# The Geochemical Field Barrel Program, Cerro Corona Mine.

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# **Cerro Corona Mine**

 Cerro Corona is a Cu-Au open pit mine located in the highest part of the Western Cordillera of the Andes in Northern Peru, approximately 600 km north-northwest of Lima near the village of Hualgayoc.





# **Cerro Corona Mine**

- The deposit is within a very mineral rich district hosting epithermal, porphyry and polymetallic style mineralisation, with known exploitation occurring in the region since the Incan rule.
- The mine began construction in 2006 and operations in 2008.
- The field barrel program started in 2007.



## **Cerro Corona Mine**

- Currently, the mine's Mineral Resources are constrained by the capacity to place waste rock and the Mineral Reserves are constrained by the capacity of the tailings management facility.
- Therefore, waste management plays a very critical role to the project and has been given a high priority by the company.
- The objectives of this presentation are to provide an overview of the field barrel program, with focus on some of the more novel tests and results and the ways in which results are integrated into the operations.



# **Geological Setting**

- The deposit is a subvertical, cylindricalshaped diorite porphyry hosted in mid-Cretaceous limestone, marls and siliciclastic rocks.
- Alteration includes moderate to strong potassic alteration, late, semipervasive argillic alteration and locally, structurally controlled phyllic alteration.



### **Geological Setting**

- Dominant fault zones such as in the West Pit Limestone have played a role on distribution of sulphides, clays.
- Oxidation extends with depth from a fairly distinct oxide cap into mixed and supergene zones and further into hypogene mineralisation.





## Field Barrel Program

The aspects of the program that are the focus for this presentation:

- 1. Waste Class Characterization
- 2. Lime Amendment Trials
- 3. Stacked Barrels





Waste Class Characterization

• Lime Amendment Trials

## Waste Classification



#### Waste Classification



Waste Class Characterization

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#### Waste Classification



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# Waste Classification: Criteria

- Class A: Acid generating & metal leaching diorite; total S > 0.5%.
- Class B: Non-acid generating, metal leaching (predominantly metalloids) limestone; total S >2%.
- Class C: Low potential acid generating and/or weakly metal leaching; total S between 0.3% and 0.5% if diorite and less than 2% if limestone.
- Class D: Non-acid generating and negligible metal leaching; total S < 0.3% if diorite and any marble.
- Criterion were initially determined by static testing and refined through the field barrel kinetic program.
- Barrels representing these waste classes are monitored and leachate characteristics for each class type can be quantified.

Waste Class Characterization

• Lime Amendment Trials

#### Waste Rock Field Barrels



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## **Verification Sampling/Testing**



	CSA24V	CSA24V	CSA24V	CLA36E	CLA36E	CLA36E	CLA36E	CLA36E	SOIL_COND
	S_Total	S_Sulfato	S=	NNP	NP	AP	рН	NP/AP	
	%	%	%	T/1000	T/1000	T/1000	Sin Unidad	Sin Unidad	dS/m
Limite Detec.	0.01	0.01	0.01	0	0	0.01	0.1	0	0
WSF3835-1	0.28	0.16	0.12	-3	0.69	3.72	4.3	0.2	3.71
WSF3835-2	0.86	0.4	0.46	-17.3	-2.9	14.44	3.9	-0.2	6.76
WSF3835-3	5.82	0.19	5.63	-176.6	-0.6	176	4.6	0	11.89
WSF3835-4	1.72	0.33	1.39	-45.3	-1.9	43.44	4	0	3.14
WSF3835-5	4.02	0.5	3.52	-107.9	2.21	110	5.1	0	8.67
WSF3835-6	4.18	0.21	3.97	-138.4	-14.4	124	3	-0.1	13.62

Waste Class Characterization

• Lime Amendment Trials

## Waste Class Characterization

Program is used to:

- Track evolving chemistry from each waste type,
- Allow targeted sorting and placement on the basis of expected geochemistry,
  - Waste Class A placed in the management facility where there is high degree of water control and lower potential for long term oxygen ingress
  - Waste Class B placed in higher elevations of the waste facility
  - Waste Class C used for construction in specific zones as low permeability material
  - Waste Class D used for construction as rock fill in particular areas
- Document placement of waste types in the management facility to support closure planning and updates to water quality predictions and water management planning.

Waste Class Characterization

• Lime Amendment Trials

# Lime Amendment Trials

- The original EIA for the project included mixing of limestone with PAG rock to delay the onset of ARD for a period of 10 years.
- The field barrel program was in part designed to test this control measure and has been developed to assess:
  - Dosage,
  - Form, and
  - Degree of mixing



- Waste Class Characterization
- Lime Amendment Trials

# Lime Amendment: Dosage

- The evaluation of the effectiveness of lime to delay the onset of ARD using different dosages was tested using quadruplicate samples with varying amounts of fine grained limestone.
- Amounts tested in the set illustrated here ranged from 4.5 to 37.5 kg CaCO<sub>3</sub>/t limestone.
- In all barrels, acidity values increased quickly with no marked difference or delay related to lime dosage.



Waste Class Characterization

# Lime Amendment: Form

- The form of lime was also evaluated, via quadruplicate sets.
- Lime was added as fine grained limestone (CaCO<sub>3</sub>), slurried lime (CaOH)<sub>2</sub> and a mixture of both forms.
- Results typically showed a quick onset of low pH conditions in the diorite with no an



in the diorite with no amendment added, a similarly quick onset to low pH for that with the fine grained limestone and a delay of approximately six months for the amendment that used slurried lime and limestone. The barrel with only slurried lime had an initial strongly alkaline pH during slurry elution then declined to values similar to that in other barrels.

Waste Class Characterization

• Lime Amendment Trials

- The degree of mixing was evaluated, with quadruplicate samples as:
  - one barrel having no limestone;
  - the second barrel had limestone added in layers;
  - the third layer had the same dosage as the second but added as an intimate mix; and
  - the fourth had a higher dosage (~10 x) added as an intimate mixture.



Waste Class Characterization

Lime Amendment Trials

- The barrel with no added limestone produced acidity in the leachate that is generally one to two orders of magnitude higher than the barrels that were amended for almost three years.
- A greater difference is seen in those barrels in which limestone has been intimately mixed rather than placed in shallow layers.
- Similar effect is seen in both the high and low dosage mixed samples.



Waste Class Characterization

- The barrel with no limestone had pH values between 4 to 5.
- The layered sample showed values slightly better; ~5 to 6.
- The same limestone dosage in a mixed scenario showed a fairly consistent pH range between 6 and 7.

![](_page_37_Figure_4.jpeg)

• The highest dosage mixed sample typically measured between 7 and 8.

Waste Class Characterization

Lime Amendment Trials

• For metals such as Cu that are strongly controlled by pH, the influence of intimate mixing of limestone appears to be critical to the success of limestone amendment.

![](_page_38_Figure_2.jpeg)

Waste Class Characterization

Lime Amendment Trials

![](_page_39_Picture_1.jpeg)

• Waste Class Characterization

Lime Amendment Trials

- The stacked barrel evaluation moved sets of individual barrels with known leachate chemistry into a stacked configuration.
- The key objective was to evaluate evolution of leachate chemistry as contact water moves from one material type through another.
- Seven sets are currently being evaluated, this presentation focuses on two:
  - Class B non-PAG limestone waste over Class A PAG diorite waste
  - Class A PAG diorite waste over Class B non-PAG limestone waste

![](_page_40_Figure_6.jpeg)

Waste Class Characterization

Lime Amendment Trials

- Within a matter of ~6 months, both sets of stacked barrels reported low pH leachate dominated by Class A PAG diorite.
- Alkalinity from the limestone above the diorite was not able to buffer the acidity produced from the diorite at the ~1m der

![](_page_41_Figure_3.jpeg)

diorite at the ~1m depth scale of the barrels.

- Similarly, acidity from the Class A diorite was not substantively buffered by limestone below it along the flowpath, though pH values are approximately one unit higher than the counterpart configuration.
  - Waste Class Characterization
- Lime Amendment Trials

- Average values however show slight differences in the two configurations.
- Concentrations of key parameters were lower when limestone was below the metal generating Class A diorite.

This suggests
some degree of
mineral reaction
and precipitation
occurring along
the flow path as
the acidic
solutions
move through
the limestone.

![](_page_42_Figure_4.jpeg)

Waste Class Characterization

Lime Amendment Trials

# Conclusions

- The Cerro Corona field barrel program continues to provide insight into the geochemical weathering behavior of different material types that need to be managed on the mine.
- Waste types ranging from PAG to neutral pH metal leaching and non-PAG materials are present, each with distinctly different geochemical characteristics.
- Results from the barrel program have been used to define and refine criteria on which waste types are assigned.
- Waste from the pit is assigned a classification on this basis and tracked from the pit to placement in the storage facility or as construction materials.
- Waste type definition and operational assignment allows for continued waste management planning, including justification of certain waste types for certain construction needs and is used to support mine closure planning.

Waste Class Characterization

• Lime Amendment Trials

# Conclusions

- Evaluations of limestone amendment have led to some changes in waste management from that provided in the original EIA for the project.
- Dosages originally intended to provide a substantial delay period have not been successful at the field barrel scale.
- Results tend to indicate that differing behaviors can be expected depending on the form of the amendment used, and have shown the importance in the success of lime amendment with respect to the degree of mixing.
- Evaluations of leachate quality as sequenced from one material type to another provide insight into contact water quality evolution along a flow path.
- On-going results will be used to inform updates of water quality predictions, water treatment evaluations and for closure planning.

Waste Class Characterization

• Lime Amendment Trials

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![](_page_45_Picture_2.jpeg)