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Treating Orisyvo’s refractory gold ore using Metso's BIOX® technology

Mexico
Guerrero, Acapulco
Mining Convention
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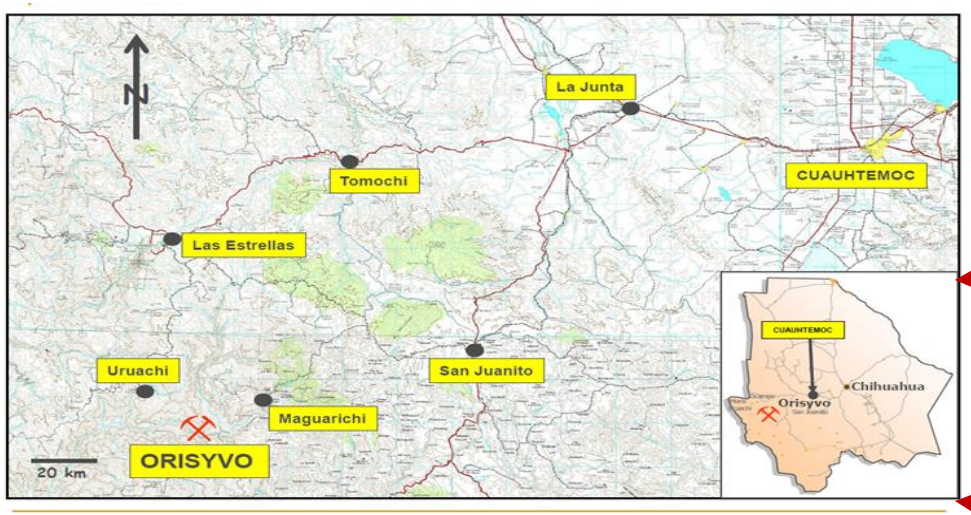
Agenda

- Orisyvo Gold Project
  - Location
  - Background
  - Refractory nature
  - Concentrate characteristics and suitability to BIOX
- BIOX Technology
  - Key facts
  - Technology users
  - Orisyvo project trajectory : pre-feasibility and feasibility testing
  - Performance metrics
  - Design basis
  - Project status

Orisyvo Gold Project

Location

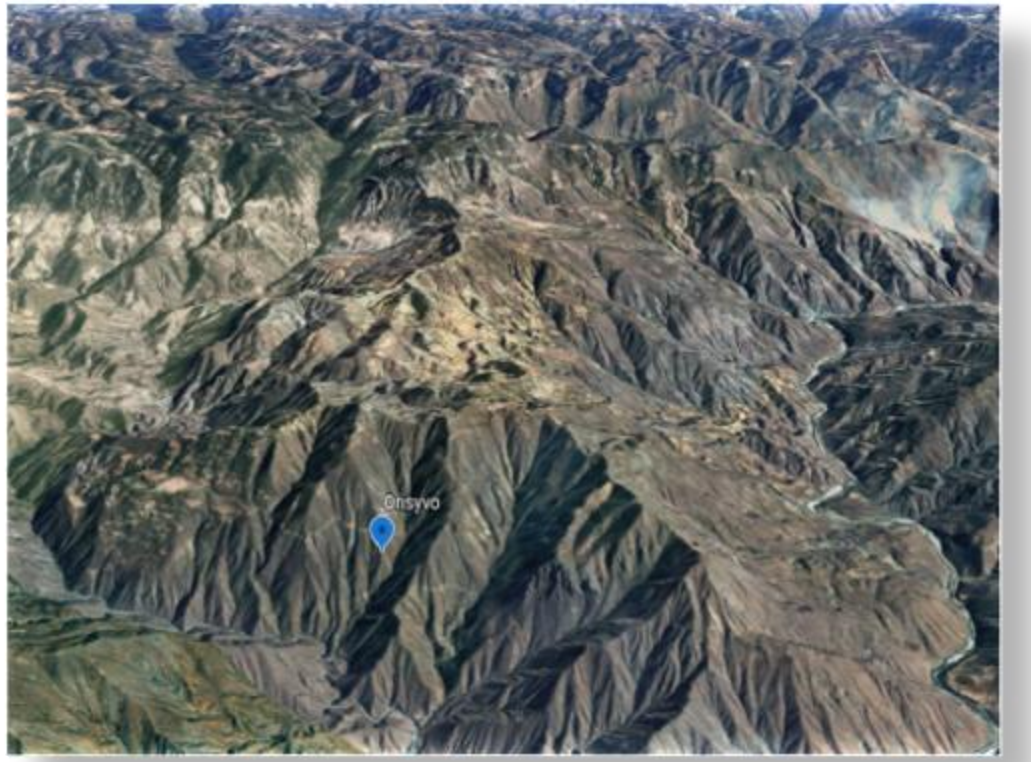


- Located to the south-west of the state of Chihuahua, Mexico. Approximately 250 km from the capital city (Chihuahua).
- Access through the city of Chihuahua by an existing road passing by the towns of Cuauhtémoc - La Junta - Tomochi - Las Estrellas and Uruachi (340 km), finally a dirt road from Uruachi to Orisyvo (25 km)

Orisyvo Gold Project

Background

- Advanced exploration project under review
- World class, high sulphidisation epithermal disseminated gold deposit
- Low Ag and trace Cu, Pb and Zn levels
- Exploration commenced in 1996 until 2021
- More than 500 drill cores at around 208 000m
- Resource classification:
  - 57.3% Oxides
  - 42.7% Sulphides
  - Estimated 90 m tonnes averaging 1.7 g/t Au
- Planned extraction via underground mining
- LOM expected over 14 years with potential for extension
- Estimated Au resource around 9 5000 kOz



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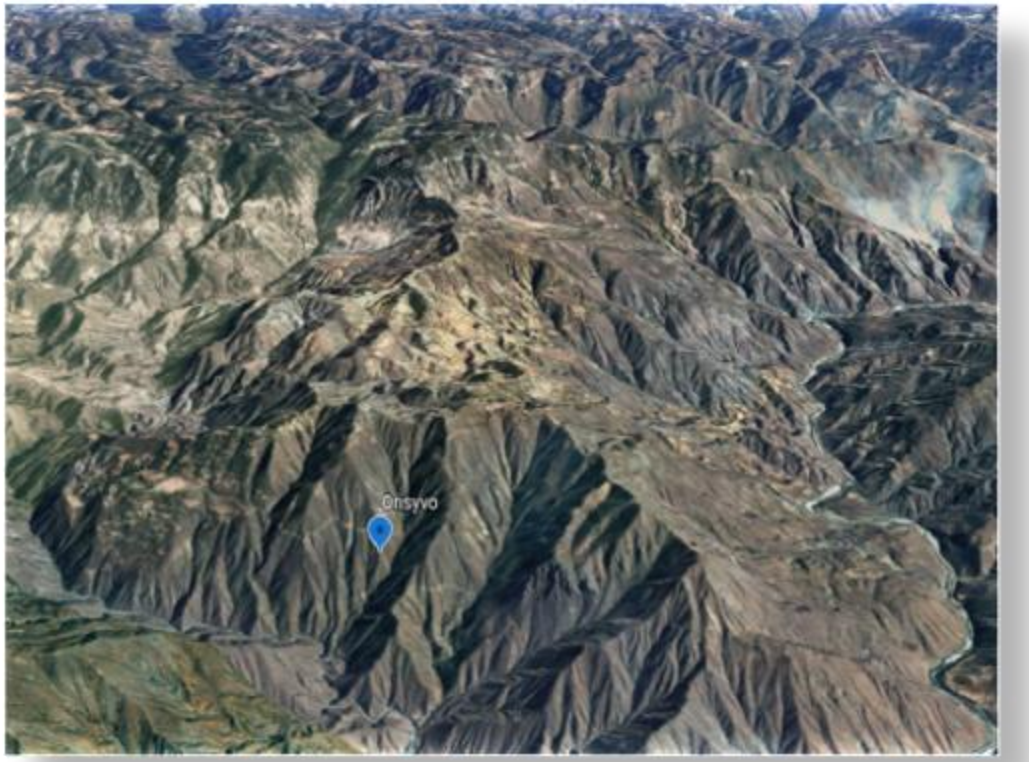
Orisyvo Gold Project

Background

- Expected to generate ~ 4 000 direct jobs and 2.5X more indirect jobs
- Will benefit 22 communities (across 5 municipalities)
- Estimated capacity of 15 000 tpd of ore targeting 1 500 tpd of pyrite concentrate
- Over the past few years several metallurgical investigations undertaken to describe refractory nature of ore
- Mineral “direct leaching” as well as “flotation and concentrate leaching”
- Concentrate characteristics:
  - Around 10 g/t Au
  - Around 35% Sulphur
- Pre-feasibility studies completed evaluating processing technologies for optimal gold recovery focusing on the suitability of pre-oxidative technology solutions



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BIOX Technology

Key Facts

- Effective, simple oxidative process for metal liberation requiring low skillset
- Commercially available > 30 years
- 14 Plants in 9 countries, 9 plants currently in operation
- Total gold production from BIOX > 36 million ounces (Oz)
- Versatile technology
  - 3 000 m above sea level
  - Tropical and arid regions
  - Temperatures: -40^{o}C in winter to 45^{o}C in summer
- Operating plant sizes of 60 tpd to 2 700 tpd
- Environmental studies conclusively proven
  - Proven arsenic fixated in a 2-Stage neutralization process
  - Residues have USA EPA compliance for arsenic mobility
  - Good quality process water produced for re-use upstream

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Technology Users

3 Users in Top Ten Gold Producers

FRESNILLO

PEÑOLES

Number 3

AGNICO EAGLE

Number 6

ANGLOGOLDASHANTI

nordgold

metals exploration

ENDEAVOUR MINING

PAN AFRICAN RESOURCES

中国黄金 China Gold

RIO ZIM RioZim Limited

Number 4

Joint Stock Company Navoi Mining and Metallurgical Company

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Orisyvo Concentrate

Principal Species and Characteristics

Mineral	Formula	Composition (%)	
		2023	2022
Galena	PbS	0.03	-
Sphalerite	$(Zn_{0.9}Fe_{0.1})S^*$	0.16	-
Chalcopyrite	$CuFeS_2$	0.06	-
Tennantite	$(Cu_{0.8}Fe_{0.1}Zn_{0.1})_{12}As_4S_{13}^*$	0.19	-
Pyrite	**FeS_2**	**44.48**	**63.20**
Molybdenite	MoS_2	0.23	-
Sulphide	**S^{2-}**	**23.7**	**34.0**
Arsenic	As	<0.1	<0.1
Copper	Cu	0.3	0.1
Quartz	SiO_2	30.07	18.00
Kaolinite	$Al_2Si_2O_5(OH)_4$	13.24	9.60
Albite	$NaAlSi_3O_8$	2.94	-
Alunite	$KAl_{3(}SO_4)_2(OH)_6$	3.86	5.10
Rutile	TiO_2	1.93	0.70
Chlorite	$(Mg_3,Fe_2)Al(AlSi_3)O_{10}(OH)_8$	0.57	-
Oxides Fe	Fe_xO_y	0.72	1.40

Suitability to BIOX

Clean pyrite dominated concentrate

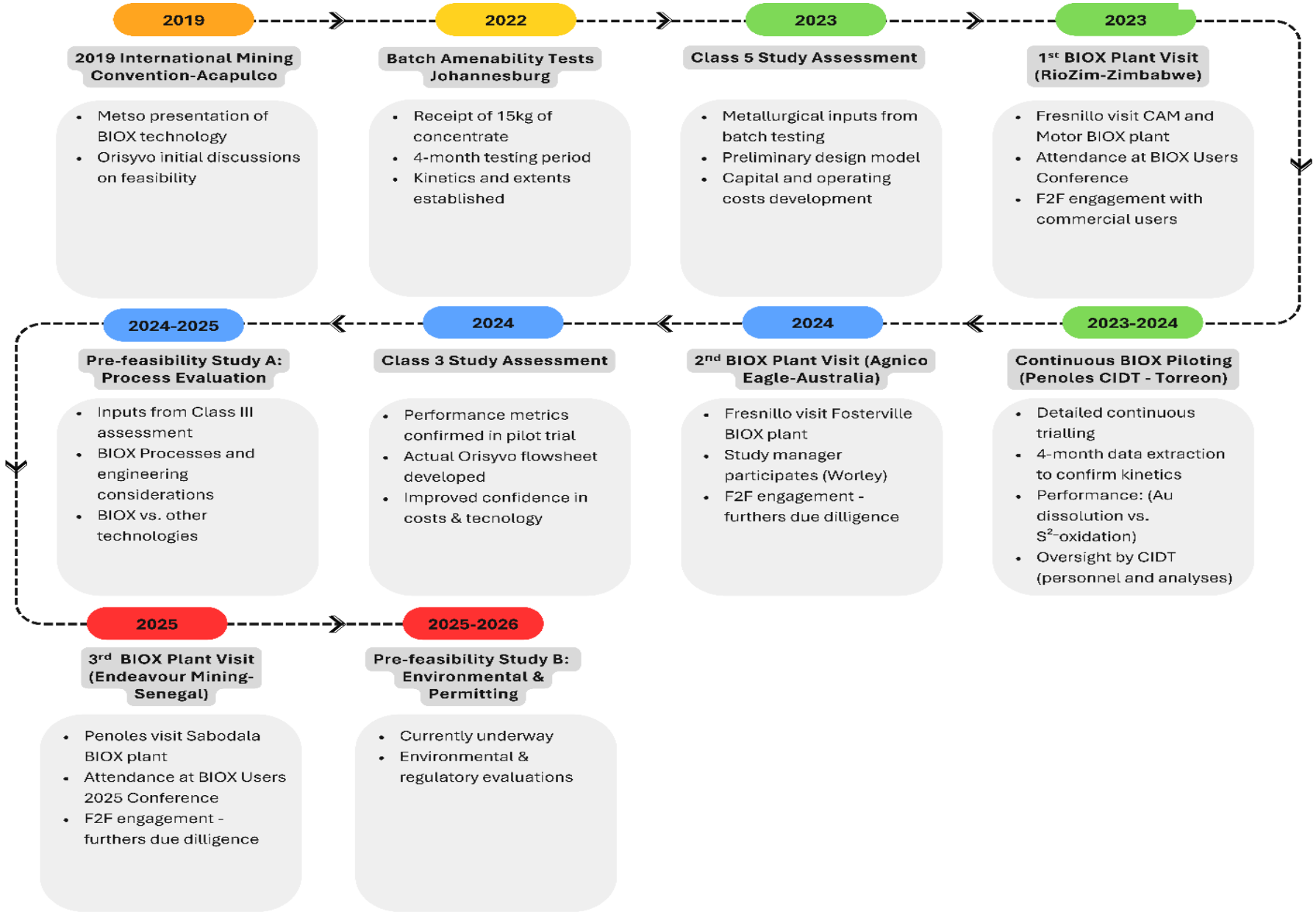
Nett acid generation (pyrite oxidation)

Limestone required to balance acid

Similar mineralogy to BIOX Users:

- Kokpathas Plant: Uzbekistan
- Fosterville Plant: Australia
- Runruno Plant: Philippines

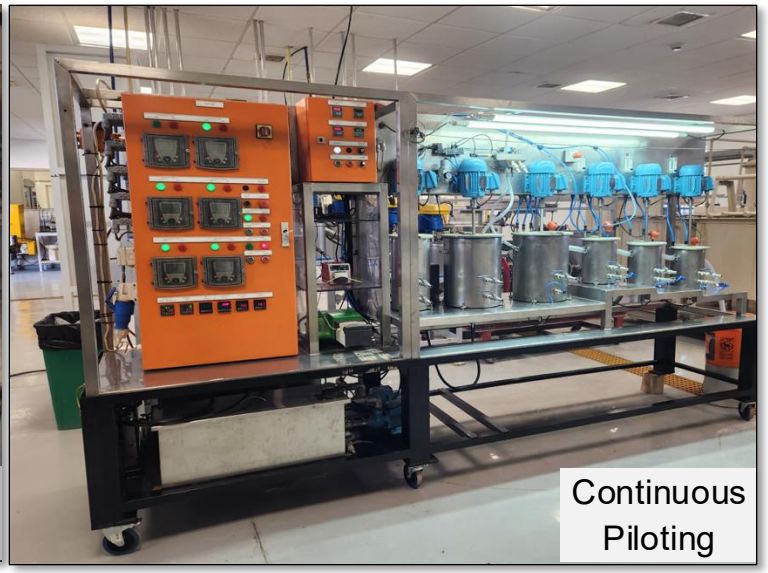
Orisyvo Development Trajectory



Prefeasibility and Feasibility Testing

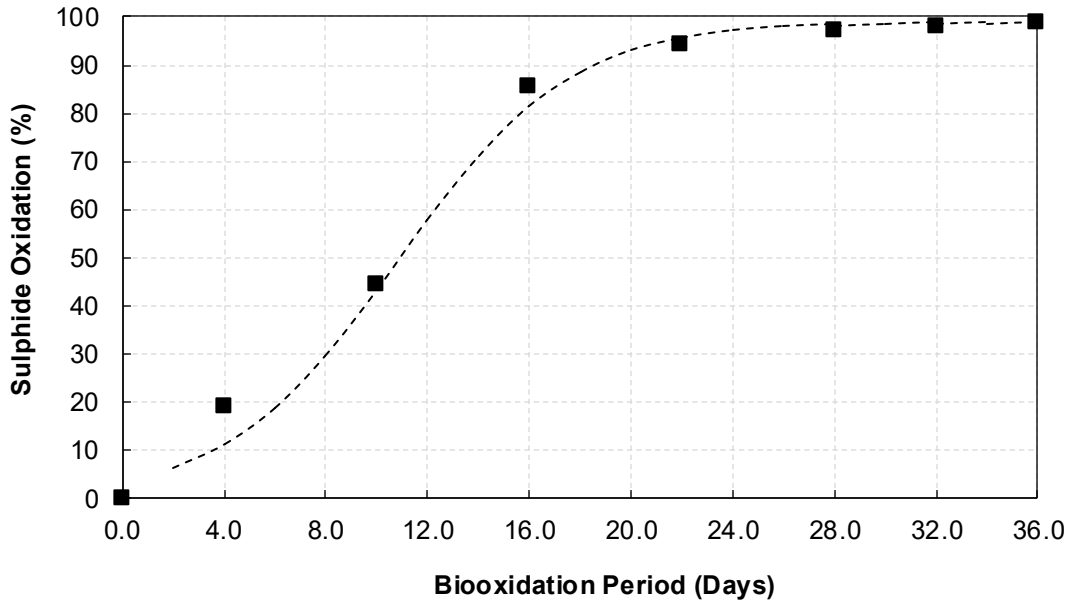
Batch (2022)	Continuous (2023)
1st Stage of Project Development	Project Definition and Detail
Indicative Sample Composition	Better Sample Representavity
Establishes Amenability of Concentrate	**Oxidation Kinetics and Confirmation of Gold Dissolution and Sulphide Oxidation Dependence**
Provides Gold Dissolution and Sulphide Oxidation Relationship	Definition of Reactor Configuration
Batch Reagent Consumptions	Process Design Criteria
Pre-Feasibility	**Feasibility to Engineering Design to Build**

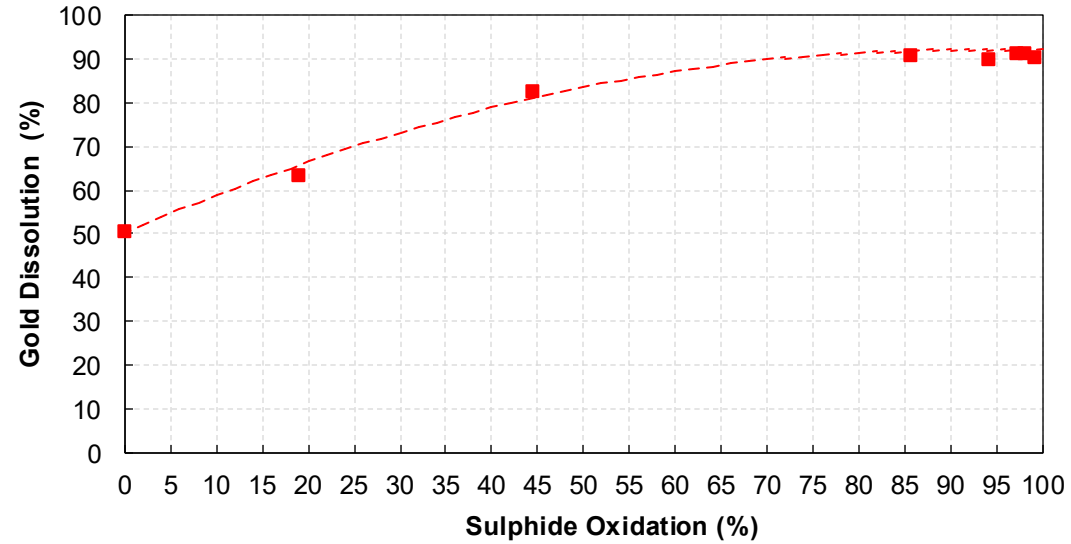

Discrete Reactors


Continuous Piloting

Performance Metrics

Pre-feasibility Study (PFS) Testing





Batch Tests: Johannesburg

Proved Orisyvo amenable to BIOX

Performance curve developed

- Sulphide oxidation of 99%
- Gold dissolution of 92%

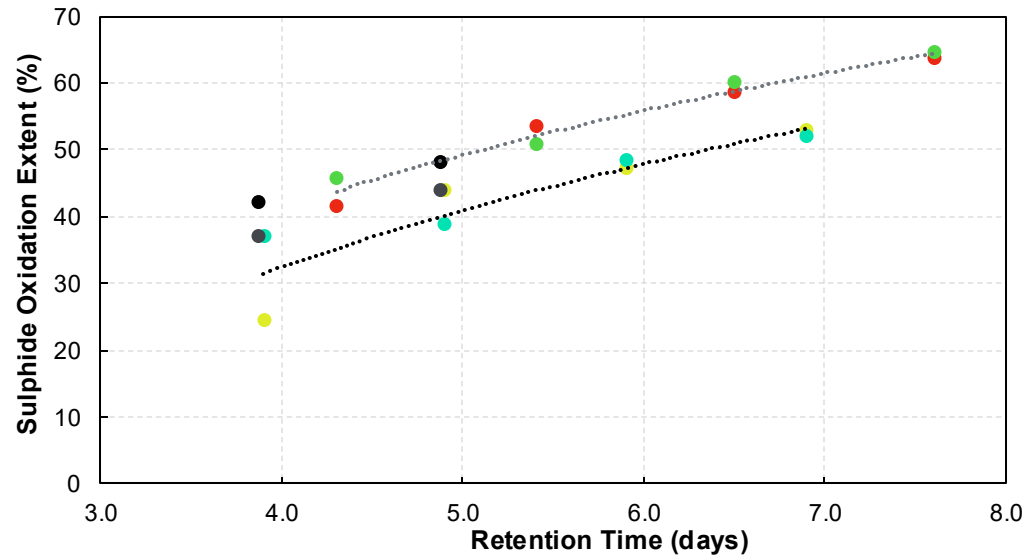
Batch kinetics established

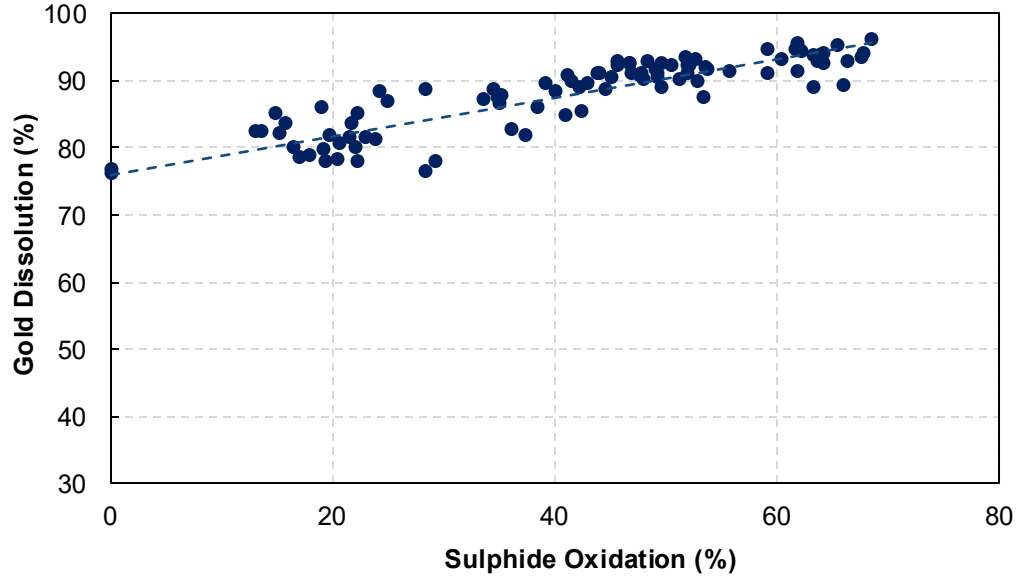
Reagent consumptions established

Inputs for Class V cost assessment

Performance Metrics

Feasibility Study (FS) Testing





Detailed 3-month Trial: Torreon

Design rates and extents established

Moderate oxidation extent of 68% for maximum 96% Au dissolution

Acid and O_2 requirements confirmed

Moderate oxidation translates to lower capital and operating costs

Inputs for Class III cost assessment

Design Basis

Mineral (S^{2-}) Oxidation Influences Design

Exothermic - remove heat via cooling towers / maintain optimum BIOX temperature

Mineral	Formula	Sulphide	Reaction Heat		O_2 Demand	H_2SO_4 Demand
		(%)	(kJ/kg)	(kJ/kg S^{2-})	(kg O_2/kg S^{2-})	(kg/kg Mineral)
Pyrrhotite	FeS	36.4	-11 373	-31 245	2.25	0.56
Arsenopyrite	FeAsS	19.6	-9 415	-48 036	3.51	0.30
Pyrite	**FeS_2**	**53.3**	**-12 884**	**-24 173**	**1.88**	**-0.41**
Ankerite	$Ca(Fe,Mg)(CO_3)_2$	-	-219.2	-	-	0.98
Siderite	$FeCO_3$	-	-326.7	-	0.07	1.27

Manage acid from FeS_2 oxidation with $CaCO_3$ / maintain optimum BIOX pH range

Deliver O_2 from air via blowers to drive oxidation / high O_2 mass transfer coefficient

Dominant Orisyvo design reactions

$$4FeS_2 + 15O_2 + 2H_2O \longrightarrow 2Fe_2(SO_4)_3 + 2H_2SO_4$$

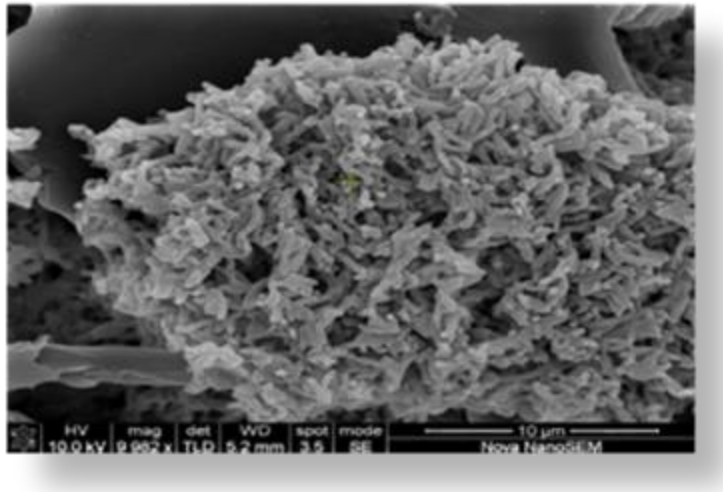
$$H_2SO_4 + CaCO_3 \longrightarrow CaSO_4 + CO_2 + H_2O$$

$$k_L.a = \frac{O_2\ Demand}{C_{sat} - Cbulk}$$

Design Basis

Orisyvo Process Design Basis

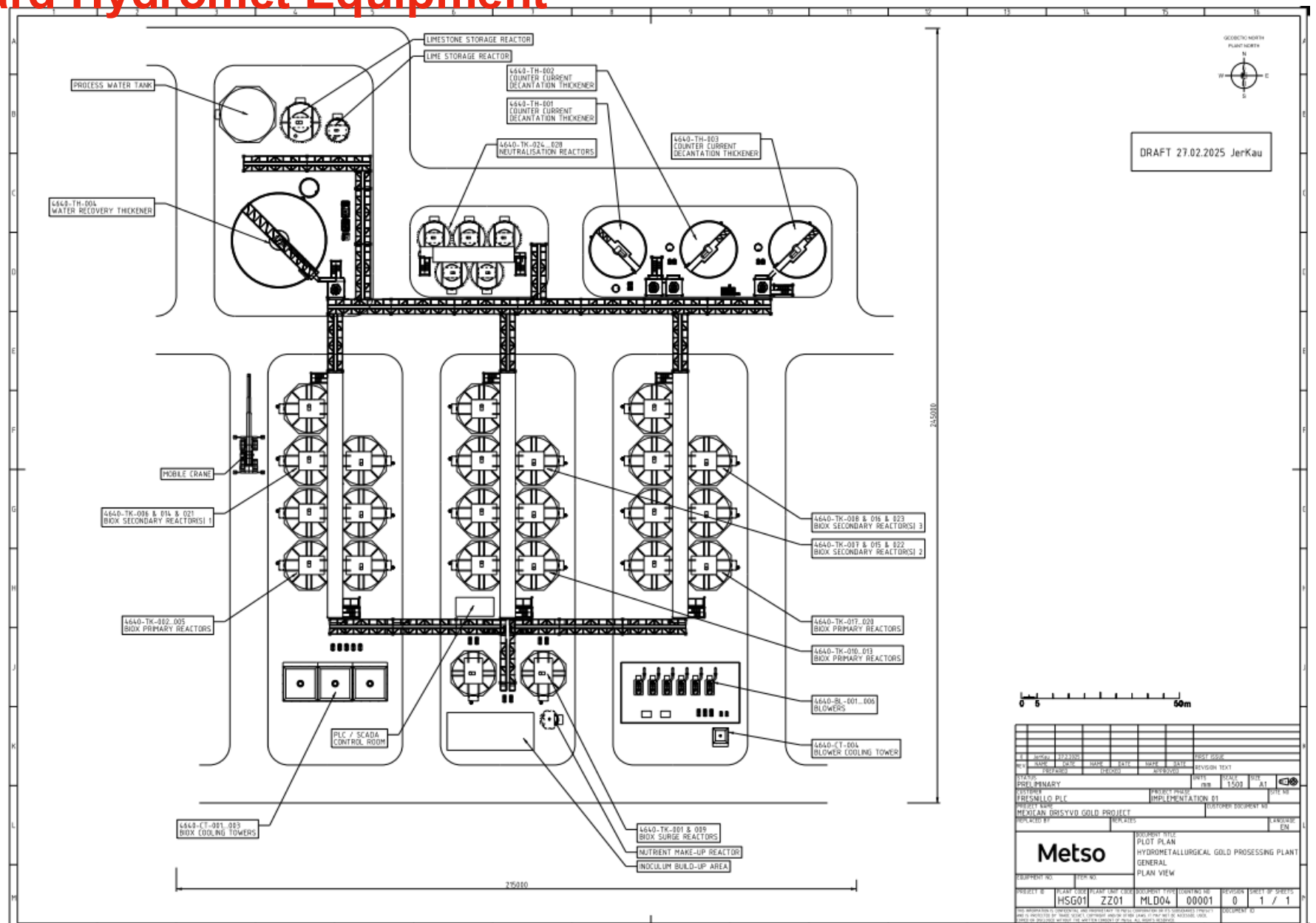
Design Parameter	Units	Value	Comment
Concentrate Throughput	tpd	1 500	Fresnillo PLC
Sulphide Oxidation Target	%	70	For maximum gold dissolution
Blower Aeration Supply	Nm^3/hr	180 000	Air required to satisfy oxidation
Heat To Remove	MW	71	Generated from exothermic S^{2-} oxidation
Reactor Temperature	°C	40 to 42	Optimal temperature for microbial kinetics
pH Control Range		1.1 to 1.4	Optimal pH range for microbial kinetics
Material of Construction		LDX 2101	Good structural properties, corrosion resistant



Dominant Species
Leptospirillum ferrooxidans
Leptospirillum ferriphilum
Acidithiobacillus ferrooxidans
Thiobacillus thiooxidans
Acidithiobacillus caldus
Ferroplasma acidiphilum

Preliminary Layout

Standard Hydromet Equipment



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Design Basis

Orisyvo Process Design Basis

BIOX Plant	Location	Number of BIOX Reactors
Suzdal	Kazakhstan	12
Jinfeng	China	16
Bogoso	Ghana	18
Orisyvo	***Mexico***	***21***
Obuasi	Ghana	25
Kokpathas	Uzbekistan	56

Orisyvo Project Status

Concluding Remarks

- Fresnillo-Peñoles is a global precious metals producer ranking as Mexico's biggest silver producer and one of its largest gold producers
- Fresnillo-Peñoles are evaluating pre-oxidative technologies for their refractory Orisyvo project that:
  - Must effectively enhance gold recovery
  - Have a global footprint with numerous references
  - Show demonstrable scale up with successful operations at or surpassing throughputs envisaged for Orisyvo
  - Be used by the global gold majors
- Fresnillo-Peñoles have undertaken a structured due diligence development program screening the BIOX technology through PFS and FS level testing and undertaking 3 technical visits to commercial BIOX operations
- Metso's BIOX technology satisfies the criteria to support adding value to the Orisyvo project

Orisyvo Project

¿Preguntas?

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