



NOVEMBER 2022

**WELCOME TO BILBAO!**

# **GENMINE**

**Innovative solutions for scaling problems in the  
Mining Industry.  
Successful experiences in LATAM.**

**Piedmont**



**DISTRIBUTOR SUMMIT**

NOVEMBER 13-17, 2022

**Fernando del Vigo**

# Membranes in mining



- Environmental discharge
- Metals concentration
- Leaching solution recovery
- Process water make up
- Domestic water



# Case study: Yanacocha gold mine

- Yanacocha (5x250 m<sup>3</sup>/hr) + Pampalaga (2x250 m<sup>3</sup>/hr)
- Barren leach solution is treated and must be discharged safely into the environment
- RO concentrate returned to leaching solution.
- Cyanides water, operation at very high pH values



# Case study: Yanacocha gold mine

- Problems with conventional antiscalant due to the progressive increase in the concentration of sulfates: severe scaling in all stages
- Membrane cleaning every 3-6 days with aggressive products and washed during a long time
- Membranes must be replaced every 6-12 months
- Low plant availability



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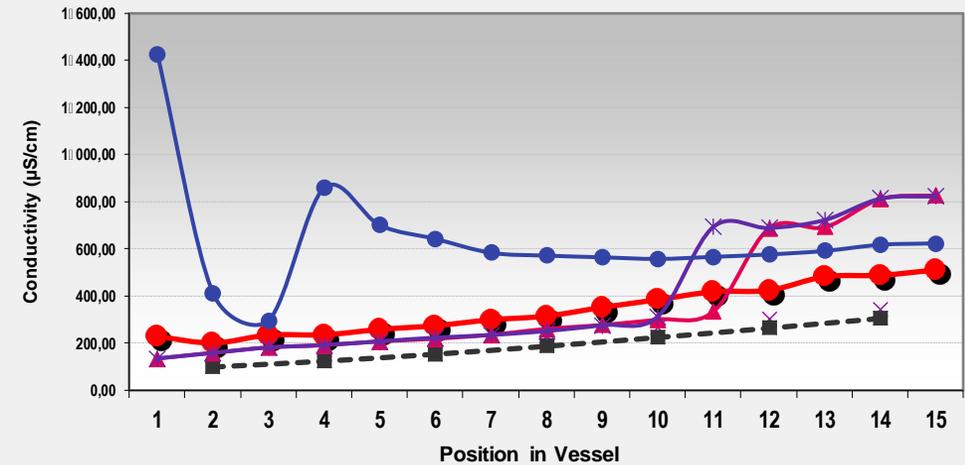
# Case study: Yanacocha gold mine

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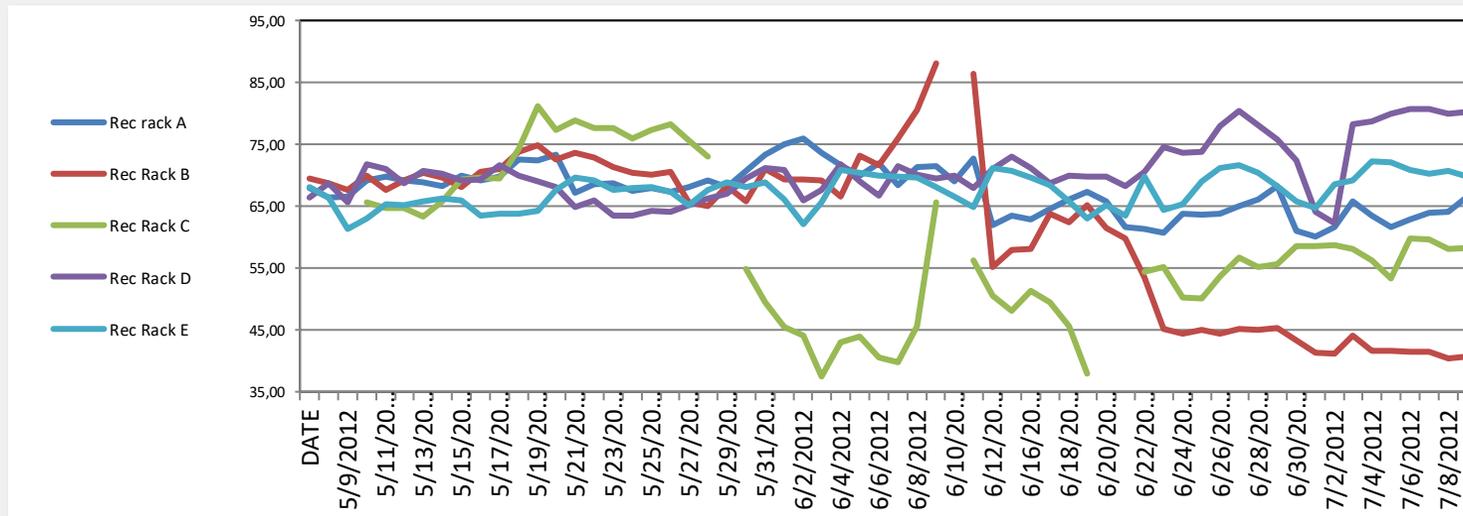


# Case study: Yanacocha gold mine

- Free cyanide 30-50 mg/L → water pH >8.7
- Very high Calcium & Sulphates concentration.
- High concentration of heavy metals.
- Operation with variable conversion rates: hydraulic problems



Recovery

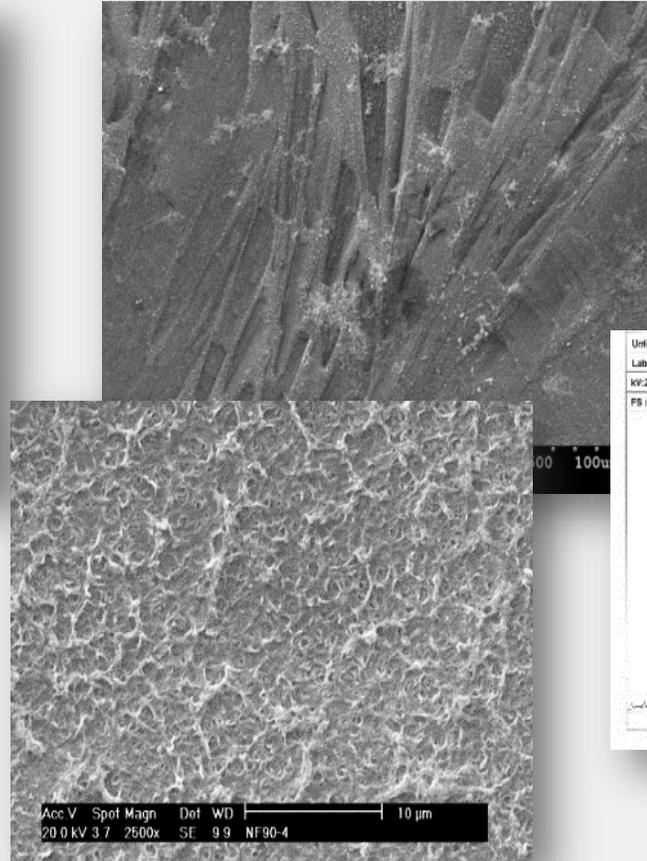


# Case study: Yanacocha gold mine

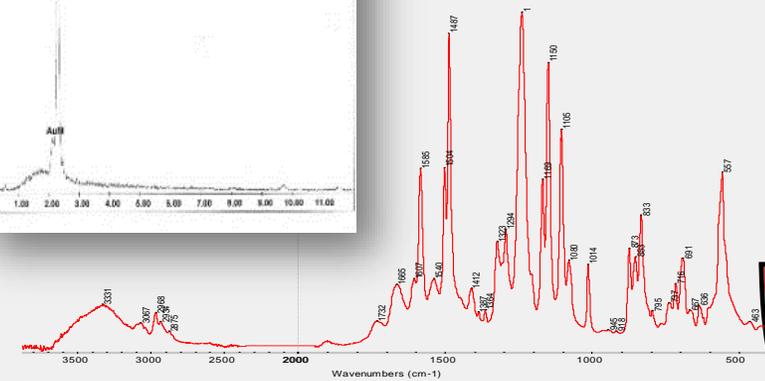
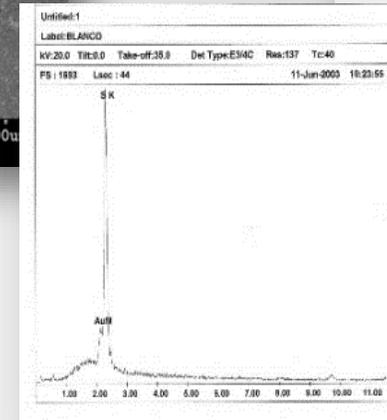
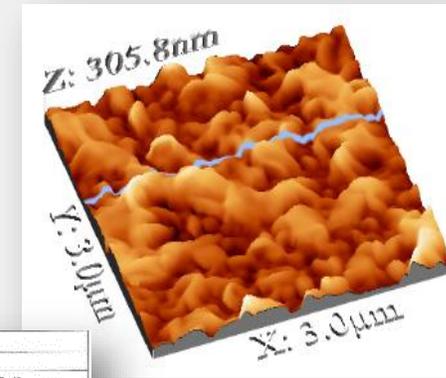
## MACROSCOPIC



## MICROSCOPIC



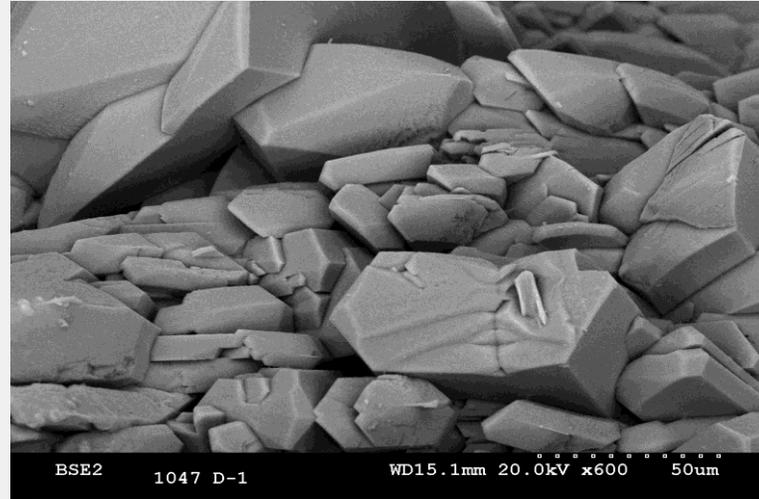
## TECHNIQUES



# Caso de estudio: Minería



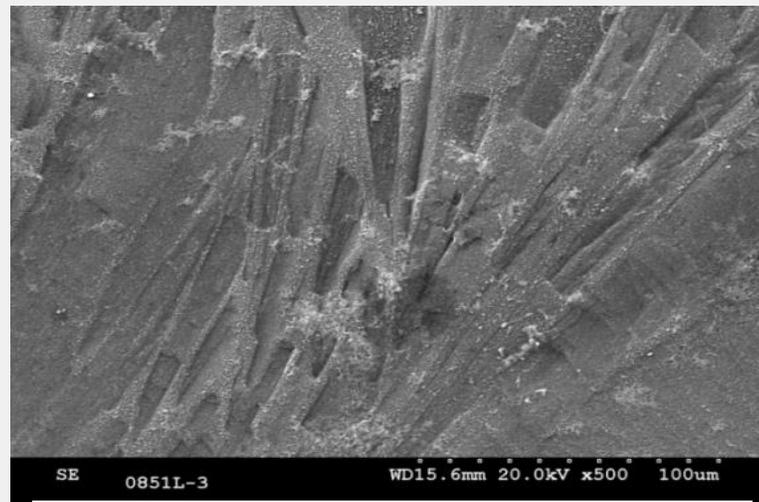
**Spacer totally scaled**



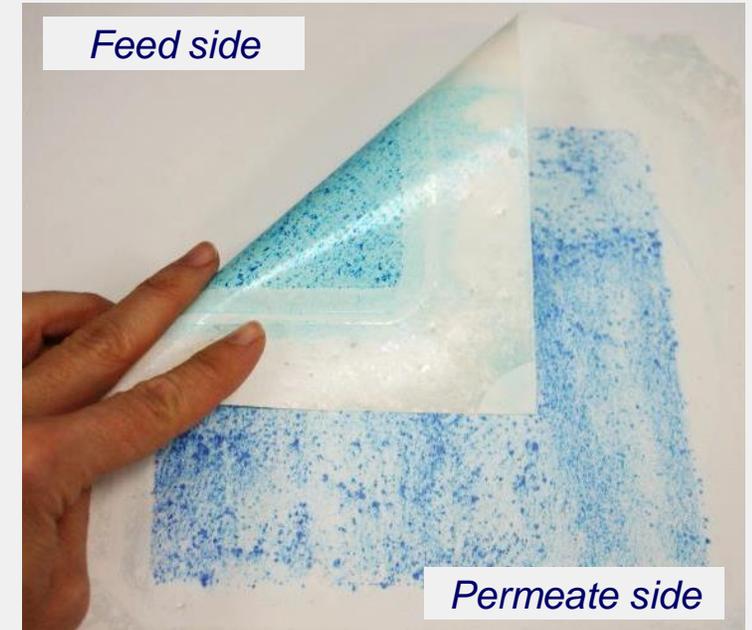
**CaSO<sub>4</sub> crystals**



**Clean membrane**

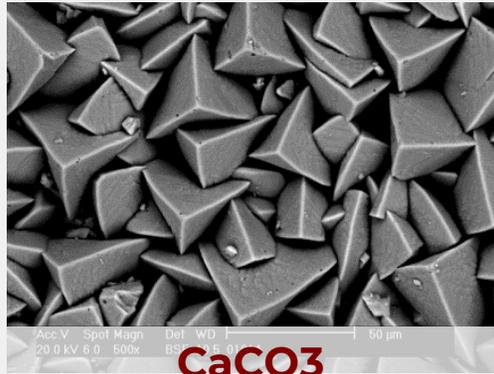


**Membrane damaged by**

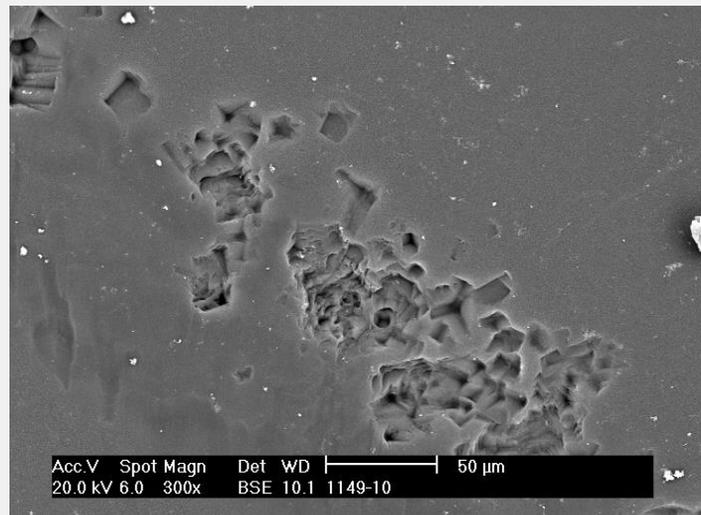
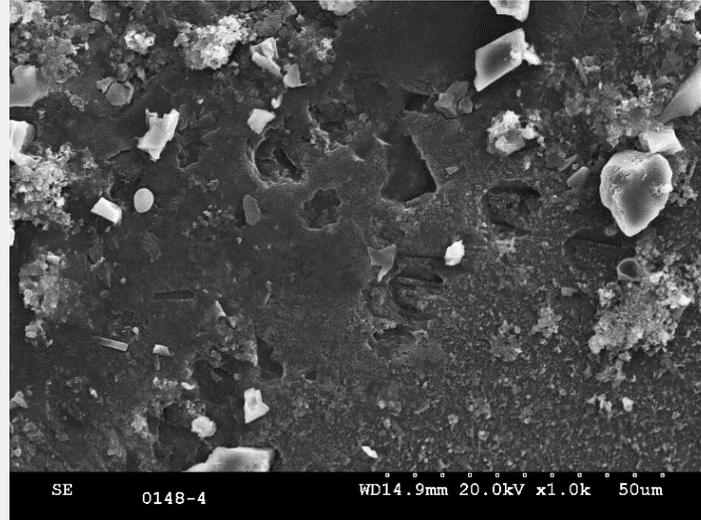
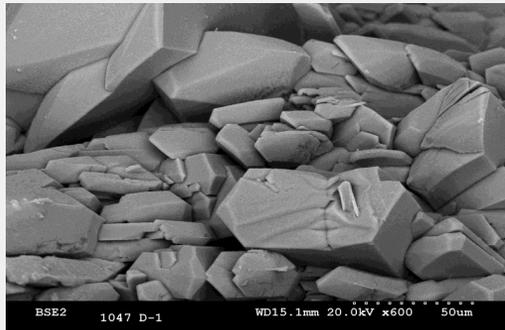


# Case study: Yanacocha gold mine

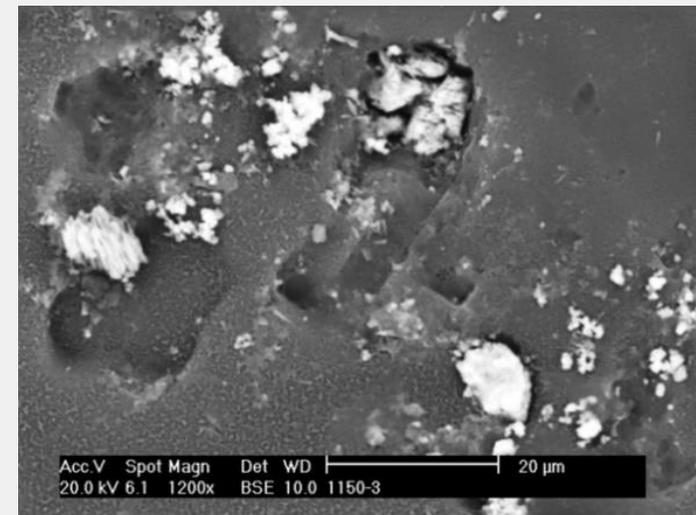
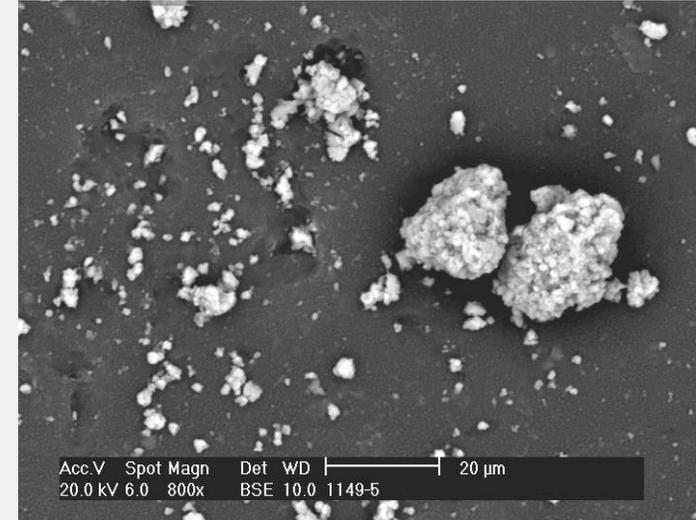
## Scaling damage



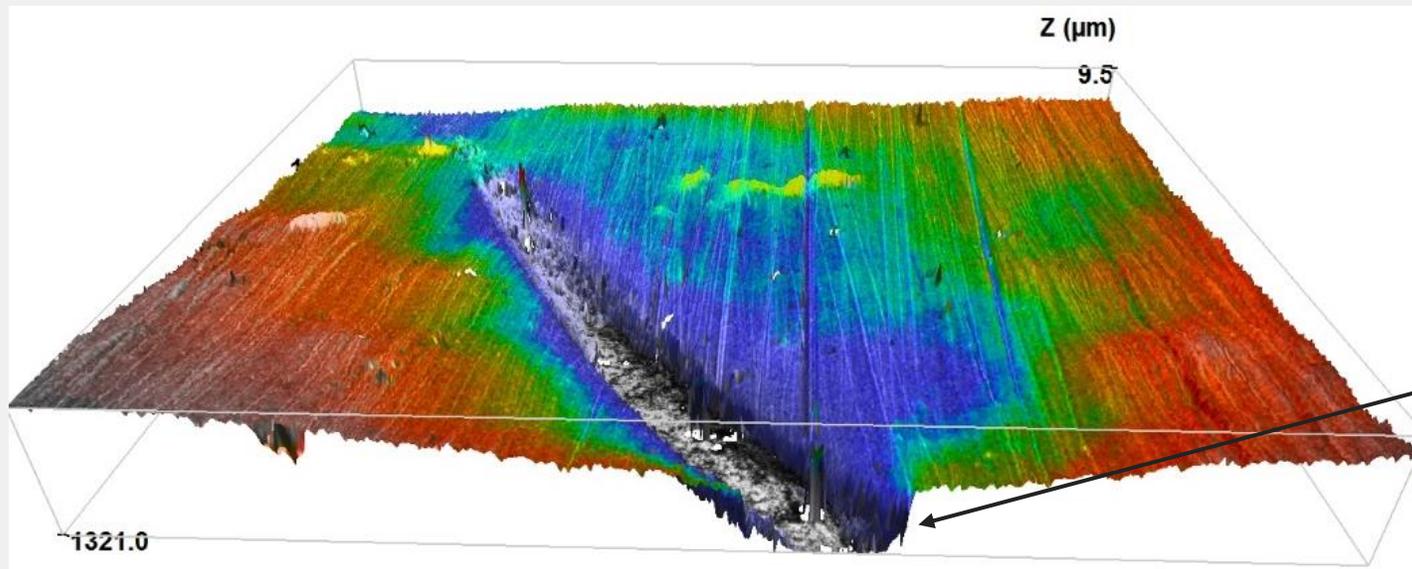
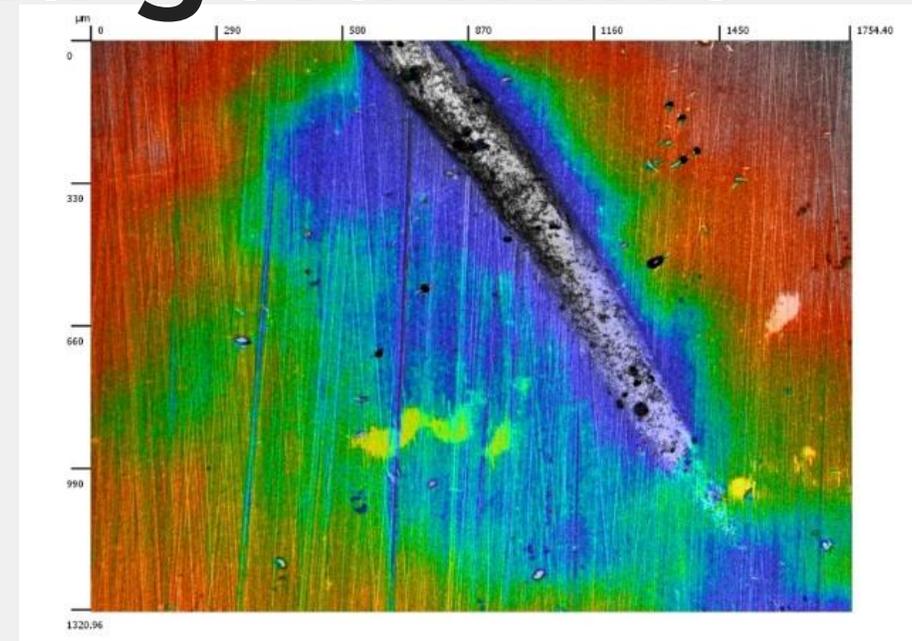
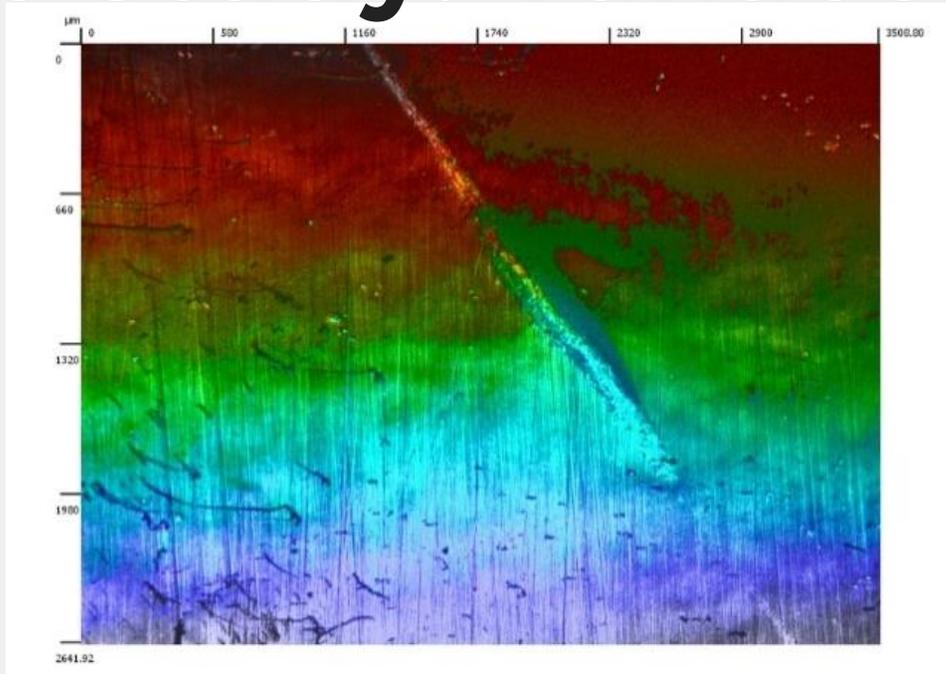
**CaSO<sub>4</sub>**



## Metals damage



# Case study: Yanacocha gold mine



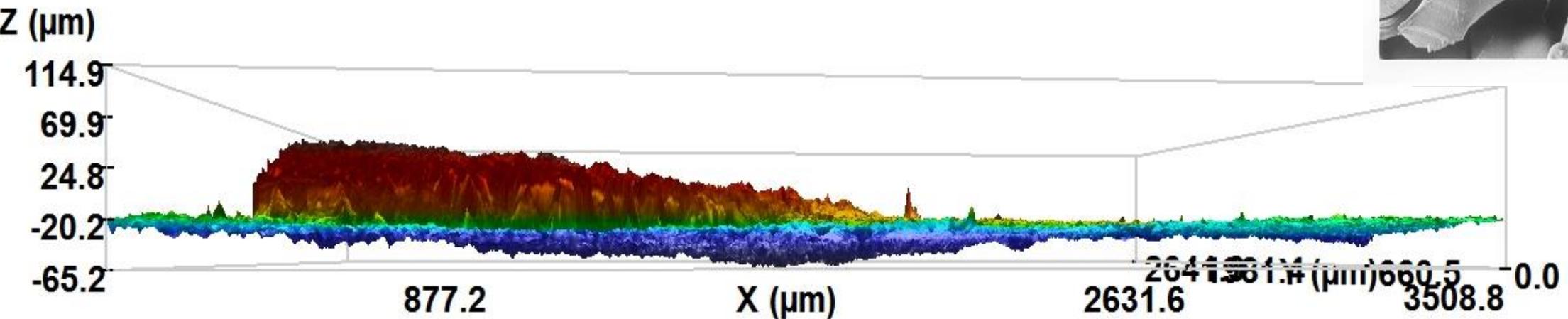
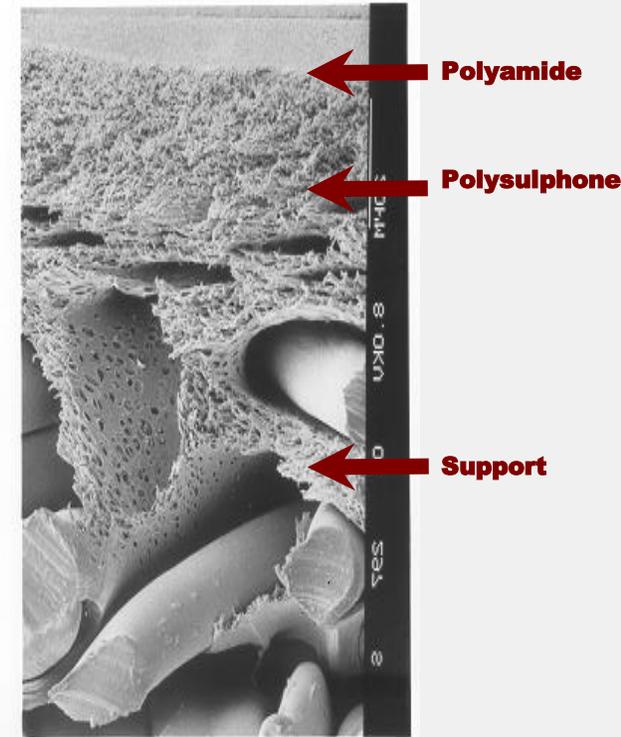
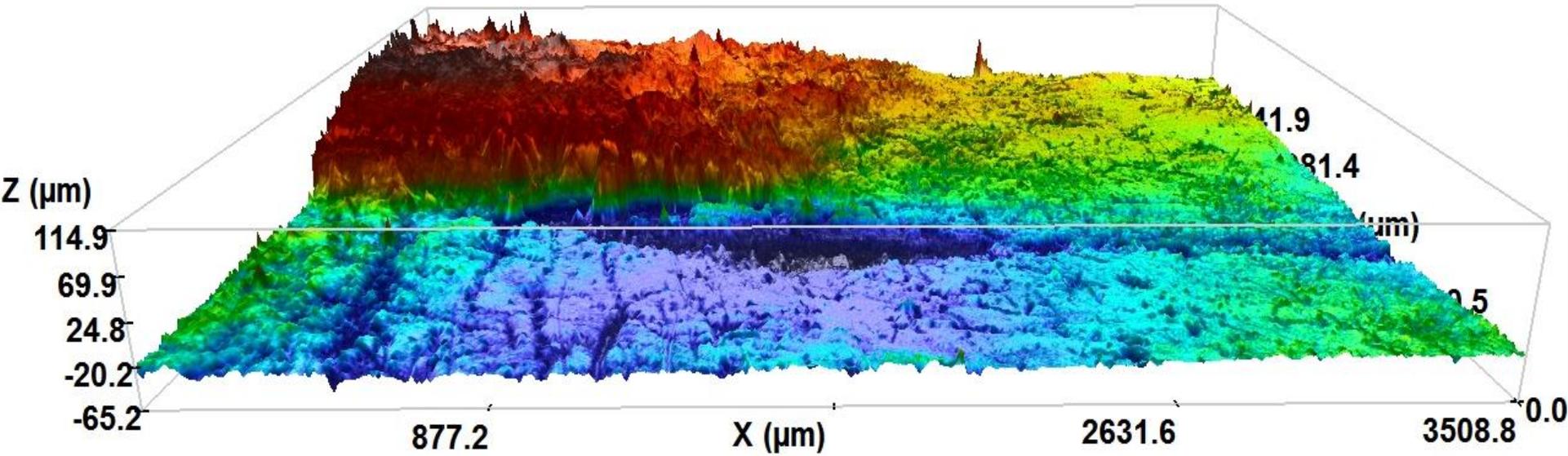
3D Microscopy

Max  
deep:  
12-14  $\mu\text{m}$



# Case study: Yanacochoa gold mine

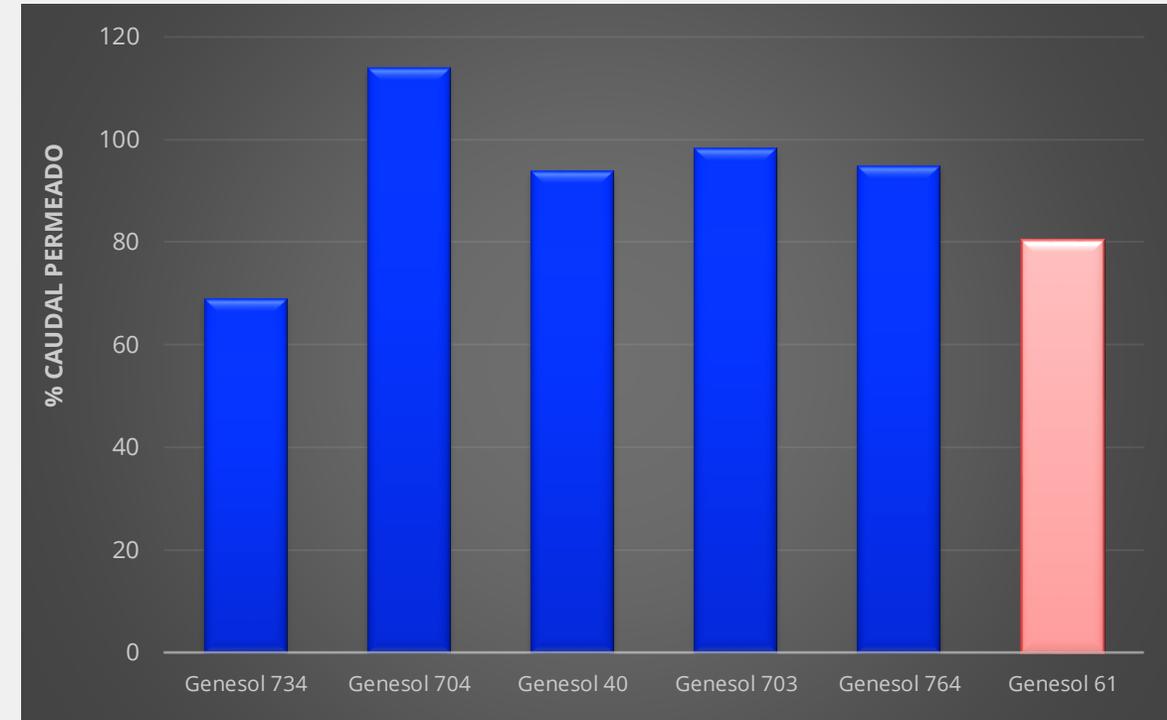
3D Microscopy



# Case study: Yanacocha gold mine

## Lab cleaning – 1st stage membrane

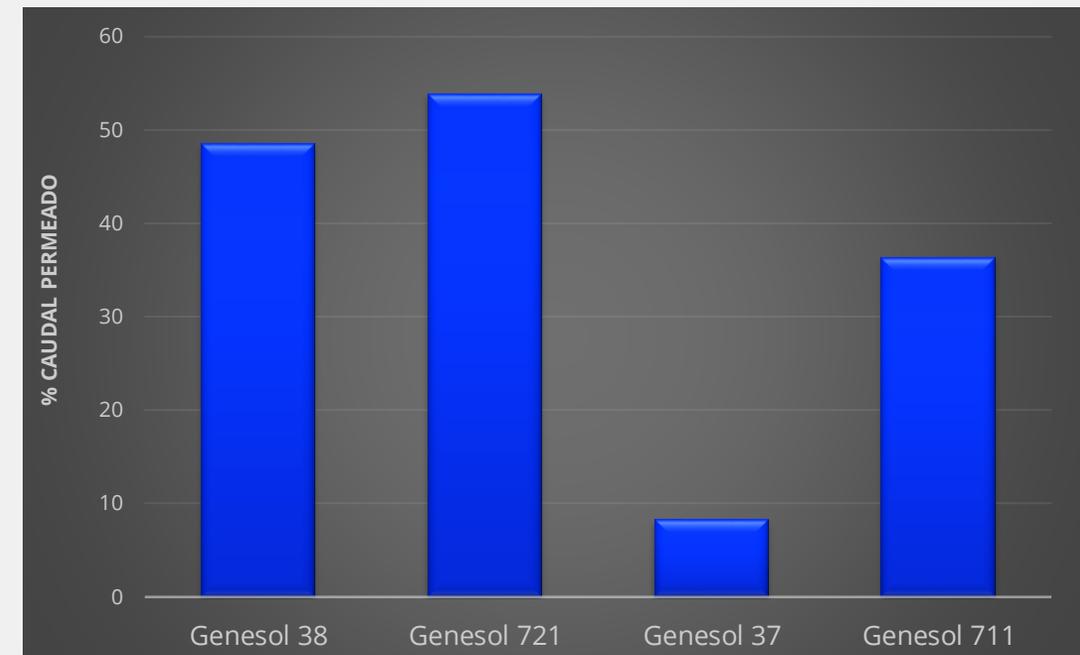
Membrana Primera Posición		Caudal permeado (l/m <sup>2</sup> h 25 °C)			% Retención sales (CE)		
		Antes	Después	%	Antes	Después	
Limpieza 1	2% Genesol 734 a 35-40° (2 horas)	32,07	54,14	+68,8	93,02	95,63	↑
Limpieza 2	2% Genesol 764 a 35-40° (2 horas)	28,55	61,15	+114	93,90	97,64	↑
Limpieza 3	2% Genesol 61 a 35-40° (2 horas)	27,68	49,89	+80,2	93,77	97,23	↑
Limpieza 4	2% Genesol 40 a 35-40° (2 horas)	28,70	55,67	+93,9	92,10	94,41	↑
Limpieza 5	2% Genesol 704 a 35-40° (2 horas)	33,22	65,84	+98,2	91,28	95,17	↑
Limpieza 6	2% Genesol 704 a 35-40°C (2 horas)	32,08	62,53	+94,9	94,06	97,23	↑
Limpieza 7	Paso 1: 2% Genesol 704 a 35-40°C (2 horas)	32,08	62,53	+94,9	94,06	97,23	↑
	Paso 2: 1% Genesol 721 a T.amb.(1 hora)	62,53	62,08	-0,7	97,23	97,17	=
	Paso 3: 2% Genesol 704 a 35-40°C (2 horas)	62,08	70,62	+13,7	97,17	97,11	=
	<b>Global</b>			<b>+120</b>			<b>↑</b>
Limpieza 8	2% Genesol 764 a 35-40° (2 horas)	27,73	40,81	+47,1	93,17	93,06	↓
	Paso 2: 2% Genesol 704 a 35-40°C (2 horas)	40,81	64,41	+57,8	93,06	96,60	↑
	<b>Global</b>			<b>+132</b>			<b>↑</b>
Limpieza 9	Paso 1: 2% Genesol 704 a 35-40°C (2 horas)	31,87	62,15	+95,0	90,90	95,21	↑
	Paso 2: 1% Genesol 38 a T.amb.(1 hora)	62,15	40,14	-35,4	95,21	94,43	↓
	Paso 3: 2% Genesol 704 a 35-40°C (2 horas)	40,14	70,00	+74,5	94,43	95,64	↑
	<b>Global</b>			<b>+119,6</b>			<b>↑</b>



# Case study: Yanacocha gold mine

## Lab cleaning – 3rd stage membrane

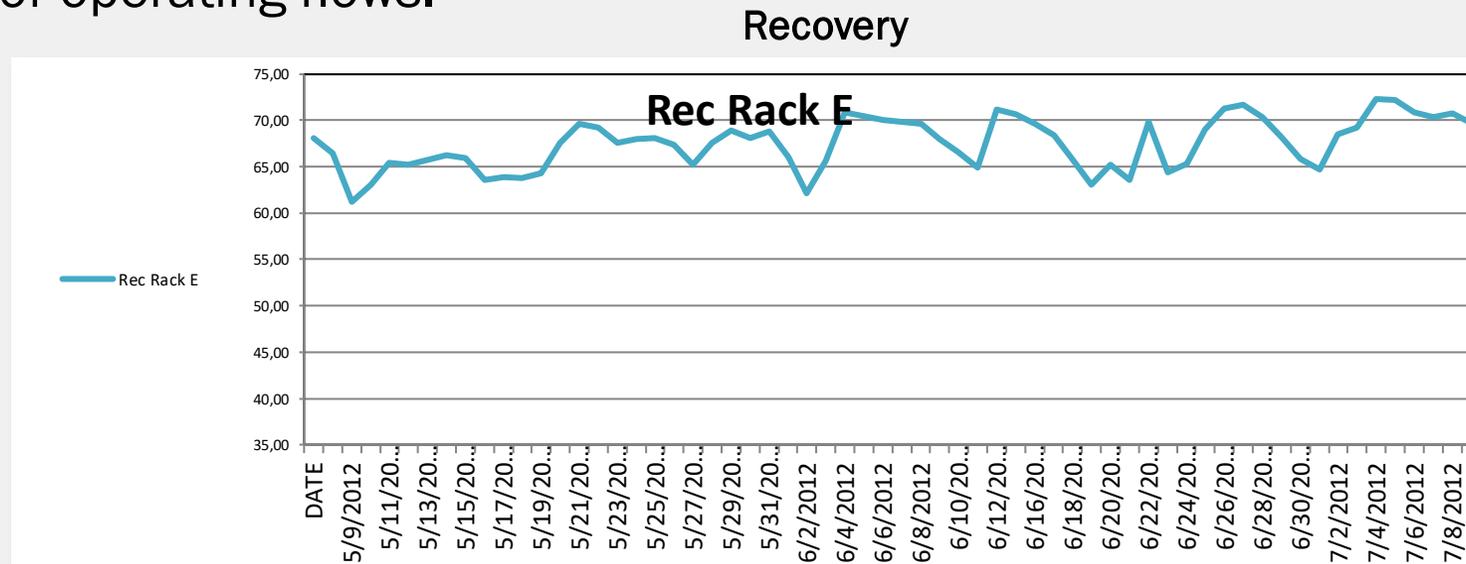
Membrana última posición		Caudal permeado (l/m <sup>2</sup> h 25 °C)			% Retención sales (CE)		
		Antes	Después	%	Antes	Después	
Limpieza 1	2% Genesol 38 a T.amb. (1 hora)	23,02	34,19	+48,5	83,19	94,37	↑
Limpieza 2	1% Genesol 721 a T.amb. (1 hora)	24,81	38,16	+53,8	84,60	93,61	↑
Limpieza 3	1% Genesol 37 a T.amb. (1 hora)	28,06	30,36	+8,2	82,62	82,68	=
Limpieza 4	1% Genesol 711 a T.amb. (1 hora)	24,26	33,06	+36,3	82,33	92,87	↑
Limpieza 5	2% Genesol 704 a 35-40°C (2 horas)	25,00	55,68	+123	84,94	94,23	↑
Limpieza 6	Paso 1: 2% Genesol 704 a 35-40°C (2 horas)	25,00	55,68	+123	84,94	94,23	↑
	Paso 2: 1% Genesol 721 a T.amb. (1 hora)	55,68	60,05	+7,8	94,23	95,91	↑
	Paso 3: 2% Genesol 704 a 35-40°C (2 horas)	60,05	71,84	+19,6	95,91	96,44	↑
	<b>Global</b>			<b>+187</b>			↑
Limpieza 7	Paso 1: 1% Genesol 721 a T.amb. (1 hora)	24,86	28,63	+15,2	81,65	87,28	↑
	Paso 2: 2% Genesol 704 a 35-40°C (2 horas)	28,63	70,28	+145	87,28	95,48	↑
	<b>Global</b>			<b>+183</b>			↑
Limpieza 8	Paso 1: 2% Genesol 704 a 35-40°C (2 horas)	28,74	49,14	+70,9	81,54	90,71	↑
	Paso 2: 1 Genesol 38 a T.amb. (1 hora)	49,14	42,57	-14,2	90,71	92,83	↑
	Paso 3: 2% Genesol 704 a 35-40°C (2 horas)	42,57	66,70	+56,7	92,83	94,38	↑
	<b>Global</b>			<b>+132,1</b>			↑



# Case study: Yanacocha gold mine

## Recommendations:

- Replace conventional antiscalants with a specific antiscalants → Genesys CAS (CaSO<sub>4</sub> & heavy metals).
- Use differential pressure, permeate flow rate and conductivity data to determine the need for cleaning.
- Data normalization and study of the fouling/scaling trend.
- Use of less aggressive cleaners, more specific and have a shorter action time.
- Optimization of operating flows.

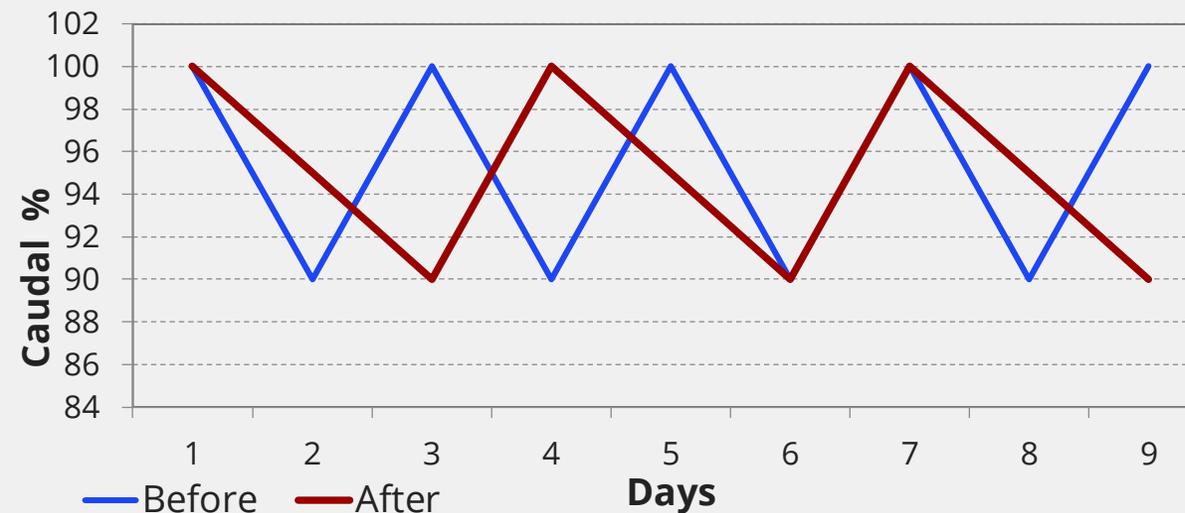


# Case study: Yanacocha gold mine

## Results:

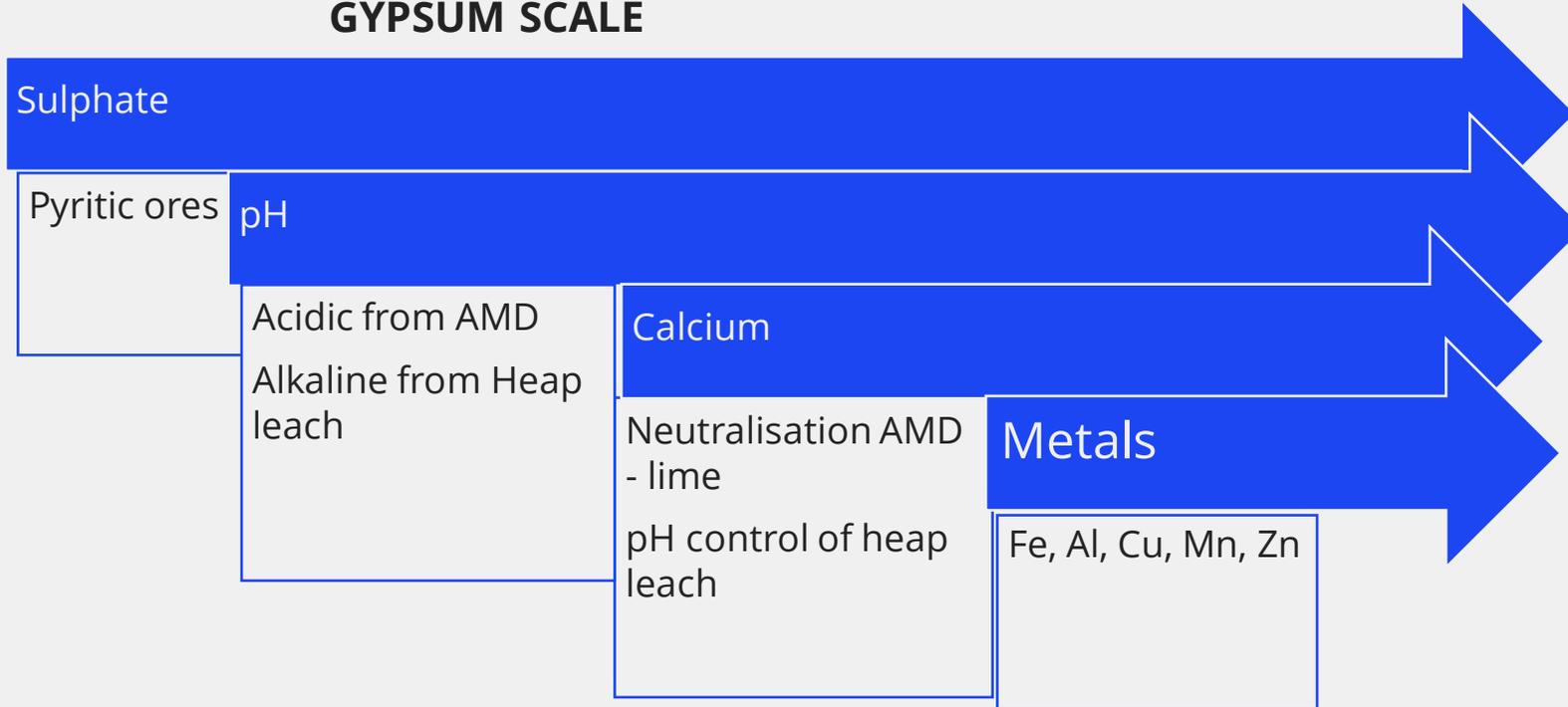
- Average **recovery** increase from less than 45% to **66%**
- **Savings** of more than 1 million m<sup>3</sup> of water per year
- The frequency of **cleanings** was cut in half.
- The **lifetime** of the membranes tripled.
- The **energy** cost of operation was reduced by more than 50%

Cleaning cycles before and after the use of specific  
antisclant



# Limitations of RO/NF plants use

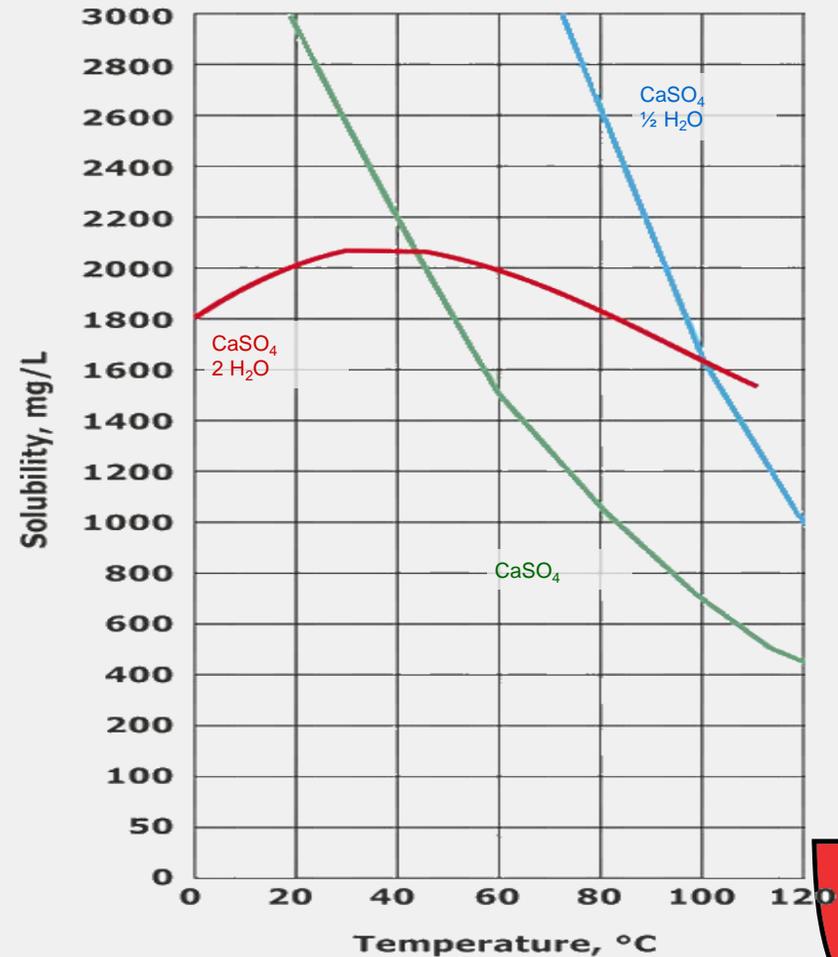
## GYPSUM SCALE



# CaSO<sub>4</sub> chemistry

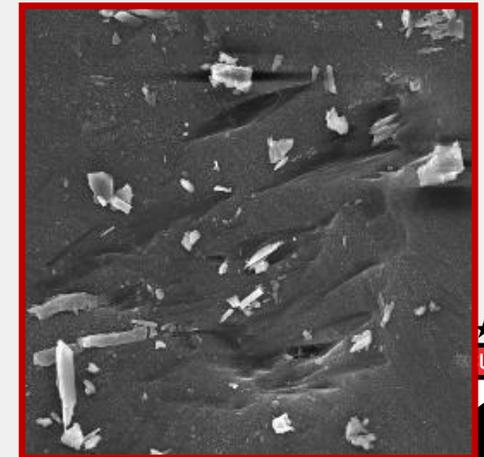
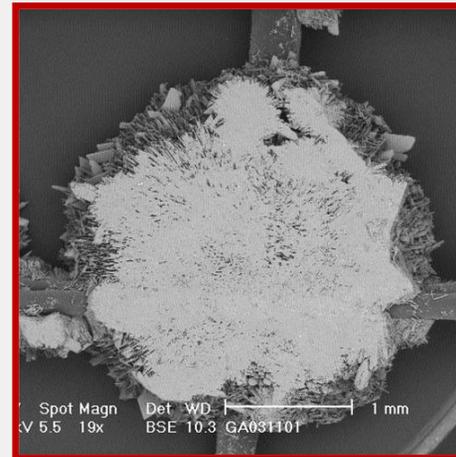
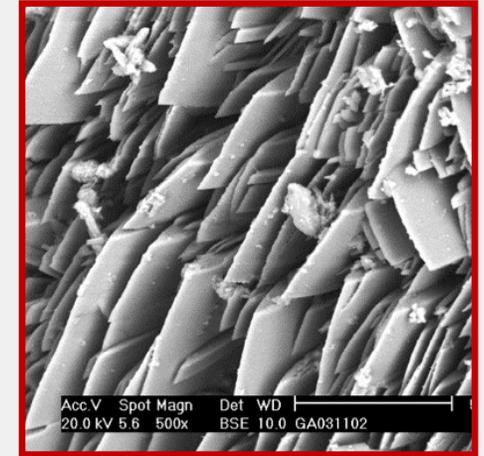
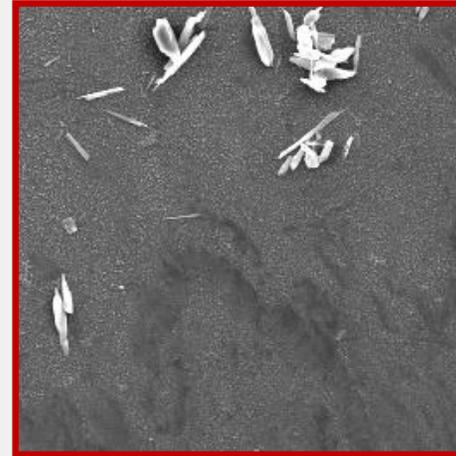
Three major forms of CaSO<sub>4</sub>:

- Anhydrite  $\text{CaSO}_4$
- Dihydrate  $\text{CaSO}_4 \cdot 2 \text{H}_2\text{O}$
- Hemihydrate  $\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$
- Solubility of CaSO<sub>4</sub> decreases significantly below 20°C
- CaSO<sub>4</sub> solubility is pH independent, slight decrease under acidic conditions



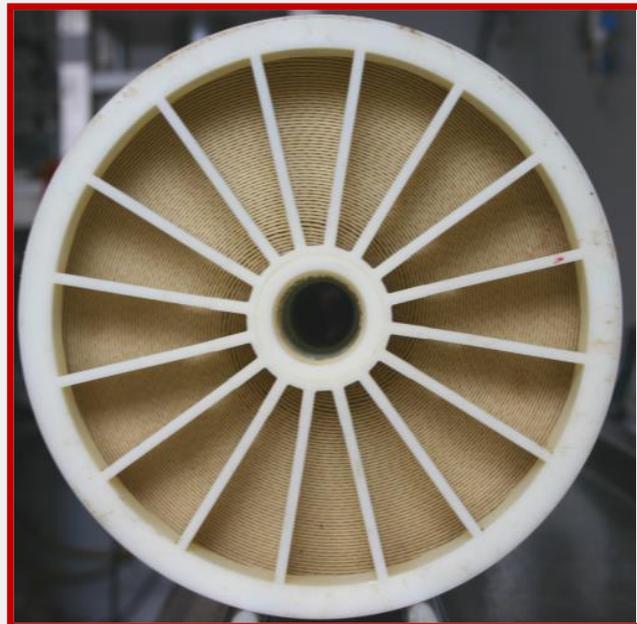
# CaSO<sub>4</sub> chemistry

- CaSO<sub>4</sub> initially occurs as needles
- Growth as platelets & rosettes
- Growth in areas of low turbulence
- Without treating the scale will damage the membrane
- The damage to the polyamide will generate an irreversible increase in the passage of salts.



# The need for antiscalants

- $\text{CaSO}_4$  scale will be formed in all reverse osmosis plants working with high sulfate concentrations, regardless of the operating pH.



# EventMobi

Can you modify  $\text{CaSO}_4$  scaling potential by:

1. Increasing/decreasing temperature?
2. Increasing/decreasing pH?
3. Increasing/decreasing recovery?
4. Using a softener?



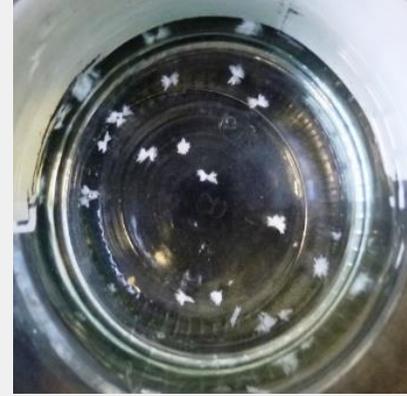
# Lab inhibition tests



no antiscalant



3 mg/l



6 mg/l



10 mg/l

## Beaker tests :

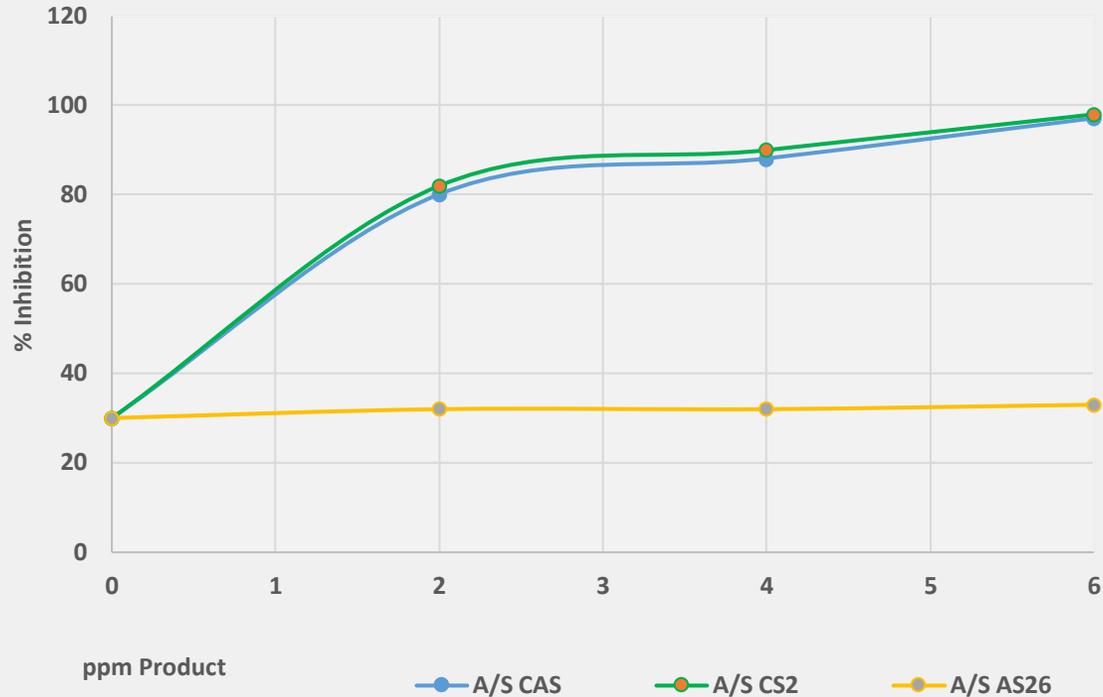
- Genesys CAS / CS2 (pH 7 to pH 11)
- Genmine AS26 (pH <4 – acidic water)
- 2.000 mg/L Ca + 20.000 mg/L SO<sub>4</sub> (CaSO<sub>4</sub> saturation x7.5)
- Metals: Fe, Cu, Al, Mn y Zn (0 a 300ppm)

- 2 years research
- >200 beaker tests
- 67 test on membranes



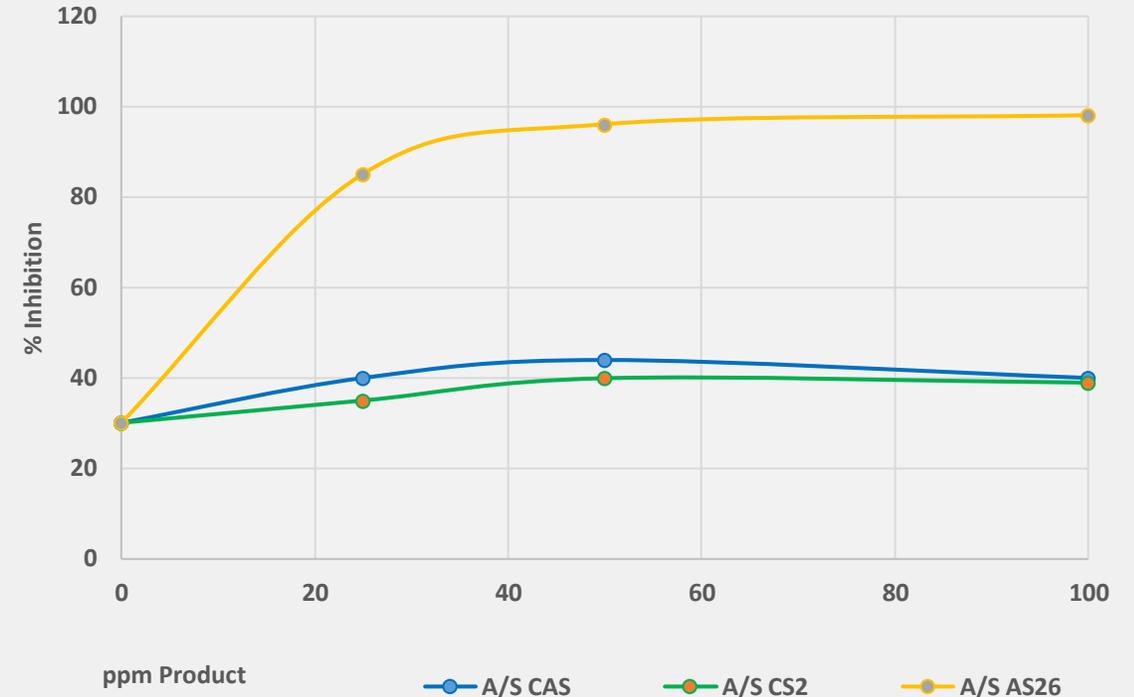
# Antiscalant performance

CaSO<sub>4</sub> (x7.5 sat) @ pH 7.0



CAS & CS2 inhibit CaSO<sub>4</sub> scaling at pH 7 (low dosages)

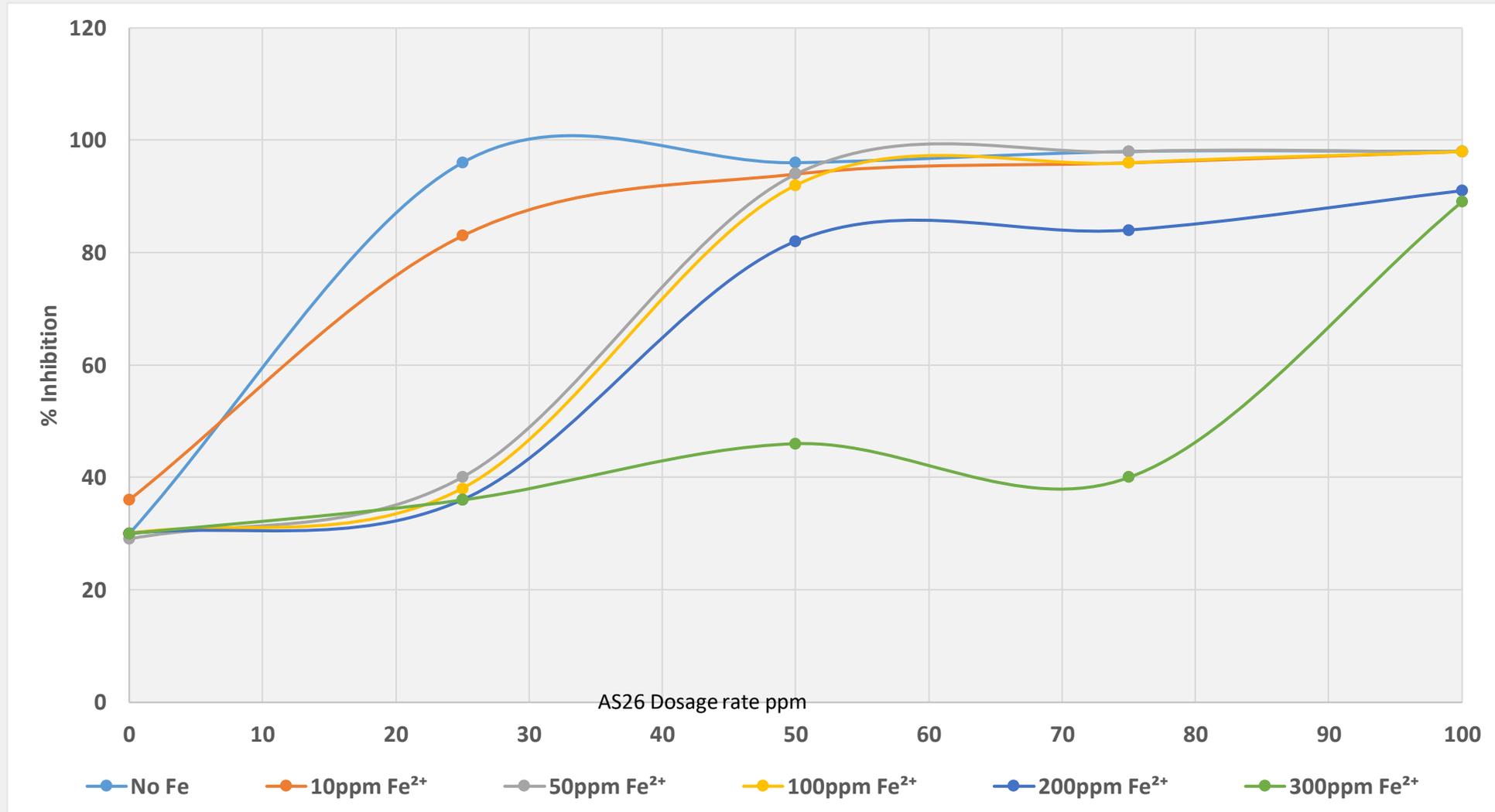
CaSO<sub>4</sub> (x7.5 sat) @ pH 2.0



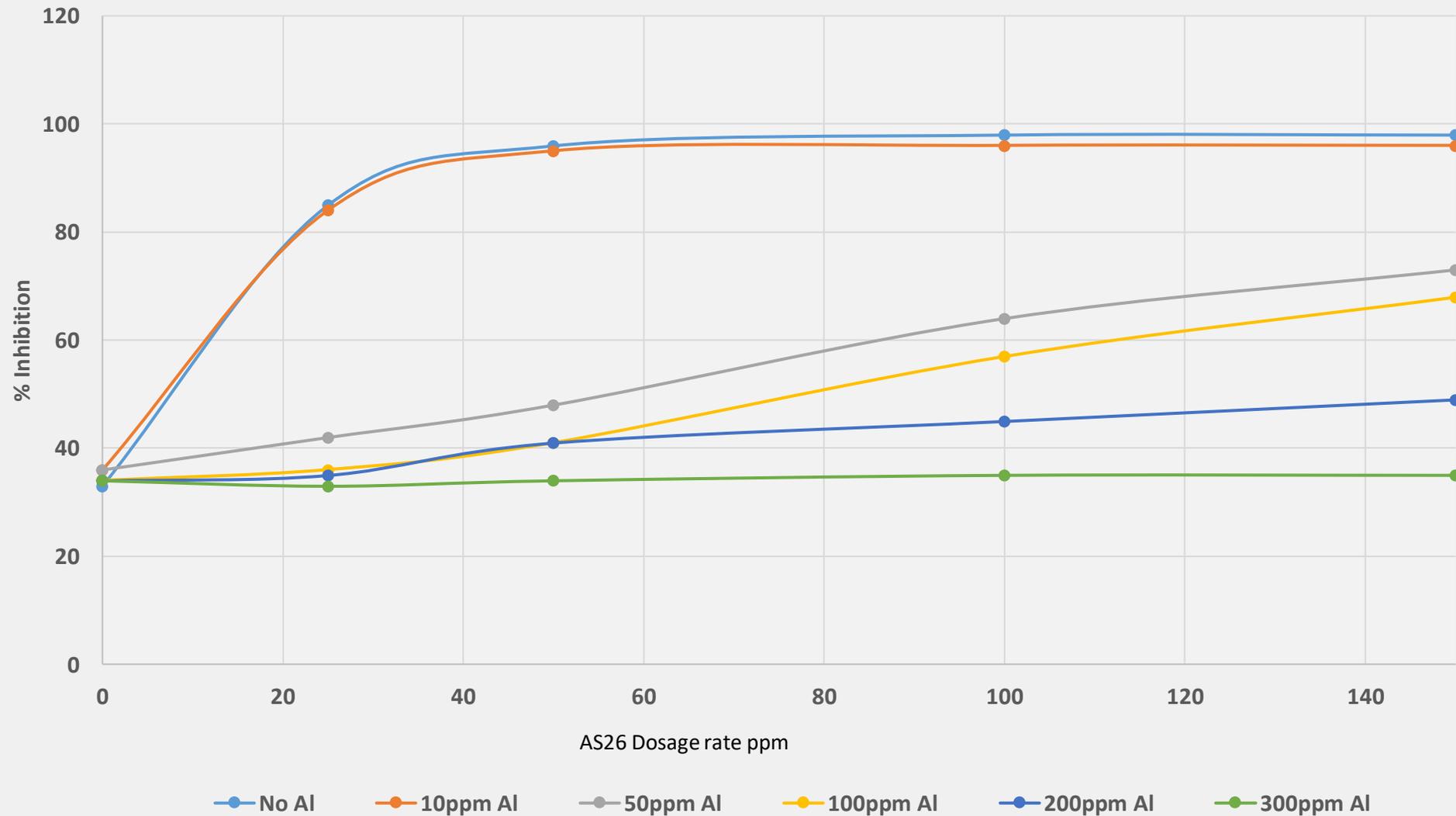
CAS & CS2 do not inhibit CaSO<sub>4</sub> at pH acid  
AS26 inhibit CaSO<sub>4</sub> at pH 2 (high dosages)



# AS26 CaSO4 inhibition with Iron



# AS26 CaSO4 inhibition with Aluminium



# Membrane tests

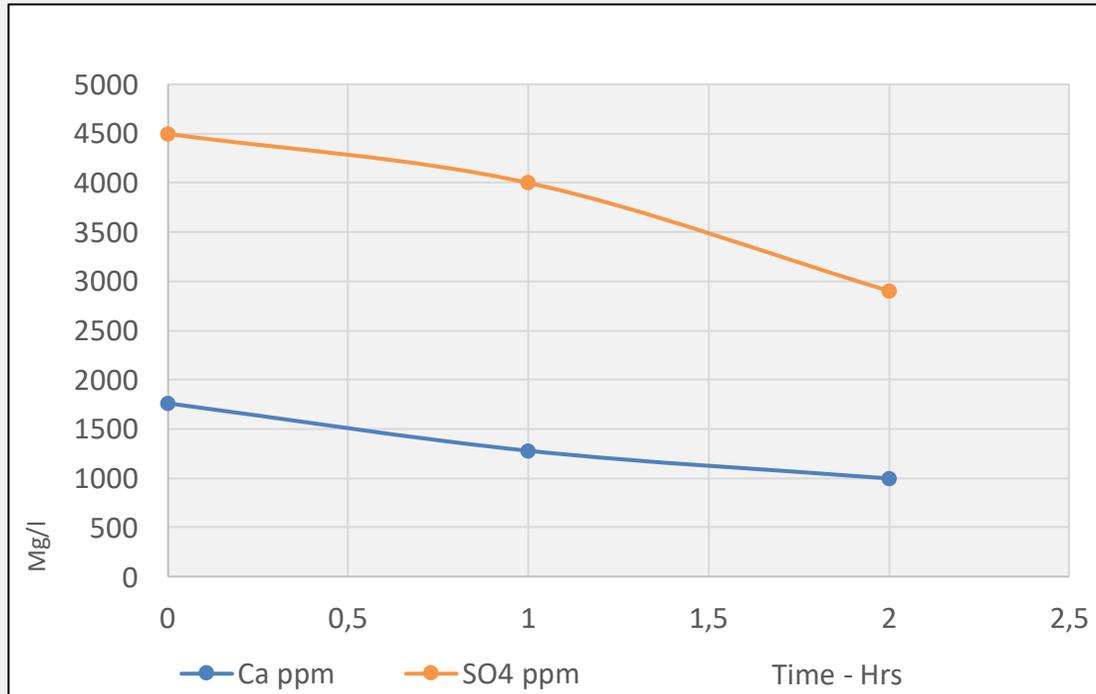
## Test conditions:

- Antiscalant Genesys AS26
- Room temperature, 2 hrs recirculation
- 2.000 mg/L Ca + 5.000 mg/L SO<sub>4</sub> (CaSO<sub>4</sub> saturation x3)
- Metals: Fe (0 a 300ppm)
- Standard polyamide membrane (133 cm<sup>2</sup>)
- The Flat Sheet Rig houses a membrane and spacer coupons
- Monitor Ca<sup>2+</sup> & SO<sub>4</sub> levels
- Monitor membrane performance
- Weigh membrane and spacer.



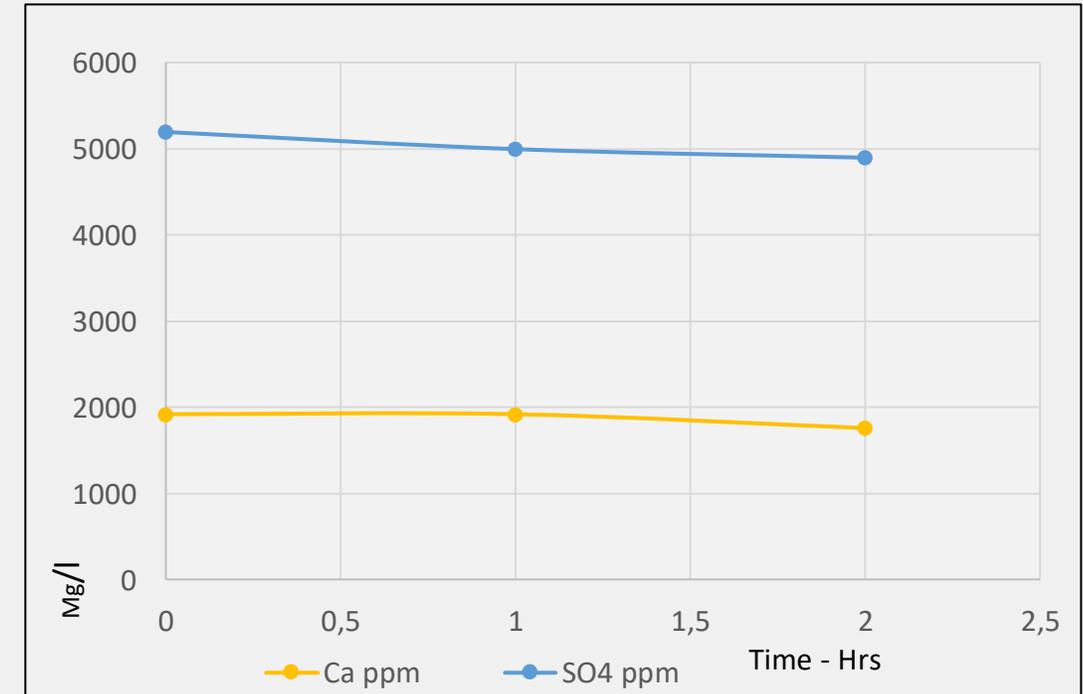
# Ca<sup>2+</sup> & SO<sub>4</sub><sup>2-</sup> 2 hr, 100 mg/L Fe & pH 3

NO antiscalant



Lost 2.000 mg/l SO<sub>4</sub><sup>2-</sup> & 1.000 mg/l Ca<sup>2+</sup>

With antiscalant

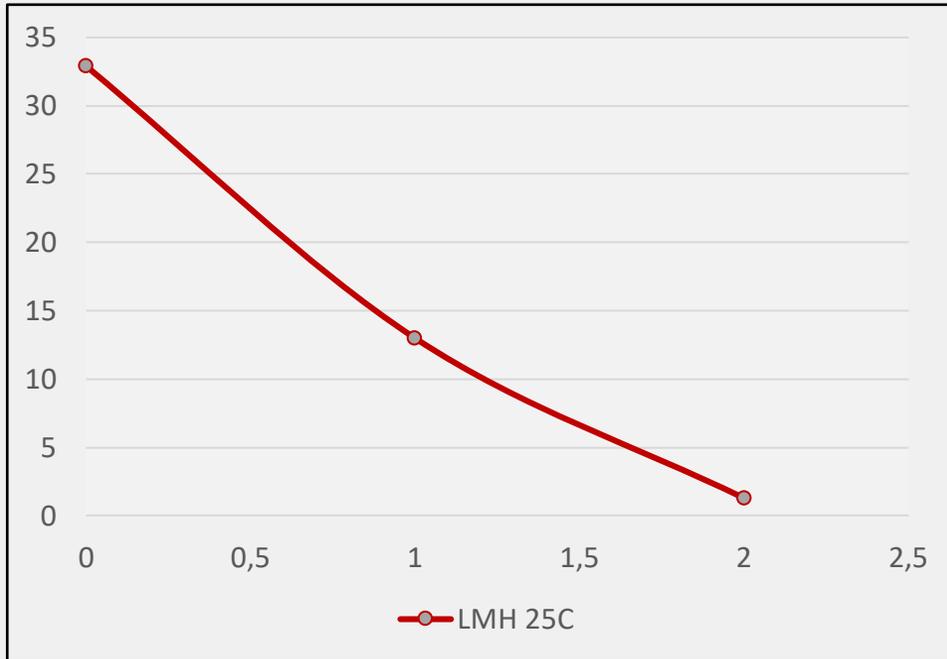


Lost 300 mg/l SO<sub>4</sub><sup>2-</sup> & 160 mg/l Ca<sup>2+</sup> ★★★★★★



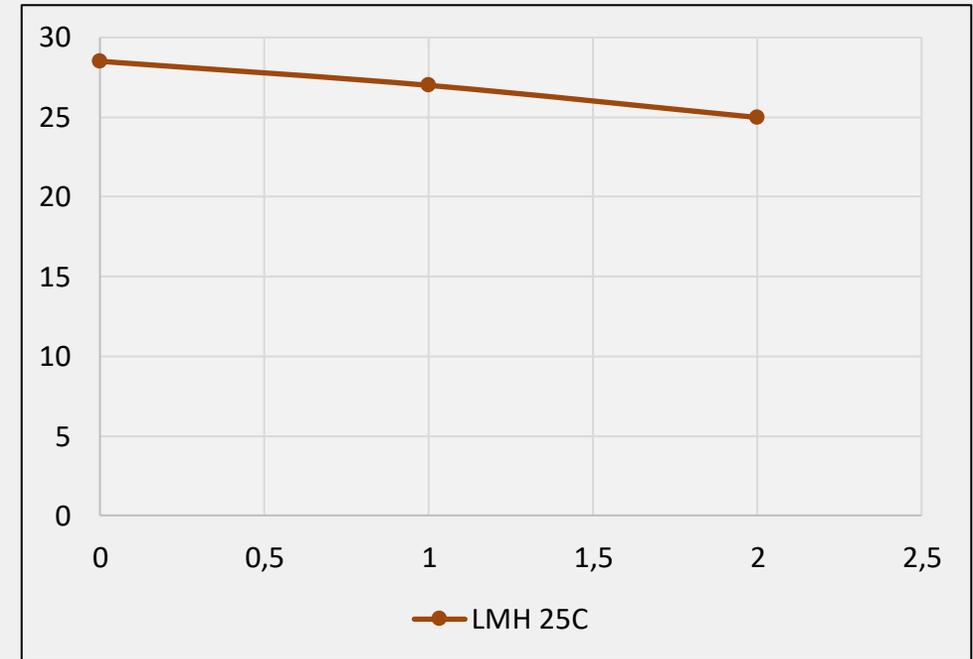
# Flux loss 2 hr, 100 mg/L Fe & pH 3

NO antiscalant



96% reduction

With antiscalant

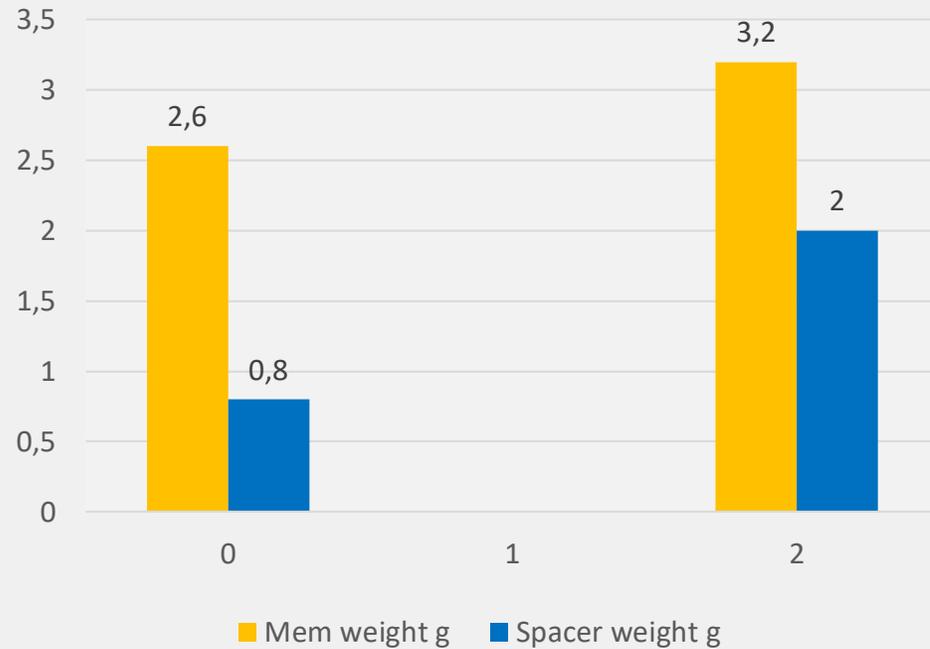


12% reduction



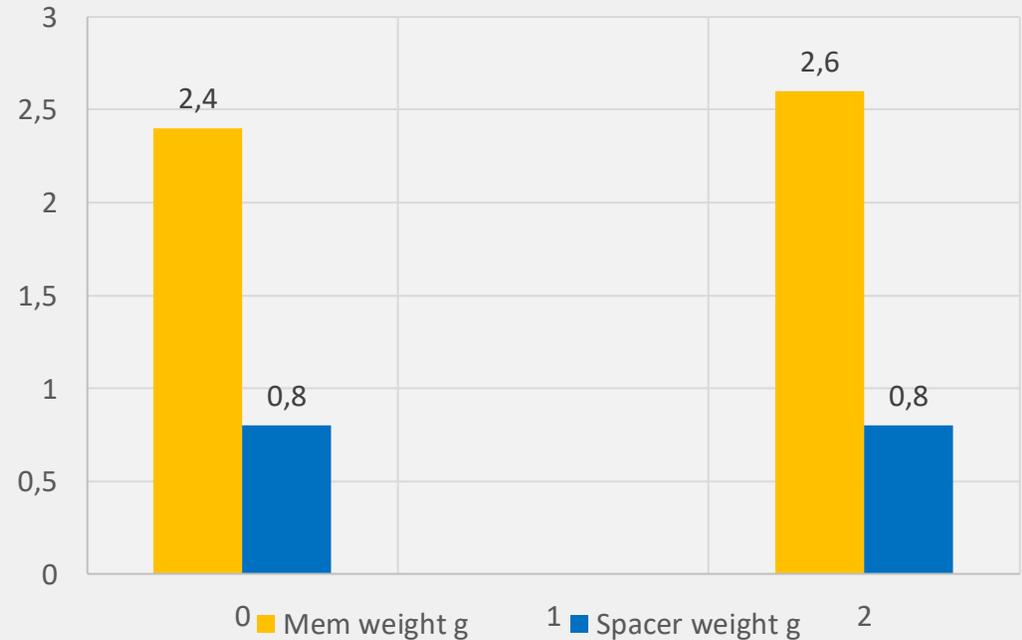
# Membrane & Spacer weight

NO antiscalant



**Weight increase 1.8g**

With antiscalant



**Weight increase 0.2g**



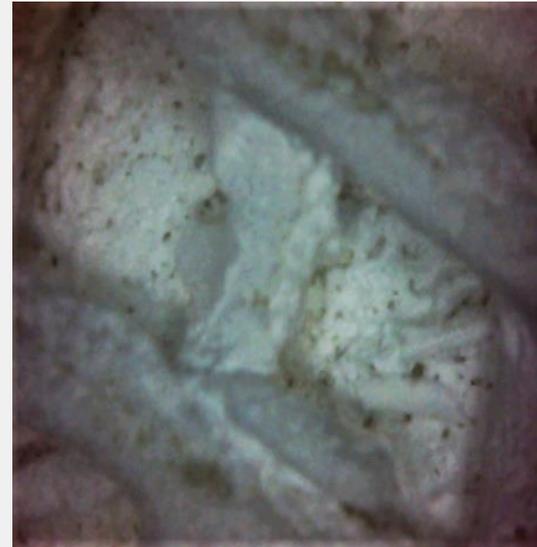
# Membrane & Spacer weight

Membrane+Spacer

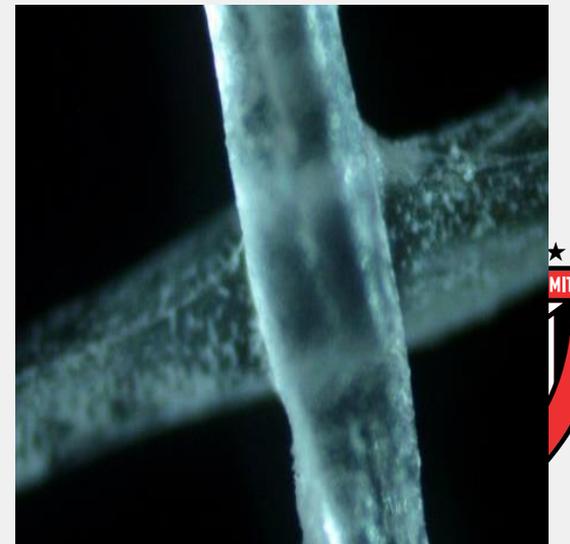
Membrane&Spacer x10

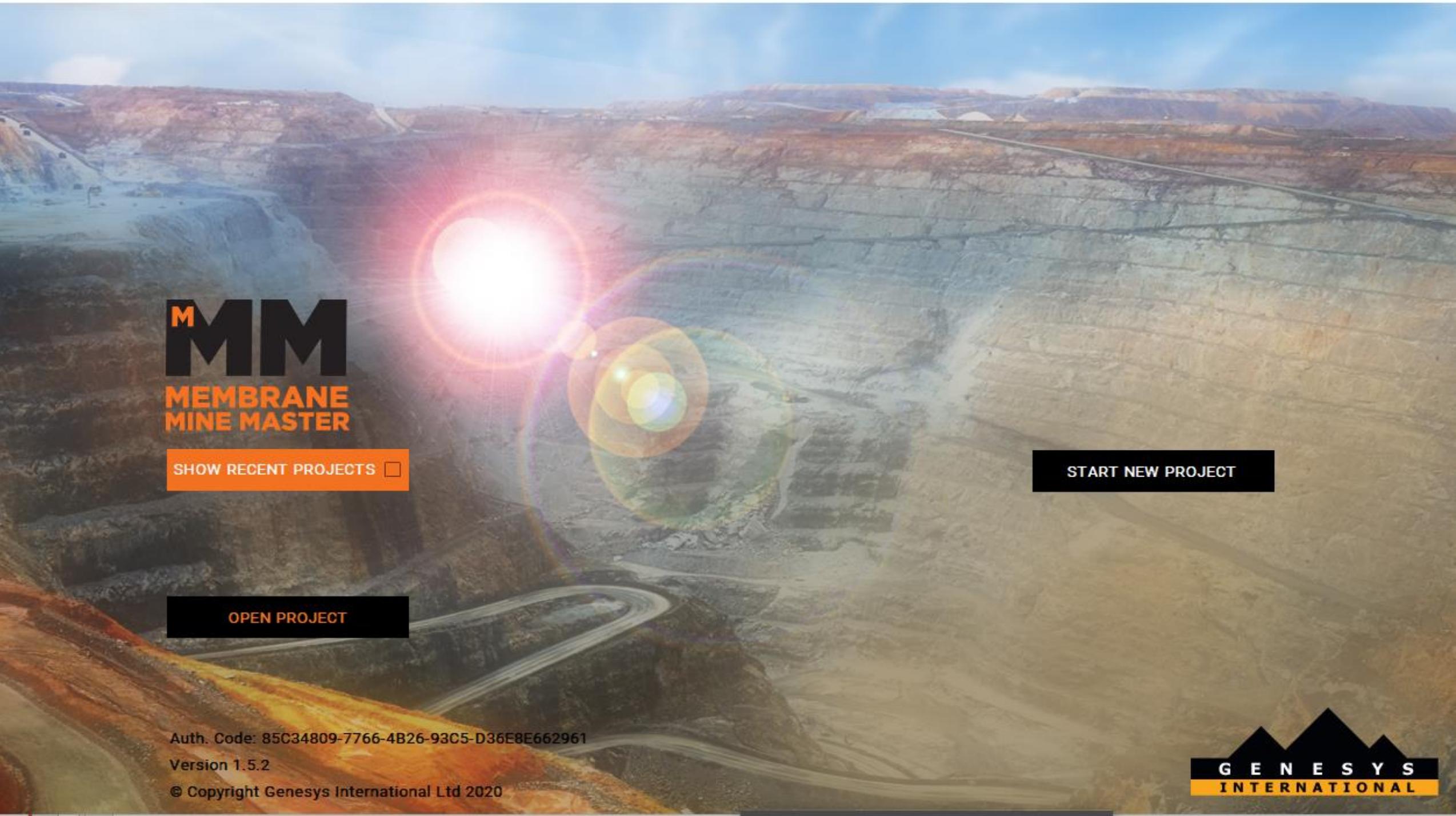
Spacer x40

No antiscalant



With AS26





**M**  
**MM**  
**MEMBRANE**  
**MINE MASTER**

SHOW RECENT PROJECTS

OPEN PROJECT

START NEW PROJECT

Auth. Code: 85C34809-7766-4B26-93C5-D36E8E662961

Version 1.5.2

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**INTERNATIONAL**

# Project Plant data & Water Analysis

Membrane Mine Master Jerritt Canyon Gold

Project Data | Graph View | Table View | Metals Save As... | Generate Report...

**MM MEMBRANE MINE MASTER**

**Project Information**

Project Name / Reference	Jerritt Canyon Gold RO Feed
Contact Name	George Tinkorang
Company	Jerritt Canyon Gold
Date	19th June 2020
Report Author	Steve Chesters
Contact Number	00441606827398
Email Address	schesters@genesysro.com

**Water Type** **Membrane Manufacturer**  
Brackish Water Brackish Water

**Membrane Model**  
Polyamide

**Average Salt Passage**  
0.5 %

**Plant Operating Data**

Permeate Flow	603.5	GPM
Recovery Rate	70.0	
Feed Flow	862.1	
Concentration Factor	3.33	
Concentrate Flow	258.6	
pH Raw Water	7.12	
pH Feed Water	7.12	
Operating Pressure	15.0	bar
Operating Temperature	20.0	°C
Operating Time	24.0	hours/day

**Feed Water Analysis** mg/L

Calcium	3700.00	Sulphate	2000.00
Magnesium	360.00	Chloride	11458.37
Sodium	3200.00	Fluoride	0.00
Potassium	470.00	Bicarbonate	42.65
Barium	0.19	Carbonate	0.00
Strontium	15.00	Nitrate	17.00
Iron(II)	0.00	Silica	0.00
Iron(III)	0.00	Phosphate	0.00
Aluminium	0.00		
Manganese	0.00		
Copper	0.00		
Zinc	0.00		

**Cations** 365.80 Meq/L **Anions** 365.81 Meq/L

Balance Ions

**GENESYS INTERNATIONAL**



# Scaling potential



# Membrane MineMaster Report

## User & Plant Details

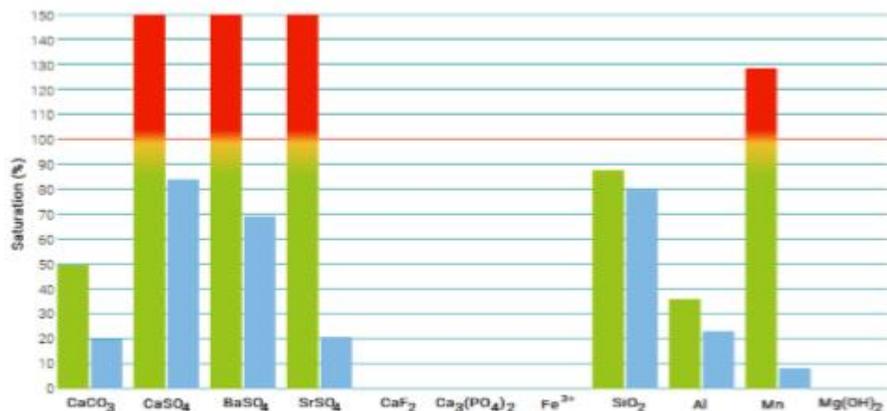
Project Name / Reference: Jerritt Canyon Gold RO Feed  
 Contact Name: George Tinkorang  
 Company: Jerritt Canyon Gold  
 Date: 19th June 2020  
 Report Author: Steve Chesters  
 Contact Number: 00441606827398  
 Email Address: schesters@genesysro.com

Recommended Product: **Genmine AS26**

## Dosing Data

For Scale Control - Feed	26.65	mg/l
For Metal Control - Feed	24.14	mg/l
For Iron(II) Control - Feed	17.41	mg/l
For Iron(III) Control - Feed	0.00	mg/l
For Aluminium Control - Feed	6.73	mg/l
Total Dosage	50.78	mg/l
Dose In Concentrate	146.85	mg/l
Set Dosing Pump To	9712.12	ml/hr
Daily Requirement	314.67	kg/day

## Saturation Graph



## Scaling Indices

	CaCO <sub>3</sub>	CaSO <sub>4</sub>	BaSO <sub>4</sub>	SrSO <sub>4</sub>	CaF <sub>2</sub>	Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>	Fe(OH) <sub>3</sub>	SiO <sub>2</sub>	Al(OH) <sub>3</sub>	Mn	Mg(OH) <sub>2</sub>
Conc. Untreated	49.45	841.00	2761.22	209.05	0.00	0.00	0.00	87.61	35.87	128.24	0.00
Conc. Treat.	20.00	84.10	69.03	20.90	0.00	0.00	0.00	79.65	23.30	8.55	0.00

## Water and Membrane Details

Water Type: Brackish Water  
 Membrane Manufacturer: Brackish Water  
 Membrane Type: Polyamide  
 Average Salt Passage: 0.5 %

## Acid Dosing

Acid dosing is not required.

# Membrane MineMaster Report

## Water Analysis Data

Component	Feed Water mg/L	Concentrate mg/L
Ca <sup>2+</sup>	3700.00	12271.67
Mg <sup>2+</sup>	360.00	1194.00
Na <sup>+</sup>	3200.00	10613.33
K <sup>+</sup>	470.00	1558.83
Ba <sup>2+</sup>	0.19	0.63
Sr <sup>2+</sup>	15.00	49.75
Fe <sup>2+</sup>	10.00	33.17
Fe <sup>3+</sup>	0.00	0.00
Al <sup>3+</sup>	1.00	3.32
Mn <sup>2+</sup>	1.00	3.32
Cu	5.00	16.58
Zn	5.00	16.58
SO <sub>4</sub> <sup>2-</sup>	2000.00	6633.33
Cl <sup>-</sup>	11468.37	38003.58
F <sup>-</sup>	0.00	0.00
HCO <sub>3</sub> <sup>-</sup>	54.82	181.80
CO <sub>3</sub> <sup>2-</sup>	0.00	0.00
CO <sub>2</sub>	8525.94	8525.94
NO <sub>3</sub> <sup>-</sup>	17.00	56.38
SiO <sub>2</sub>	40.00	132.67
PO <sub>4</sub> <sup>3-</sup>	10.00	33.17

## Operation Details

Permeate Flow: 5000.0 m<sup>3</sup>/day  
 Recovery Rate: 70.0 %  
 Feed Flow: 7142.9 m<sup>3</sup>/day  
 Concentration Factor: 3.33  
 Concentrate Flow: 2142.9 m<sup>3</sup>/day  
 pH Raw Water: 3.7  
 pH Feed Water: 3.7  
 Operating Pressure: 15.0 bar  
 Operating Temperature: 20.0 °C  
 Operating Time: 24.0 hr/day

## Water Indices

Index	Feed Water	Concentrate
pH	3.70	3.72
TDS	21335.21	71117.37
Ionic Strength (I)	0.50	1.65
LSI	-2.72	-1.52
Alkalinity ppm CaCO <sub>3</sub>	25.00	139.54

## Scaling Indices Feed

Scaleant Type	Feed Water Untreated (%)	Feed Water Treated (%)
CaCO <sub>3</sub>	9.21	4.61
CaSO <sub>4</sub>	144.13	14.41
BaSO <sub>4</sub>	723.55	18.09
SrSO <sub>4</sub>	29.21	2.92
CaF <sub>2</sub>	0.00	0.00
Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>	0.00	0.00
Fe <sup>2+</sup>	0.03	0.00
Fe <sup>3+</sup>	0.00	0.00
SiO <sub>2</sub>	26.46	24.05
Al(OH) <sub>3</sub>	10.82	7.02
Mn	38.67	2.58
Cu	1.45	0.10
Zn	0.39	0.03
Mg(PO <sub>3</sub> ) <sub>2</sub>	0.00	0.00

## Scaling Indices Concentrate

Scaleant Type	Concentrate Untreated (%)	Concentrate Treated (%)
CaCO <sub>3</sub>	49.45	20.00
CaSO <sub>4</sub>	841.00	84.10
BaSO <sub>4</sub>	2761.22	69.03
SrSO <sub>4</sub>	209.05	20.90
CaF <sub>2</sub>	0.00	0.00
Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>	0.00	0.00
Fe <sup>2+</sup>	0.11	0.01
Fe <sup>3+</sup>	0.00	0.00
SiO <sub>2</sub>	87.61	79.65
Al(OH) <sub>3</sub>	35.87	23.30
Mn	128.24	8.55
Cu	4.81	0.32
Zn	1.28	0.09
Mg(PO <sub>3</sub> ) <sub>2</sub>	0.00	0.00

The data used in Genesys Membrane MineMaster is provided in good faith.  
 The system operation is outside our control and we accept no product liability for consequential results  
 Membrane MineMaster Software Version: v1.5.2  
 Report generated at 16:56:58 on 12/10/2020



# Genmine AS26

## **Applications - Acid drainages with high sulphate concentration:**

- **Acid Mining drainages before RO**
- Acid Mining drainages before press filters (Genesol 721)
- Acid water at oil refining
- Acid water at fracking industry
- Battery industry
- Etc, etc



# Conclusions

## RO/NF plants

- recover leaching solutions
- improve metal extraction efficiency

RO/NF produce pure water permeate;

- reused as process water make-up
- discharged safely to the environment.

RO/NF Membranes can operate outside of normal specifications.

New antiscalants extend membrane life and make RO/NF technology viable.



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## Phosphonate/polymer antiscalants

- Inhibit  $\text{CaSO}_4$  8-10 times saturation pH 5-9
- Dose rate 5-20mg/l
- At pH (<4) they do not work.

## Genmine AS 26 antiscalant

- Inhibits  $\text{CaSO}_4$  8-10 times saturation pH (<4)
- Dose rate of 30-100mg/l depending on Fe & Al
- Inhibits  $\text{CaSO}_4$  with 100mg/l iron & 10mg/l aluminium at pH (<4)
- Neutralisation of feed water not needed



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# So... we got

- Range of mine specific antiscalants formulated able to work at acid, neutral or high pH
- Minewater specific scale prediction software developed
- Products in use in over 30 mine membrane plants
- Unique (AS26) product in the market for AMDs



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- **So... what else do you need?**



# h<sub>2</sub>O innovation<sup>®</sup>

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OF THE YEAR 2020

