late stage of these operations. So a great part of wastes, that is, 750 Mm<sup>3</sup> have to be dumped on an outside dump placed towards the Southwest of the mine.

The outside dump extends along 1,200 hectares having a volume of 750 Mm<sup>3</sup> and a maximum dumping height of 200 m. The materials dumped are shaly wastes from the deposit, phyllites from the border and ashes coming from the Power Plant which reach a 10% as regards total material dumped.

Handling of these materials together with the forming of a big void and a big dimension dump results on serious environmental impact which intensity shall depend upon the deposit characteristics together with material values on the surroundings, nevertheless all these are considered important and definitive.

Those impacts, resulting from mining operations are as follows:

- landscape modification;
- soil lost;
- green species lost;
- faunal alteration;
- natural drainage network modification;
- water pollution; and
- increase of erosion processes.

Recovering of these areas is the most efficient way to avoid or prevent these environmental impacts, resulting from mining operations.

Layout and construction of dumping soils will be the main parameter to which all recovering operations shall aim, for if a positive soil basis is not achieved, recovering operations outcome will be limited and costly.

Creation of an adequate dump soil shall be the basis to achieve a correct and quick restoration. At the same time, its characteristics have a high influence upon surface and deep waters, since they influence their relationship between runoff and percolation and also on running water. The knowledge of the importance of mine soil quality has drawn several authors to suggest that the follow-up of this resource may be used as a parameter to measure the recovering process success.

The important thing is for the recovering project to start as soon as possible and be integrated within the General Mining Project so as to minimise costs with best results. To achieve this, the Recovering Project should include four basic aspects.

- Drawing up of soil uses after mining operations to be achieved on a medium/long term basis.
- Selective waste and soils management to favour those uses and achieves water quality standards.
- Convenient layout to achieve previous goals and obtain a positive drainage and eroded process control.
- Technical means to set and maintain green cover.

At Puentes mine, recovering methods applied to recover the outside dump and other areas are summarise as follows:

Chemical-physical characterisation and mineral composition of wastes from the excavating front, field tests of different kinds and mixtures of wastes to envisage their behaviour as basic strata, waste classification and correct dumping on final surface of outside dump, surface forming, tests of dumped materials, infrastructure building, physio/chemical modification of strata, green cover treatment, setting of green cover.

All these subjects which make up an operation method system, end up by the follow-up of recovered areas based basically on soil and vegetation development.

In June 1999, already restored areas and those being restored amount over 750 hectares. where green strata may be found such as grasslike, bush and tress on different stages of evolution.

Since dumping operations at the outside dump are to finish on 2001 or beginning of 2002, recovering process will end, on 2003. From this date on, activities will be addressed to maintenance and watching programs.

At the end of operations, the Outside Dump will cover an area of 1200 hectares with a draining network of 55 Km and a track network of 69 Km.

Regarding green covers, they will be of the following kinds:

- coniferous	18,43%
- caduceus	39,15%
- bush	12,42%
- grasslike	28,50%
- wet areas	1,50%

## MINE VOID CONSIDERATIONS

Mining development to achieve final operating front plans to complete total excavation of East Field up to 2002. Previously, starting on 2000, excavating operations will accompany de development of an Inside Dump which wastes come from mining operations and will be active until depletion of reserves from this last field scheduled for 2009.

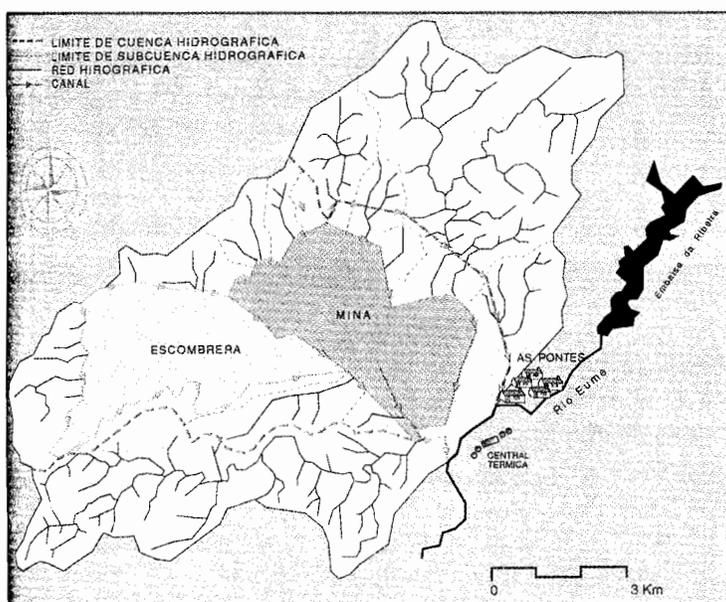


Figure 3. Mine and dump drainage basin together with safeguard canal system. 57

Once mining activities stop and as a result of material excavated, a big void there will be left, which best alternative for the future is a final lake. This lake will cover a surface of 1200 hectares, with 650 Mm<sup>3</sup> and a maximum depth of 200 m.

At present, a fact finding program is being carried out trying to envisage all the problems which may appear during the flooding stage and later, so as to recommend an operation plan which allows a preventive action able to achieve the new ecosystem be integrated within the environment in a very efficient way.

In any case and given the importance of the project, there crop up countless questions and problems to be solved as regards flooding and also related with water quality. Many of these problems may be foreseen and also envisage some of the probable solutions.

To flood the void the deposit drainage basin will have to be taken into consideration, this drainage basin is splitted into four sub-basins: north basin, mine basin, dump basin and river Maciñeira basin covering a surface of 96 km<sup>2</sup>. Taking into account all the present possibilities and bearing in mind that all the hypothesis will have to take precipitation into account, different flooding stages alternatives have been studied, resulting values ranging from few years with the most favourable alternative to a long year period following the most unfavourable one.

In any case and bearing in mind that rusty pyrite depends on the reserves, distribution, exposition time and grain size of sulphur, and that all these control factors are only conditioned by exposition time, every measure favouring a reduction on exposition time is considered favourable to the final lake water quality development. So, a quick flooding of the void with surface water may be taken as the norm. It is important to note that the incidence from drainage basin surface may vary as per surrounding limitations which may conditioned flooding time. It is of high priority to allow in extra flows besides those from chosen basin, which will help to a quick flooding of the void.

It is also interesting to know any runoffs or percolation from underground waters towards the void. In general, these flows represent a small part of water balance but nevertheless, since these runoffs have usually a very low pH they would affect environment negatively. It is important not to disregard this information as to envisage preventive or corrective measures.

A brief look at several points to be considered may bring us the following:

- Concerning targets
  - \* Possible future lake uses; and
  - \* Use selected based on economic reasons and lake possibilities.
- Concerning flooding stage
  - \* Advantages and disadvantages of starting flooding before mining operations finish;
  - \* Advantages and disadvantages of starting flooding when mining is finished;
  - \* Wave influence upon slopes. Protection of the same according to their material and gradient;

- \* Influence on drainage from water increase;
- \* Flooded slopes treatment, before flooding stage;
- \* Void water level ratio; and
- \* Water quality behaviour.
- Regarding equipment and facilities
  - \* Design of facilities and equipment needed to channel water and discharge the same on void according to the flooding alternative chosen; and
  - \* Design of facilities and equipment needed to discharge water from the void to the Eume river, once waters reach flooding level.
- Regarding post-flooding stage
  - \* Lake influence upon drainage system and environment;
  - \* Comparison between pre-mining water situation with that after flooding;
  - \* Investigation about flooding areas; and
  - \* Water quality. Lymnological state;
- Regarding landscape
  - \* Treatment of out cropping surface; and
  - \* Conditioning of areas surrounding lake.



Figure 4. Mine void during flooding stage.

Concerning use, to begin with, this shall be decided subject to social parameters and in agreement with all the parties involved leading it towards natural conditions and aiming at reaching a water quality in compliance with the decided use not only on the flooding stage but trying it to be self sustained on a long term basis. Water quality is related with the following points:

- Inflow water to the void;
- Chemical balance between different flows;
- Lythological influence and kind of basin soil use collecting waters, which shall flow, to the void;
- Influence of precipitation along time;
- Correcting measures or improvement of void surrounding conditions and water quality improvement; and
- Water strata layout within void.

As regards the above, it will be important to avoid acid formation resulting from pyrite oxidation process and increase water balancing capacity in the lake. Besides, water is known to improve with time due to  $H^+$  ion consumption through reduction processes, to various element concentration reduction due to discharge of soluble compounds and by means of an inside precipitation process which takes place in the lake.

Another important point, when the lake reaches its final level, is the continuous water renewal from different run-offs. This surface water renewal will positively influence water quality.

Regarding eutrophication process, it is known that in mine voids water, even having an important quantity of nutritious elements, shows an obvious lack of plankton, algae and water plants. Nevertheless, on some places an eutrophication process is forced to benefit from the biological activity which balances pH value. In our case, eutrophication is not so important since caching areas are scarcely populated and agricultural use is low. Besides, on deep lakes like this, layers get stable, making inside change of nutritious substances to be low.

As regards lake configuration, the aim is to achieve a varied pattern and vegetation to ease the development of every kind of small biotopes. So a combination of plain and open shores with incline green ones will be the ideal; scarce and short kind of vegetation with high and dense one, specially on the outside border; deep areas together with shallow ones, swampy areas, etc. The more varied the water-land area is, the more favourable the conditions will be to animal and vegetation communities.

The relief difference between the dump and the final lake and hence the existence of different biotopes and biocenosis, shall allow the birth of a varied and rich species and communities ecosystem. This way, an environment widely settled bearing interrelated biotopes will be colonised naturally having a high development potential.



Figure 5. Lake in mine void.