

SYNTHESIS REPORT

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TITLE: SULFide Tailings Integrated Management:
The FIXed/Stabilized BACKfill as an Environmental
and Mining Necessity (SULFIXBACK)

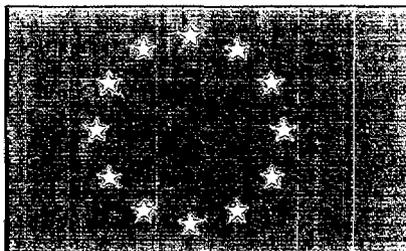
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PARTNERS : PFUTES ALENTEJANAS 1ST
CXWPCIR
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2. TITLE AND AUTHORS

Title:- Sulphide Tailings Integrated Management The Fixed Stabilized Backfill As An Environmental And Mining Necessity

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3. ABSTRACT

The backfill project brought together three mining operators - Pirites, Ahrxagrera, and Cogema- all of them with underground mines exploiting complex sulphide ores. After processing, these ores produce large amounts of sulphide tailings. Project's aim was to develop a solution for the use of these tailings in the underground mine backfill,

Extensive research and testing was done during 42 months of Project life. Besides the three mining operators, the consortium included other partners two Universities, Lisbon(IST) and Nancy(CNRS), one Research Institute(D@L), and Cimpor (Portuguese cement producer) with its Central Testing Laboratory. With this kind of partnership, the Project benefited both from people with large industrial experience and highly qualified research background. The study comprised of a comprehensive programme of fundamental and applied research including extensive laboratory testing and some pilot scale work.

All three sulphide tailings were studied. Besides full chemical, size and mineralogical characterisation, different approaches to inertization process were investigated aiming chemical stability to inhibit sulphide oxidation. Mechanical strength behaviour of mixtures of these tailings with different binders was tested. Because of the fineness of all these tailings, their auto-ignition potential was assessed.

The results demonstrated that the disposal of all three tailings in the underground backfills is technically attainable. Nevertheless, the conditions for each case are different from one another. Overall testing methodology has been developed, but the solution for each case must be established after comprehensive testing following that methodology. Industrial application of any solution requires cost/benefit analysis to assess its economic viability. This assessment should contemplate long-term view. In this respect Cogema case deserves a special reference, as it has already started to introduce the Project findings into the normal operation at one of its mines.

4. INTRODUCTION

Most of the base metals (Cu, Pb, Zn) and gold producing mines exploit and process sulphide mineralization creating large amounts of sulphide tailings (normally pyrite and arsenopyrite are the major components) which have to be properly disposed.

At present, the most widely adopted solution is the surface disposal in ponds under wet or dry covers. Although this solution is currently been accepted, its soundness in long -term view is being questioned.

Most significant problem is the environmental impact caused by these tailings as a consequence of the oxidation of sulphide minerals which are highly reactive when exposed to the air and water. Leaching and flushing of the oxidation products introduce acid contaminants in the surrounding medium. The flow of acid contaminants react with the rock formations in contact, and modifying its pH cause the contamination of the drainage system with pollutants.

Integrated management of sulphide tailings aimed their use as backfill material in the underground mines.

Three E.U. mining operators - Pirites, Almagrera, and Cogema - all of them with underground mines exploiting complex sulphide mineralization, have to handle large amounts of sulphide tailings. The solutions in current use are not considered totally satisfactory in long-term view. Aiming the development of an alternative to the present day solution, the three - Pirites, Almagrera, and Cogema - decided to join efforts to study the problem. SUMBACK Project was the result of this joint decision. It was clear to all three that a comprehensive programme including fundamental and applied research was essential. To assure this input, the other partners who joined the Project were: two Universities- Lisbon(IST) and Nancy(CNRS), one Research Institut@NPL), and Cimpor (Portuguese cement producer) with its Central Testing Laboratory.

The Project lasted 42 months with extensive laboratory research and testing work, The study focused all three tailings, and teams from all three countries- Portugal, Spain and France - took part in the investigation. The Project has provided material for four Doctorate works (one in Portugal and three in France) and one Master's thesis (Portugal). The Project results have been presented to International Workshops and Conferences. A dozen of international publications are already made.

The Project results show that all three tailings could be used in underground backfills. The best technical conditions have to be established for each case following the methodology developed during the Project. Economic viability of integrating the technical solution in the normal industrial practice depends on cost/benefit analysis of each case.

5. TECHNICAL DESCRIPTION

The study focused on the samples of the sulphide tailings of the three mining operations (Pirites, Almagrera and Cogema).

It should be referred that the sulphide ores exploited by the above mines show notorious variability not just between different orebodies and ore types but between samples of the same ore type, Tailings resulting from these ores show the same pattern. This fact makes essential the detailed characterization of the samples in order to interpret the respective results aiming their wider application.

Besides sample characterization, research work focused most heavily on chemical stability and inertization processes, Development of a sound inertization process was considered as a priority and different research approaches were investigated. Selection of an optimum binder was also investigated which led to the establishment of the best tailings' binder mixtures. These mixtures were extensively tested for the fitness of mechanical strength and its consistency over a period of time of up to one year. As all three tailings contain very fine material, potential for auto-ignition exists and this risk was assessed.

Hydrogeological impact in the surrounding environment where the sulphide tailings are used in underground backfills was studied having in mind the protection of the underground waters from pollutant contamination. The case in study was the Moinho Mine (Pirites).

Pilot testing was done with bulk samples (piles) of 100 and 150 Tons. Backfilling conditions and sulphide oxidation behaviour were investigated.

SAMPLE CHARACTERIZATION

Chemical and toxicological analysis

Chemical analysis of the three tailings are given in the following table:

| Chemical Element | Tailings from | | |
|------------------|---------------|---------|-----------|
| | Cogema | Pirites | Almagrera |
| Fe (%) | 25.3 | 43.05 | 40.38 |
| S (%) | 23.02 | 46.42 | 39.83 |
| As (%) | 11.65 | 1.02 | 0.55 |
| Cu (%) | 0.08 | 0.21 | 0.48 |
| Co (%) | 0.2 | 0.6 | 1.42 |
| Zn (%) | 0.12 | 2.67 | 0.84 |
| Sb (ppm) | 2125 | 659 | 767 |
| Hg (ppm) | 0.2 | 98 | 31 |
| Cd (ppm) | 20 | 75 | 13 |
| Pb (ppm) | 19 | 33 | 2? |

Mineralogical composition of three sampies with srdphide and gangue minerals and possible pollutants is summarized in the following table.

| | SULPHIDES | POSSIBLE POLLUTANTS | GANGUE |
|---------------------------|--|---|----------------|
| COGEMA TAILINGS | Pyrite FeS ₂ | As, SO ₄ ²⁻ | Chlorite |
| | Arsenopyrite FeAsS | As, SO ₄ ²⁻ | Quartz |
| | Berthierite FeSb ₂ S ₄ | Sb, SO ₄ ²⁻ | Micas |
| | Marcassite FeS ₂ | SO ₄ ²⁻ | Dolomite |
| PIRITES TAILINGS | Pyrite FeS ₂ | As, SO ₄ ²⁻ | Quartz |
| | Chalcopyrite CuFeS ₂ | Cu, SO ₄ ²⁻ | Magnetite |
| | Sphalerite ZnS | Zn, Cd, Hg, SO ₄ ²⁻ | Cassiterite |
| | Galena PbS | Pb, SO ₄ ²⁻ | |
| | Fahlores Cu ₁₂ (As.Sb) ₄ S ₁₃ | Cu, Zn, Hg, As, Sb, SO ₄ ²⁻ | |
| | Sulfoantimonides of Sb, Pb, Cu, Bi | Pb, Cu, Bi, Sb, SO ₄ ²⁻ | |
| | Pyrrhotite Fe (1-x)S | SO ₄ ²⁻ | |
| Arsenopyrite FeAsS | As, SO ₄ ²⁻ | | |
| ALMAGRERA TAILINGS | Pyrite FeS ₂ | As, SO ₄ ²⁻ | Sidérite |
| | Chalcopyrite CuFeS ₂ | Cu, SO ₄ ²⁻ | Quartz |
| | Sphalerite ZnS | Zn, Cd, Hg, SO ₄ ²⁻ | Micas-Chlorite |
| | Galena PbS | Pb, SO ₄ ²⁻ | Dolomite |

The above results indicate that most abundant sulphide mineral in the three tailings is Pyrite, although Cogema sample also contains high quantity of arsenopyrite.

Arsenic is the common potential pollutant for all three tailings. The other potential pollutants are Sb, Pb, Cd, Hg and Zn.

Grain size and mixed particles

The global laser granulometric study indicated that all three tailing samples were very fine with an average grain size of 18 micra.

The quantity of ultra-fines contained (minus 5 micra) is important, for Cogema and Pirites (10 to 15%) and for Almagrera (more than 60%).

Frequency of mixed particles is very low both for Almagrera and Cogema, on the contrary, Pirites tailings show many mixed particles (all containing pyrite) in the coarse fractions.

Particle Surface Characterization

Surface state analysis by XPS indicated an overall oxidation at mineral surfaces. BET measurements of specific surface indicated values varying from 1,04 m²/g to 4,74 m²/g

Leachability of solid particles

Electrochemical behaviour of tailings was compared with pure pyrite and arsenopyrite, using carbon paste electrodes. It appears that the oxidation behaviour of the three tailings in cement equilibrated medium is very different.

Leachates obtained from Soxhlet extraction confirmed the chemical and mineralogical findings about potential pollutants. Arsenic is the main common potential pollutant for all three tailings, while Cd and Pb are additional potential pollutants for both Pirites and Almagrera tailings and Sb is more important in Cogema sample.

Although raw tailings show high oxidability, their reactions with Ca²⁺ basic solutions induce partial insolubility of arsenic.

RESEARCH OF THE BEST CFS (CHEMICAL STABILITY AND SOLIDIFICATION) PROCESS

Chemical fixation

Three different cements, ordinary Portland cement [OPC], blast furnace cement (13FC) and aluminous cement (AC) were selected to prepare mortars after mixing with tailings. Besides these 3 cements, in case of Cogema, also lime entered in the preparation of mixtures. Weight of cement in the mixture varied from 5 to 20%, and of the lime between 10 and 20%. Mortars (2x2x7 cm) were kept 28 days in a moisture chamber. Soxhlet extraction leaching tests on mortar samples lasted 10 days under oxygen flow with control of pH, Eh, leachates composition and observation of solids by optical and SEM microscopes.

Main findings of this study were:

- Arsenic and antimony release drops significantly with the increase of portlandite content of the matrix, as excess of lime improves the As retention in the calcium arseniate form.
- 13FC cement has a positive effect on lead and zinc retention, on the contrary these elements are more soluble with lime.
- Microporosities of mortar are smaller with BFC cement than (3PC cement).
- With the increase of tailings percentage in mortars respective porosities also increase.
- The difference between OPC and E3FC mortar porosities becomes smaller with the increase of tailings percentage.
- More cement improves the adhesion of the cement components to sulphide surfaces.
- Macro porosity due to trapped air bubbles increases when tailings are present, compared to pure cement pastes.
- 13FC cement is recommended as binder for the backfill preparation as it seems to have a protective behaviour against the sulphide oxidation.

Characterization of mortar after ageing and weathering

The consequence of ageing and weathering process was investigated studying the evolution of the microstructure and chemical composition of the mortars upon enhanced leaching.

General and specific tendencies of alterability were examined with reflected light microscopy complemented with quantitative analysis of elemental variations within the weathering fronts in various matrices. XRD and SEM studies revealed efficient arsenic retention.

Chemical stability improvement sulphide precipitation

The investigation is related to the ability of metallic hydroxides to suppress the oxidation by air of mineral sulphides, which causes the liberation of toxic species such as heavy metals, arsenic, etc.

Pure pyrites (FeS_2) and arsenopyrites (AsFeS) as well as mineral pulps resulting from flotation by thiois, with silicate content varying from 5 to 60% were tested.

For testing this new approach, several techniques were applied to specify the speciation of metallic compounds used as adsorbate (As, Fe, Mn, Ni, Co, Al) separately in solution and at the liquid-solid interfaces photoelectron spectroscopy (AES), electrokinetic and electrochemical methods, ionic chromatography, nephelometry, etc.

The best conditions for the preconditioning of the mineral pulps have been obtained with nickel salts chosen as model adsorbates because of its high recovery power, of its ability to render hydrophobic others sulphides such as galena and chalcopyrite, and of its properties as flocculant.

At pH=10, the electrical charge of mineral sulphides is highly negative, while that of Ni(OH)₂ colloids is highly positive. The progressive addition of Ni(II) into the pulp led to its flocculation and the electric charges of the mineral sulphides became positive. The dielectric permittivity of the pulp evidences the loss of the conductivity of the mineral after a sufficient amount of Ni(II) salt is added (Fig. 1).

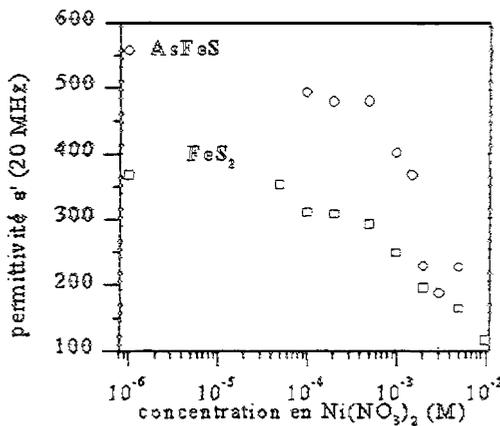


Fig. 1 Variation of permittivity ε' (MHz) of pyrite and arsenopyrite with the amount of Ni(II)

XRF measurements prove that Ni(II) is under hydroxyde form at the interface and not as sulphide as has been previous thinking. The charge effect observed in XRF spectra confirms the uncondutive character of the Ni(OH)₂ coating on FeS₂ and on AsFeS. In the optimal conditions, the number of hydroxyde layers on pyrite has been estimated to five. The performance of the Ni(II) coating at pH 10, has been tested by ionic chromatography, the samples being in contact with concentrated 1+202 solutions (O.I.vf). For arsenopyrite, the percentage of arsenic liberated is reduced by a factor between 5 to 7 according to the experimental conditions. The behaviour of Fe(III), Mn(II), Al(III) hydroxides have also been studied. Their adsorption is also function of their electric charges, at corresponding lower pEI (7-9). Factors such as time, concentration and oxidation state of the minerals have to be considered to optimise the present results.

MECHANICAL CHARACTERIZATION OF CEMENTED BACKFILLS

Three sets of tests were performed for the mechanical characterisation of the backfills. These included settlement, direct shear and uniaxial compressive resistance.

Mixtures of aH three tailings were tested. Compositions of mixtures were established according to the results of CFS tests and are shown in the following table:

| Mines | Backfill Compositions | | | |
|-----------|-----------------------|------------|-----------|-----------|
| | Dry Tailings (%) | Cement (%) | Chalk (%) | Water (%) |
| COGEMA | 65 | 10 | 0 | 15 |
| | 60 | 10 | 5 | |
| | 41 | 17 | 17 | |
| HRITES | 82 | 0 | 0 | 18 |
| | 79 | 3 | | |
| | | 5 | | |
| | | 10 | | |
| ALMAGRERA | 82 | 0 | 0 | 18 |
| | 79 | 3 | | |
| | 77 | 5 | | |
| | 72 | 10 | | |

Backfill percentage compositions in weight for the three mines.

Settlement tests

All above mixtures were tested for three curing times (1,6 and 12 months). For each test the following parameters were measured: permeability (K), consolidation coefficient (Cv), oedometric compressibility coefficient (rev) and maximum settlement (s_{max}). Example of the values of measurements for curing time of 12 months is presented in the following table. No big variations of these values are observed for the different curing times.

| MrN~ : | " BACKFILL Cm.msrrkm | | | . " "=LMUM ~ETTixMEiy (% height) | m _v (m ² /M N) | C _v ^[1] (m ² /ye ar) | K (×10 ⁻¹⁰ m/s) |
|-----------|----------------------|----------------|--------------|--|--|---|----------------------------------|
| | Cement (%) | Chalk (%40) | Water (%) | | | | |
| COGEMA | 10 | 0 | 25 | 2.75. " | 0.028 | 21.9 | 1.87 |
| | 10 | 5 | | 2.20 " .: | 0.017 | 19.2 | 1.02 |
| | 17 | 17 | | "1.66 : | 0.009 | 9.4 | 0.25 |
| PIRITES | 0 | 0 | 18 | 9.38 ~ ~ .: | 0.042 | 22.3 | 2.93 |
| | 3 | | | 10.93 . " | 0.073 | 17.9 | 4.08 |
| | 5 | | | gg " : i | 0.075 | 15.2 | 3.57 |
| | 10 | | | . ~ > *g " | 0.041 | 13.9 | 1.77 |
| ALMAGRERA | 0 | 0 | 18 | 10.58 . . ' : | 0.067 | 22.0 | 4.57 |
| | 3 | | | . : 6 . ? 7 | 0.064 | 20.9 | 4.17 |
| | 5 | | | say- . . . : | 0.053 | 16.2 | 2.66 |
| | 10 | | | 2.37. . , | 0.023 | 16.8 | 1.18 |

^[1] Determined using the Taylor's Method'.

Results of settlernertt tests for a curing time of 12 months.

As a general common result of these tests one can conclude that aH the mixtures show a very low compressibility and practically no permeability.

Direct shear tests

These tests were done on the same mixtures as for above testing, but with only 2 curing times of 6 and 12 months. The following table include the results of the two measured parameters: cohesion (c) and friction angle (ϕ) after 12 months of curing time.

| Mixture | Composition (%) | | | Cohesion (kPa) | Friction Angle (°) |
|------------|-----------------|-----------|-----------|----------------|--------------------|
| | Cement (%) | Chalk (%) | Water (%) | | |
| COGEMA | 10 | 0 | 25 | 33.3 | 32.3 |
| | 10 | 5 | | | |
| | 17 | 17 | | | |
| PIMTES | 0 | 0 | ~g | 34.2 | 31.1 |
| | 3 | | | | |
| | 5 | | | | |
| | 10 | | | | |
| ALMAGIUN?A | 0 | 0 | la | 34.7 | 31.3 |
| | 3 | | | | |
| | 5 | | | | |
| | 10 | | | | |

~il Parameters not achieved due to the hardness of the specimens that exceeds the shear machine capacity.

Results of the direct shear tests for the specimens of 12 months of curing time.

The Results indicate that the cohesion has an identical evolution with the cement percentage for Pirites and Almagrera mixtures, while the Cogerna mixtures show high values. The friction angle shows small variations (max. up to 15%) with cement percentage and different curing times.

The main conclusion of these two set of testing was that the addition of adequate quantity of proper cement, besides contributing to the inertization of tailings material, is also very effective for the improvement of the backfill mechanical behaviour.

Uniaxial Compression Resistance Tests @.C.R)

For this set of testing 69 different mixtures were examined for curing time varying from 7 to 365 days. Following table shows the number of mixtures tested for each tailings.

Time schedule of the compression tests

| Number of Mixtures to be done | | | | |
|-------------------------------|-----------|---------------------|-----------|-------------|
| Curing Time (days) | Mines | | | Total |
| | Cogema | Pirites Alentejanas | Almagrera | |
| 7 | 3 | 4 | 4 | 11 |
| 28 | 3 | 4 | 4 | 11 |
| 1561 | 3 | 1 | 4 | I 4 1 1 1 1 |
| 128 | 3 | 4 | 4 | 11 |
| 12561 | 3 | I | 4 | ! 4 1 1 1 1 |
| 365 | 6 | 4 | 4 | 14 |
| Total | 21 | 24 | 24 | 69 |
| Number of provets to test | | | | |
| Curing Time (days) | Mines | | | Total |
| | Cogema | Pirites Alentejanas | Almagrera | |
| 7 | 9 | 12 | 12 | 33 |
| 28 | 9 | 12 | 12 | 33 |
| (5 6 i 9 i 1 2 \ 1 2) | 3 | 3 | 1 | 3 3 1 |
| 128 | 9 | 12 | 12 | 33 |
| 256 | 9 | 12 | 12 | 33 |
| 365 | 18 | 12 | 12 | 42 |
| Total | 63 | 72 | 72 | 207 |

Although the results are different for each mixture, for all three tailings the addition of cement improved the uniaxial compression resistance (U.C.R.) although up to 5*A of cement addition, this improvement is negligible. Any significant improvement requires the addition of cement of 10*A.

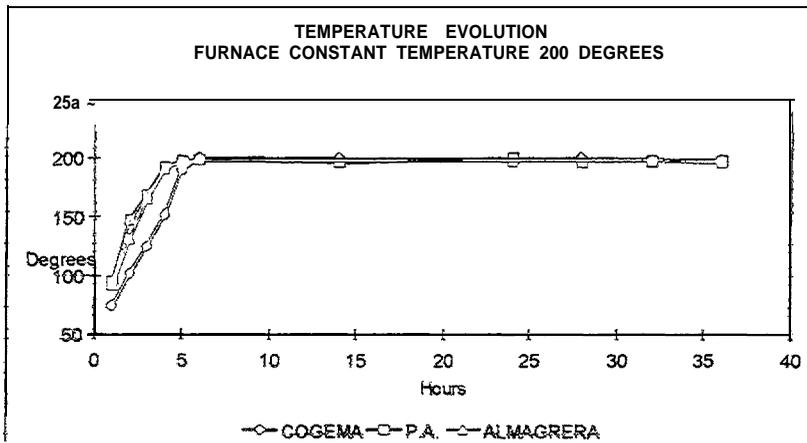
U.C.R. values increase up to a certain curing time. Generally after this point of time U.C.R. values stabilize or decrease slightly.

AUTO-IGNITION POTENTIAL ASSESSMENT

Heating Tests

All three tailings were tested. Nine laboratory tests were made, three for each tailing heating 700 g of sample at constant temperature in the furnace. Keeping the furnace temperature constant at 200°C, 250°C and 300°C, the sample temperature was recorded along the time intervals of 1, 2, 3, 4, 5, 14, 24, 28 and 36 hours.

Graph



The moisture contents of the three tailings at the beginning of the tests were:

- Cogema Tailings - 17.5%
- Pirites Tailings - 9.5%
- Almagrera Tailings 11.2%

Neither of 9 tests indicated abnormal heating, concluding that these tailings have no auto-ignition capability.

Thermogravimetric tests

Only samples of Almagrera tailings were used for these tests. Test procedure is conventional and consists in heating a weighted sample at a prefixed heating speed (10°C min⁻¹), and monitor the weight changes and weight increment velocity along a certain temperature range (up to 1100°C). Results of weight changes correspond to Thermal Gravimetric Analysis (T. G.A.), while the changes of increment velocity correspond to Differential Thermal Gravimetric Analysis (D. T. G.A.). Tests were done with surrounding atmosphere compositions of air and nitrogen. This intended to simulate the backfilling conditions during normal operation and on the complete filling of the stope.

The results showed that under air atmosphere the auto-ignition starts only when temperature level reaches 400°C. Under nitrogen atmosphere the minimum temperature level is 416°C, but in this case the continuing of auto-ignition reaction requires external source of heat.

Findings of this testing clearly indicates that the three sulphidic tailings from Pirites, Almagrera and Cogema present no risk of auto-ignition for their use in underground backfill

HYDROGEOLOGICAL IMPACT

Protection of underground water against contamination, even in the long-term view deserves priority consideration. Disposal of sulphide tailings in the underground mine backfill can create potential for pollutant contamination of the surrounding environment, depending on its geological characteristics. A detailed geological investigation becomes essential to ascertain the conditions of mine water flows drained through underground backfills.

Hydrogeological conditions of Moinho Mine (Pirites) were studied to investigate the impact of using sulphide tailings in the backfill of underground stopes. The study investigated the time intervals after which a target underwater source becomes contaminated due to backfill,

Starting from the information on the local geology, climate, rock mass properties, mining method and tailings composition, six scenarios of probable situations were established. The difference between the scenarios was the backfilling conditions of the tailings which varied from raw tailings without any lining of the backfill chamber up to inertized tailings with the shortcrete lining. The first scenario was the least protective case and the last one included the highest protection.

Simulation method using a computer 3-D model revealed that in the least protective case it will take 9 years to contaminate the groundwater target-source, while in the highest protection case it will be almost 200 years to reach the same situation. The results show that alternatives for improved practices do exist with attached increased costs and it might be possible to improve the decision process after some reflection of these types of findings.

PILOT SCALE WORK

Cogema has begun to apply the Project findings in the backfilling operation at its Boumeix Mine. Implementation of this practice preceded by a pilot scale backfill test with a bulk sample of about 100 tons. The tailings were mixed with OPC, lime and gravel and compacted immediately after mixing.

A water collecting pipe was installed in the pile to monitor the water characteristics. Uniaxial compressive resistance measured after 28 days indicated 1.5 to 2.2 Mpa.

Almajera studied the oxidation capabilities of its sulphide tailing preparing two piles of 150 tons each. The first one consisted of fresh product coming from the plant and the second with material stored at the surface with more than 15 days of exposure. In each pile temperatures were recorded in two different points, one at the center of the pile and the second near to the top. It was found out that at both points the temperature increases up to a certain level (around 55°C at the center and 70°C at the top) after 15/20 days, and from then on begin to decrease reaching the level of atmospheric temperature after 60 to 70 days.

The analyses of the material after three months showed that only fresh tailings contained products of oxidation and that the sulphate content of the fresh tailings after oxidation was almost similar to that of the exposed tailings at beginning and without alteration during the test (see Table below).

| ELEMENT | FRESH MATERIAL | | STOCKPILE MATERIAL |
|------------------|----------------|-------|--------------------|
| | INITIAL | FINAL | INITIAL - FINAL |
| H ₂ O | 11.5 | 5.35 | 7.65 |
| S (SULPHIDE) | 44.87 | 42.02 | 42.38 |
| S (SULPHATE) | 0.33 | 2.43 | 2.22 |
| S (TOTAL) | 45.2 | 44.45 | 44.6 |

These results suggest that auto-oxidation of pyrite may be limited to ultrafine grains. The reaction stops when these portion of the material is oxidised.

6. RESULTS

The results of the Project work are valuable to prepare a solution for the use sulphide tailings in the underground mine backfill. Normally, these type of tailings are not considered for this purpose, certainly because of the potential problems caused by sulphide in the surrounding environment. Results of research work indicate that new approaches can be envisaged to tackle this problem.

Application of the Project results is already in practice at the Le Bourneix Mine in France. The main problem in this case is the retention of arsenic impeding its release in the mine water to protect the ground water sources in the vicinity. The efficiency of the inertizing process developed during the Project work will be tested.

The importance of the Project work results could not be judged without new cases of industrial applications.

Each industrial application will require the definition of the best conditions for backfill solution with its sulphide tailings. Vast experimental data obtained during the project work has made possible to establish guidelines for the methodology to follow. Importance of this aspect cannot be overlooked when it is known that most of the sulphide ores are of complex nature and their tailings maintain this characteristic. Existence of comprehensive background data as the result of Sulphback Project is a valuable contribution to consider an alternate solution to the present sulphide tailings disposal.

7. CONCLUSIONS

The results of the research and experimental work performed within the framework of the SULHBACK PROJECT show that the tailings obtained from the mining operations exploiting arid processing sulphide mineralizations can be prepared to be used as underground backfill or storage.

This can represent an opportunity for a viable alternative for present day solutions of surface "underwater or "with dry cover storage of sulphide tailings.

All three different tailings (Pirites, Cogerna and Ahriagera) studied within the Project resulted from sulphide ore processing. Therefore, the best conditions for the disposal of each of them in different arid GWM be defined only after testing.

The work done under SULFIBACK PROJECT -provides the basis to develop a methodology for testing of each material covering:

- the characteristics
- chemical stability and mineralization
- Wet-ignition potential
- mechanical strength and cohesion

The results of this testing should provide the basis for the assessment of technical and economic viability of the underground disposal of sulphide tailings as an alternative to the present-day solutions.

8. ACKNOWLEDGEMENTS

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The work reported here is the result of efforts from large number of highly skilled people from all the Project Partners whose contributions and the spirit of collaboration are gratefully acknowledged.

9. REFERENCES

A list of publications already presented and scheduled to be delivered in the near future relating to the work performed under Sulfidback Project is presented.

1-- Mechanical Properties of Cemented Sulphide Mine Tailings Studies by C. Dinis daGama e HumbertoGuerreiro

To be presented at the 6th - National Geotechnical Congress (Congresso Nacional de Geotecnia) - Lisboa, Sept 97.

2- Sulphide Tailings Management - Sulfidback by Lopes/G. Videau.

Presented during the Lisbon joint Workshop on Mining Processing and Recycling (Sept96).

3- Picquet I., Marion P; (1-994)

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