



Zincore Metals Inc.

Project Report

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Inc.

ACCHA AND YANQUE TEST WORK

PRELIMINARY PYROMETALLURGICAL AND HYDROMETALLURGICAL TESTS

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EXECUTIVE SUMMARY

Zincore Metals Inc. is exploring the opportunity to produce zinc from the Yanque and Accha deposits. Test work utilising flotation technology did not prove to be successful and the alternative routes of reductive roasting or direct alkali leaching were considered.

The test work was conducted on composite samples made up from a representative drill cores from across the two deposits. The selection and preparation of the composite samples followed a rigorous methodology that would be considered best practice.

The application of reductive roasting for the extraction of zinc from the Accha and Yanque deposits is a viable process. Extractions of 76% and 97% were measured after 4 hours of roasting for the Yanque and Accha deposits respectively. The test work indicates that longer roasting times may improve the extraction from Yanque, and this needs to be confirmed with more test work.

It must be noted that due to the experimental procedure and the fact that not all the fume could be collected, these extraction figures were calculated by difference from the feed and slag analysis, and that these values need to be confirmed in pilot plant test work.

The application of alkali leaching produced significantly lower extraction and isn't considered to be viable.

The fume was analysed qualitatively and the zinc oxide concentration was found to exceed 90% for both Accha and Yanque, with the concentration of fluorine (F) and chlorine (Cl) in Accha found to be 0.13% and 0.11% respectively. Calcining of the fume resulted in the fluorine and chlorine levels decreasing to 0.0085% and 0.006% respectively. High quality zinc oxide (>95%) can therefore be produced from the ore.

The carbon consumption for the reduction of Accha and Yanque ore were stoichiometrically calculated to be 72kg and 25kg per tonne respectively. This is not the total carbon requirement and excludes the carbon consumed for heating the kiln.

The two ores showed different response to the reductive roast and the Yanque ore was found to melt at temperatures exceeding 1050 degrees Centigrade.

The test work would indicate that the two ores must be processed separately due to the different temperature profiles and reaction kinetics.

Lead extraction in the reductive roast varied from 20% to 90% and the opportunity exists to produce a lead by-product. This opportunity was not the focus of the preliminary study and must be considered for the future.

Pilot plant test work is recommended to confirm the findings, determine the operating cost of the proposed plant and produce product for the development of the downstream processes.

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1. INTRODUCTION

Test work aimed at producing a flotation concentrate has been done in the past on samples of Yanque and Accha ore. Due to the mode of occurrence of the various zinc and lead minerals the test work did not produce suitable results.

The next step in developing the potential process route was to consider the direct pyrometallurgical and hydrometallurgical processing of the whole ore. The objective of this test work is to explore the potential application of zinc fuming or alkali leaching to extract the valuable mineral to a “concentrate” for further processing.

The test work was done at the Mintek research facility in South Africa. Mintek is a globally recognised metallurgical research institute with a track record in both pyrometallurgical and hydrometallurgical research.

This report serves as a summary of the Mintek report no. 5580 titled “EVALUATION OF RECOVERY OF ZINC FROM PERUVIAN DEPOSITS THROUGH LOW TEMPERATURE REDUCTIVE ROASTING AND ALKALI LEACHING” dated 15 April 2010. This report should be consulted should more detailed information be required.

2. TEST WORK PROCEDURE

2.1 Sample Selection

In preparation for the flotation test campaign drill cores were produced from across both ore bodies and a robust sample selection procedure was used. A best-practise methodology was applied in generating composites of the various drill cores and the methodology was reported in detail..

Applying the methodology used in the previous test work composites were prepared of the Accha ore and Yanque ore. The composites were split into 20 samples of 500 grams each using a rotating riffle splitter. All sampling procedures used in the test work meet best-practise criteria.

2.2 Feed Analysis

Samples were submitted for detailed chemical analysis and mineralogical characterisation using X-ray Diffraction (XRD).

2.3 Pyrometallurgical Procedure

The first step in the test programme is the determination of mass gain/loss at elevated temperature in air and in an inert atmosphere. This can be summarised as follows:

- Samples were submitted for tests to determine the Loss-on-Ignition to determine potential mass loss due to the volatilisation of carbonates and hydrated minerals by heating the samples to 1000 degrees Centigrade in air;
- Thermo Gravimetric analysis of the samples was done to determine the potential mass loss while increasing the temperature from 25 to 1350 degrees Centigrade in an inert argon atmosphere.

Reductive roasting of the sample in a 30kW induction furnace was performed on a mixture of ore and carbon. The carbon acts as the reductant and is used to reduce all the oxides of iron, zinc and lead. The amount of carbon required in each test was determined stoichiometrically based on the initial sample chemical analysis. In order to ensure that enough carbon is available for the reaction 20% excess carbon was added. The amount of carbon used in the test work equates to 72kg per tonne of Accha ore and 25kg per tonne of Yanque ore.

The mixture was placed into a high purity cast crucible and heated in the induction furnace under an inert argon atmosphere for four hours. The slag was allowed to cool in air to room temperature.

The fume emanating from the furnace was collected in a vacuum for analysis. The bench-scale test rig used is not designed to capture all of the fume and the analysis is purely indicative of the relative concentrations.

Slag masses were measured and the slag assayed. The recovery of zinc and lead to the fume was determined by difference.

One sample of the Accha fume was collected and subjected to an oxidative roast at 1000 degrees Centigrade to observe how the zinc, lead and any contaminants such as chlorine or fluorine would react.

2.4 Hydrometallurgical Procedure

Samples from Accha and Yanque were slurried in a 2mol/litre ammonium carbonate solution. A 25% ammonia (NH₃) solution was added to maintain the pH of the solution at the required setpoint. The solution was continually stirred and the temperature maintained at 45 degrees Centigrade.

Solids analysis was conducted by ICP-OES (detection limit 0.05%) on the feed and leach residue. Final leach solutions were submitted for solution scan and intermediate solutions for ICP-OES (detection limit 2mg/litre).

3. RESULTS AND DISCUSSION

3.1 Pyrometallurgical Test Work

3.1.1 Analysis of Feed

Detailed analysis of the feed revealed that the ores are significantly different. The major differences are summarised below.

Element	Yanque [%]	Accha [%]
ZnO	9.56	15.6
PbO	4.84	3.73
FeO	5.02	28.3
SiO ₂	50.1	18.4
K ₂ O	7.30	2.22
MgO	4.28	0.58
Al ₂ O ₃	10.5	4.71
CaO	7.28	16.8
TiO ₂	0.53	0.18

The fluorine (F) and chlorine (Cl) assays for the two ores are similar at circa 0.20% and 0.05% respectively.

3.1.2 Loss on Ignition

The loss on ignition at 1000 degree Centigrade in air for Yanque was 15.3% and that of Accha 21.6%.

3.1.3 Thermo Gravimetric Analysis (TGA)

The response of the Yanque ore to the TGA under inert conditions indicates that the rate of mass loss from the Yanque ore was significantly slower than the Accha ore. The reaction appeared to be complete in Accha after 3 hours while the reaction in Yanque appeared to require 8 hours. This may not be directly related to the rate of extraction of zinc however it illustrates the difference in the ores.

The difference in behaviour may be expected as the mass % of ZnO, PbO and FeO in the Yanque ore is significantly less than that in Accha and the rate of extraction is driven by concentration.

The mass loss in the Yanque ore was lower at just over 25% while the mass loss for the Accha ore is just over 45%.

3.1.4 Reductive Roasting Results

An extraction of 75.8% zinc was achieved on the Yanque ore after four hours roasting at 1050 degrees Centigrade. This is a significant improvement on the recovery achieved on the flotation test work.

It is the authors opinion that given the slow response of the Yanque ore observed during the Thermo Gravimetric Analysis a higher extraction may be possible for a longer roasting time. This needs to be tested.

What is interesting to note is that at lower temperatures the lead extraction was poor (circa 20%) and improved with an increase in temperature to circa 88%. The mechanisms responsible for the “contradictory” behaviour between lead and zinc must be investigated.

The extraction of zinc and lead from the Accha ore is 96.6% and 87.6% respectively for the test at 1150 degrees Centigrade. The rate of extraction was significantly faster than that observed in the Yanque test. Increasing the temperature to 1250 degrees Centigrade did not increase the zinc extraction significantly (97.3%) however resulted in a decrease in the lead extraction to 59%.

An important observation made in the test work was that the Yanque ore tended to melt at temperatures between 1050 and 1150 degrees Centigrade. The Accha ore did not show signs of melting at temperatures of up to 1250 degrees Centigrade. While this is not a major issue it must be noted. This difference in behaviour is not surprising given the difference in mineral content in the two feed ores.

What this finding does however indicate is that mixing of the two ores would not be recommended. This was confirmed in the test work where mixing of the ores didn't increase the temperature of melting. In addition, the carbon requirement and ore grades are significantly different for the two ores.

The summarised composition of the fume extracted is reported in the table below.

Element	Yanque (red. roast) [%]	Accha (red. roast) [%]	Accha (calcined) [%]
ZnO	101	91.3	92.8
PbO	16.6	17.6	2.82
FeO	2.13	0.57	0.95
F	0.13	0.13	0.085
Cl	0.11	0.11	0.006

The Yanque fume was produced at 1050 degrees Centigrade and the composition compares well with the Accha fume produced for the reductive roast only.

The same sample reported for the Accha reductive roast was calcined in an oxidising environment at 1000 degrees Centigrade. The dramatic reduction in the chlorine (Cl) and fluorine (F) concentrations is very positive. A similar test must be conducted for the Yanque ore.

3.2 Hydrometallurgical Test Work

The leach extractions of zinc for the Yanque ore were poor at 30% for tests conducted at pH 10 and 10.5.

The leach extractions for Accha were slightly better at 61% and 56% for the pH 10 and pH 10.5 tests respectively.

The carbonate leach was very selective for zinc but the low extractions do not make the process viable.

4. CONCLUSIONS AND RECOMMENDATIONS

The test work has successfully demonstrated the application of reductive roasting as a process route for the extraction of zinc and lead from the Yanque and Accha deposits. The extraction of zinc was 75.8% and 97.3% for Yanque and Accha respectively.

Longer roasting times may improve the extraction from Yanque and it is recommended that further test work must be conducted.

It must be noted that due to the experimental procedure and the fact that not all the fume could be collected, these extraction figures were calculated by difference from the feed and slag analysis, and these values need to be confirmed in pilot plant test work.

The analysis of the fume from the roast indicated zinc oxide content in excess of 90% for both Accha and Yanque. Calcining of the fume from the Accha roast has shown to significantly reduce the content of fluorine (F) and chlorine (Cl) to levels of 0.085% and 0.006% respectively yielding a product with a zinc oxide grade in excess of 95% (calculated by difference). The lead content was also reduced significantly.

The lead extraction in the reductive roast process varied from 20% to 90%. There is the added opportunity of producing a lead by-product however this was not the focus of the preliminary test work.

The carbon consumption for the reduction of Accha and Yanque ore were stoichiometrically calculated to be 72kg and 25kg per tonne respectively (including a 20% excess). This is not the total carbon requirement and excludes the carbon consumed for heating the kiln. This will have to be determined in the pilot plant.

Pilot plant test work is therefore recommended to confirm the preliminary findings, generate an operating cost for the process and produce a bulk product for test work to define the requirements of the downstream processes.