Skorpion Zinc: Mine-to-metal zinc production *via* solvent extraction

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Traditional Zinc Processing

- Usually present as sulphide
- Amenable to upgrading
- Roast-Leach-Electrowin process

→ Oxides and silicates considered “untreatable”

Skorpion Zinc

Oxide/silicate:

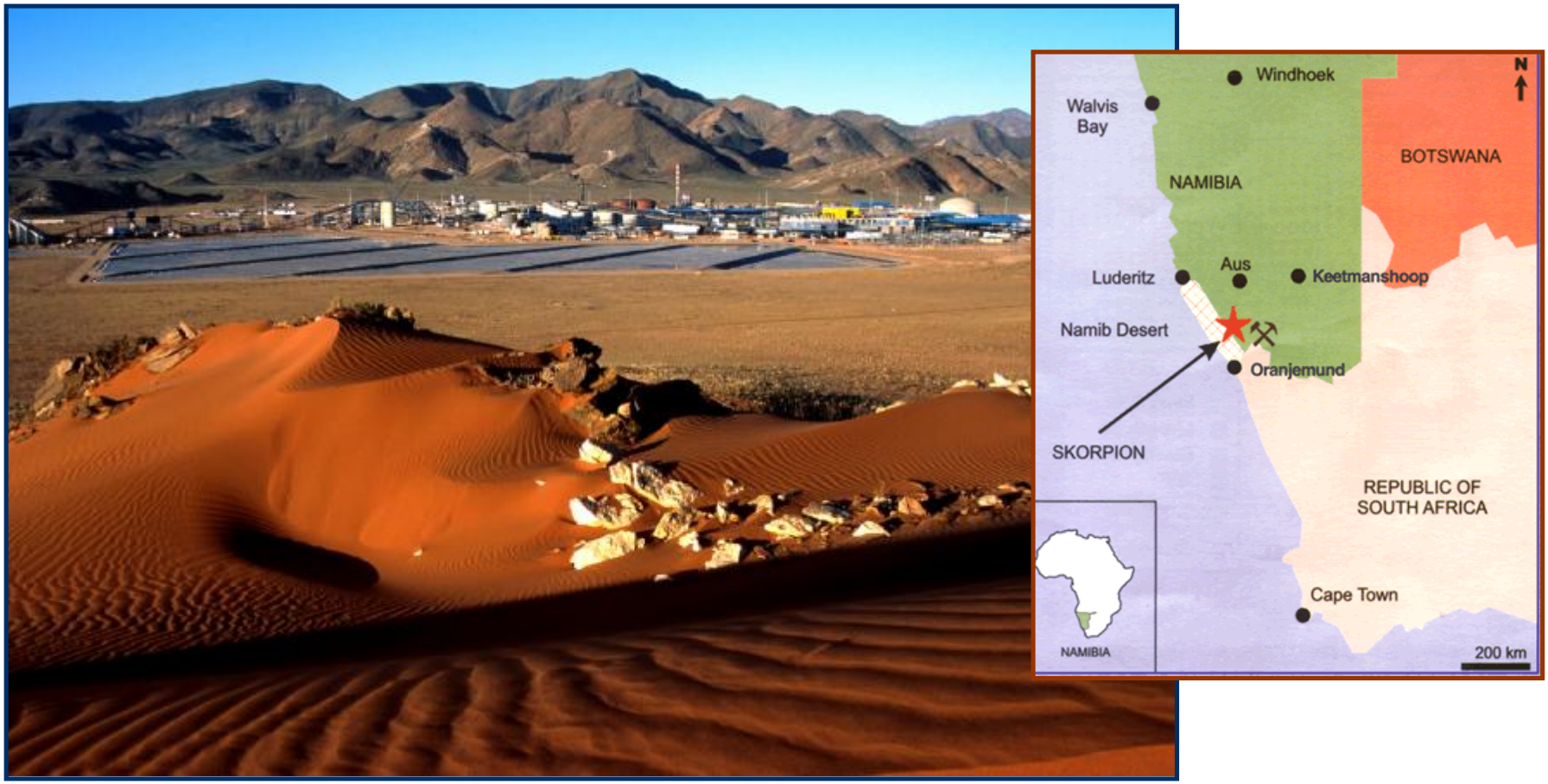
Zn	10 - 40%
Si	26%
Fe	2 - 3%
Some Cl and F	

- First application of Zn SX to primary processing
- Silicate leaching technology
- First metal May 2003
- 150 000 t/a SHG zinc (>99.995% purity)

Overview

- Electrolyte requirements for Zn EW
- Skorpion Zinc flowsheet
- Challenges and process improvements during first 5 years of operation
- Comparison of design and actual performance

Skorpion Zinc

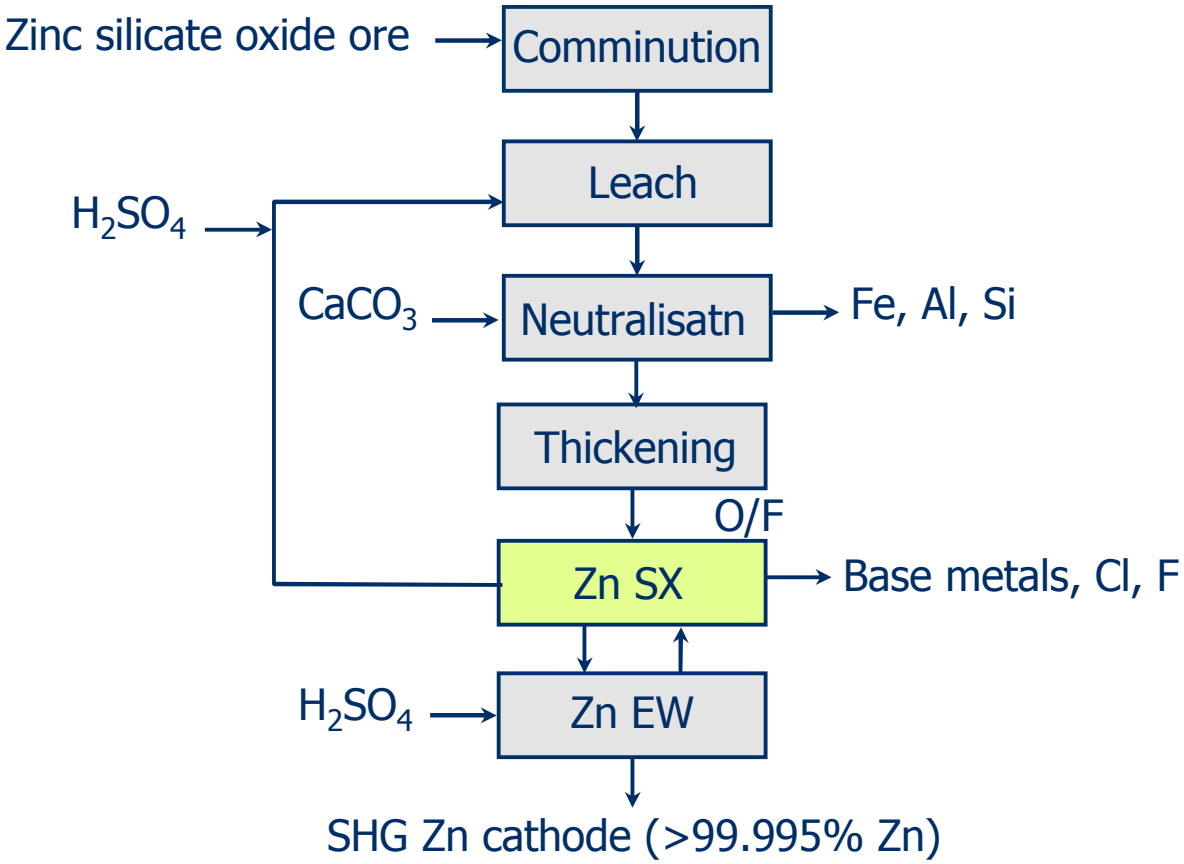


Skorpion Zinc

Advance Electrolyte Specification

Element	Concentration (mg/l)	Element	Concentration (µg/l)
Zn	> 90 000	Ga	3
Mn	2 000	Ge	< 10
Cd	< 0.05	As	< 10
Co	< 0.05	Sn	< 1
Ni	< 0.05	Sb	< 1
Fe	< 5	Te	< 1
Cl	< 0.1	Tl	25
F	< 0.02		

Simplified Skorpion Flowsheet



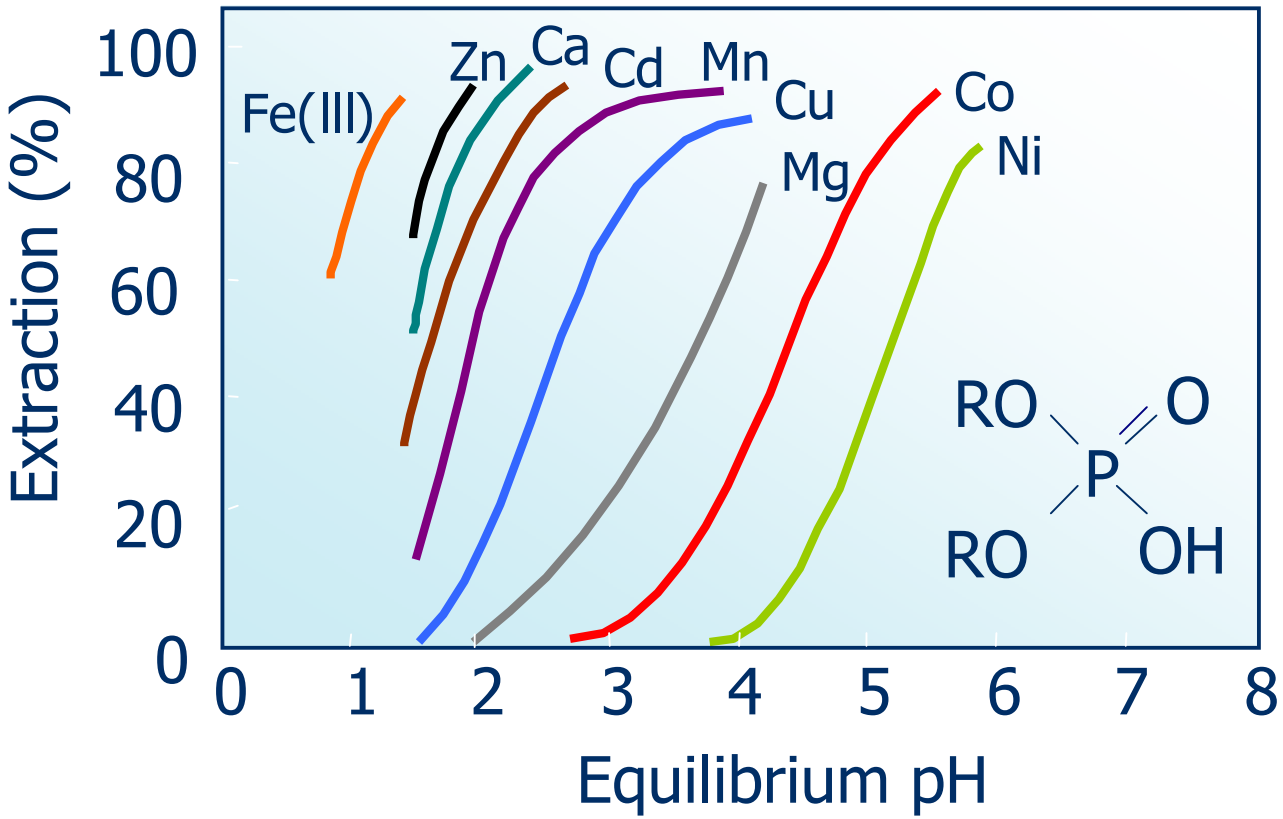
Silicate Leaching

- High SiO_2 in ore
- Avoid conditions for silica gel formation
- Minimise Zn losses in filtration

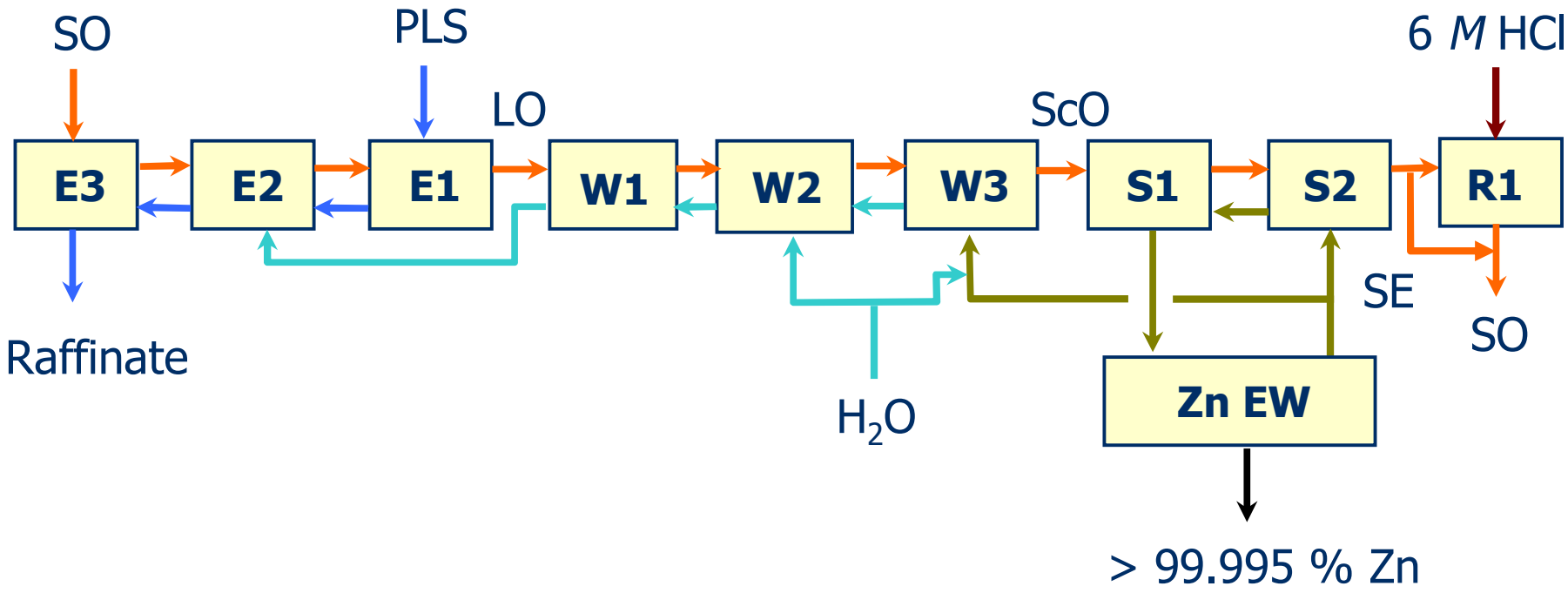
→ dilute leach liquor (30 g/L Zn)

→ upgrade and purify by SX

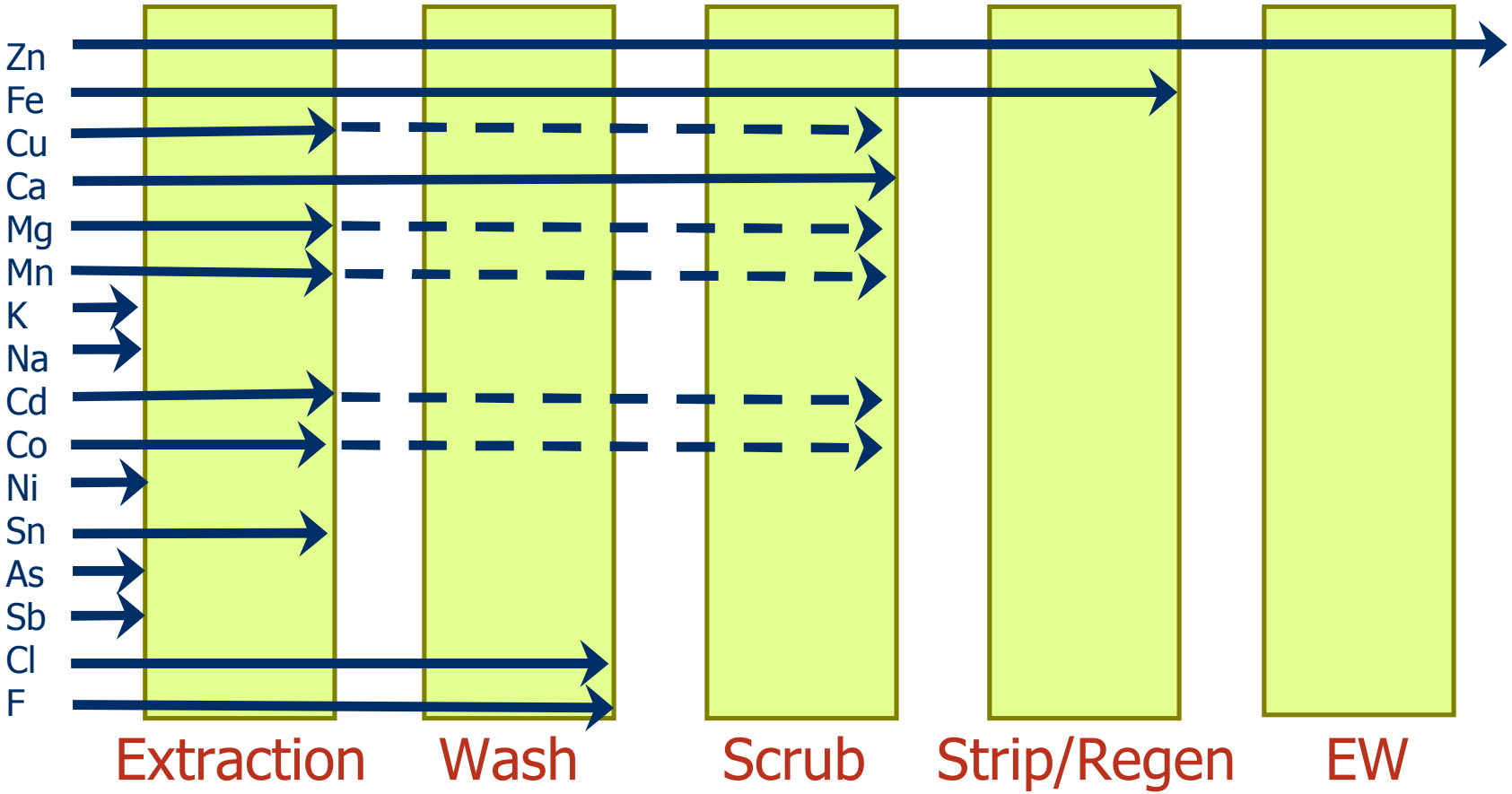
Zn Extraction by D2EHPA



Skorpion Zn SX Circuit



Selectivity of SX



From Técnicas Reunidas

Full-Scale SX Process Performance

Element	Specification for AE (mg/l)	Skorpion electrolyte (mg/l)
Zn	> 90 000	~ 120 000
Cd	< 0.05	0.012
Fe	< 5	< 5
Mn	< 3000	2500
Co	< 0.05	0.07
Ni	< 0.05	0.07
Ca	—	~ 50
Cl	< 100	56
F	< 20	3

Full-Scale SX Process Performance

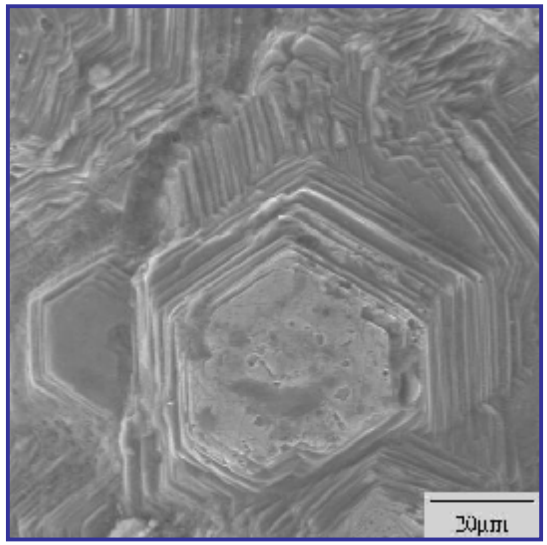
- Selectivity matches theory
- Capacity exceeds design — 107 % Zn transfer

Challenges

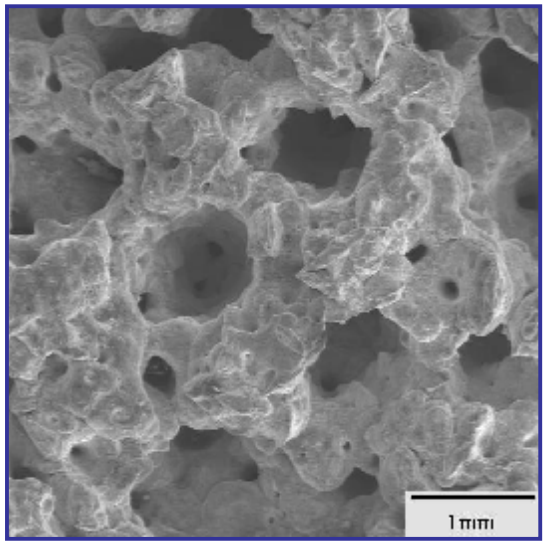
- Organic transfer to EW
- Solids in PLS
- Health of organic phase
- Fire risk – single stream: 100% production loss

Process Improvements

Minimisation of organic transfer to EW



No D2EHPA



5 mg/L D2EHPA

Process Improvements

Minimisation of organic transfer to EW

Advance electrolyte processed through

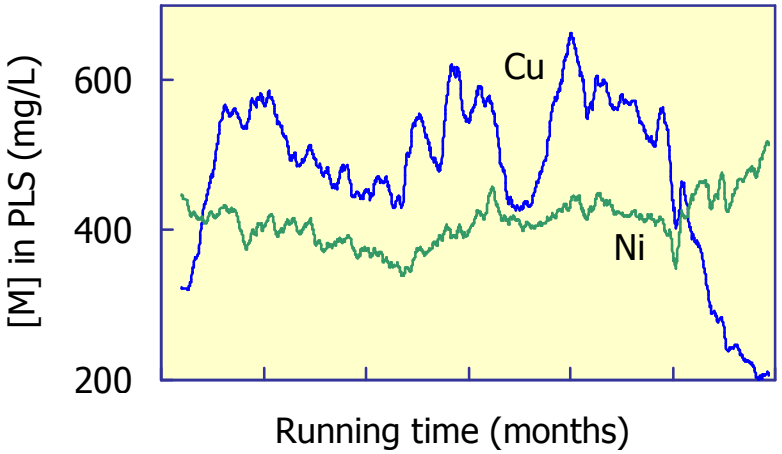
- aftersettler
- flotation column
- activated carbon filter/coalescers (lead-lag configuration)

→ < 1 mg/L OE

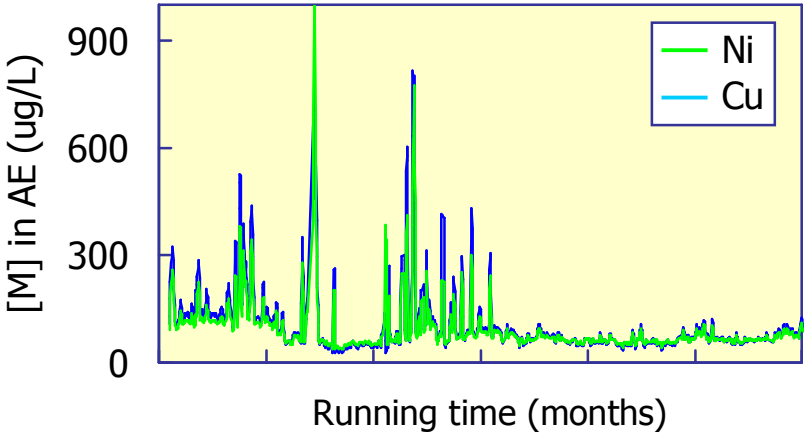
Process Improvements

Deportment of impurities to electrolyte

SX Feed



Advance electrolyte



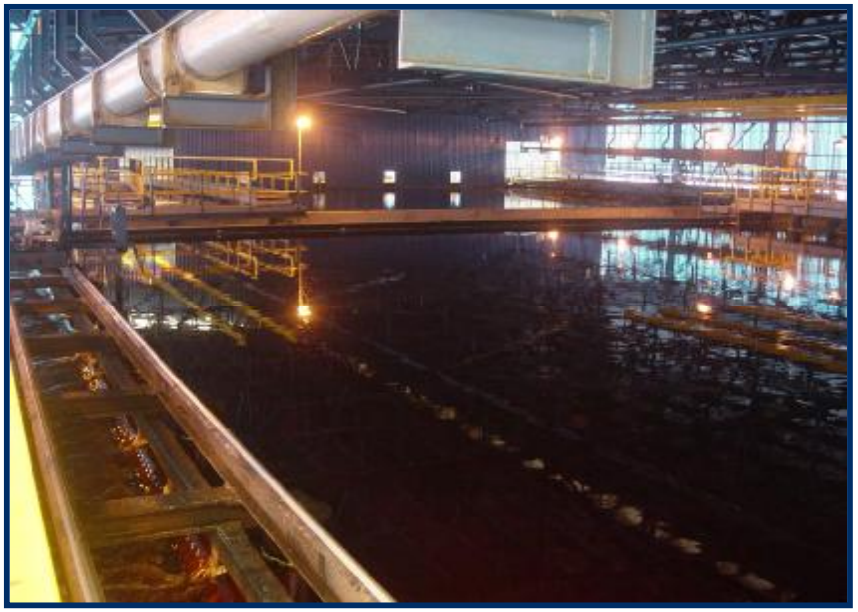
Electrowinning of Zinc

Half-cell reduction	E^o (V)
$Cu^{2+} + 2\,e \rightarrow Cu$	0.34
$2\,H^+ + 2\,e \rightarrow H_2$	0.00
$Ni^{2+} + 2\,e \rightarrow Ni$	–0.26
$Co^{2+} + 2\,e \rightarrow Co$	–0.28
$PbSO_4 + 2\,e \rightarrow Pb + SO_4^{2-}$	–0.35
$Cd^{2+} + 2\,e \rightarrow Cd$	–0.40
$Zn^{2+} + 2\,e \rightarrow Zn$	–0.76
$Mn^{2+} + 2\,e \rightarrow Mn$	–1.18

Process Improvements

Deportment of impurities to electrolyte

- Solids in PLS
  ~100 mg/L TSS (target <10 mg/L TSS)
  excessive crud formation
- Linked to excursions of Ni, Co
- High organic consumption



Process Improvements

Control of solids' deportment to SX

Original design

- thickener
- clarifier
- sand filters

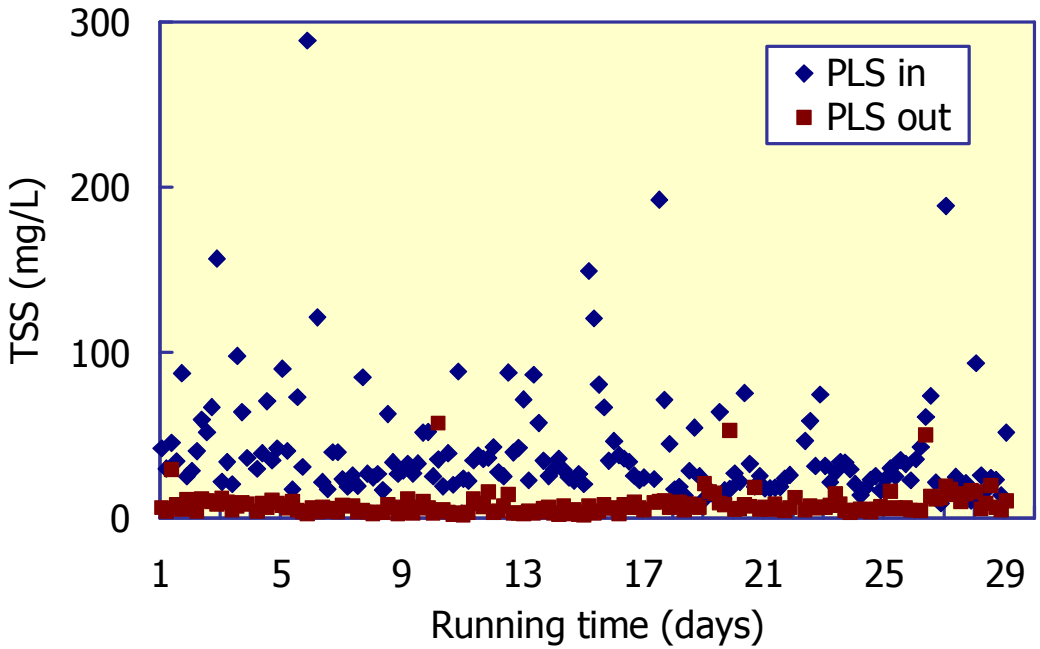
Process improvements

- PLS ponds
- avoid colloidal silica formation
- pH control of leach
- avoid leach plant downtime
- reduce mixer air entrainment
- Roymec pinned-bed clarifier

Process Improvements

Control of solids' deportment to SX

Pinned-bed clarifier → <10 mg/L TSS



PLS and Electrolyte Composition

Element	PLS (mg/L)		AE (mg/L)	
	Design	Actual	Design	Actual
Al	300	82		190
Ca	650	660		50
Cd	100	330	<0.05	0.01
Cl	5000	1030	<100	50
Co	100	18	<0.05	0.02
Cu	700	500	<0.05	0.09
F	200	40	<20	7
Fe	5	1.5	<5	<5
Mg	200	1040		
Mn	500	2120	3000	2200
Ni	800	330	<0.05	0.08
Si	40	70		
Zn	30 000	38 000	90 000	117 000

Advantages of Zn SX

- High Si in ore
  - Dilute leach solution to avoid silica gel
  - Minimise soluble zinc losses in filtrate

Advantages of Zn SX

- High Si in ore
- EW very sensitive to impurities
  - Reject Cu, Ni, Co, Cd, Mn, Mg
  - Reject F, Cl
  - Reject Ca

Advantages of Zn SX

- High Si in ore
- EW very sensitive to impurities
- Upgrade
  - 30 g/l Zn in PLS
  - > 100 g/l Zn in AE

Advantages of Zn SX

- High Si in ore
- EW very sensitive to impurities
- Upgrade
- SHG Zn
  - > 99.995 % purity

SHG Zinc Cathode

Element	SHG spec.* (ppm)	Skorpion (ppm)
Cd	30	0
Cu	10	7
Fe	20	3
Pb	30	25
Sn	2	2
Zn	999950	999963

** British standard, 1996*

Product Quality

150 000 t/a

>99.995% Zn

SHG Zn

Conclusions

- Breakthrough technology for zinc oxide treatment – "untreatable" ore
- First mine-to-metal operation
- Robust technology
- SX process considered a technical success
- Consistent production of 150 000 t/a SHG Zn
- Amongst world's highest quality and lowest cost zinc producers (2007 C1 US¢ 32/lb Zn)

Acknowledgements

Skorpion Zinc

Anglo Base Metals

Sole 2001, Proceedings 6th World Congress Chemical Engineering, Melbourne

Fuls *et al*. 2005, Proceedings ISEC 2005, Beijing

Gnoinski *et al*. 2005, Proceedings Lead-Zinc 2005, Osaka

Sole *et al*. 2008, Proceedings ISEC 2008, Tucson, AZ