TAILINGS DISPOSAL AT NEVES-CORVO MINE, PORTUGAL

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SOMINCOR, Neves-Corvo Mine, Portugal

INTRODUCTION

Neves-Corvo, Somincor's high-grade copper-tin underground mine, is located the southern part of Portugal, 220 Km south of Lisbon, and on the south western limit of the Iberian Pyrite Belt.

The Mine is owned and operated by Somincor, and was discovered in 1977, by an association of SOCIEDADE MINEIRA DE SANTIAGO (a Portuguese state company) with two French partners, SEREM (BRGM) and PENARROYA, wich formed SOMINCOR in 1980, to develop and operate the deposits.

In 1985, RTZ acquired the French shareholding, representing 49% of the Company. The Portuguese state through EDM owns the balance.

The orebody is composed of five lenses of sulphides, overlain by 250 to 650 meters of sedimentary rocks, with the highest base metals grades known in the Iberian Belt.

Ore reserves are recognized for a mine life of approximately 20 years, for the copper resources and 10 years for the tin resources.

Substantial reserves of polymetallic ores, with zinc are still under study at the feasibility stage.

Current geological reserves consist of 30.25 million tonnes of copper ore grading 7,94% Cu and 2,68 million tonnes of copper/tin ore grading 13,62% Cu and 2,42% Sn, located mainly in two massive sulphide deposits, called Corvo and Graça.

SITE CONDITIONS

The mine is located in a landscape of rolling hills with the elevation varying from slightly over 250 m down to the elevation of the Oeiras River bed at 190 m. Oeiras River is the most important stream of this region, a tributary of the Guadiana River.

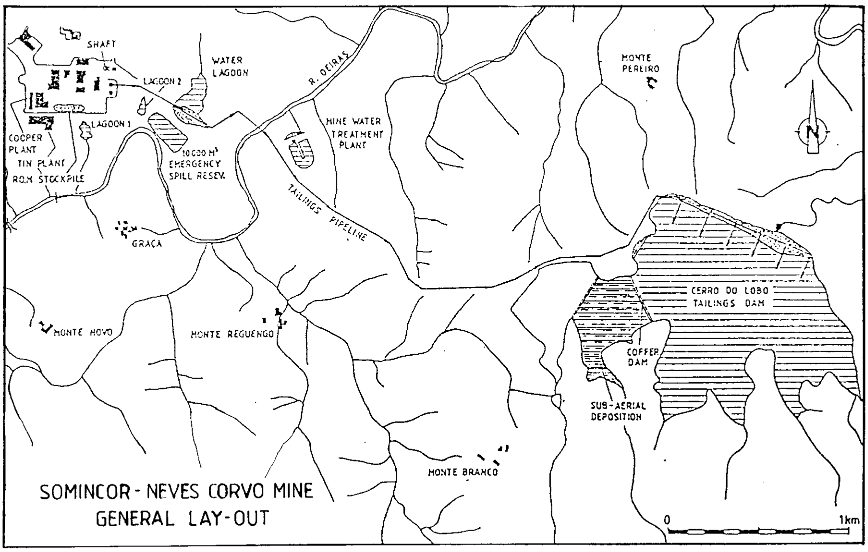

Fig. 1

Hydrogeologically, the area is characterized by Paleozoic-metamorphic rock formations, with the main outcrops essentially graywackes and shales of the Flysch Group, considered as a whole as a low permeability complex.

The climate is arid with great annual variations of rainfall. Prevailing winds are from the northwest.

The average daily temperature for the last 30 years (T), as well as the average maximum (TM) and average minimum (Tm) air temperatures are shown in table 1.

Production started at the end of 1988, and full production will be achieved by the end of this year, treating 1.6 million tonnes a year, producing in excess of 130 000 tonnes of copper and 5 500 tonnes of tin, in concentrates, annually.

Because of the high grade ore value and the orebody geometry, mining uses a cut and fill method with cemented backfill.

Processing is achieved by two concentrators, a copper plant and a copper tin plant. Both are conventional plants, using flotation and/or gravity methods, with the main feature being the fine grind grain size required to obtain a good liberation, 20 micron.

The major potential sources of environmental impact have been studied during the early stages of the project, and taken into consideration during the construction of installations and operations at the mine.

Tailings disposal has received particular attention, being a potential source of ground water, surface water and dust pollution. Numerous studies have been commissioned and will continue, to minimize the impact of Neves-Corvo operations on the Environment.

TABLE 1

T	TM	Tm
15.7º C	22.2º C	9.1º C

The monthly rainfall distribution shows the existence of two periods. One, rainy from October to March and another, dry, from May to September. April is the transition month between those periods.

Table 2 shows the 28 years average rainfall (1959-1987) in mm by month distribution.

TABLE 2

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
Rainfall (mm)	52.1	63.7	60.4	57.1	59.7	44.1	35.2	21.8	10.7	4.0	2.0	18.0	426.5

Table 3 shows the evaporation average values calculated using the Penman method, for the same 28 years (1959-1987), distributed by month.

TABLE 3

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APRIL	MAY	JUN	JUL	AUG	SEP	TOTAL
Evaporation (mm)	90.5	43.6	27.4	29.4	46.0	81.6	113.4	163.0	199.2	240.2	220.5	147.1	1401.9

TAILINGS PHYSICAL AND CHEMICAL CHARACTERISTICS

Fig. 2 and table 4 give details of the physical and chemical characteristics of the combined tailings product, from the copper and tin concentrators.

These are pumped as a slurry with 30% solids pulp density to the Cerro do Lobo tailings depository and subaqueously deposited.

The solids average specific gravity is 4.1. and the slurry pH is comprised between 9.5 and 10.

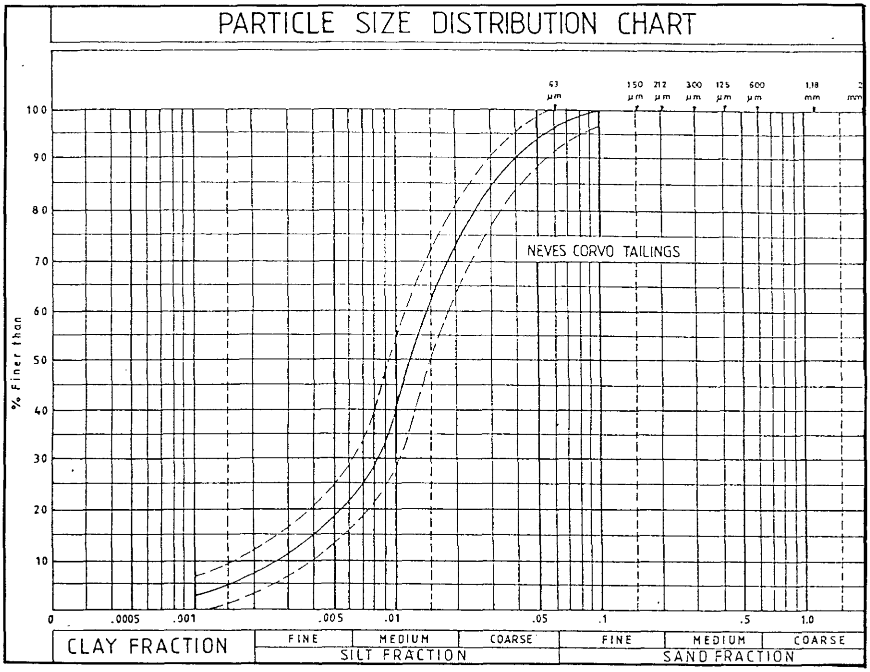

Fig.2

TABLE 4

Chemical Analysis of Neves-Corvo Tailings

	Typical	Min.	Max.
Cu%	0.9	0.6	1.50
Pb%	0.1	0.08	0.15
Zn%	0.2	0.1	0.5
S%	25	20	42
Fe%	20	16	35
Sn%	0.5	0.3	1
As ppm	3500	2000	7000
Sb ppm	400	250	1000
Bi ppm	100	70	150
Ag ppm	30	15	50
Hg ppm	10	5	20

TAILINGS DISPOSAL CONCEPTUAL DESIGN

Waste products of other mining operations worldwide, in particular mill tailings, have been disposed of in lakes, natural depressions near to the mine sites, enclosed valleys and in engineered impoundment basins. Despite the fact of a proper design for each situation, the latter method of disposal together with a proper management of the deposition, is considered to be probably the best long term safe disposal of mill tailings.

The oxidation of the sulphide tailings is controlled by the ease with which oxygen can permeate into the tailings mass. Sub aqueously deposited pyrite oxidises at a substantially reduced rate which is controlled by the quantity of dissolved oxygen in the tailings water. This fact also allows contained metal values to be preserved.

In the long term, acid generation can be controlled by maintaining an aqueous cover, or by the installation of an impermeable covering layer, after drainage and consolidation for reclamation, if the site is to be abandoned.

In Neves-Corvo during the conceptual stage with mill tailings being 90% sulphides, and having an important residual value in copper and tin, and the presence of heavy metals, made it essential that the disposal method was carefully investigated, to achieve a environmentally sound operation, keeping the possibility of recovery of the residual values in copper and tin, in the future.

Comparison of on-land and underwater disposal methods was done through review of literature and visits to other operations, to investigate both technical and environmental aspects. After this review, the construction of an engineend impoundment for underwater disposal of tails was selected.

The available data on tailings effluent was not sufficient to design an effluent treatment system. For this reason the dam was designed for a storage period of 3 years, with zero discharge. During this period, detailed monitoring of the water quality could be undertaken, as well as realistic hydrologic water balances, water reutilization to the process to determine whether zero discharge was practical, and to evaluate how much effluent may require treatment before re-use or disposal into the Environment.

The following advantages and disadvantages of the retained solution, were anticipated:

+ Extent of oxidation limited, minimizing the risk of groundwater pollution. Physical and chemical amelioration technically possible.

+ Metal values kept in place, and accessible for value recovery in future.

+ Prevention of wind erosion with associated dust problems.

+ Lower probability of mechanical failure of the embankment.

- Impoundment construction expensive to built.

- Low tailings deposit density allowing less efficient utilization of the depository volume.

- Reclamation to be made only at the end of dam life.

CERRO DO LOBO TAILINGS DAM

The Tailings Dam is located about 3 Km east of the mine facilities and its ultimate capacity is about 17,5 M cubic meters for a 33 m high main embankment. Smaller saddle dams about 150 m long and a maximum 12m high, define the impoundment area. Construction was planned to progress in different phases.

The depth capacity curve for the Cerro do Lobo depository indicates that some 6x10 m3 of storage volume has been created by the construction of a stage I retaining embankment to elevation 244, to be increased later to 17.5 x 10 m3 in a stage II, to elevation 253.

The main embankment of the stage I Cerro do Lobo dam comprised a 24m high, clay cored rockfill dam, designed to water retaining standards. The central clay core provides the zone of low permeability supported by mine waste rockfill shoulders, with slopes of 1:1.75 and 1:1.8.

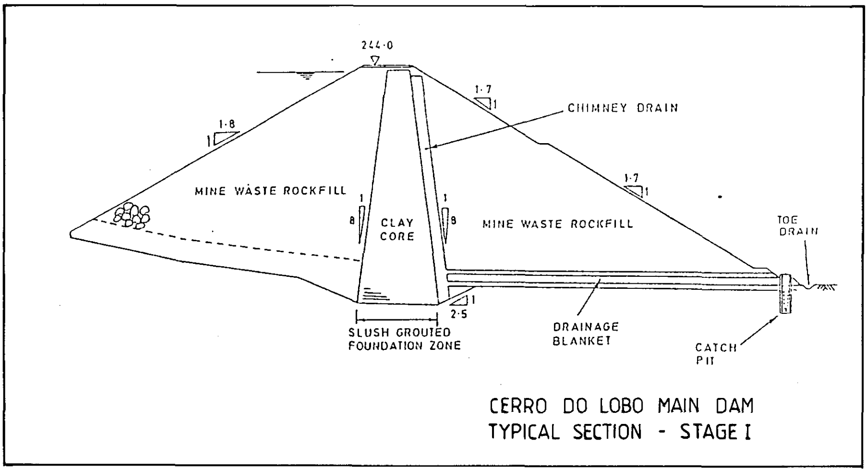

Fig. 3

Internal drainage within the embankment is provided by an inclined chimney drain located between the clay core and the downstream shoulder.

Seepage which passes through the core or through the foundation zone is collected via a drainage blanket into a shallow cut off drain at the toe of the embankment and into a deep catchpit. The catchpit has been designed to accommodate all seepage passing through the tailings dam and its foundations. All seepage thus intercepted is returned to the tailings reservoir by pumps located within the pit. By this means, water emanating from within the reservoir is sent back into the tailings dam.

The seepage collection arrangements were designed following investigation of the geological strata in the dam foundation area. At the design stage the designers undertook an investigation of the rock strata beneath the dam via a number of exploratory boreholes and concluded after extensive water absorption testing that rock permeabilities in this are were on the limit of groutability.

The designers and Somincor therefore concluded that there was no merit in undertaking foundation grouting below the dam.

Foundation treatment to the embankment was restricted to surface grouting beneath the core zone including dental concreting of all cracks and fissures exposed during foundation preparation and slush grouting to ensure that the core material would be contiguous with the foundation rock.

Consideration of the seepage flow net at the deepest and therefore the most critical section beneath the dam indicates that all seepage emanating from the upstream foundation zone of the dam will be intercepted by the drainage blanket.

TAILINGS DISPOSAL

In January 1989, sub-aqueous deposition started, from the main wall of the dam, through a series of floating discharges pipes, which allow tailings deposition to be undertaken at a distance of 100 metres from the main embankment.

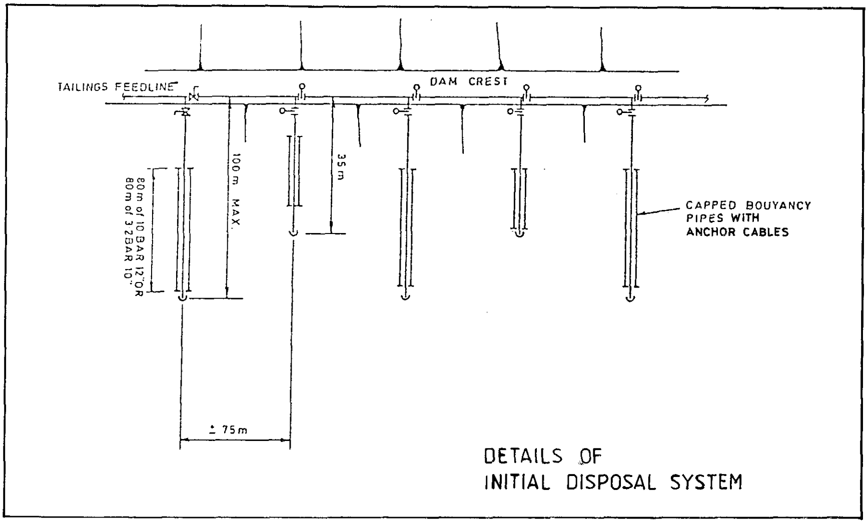

Fig. 4

The use of these floating discharge pipes was selected as a means for a more effective infilling of the depository allowing proper disposal management. As the pond increases, a ring distribution around the impoudment will be built.

Subaqueous deposition is in normal and successful operation. Negligible seepage, 4 m3/H and decreasing with time, has been closely monitored since start-up, as well as boreholes in the area, for early signs of ground water pollution.

During the initial stage of operation of the area, the opportunity was provided to undertake trials for subaerially deposition, considering the potential advantage of density, without generating acidic conditions.

The technique involves the systematic deposition of tailings in thin layers over a gently sloping beach to settle, drain and partially dry, prior to covering with a further layer. Drainage produces densities in excess of those achieved by subaqueous deposition with tailings exhibiting higher strength and lower compressivity characteristics.

A small coffer dam, located inside the main dam and above the water level in the pond was selected for the trial. This coffer dam was used during the start up of the copper concentrator, in October 1988, for the deposition on land of approximately 50 000 tons of tailings. The trial was done in parallel with subaqueous deposition in the main dam. Signs of acidic generating conditions started to appear almost immediately.

A single spraybar comprising two 10 m long limbs of 150 mm diameter pipe was used, with 50 mm holes at 1 m intervals to distribute the slurry on the tailings beach.

The spray bar was operated intermittently from the beginning of August to the end of October 1989, with the objective of discharging a new layer onto the beach over a period of either 24 or 48 hours per week.

Samples from the tailings were obtained from the periphery of the beach, on a daily basis and tested for the pH and moisture content of the paste. Individual readings from each sampling point have been combined in average values.

Although average pH values for the whole spray bar deposit remained in excess of 7, isolated readings were recorded with pH in the range of 4 to 5. These values can be attributable to isolated pockets of material that remained exposed for a long period.

Indications of densities were that average density upon completion of deposition within the depository could be estimated to be of the order of 1.4t/m3 subaqueously and 1.9t/m3 subaerially.

Allowing for the reduction in tailings density, by assuming that the final pond area occupies some 30% of the depository, resultant average density would be of the order of 1.7tm3, some 25% greater than achieved subaqueously.

However, despite any environmental considerations, the high water level already existing in the pond, and considering an eventual reconvertion to subaerial deposition system, a substantial amount of subaqueous deposition would always occur in the dam life, and the full advantage of an increased storage capacity was unlikely to be obtained.

It has also been anticipated, especially considering the climatic conditions of the area, and the total surface involved (164 Ha at final elevation), that subaerial deposition would be costly and operationally very difficult.

To management, the main potential problem with a subaerial method, if other limitations do not prevail, is the accelerated generation of acidic conditions in new tailings being deposited.

The oxidation rate of pyrite is effected by bacteria activity, where some species, operating between pH 4.5/3.5, create suitable acid conditions in which they thrive, so that the pH is rapidly reduced to below 2.0. Once the pH drops below 3.0 in the tailings mass, the situation becomes practically irreversible, with ferric iron, as a product of the reactions, triggering the oxidation of further pyrite.

The pockets where pH in the range of 5/4 were recorded would be zones where accelerated acidification would occur. The large amounts of acidity which could be generated under these conditions would have significant cost implications for the treatment of water to be reused or disposed of to acceptable standards.

SUMMARY AND CONCLUSIONS

The initial operation of Cerro do Lobo tailings depository, provided the opportunity to evaluate tailings deposition methods, either subaqueously or subaerially.

Due to the potential pollution hazard resulting from oxidation of the predominantly pyritic tailings, as well as the possible metallurgical recovery of valuable metals contained in the future, the subaqueous method was selected.

The technique provides a economic, safe and environmentally sound method of tailings storage.

pH values of water inside the tailings pond are kept at acceptable values between 6/7, limiting the oxidation of pyrite and solution of heavy metals, minimizing the risk of ground water pollution.

Seepage from the depository is negligible, probably resulting from the sealing of the bottom of the reservoir, due to the very fine nature of the tailings.

Seepage water chemistry reflects the good water quality standards of the pond.

The potential for dusting from on land or subaerial tailings deposition is totally eliminated, during the most part of the reservoir active life.

Neves-Corvo copper-tin tailings, due to their metal content must be considered as a potential mineral resource, and currently different possibilities are under discussion, mainly sulphur and base metals recovery.

If the decision for the abandonment is retained, acid generation can be controlled in the long term by the installation of an impermeable layer.

In the short term, assessment of the right techniques for effective drainage of the tailings mass will progress, to provide in the long term, the drainage of the deposit and final restoration, with the same standards of precautions in relation to the Environment, that the company has followed up to now.

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