Salt Partners

HYDROSAL-XP® Salt Purification Process

Why was it selected by BCI Minerals for the Mardie project?

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This presentation is broadcasting on YouTube under the following link:
https://youtu.be/s_ePOZp13ic

Roskill SALT ASIA 2018, InterContinental Grand Stanford, Hong Kong

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Salt production world-wide

Salt type	World production
Solar salt	100,000,000 t/y
Rock salt	100,000,000 t/y
Brines	100,000,000 t/y
Total	300,000,000 t/y

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Salt consumption world-wide

Salt user	Salt consumption
Chemical industry	180,000,000 t/y
Food	80,000,000 t/y
Other	40,000,000 t/y

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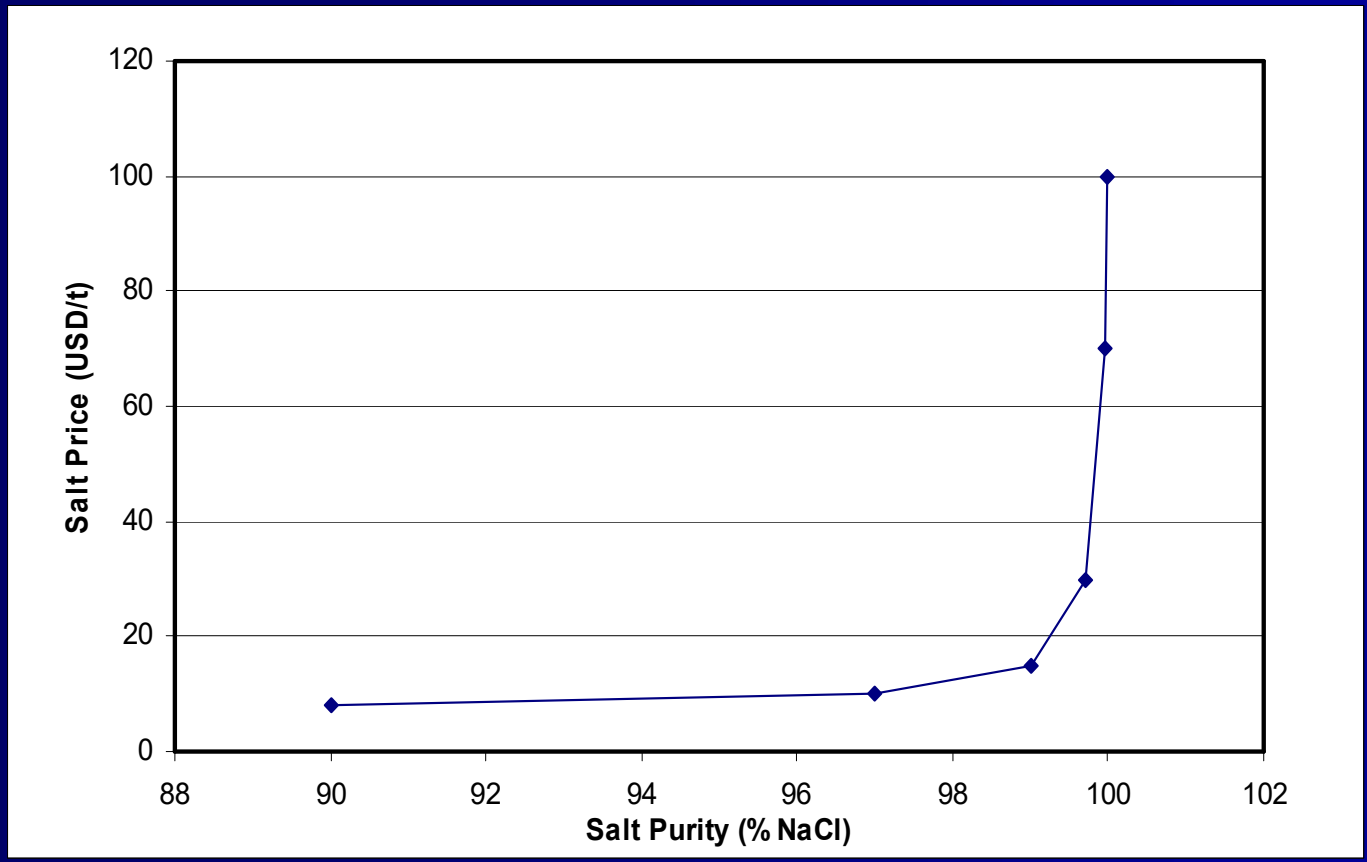
Salt prices depend on salt purity



Industrial salt prices vary between USD 10.-/t and USD 100.-/t depending on salt purity

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Impurities in salt

	Rock salt	Sea salt	Lake salt	Brines
CaSO4	0.5 – 2%	0.5 – 1%	0.5 – 2%	Saturated
MgSO4	Traces	0.2 – 0.6%	Traces	Traces
MgCl2		0.3 – 1%	Traces	
CaCl2			Traces	
Na2SO4			Traces	
KCl			Traces	
NaBr			Traces	
Insolubles	1 – 30%	0.1 – 1%	1 – 10%	

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Spraying of brine over salt on a wire mesh belt

Brine flows through a path of least resistance, forming channels.

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Submerging salt in brine in a spiral classifier

Intensive contact of salt and brine. Brine purity controlled by dilution with water, causing losses.

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Salt losses in a spiral classifier

Turbulence in a spiral classifier carries smaller salt crystals to the overflow, increasing the salt losses.

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Bypass flow of brine in a spiral classifier

Rotating screw pushes the salt in the direction of the rotation.

Salt level on the right is higher than on the left.

Brine flows back through the path of least resistance (that is on the left) bypassing the salt.

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In a spiral classifier, brine bypasses the salt

Salt is pushed to the left at the top of the picture.

Brine flows back to the right at the bottom of the picture. Brine is bypassing the salt.

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Salt purification prior to dissolution in electrolytical brine

Way back in 1979, Krebs Swiss incorporated a Salins du Midi salt washing unit in a chloralkali plant built for MISR Chemicals in Egypt

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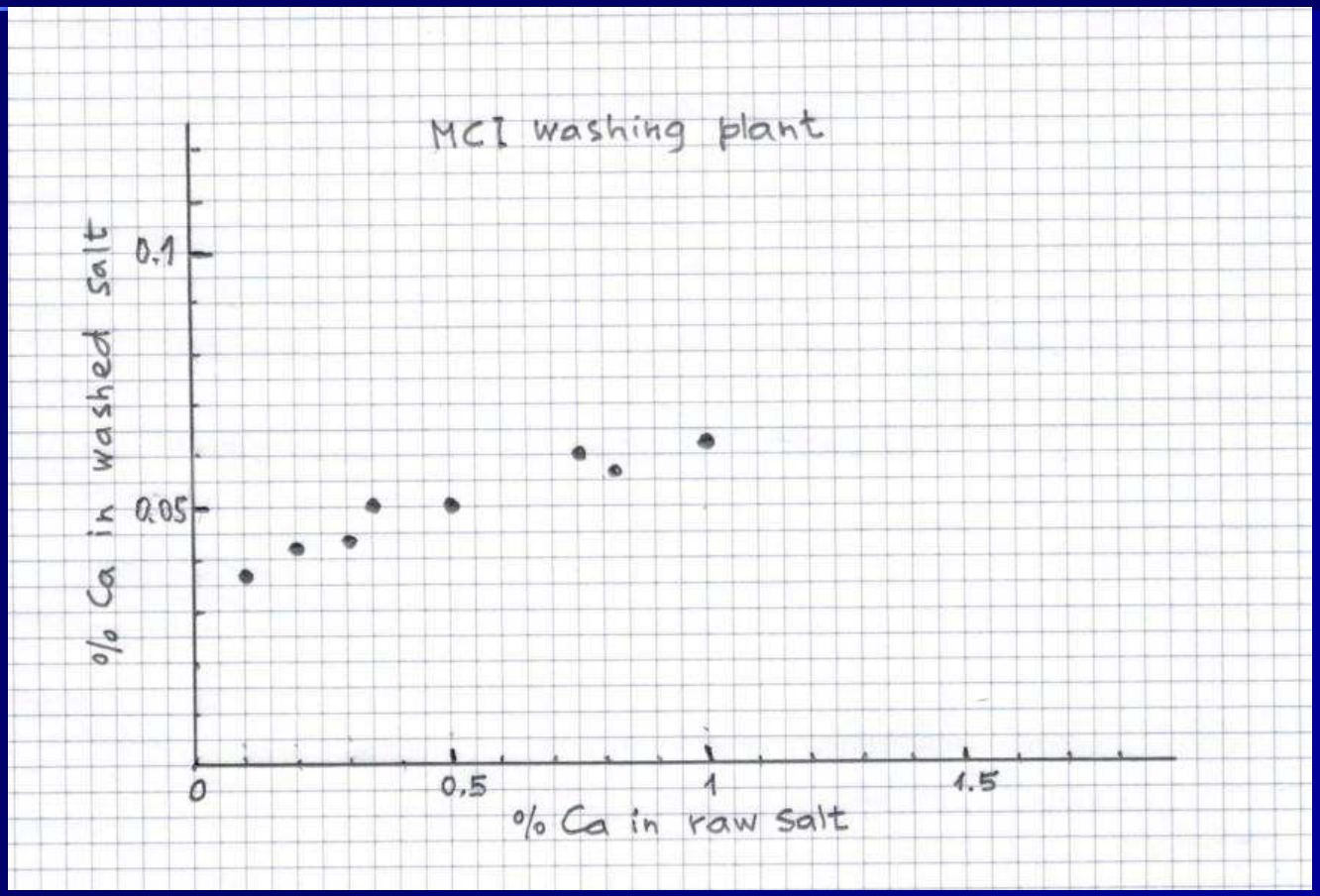
We were evaluating the washing plant performance



Fist week of operation

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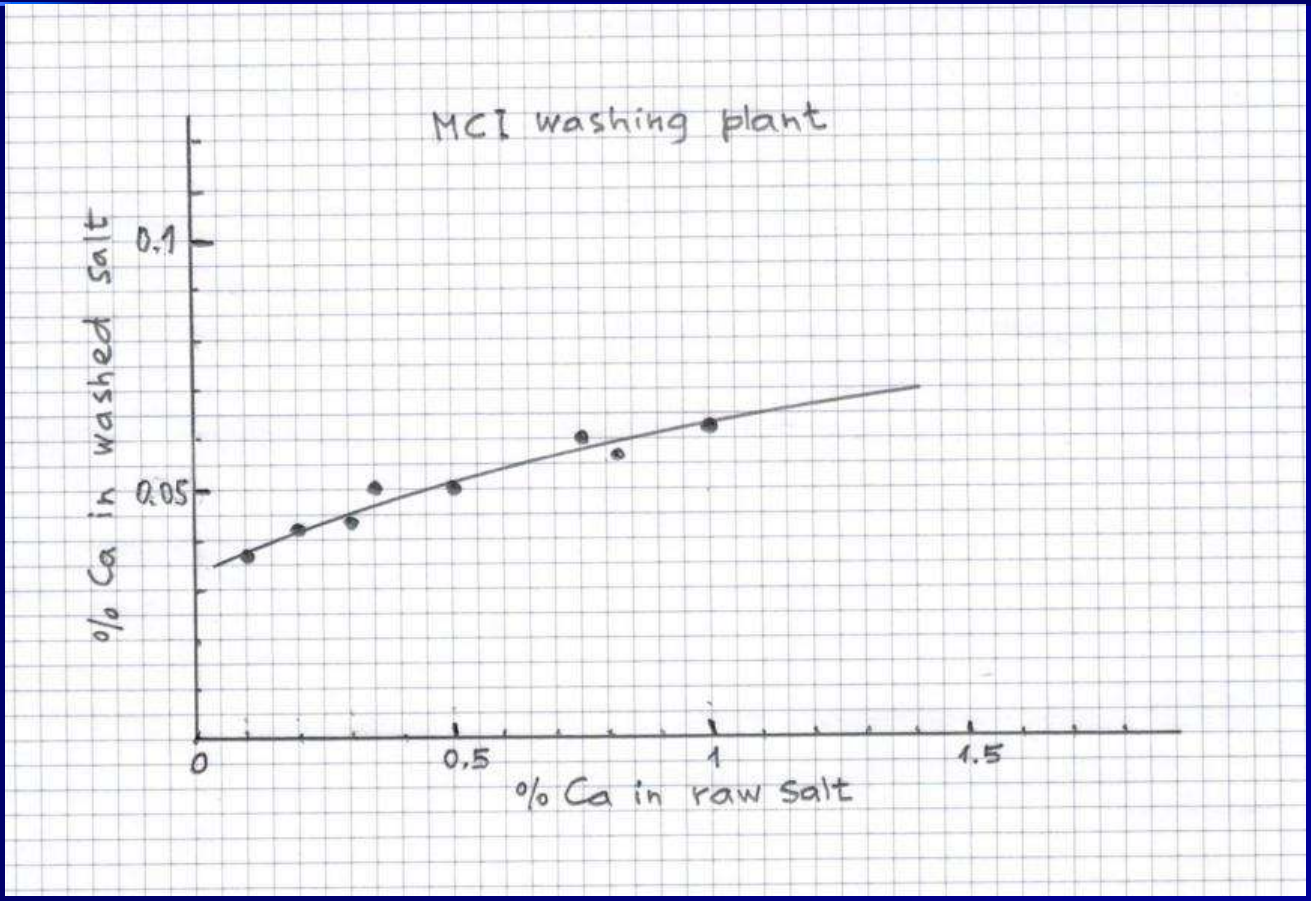
Evaluation of washing plant performance



The data fitted a nice regression curve

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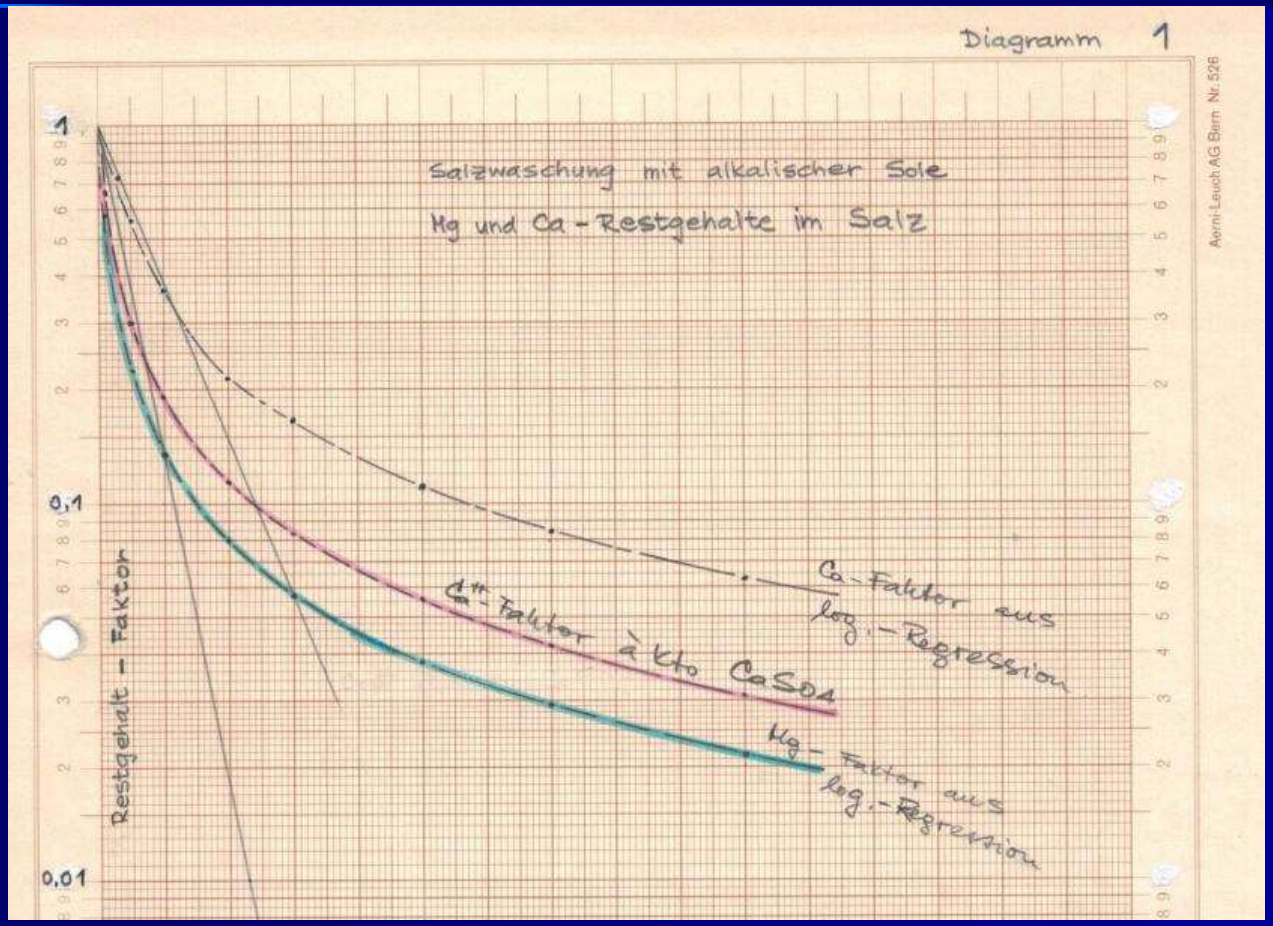
Evaluation of washing plant performance



We created a diagram to predict washed salt purity as a function of raw salt analysis

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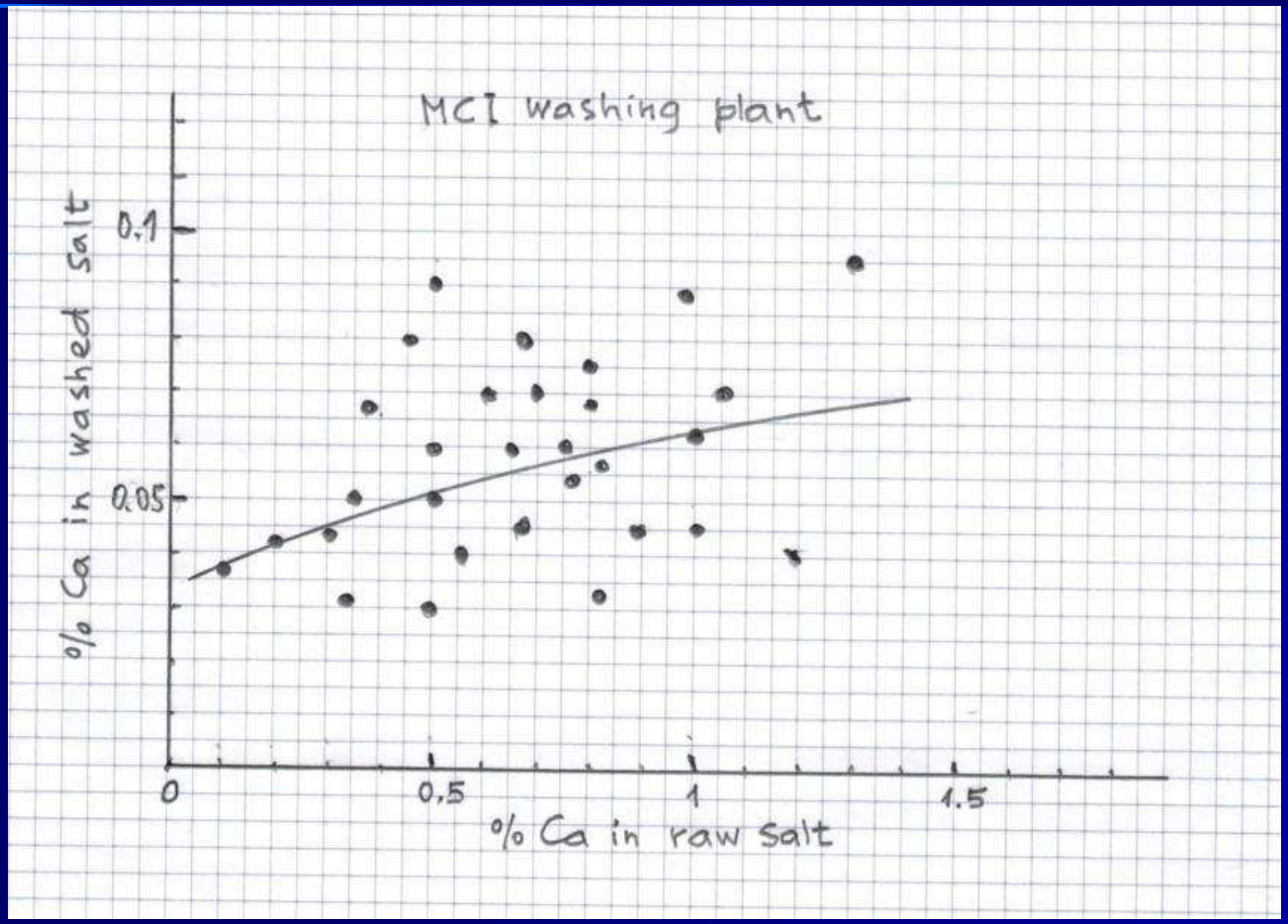
Evaluation of washing plant performance



The data received in the following days didn't fit the curve

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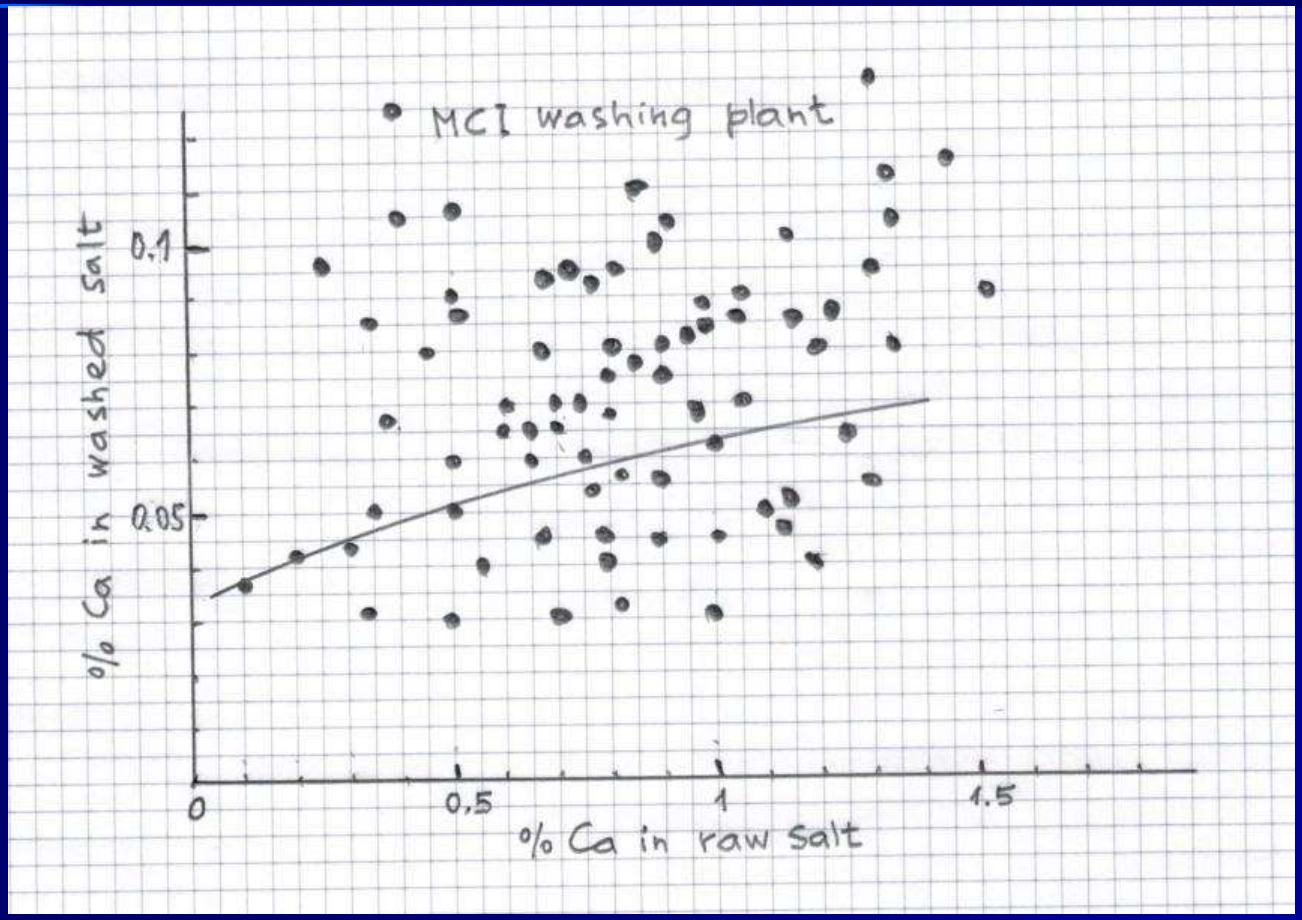
Evaluation of washing plant performance



The data received in the following weeks showed that the attempt to predict washed salt purity using regression curve was a failure.

We had to seek another solution.

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Parameters of impurity removal from salt

On what parameters can a salt purification process depend?

- Nature of impurities
- Phase equilibria of brine components
- Structure of salt crystals
- Salt and brine contact time
- Unit operations
- etc.

We had to learn the salt purification basics.

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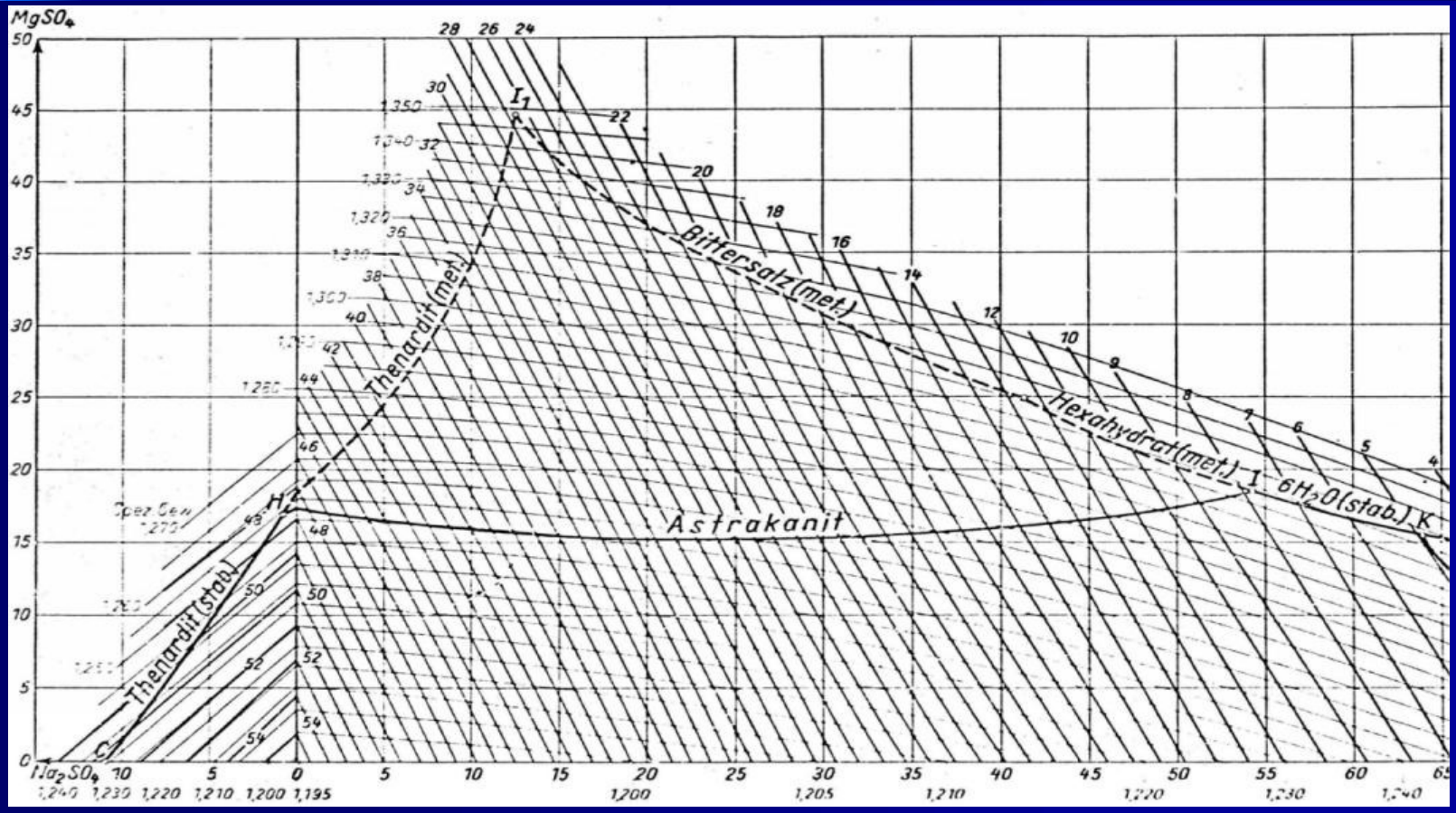
Phase equilibria of Na–Mg–Cl–SO4–H2O system



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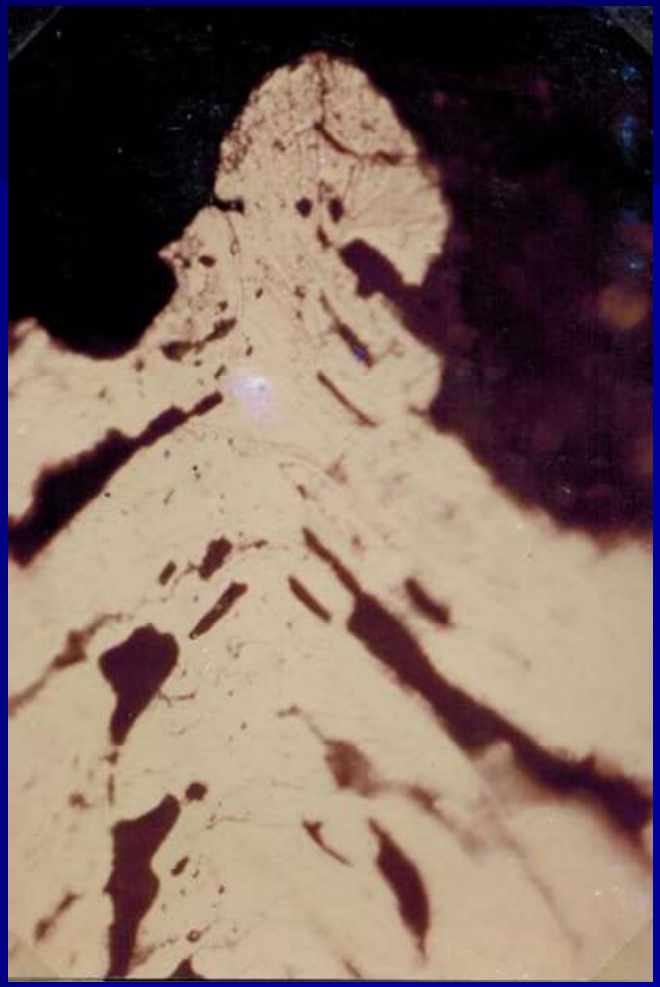
Nature of salt crystals

Broken solar salt crystal



Reflecting light reveals cavities and crevices

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10th World Salt Symposium 2018, Park City, Utah, USA

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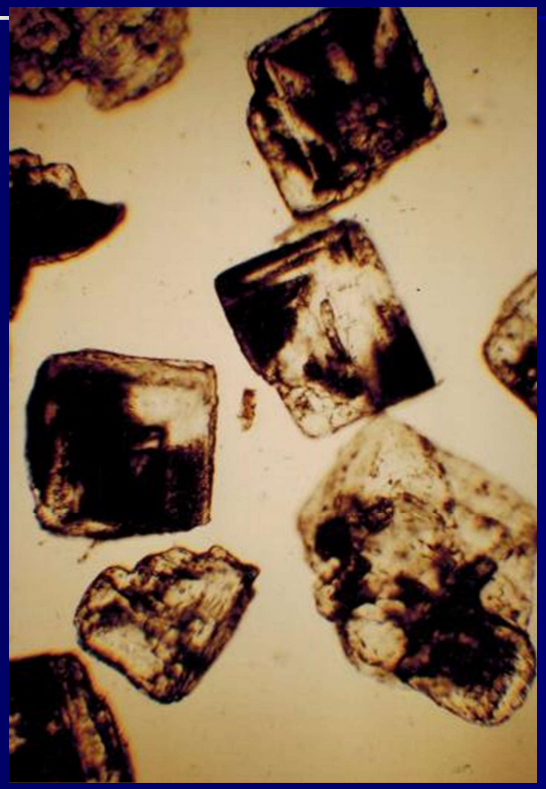
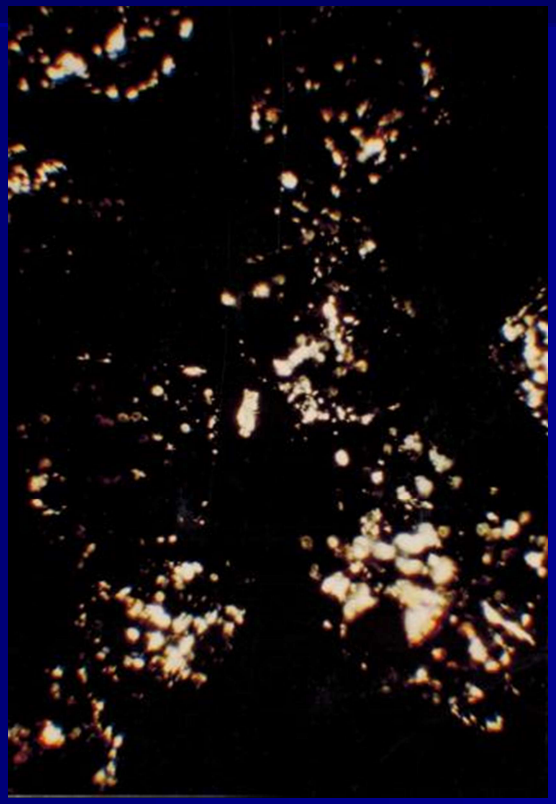
Polarised light makes salt and impurities visible



Solar salt crystals in normal light



Solar salt impurities in polarised light

Solar salt crystals and impurities in phase shifted polarised light

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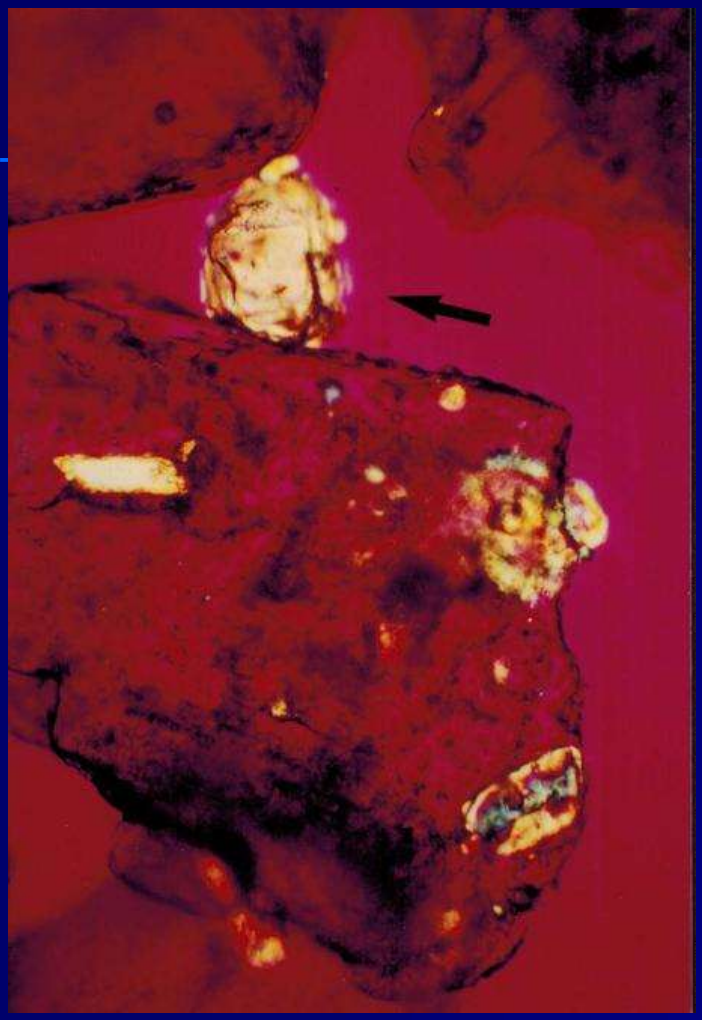
Magnesium impurities in salt



Astrakanite $Na_2Mg(SO_4)_2 \cdot 4H_2O$

Bitter salt or Epsomite $MgSO_4 \cdot 7H_2O$

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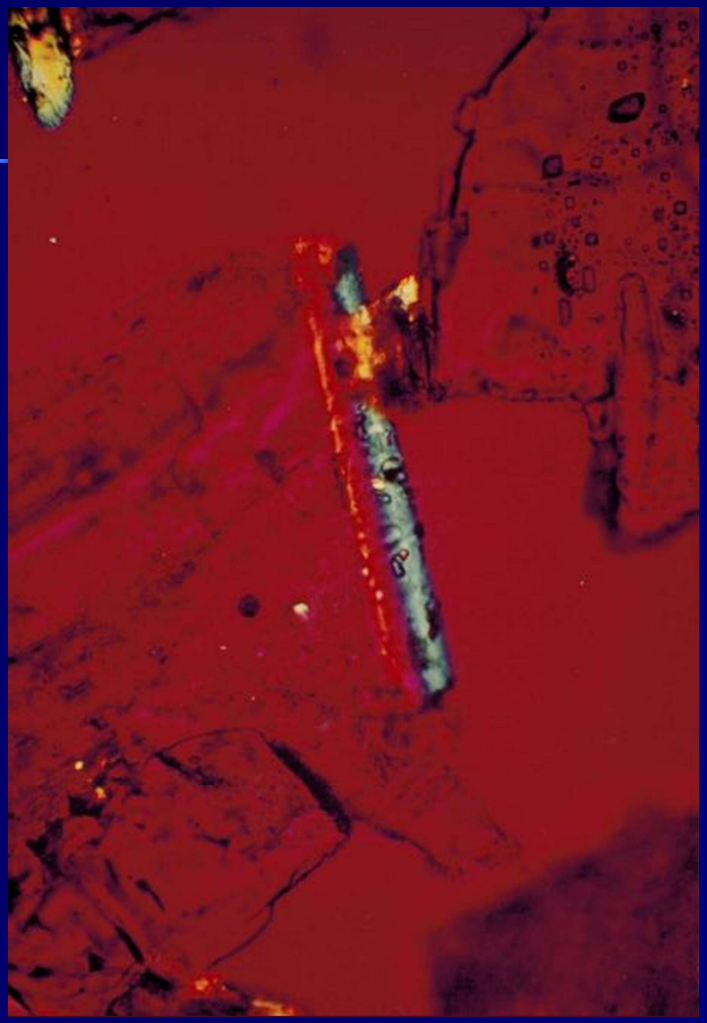
Gypsum in salt



Crystals break where gypsum is

Gypsum falls out from broken salt crystals

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Elutriation versus washing

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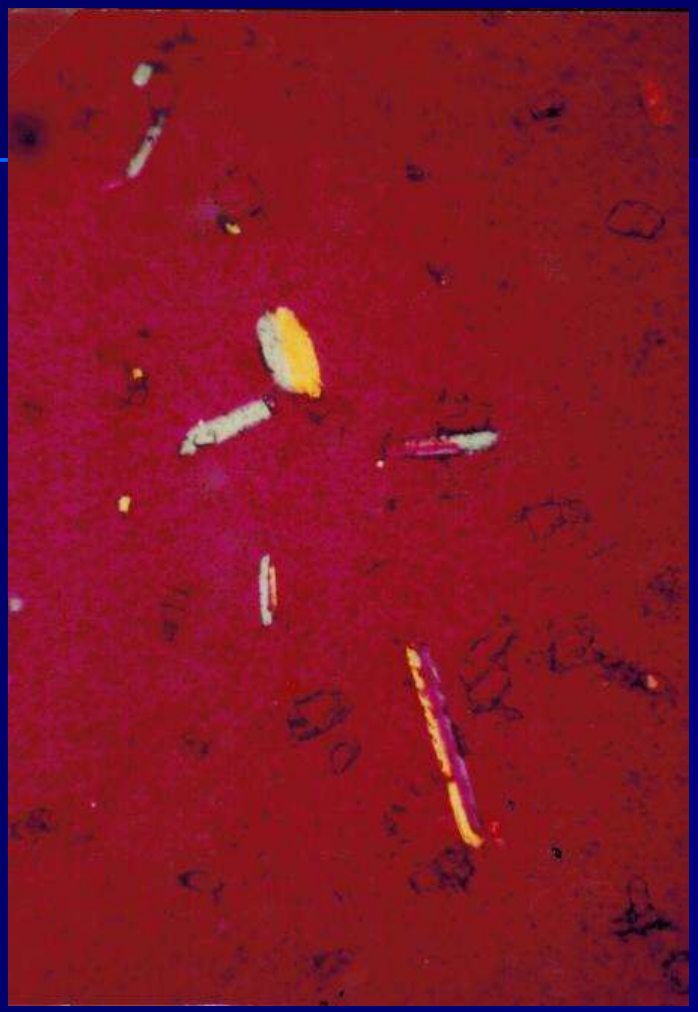

Gypsum removal by elutriation

Excessive washing dissolves salt leaving only gypsum and insolubles

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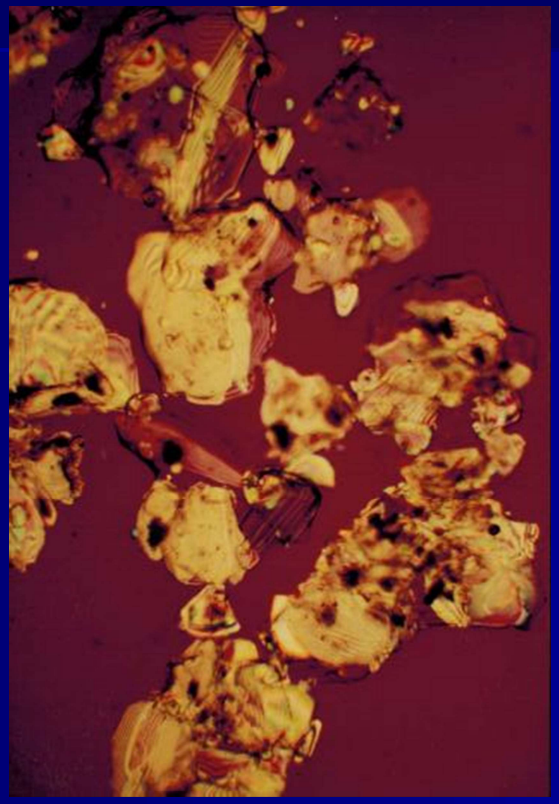
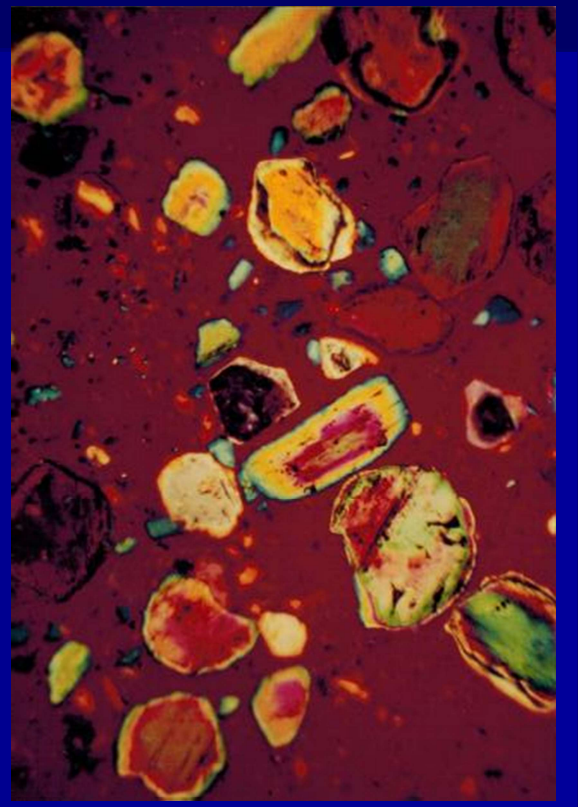
Identification of impurities by crystallisation

Gypsum
$CaSO_4 \cdot 2H_2O$



Astrakanite
$Na_2Mg(SO_4)_2 \cdot 4H_2O$



Bitter salt
$MgSO_4 \cdot 7H_2O$

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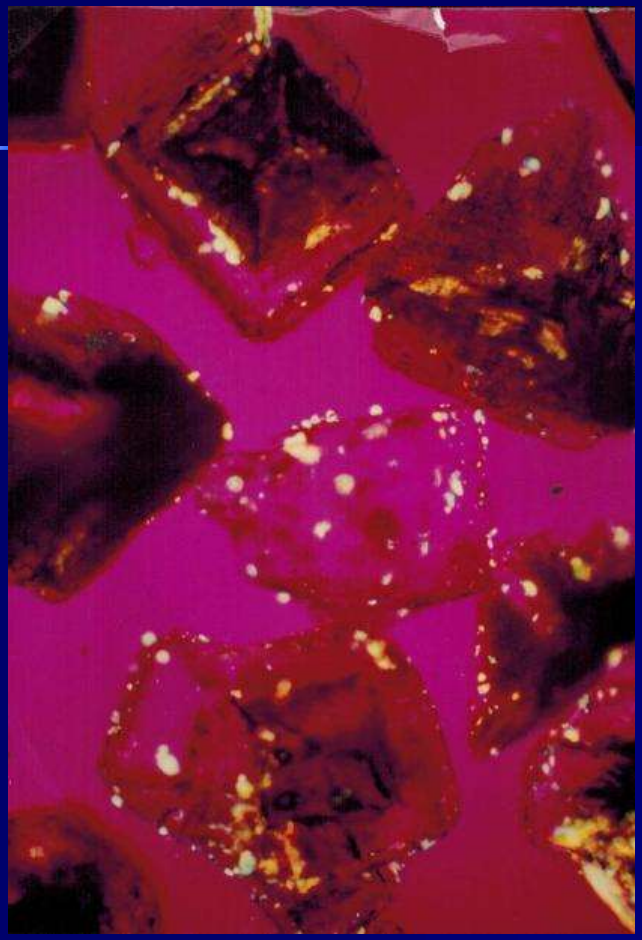
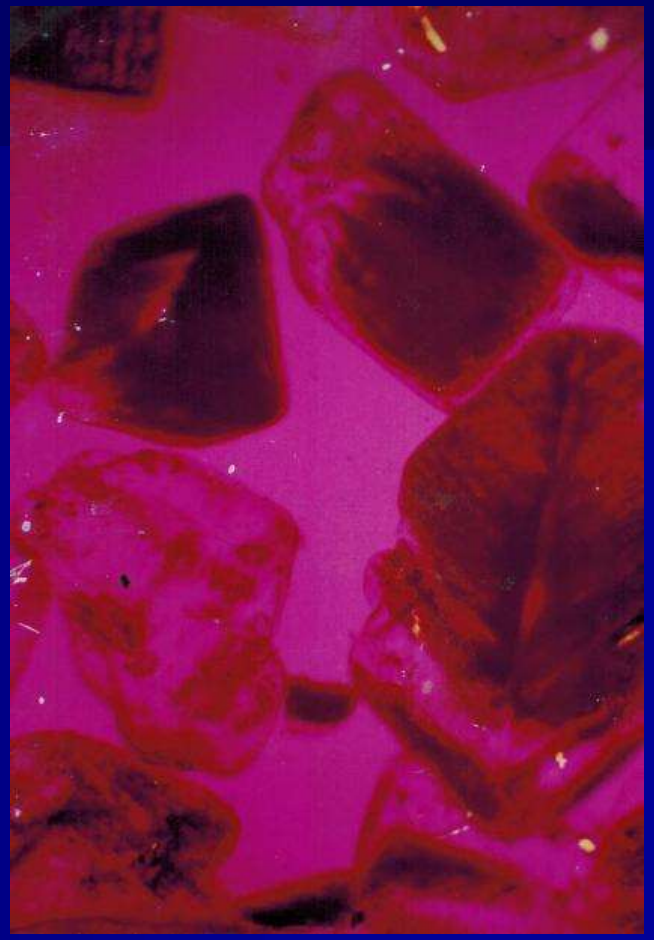
Raw salt and purified salt



Raw salt



Even repeatedly purified salt is not quite pure. This purity limit is the upgradeability.

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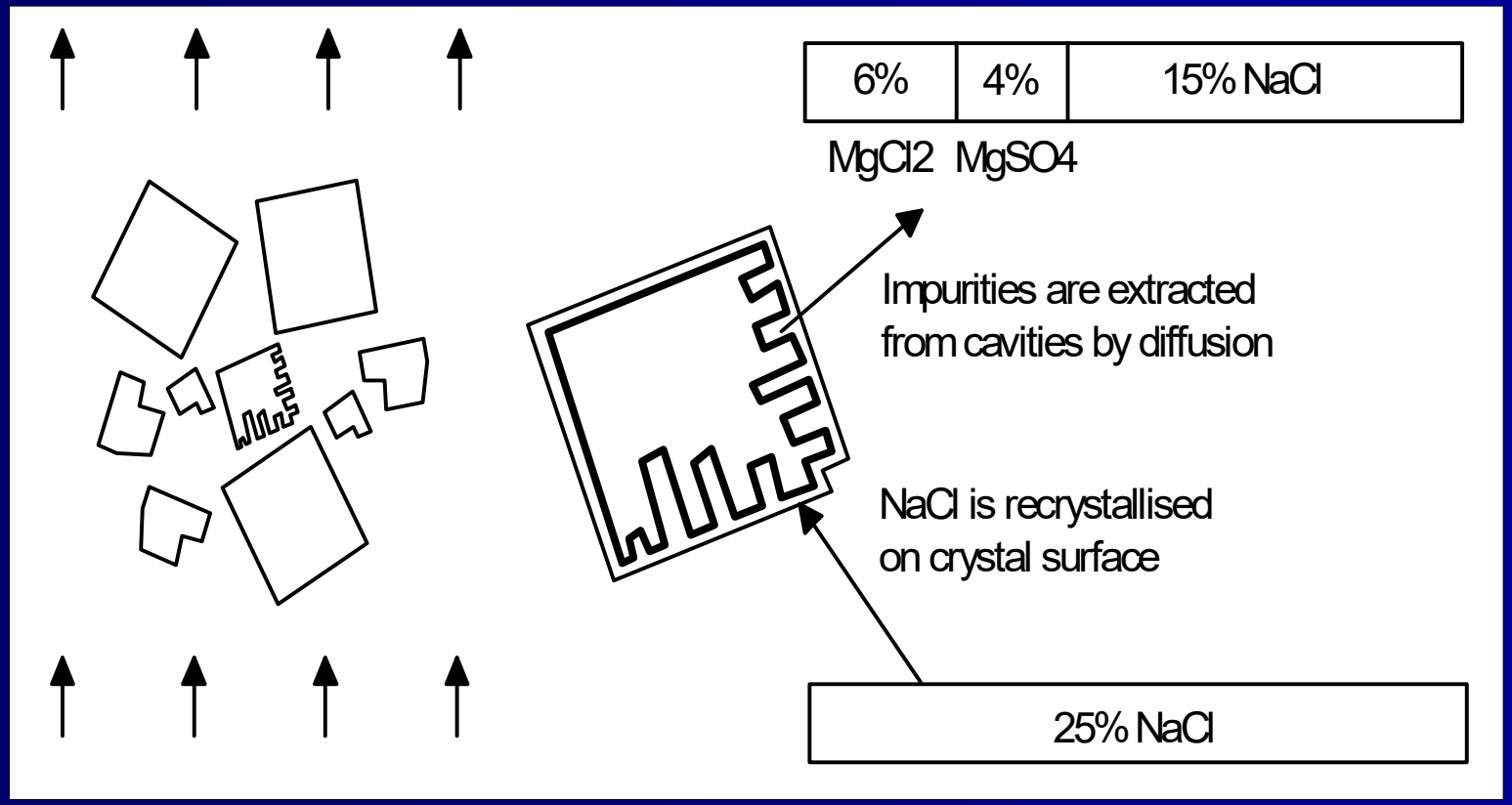
HYDROSAL Process, Hydroextraction



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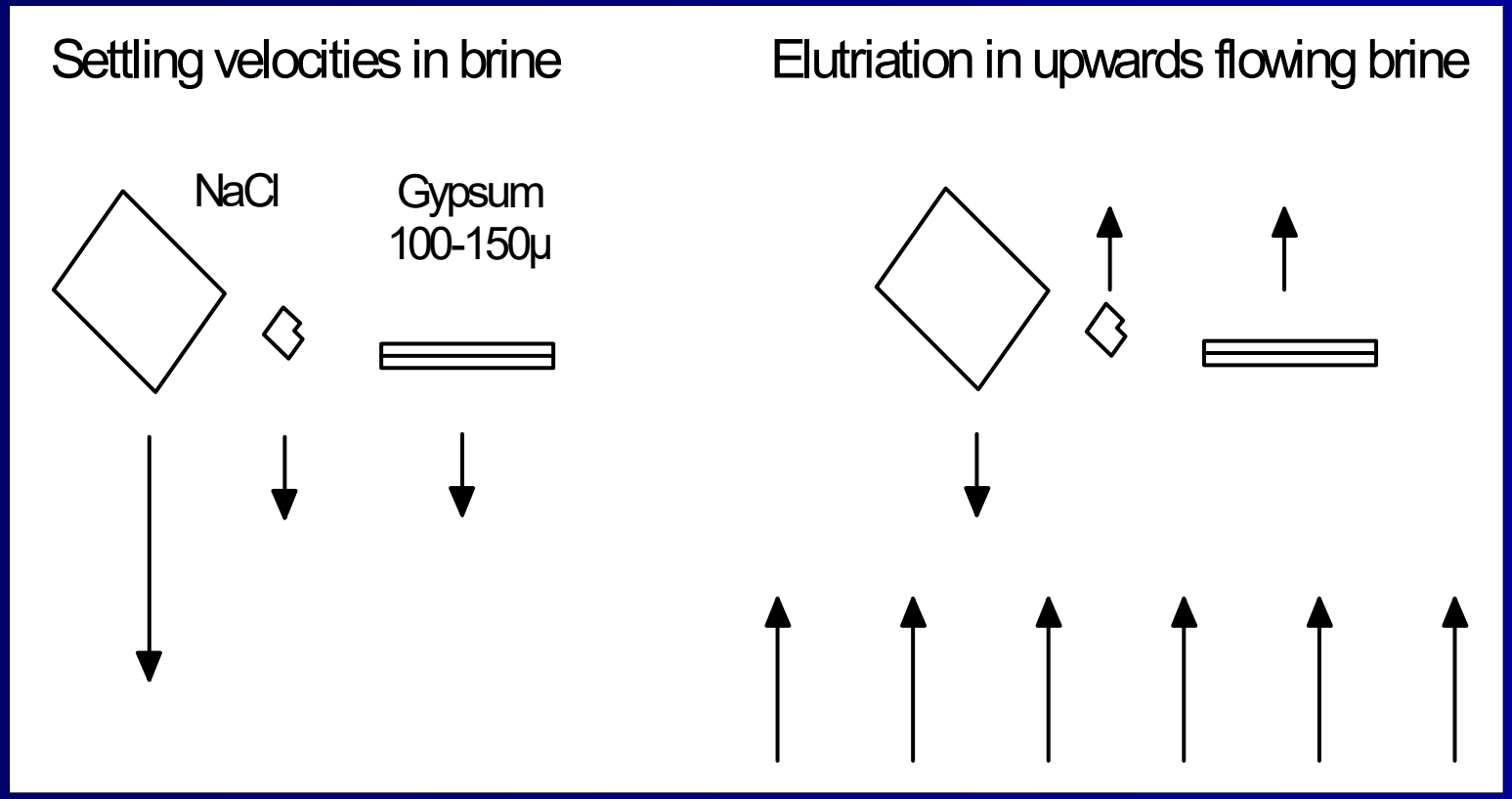
HYDROSAL Process, Elutriation



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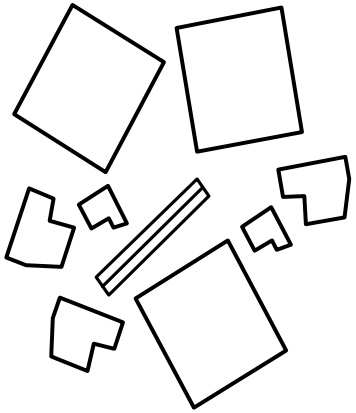
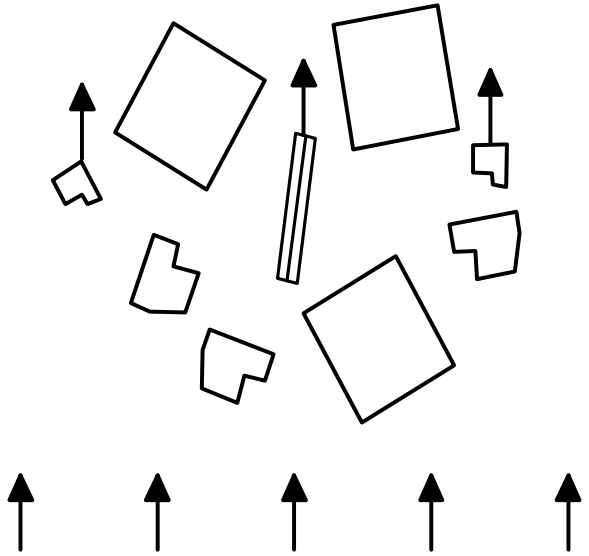
HYDROSAL Process, Hydroclassification

Salt bed with buried impurities



Hydroclassification of impurities in partially fluidised salt bed



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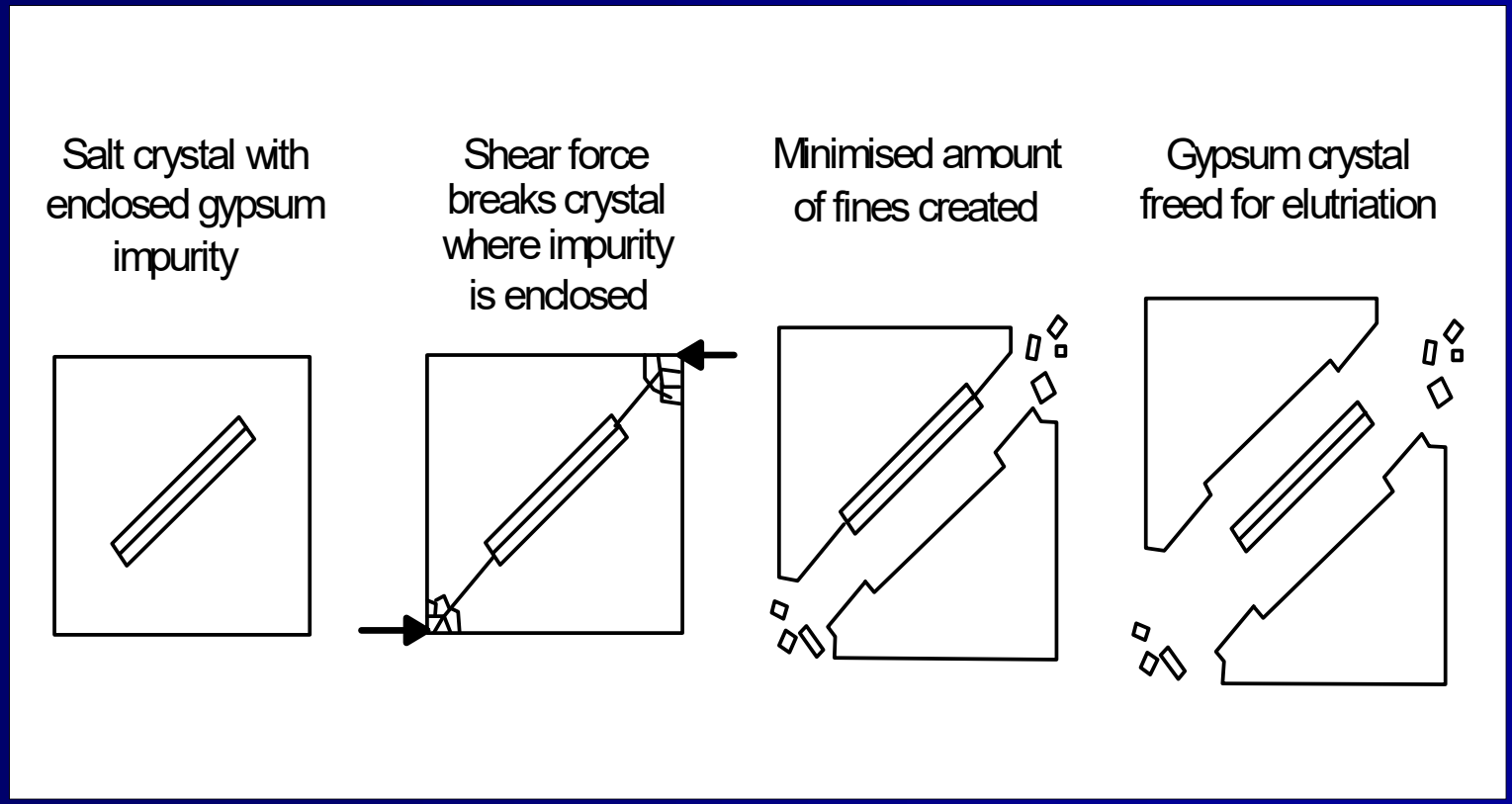
HYDROSAL, Hydromilling and shear crushing



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Development of upgradeability testing procedure

For what salt purification processes do we have to test the salt upgradeability?

- No crushing for pure coarse salt production
- Crushing for electrolytical brine preparation (3 and 1.5 mm)
- Milling for table salt production (0.8 and 0.4 mm)
- Flotation for rock salt purification (0.2 – 0.8 mm)
- etc.

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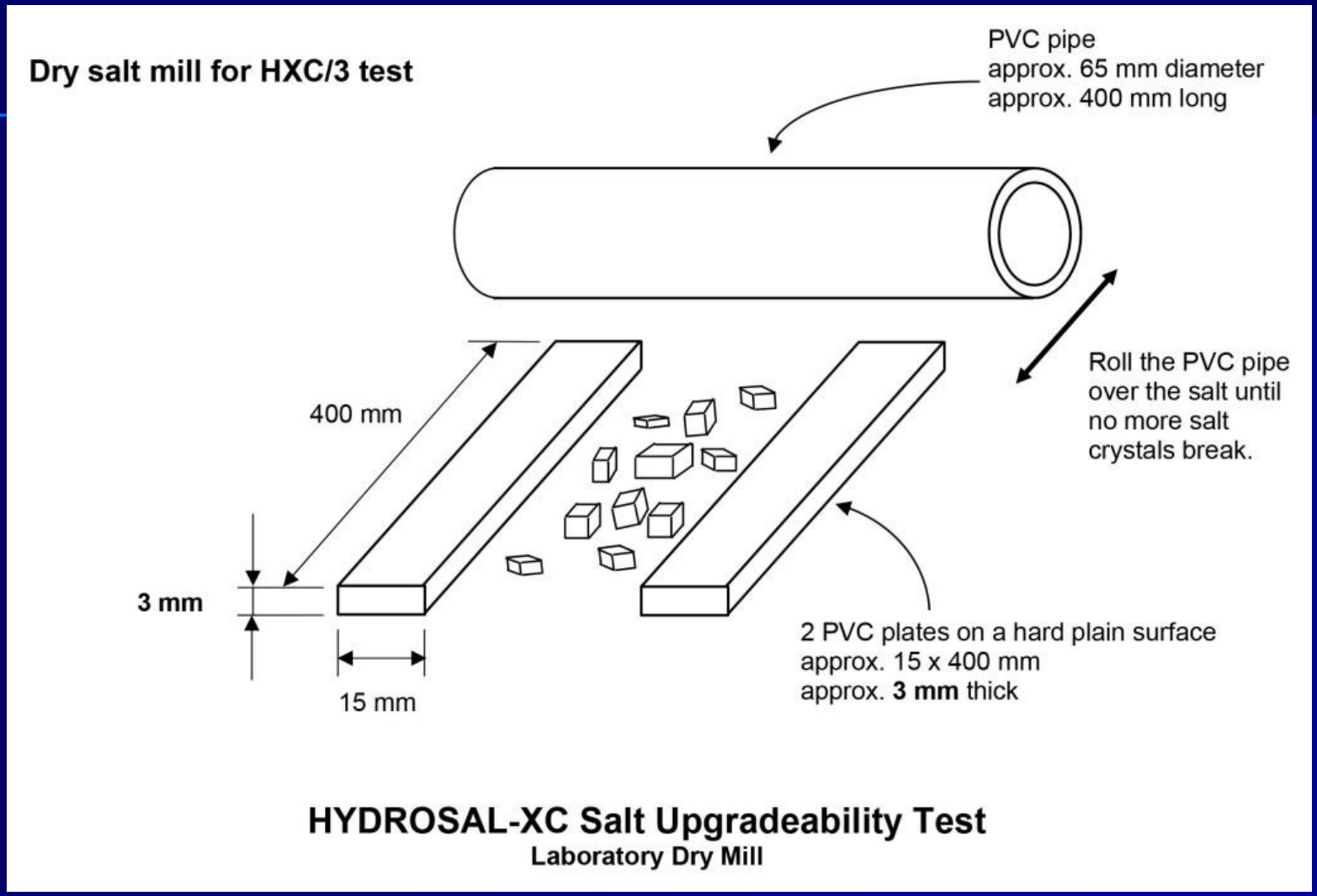
Dry salt crushing



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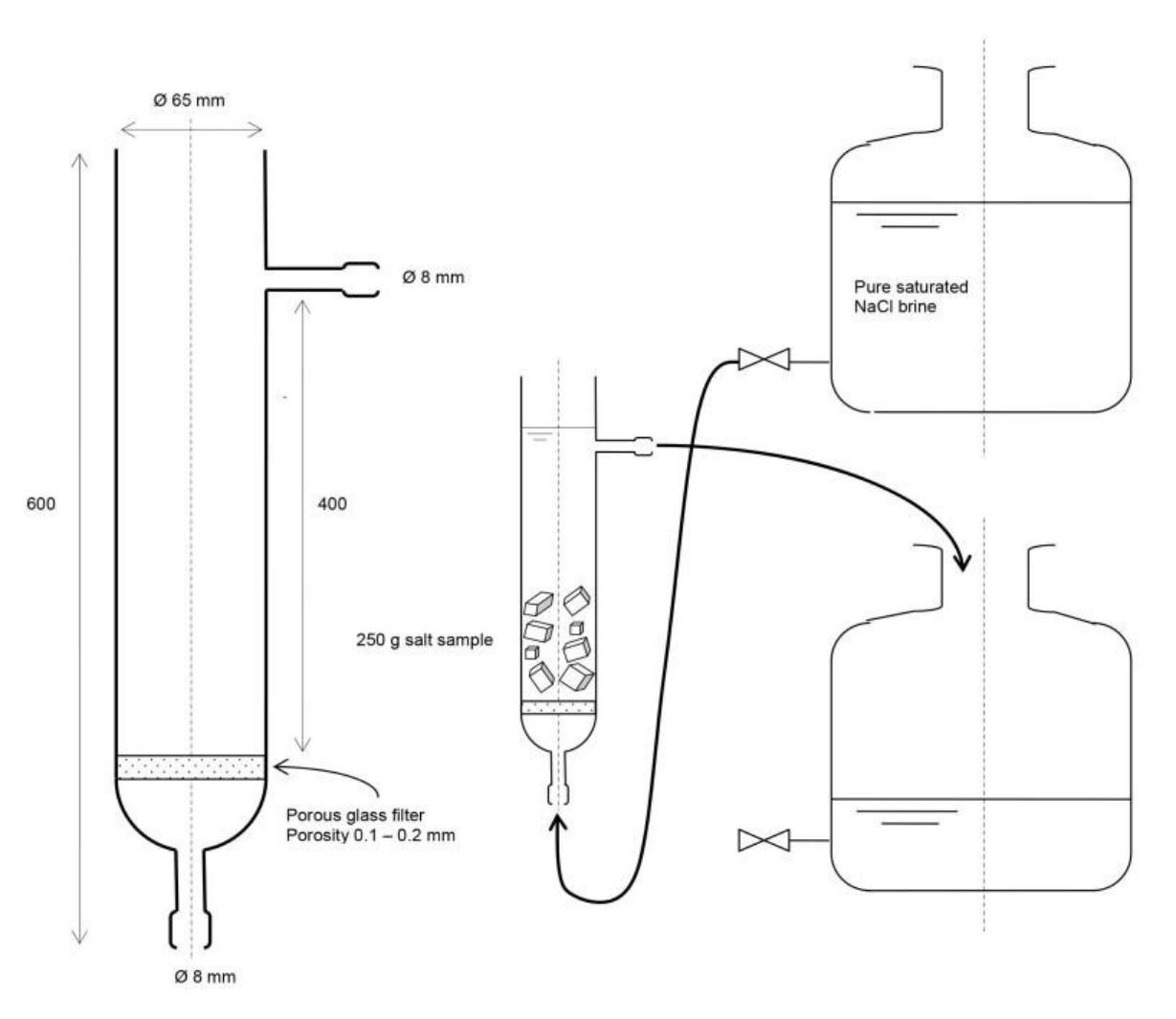
Hydroextraction



Modified from T. Masuzawa to facilitate a minimum 15 min. salt contact with pure saturated brine without recirculation

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Evaluation of upgradeability test results

- Raw salt and test purified salt are analysed
- Impurities are calculated as follows:
- Ca as CaSO4
- Balance SO4 as MgSO4
- Balance Mg as MgCl2
- Salts and insolubles are deducted from 100%
- The result is expressed as NaCl purity
- Results are shown as upgradeability curves
- Results serve selection of most economic process
- Results form bases for plant performance guarantees

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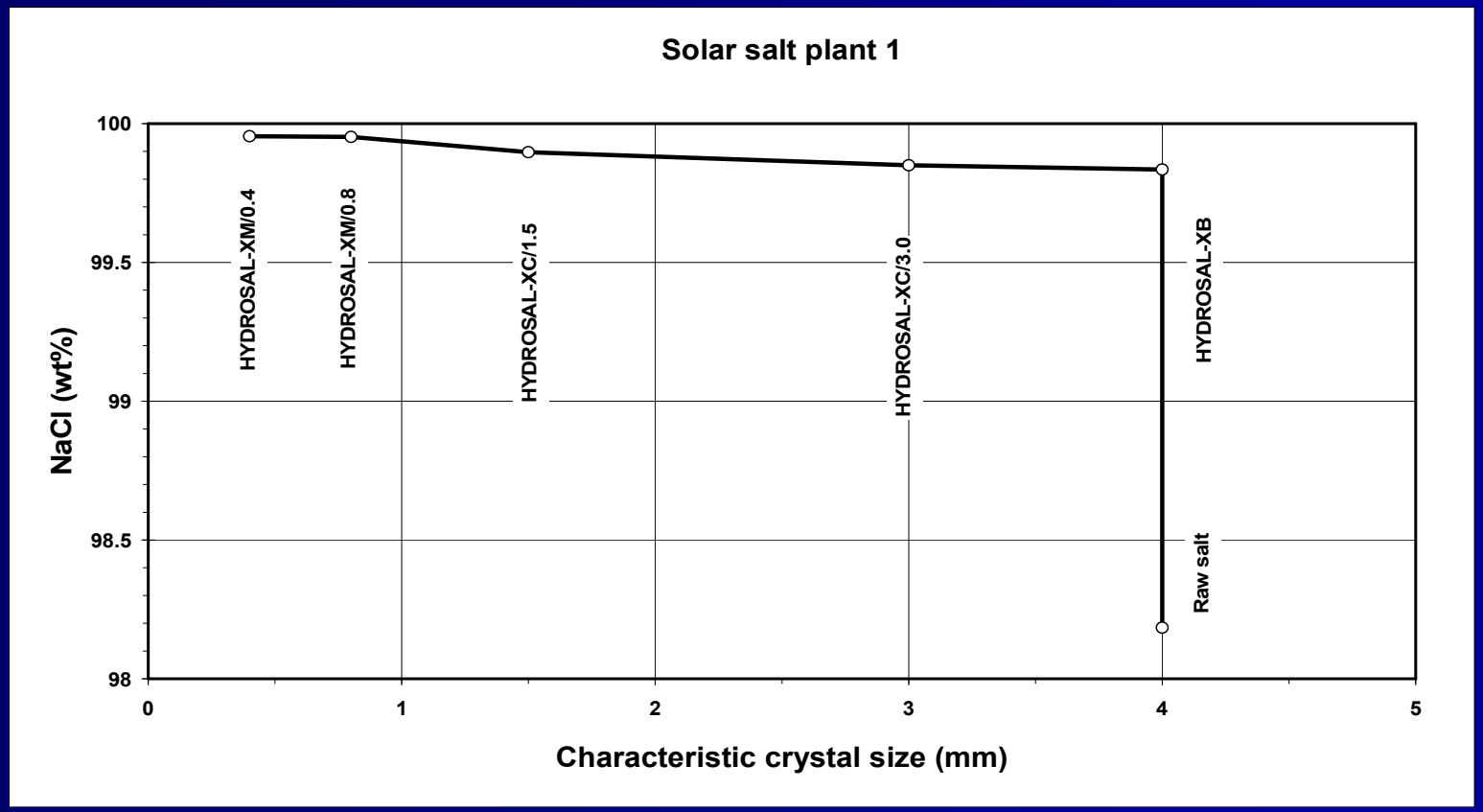
Salt upgradability test, NaCl content



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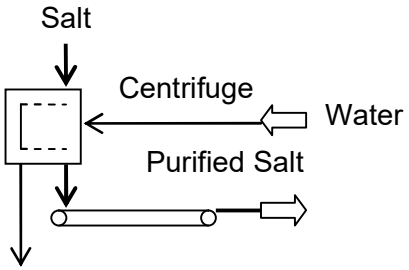
Principles of HYDROSAL Process



Centrifuge separates salt and brine

Conventional washing with water in the centrifuge

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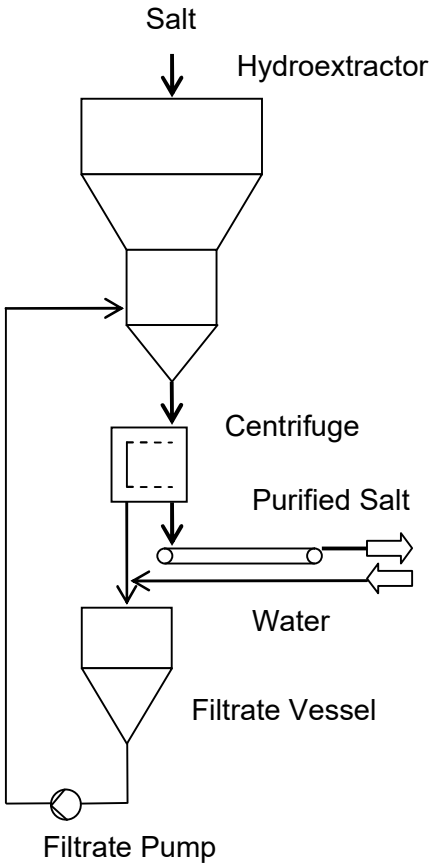
HYDROSAL Process

Dissolve salt fines in water and use this pure saturated brine to remove impurities from salt in the hydroextractor



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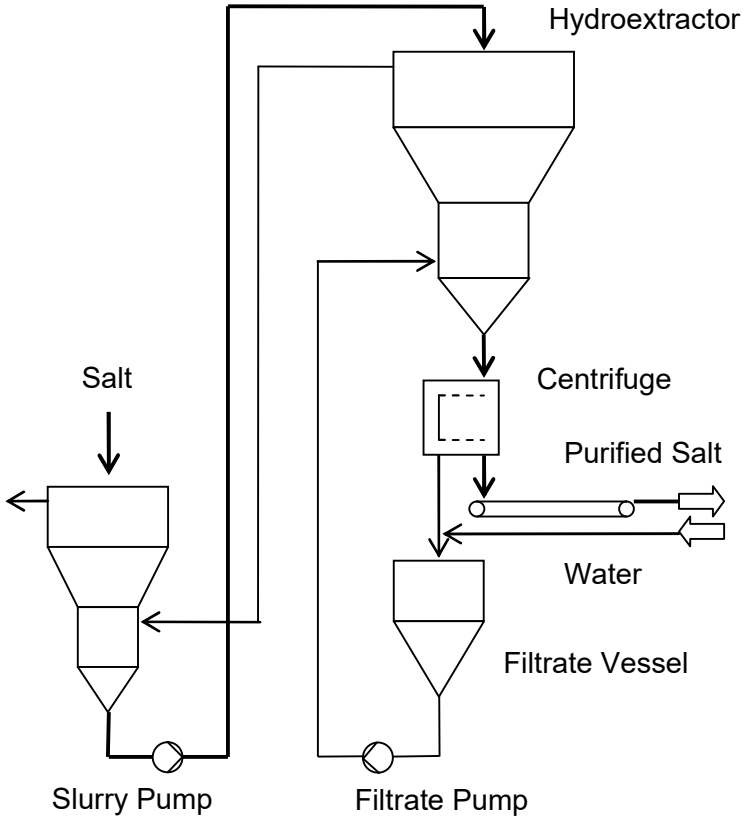
HYDROSAL Process

Hydraulically transport salt to the hydroextractor and return the transport brine to the elutriator



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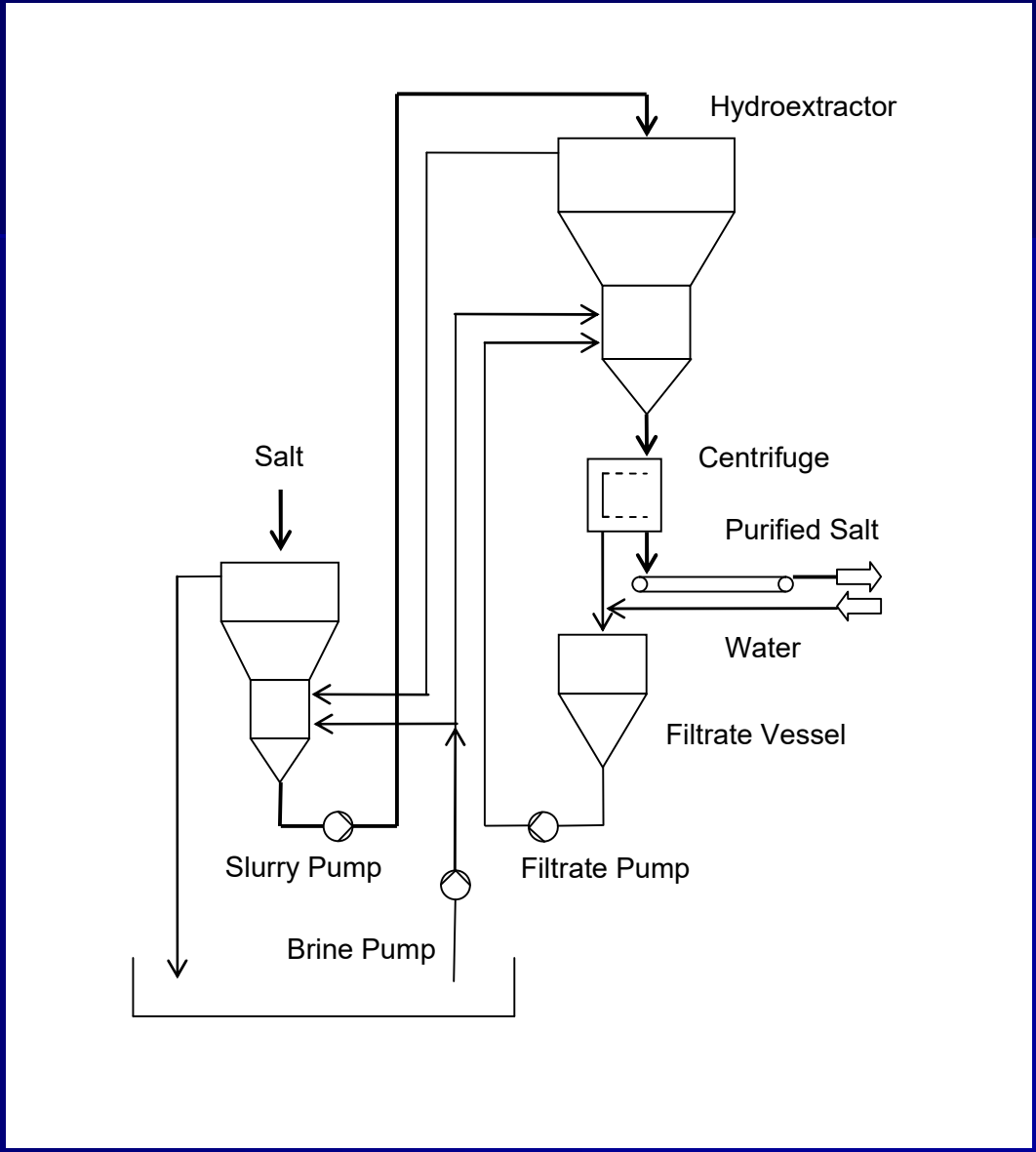
HYDROSAL Process



Circulate impure brine to control hydroclassification and elutriation efficiency

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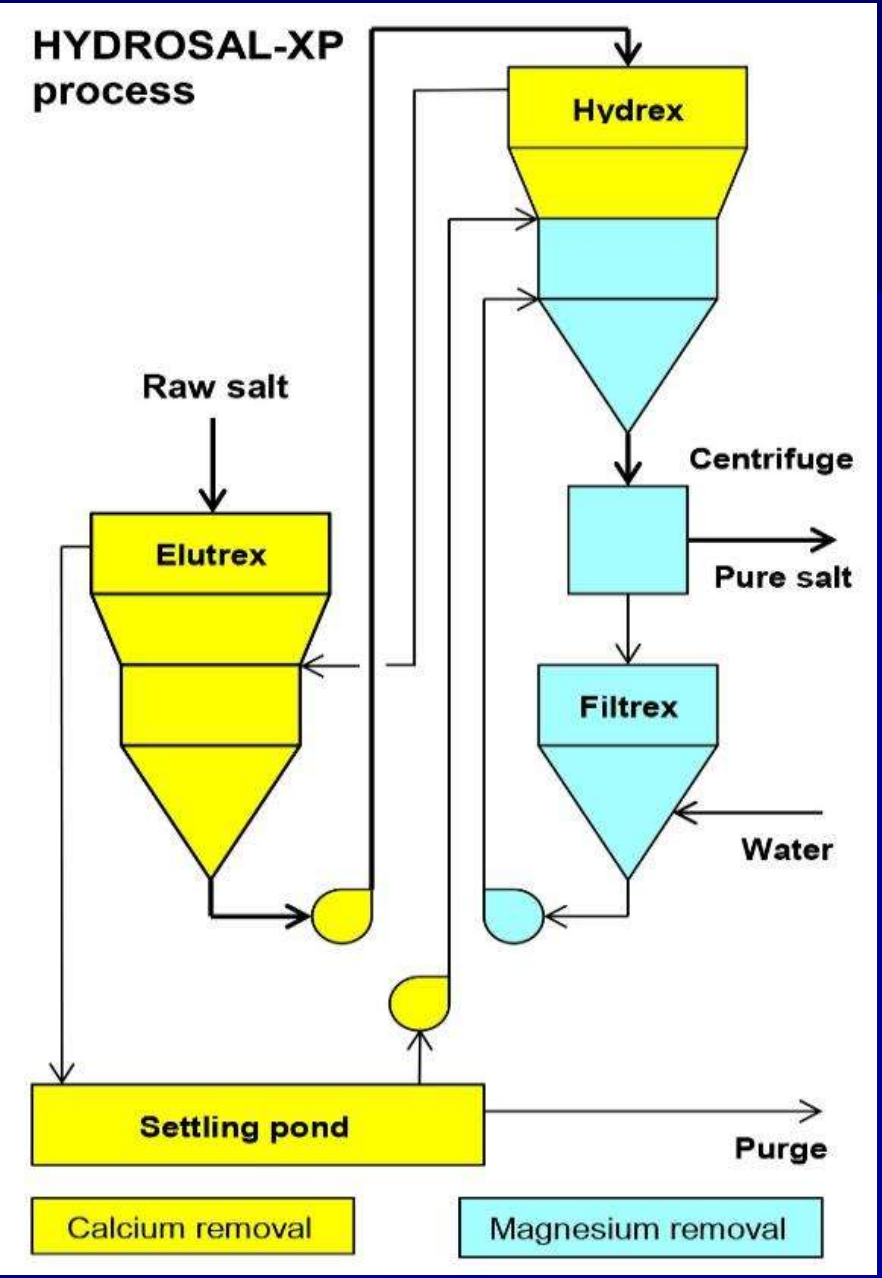
HYDROSAL Process

Separately control magnesium removal by hydroextraction and calcium removal by hydroclassification and elutriation, thus adjusting Ca : Mg ratio



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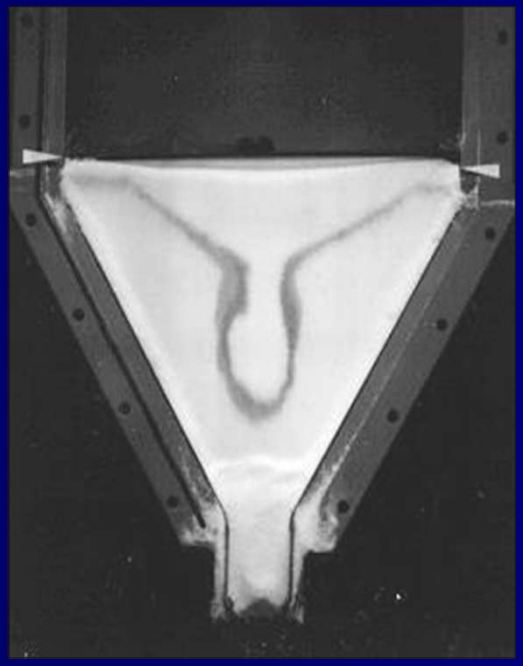
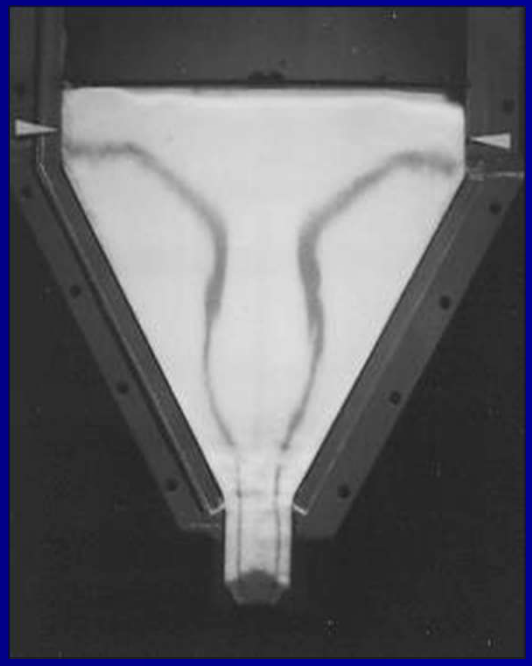
Hydroextraction does not work in all vessels



In this vessel salt flows out mainly through the centre



In the centre of the vessel rat hole develops

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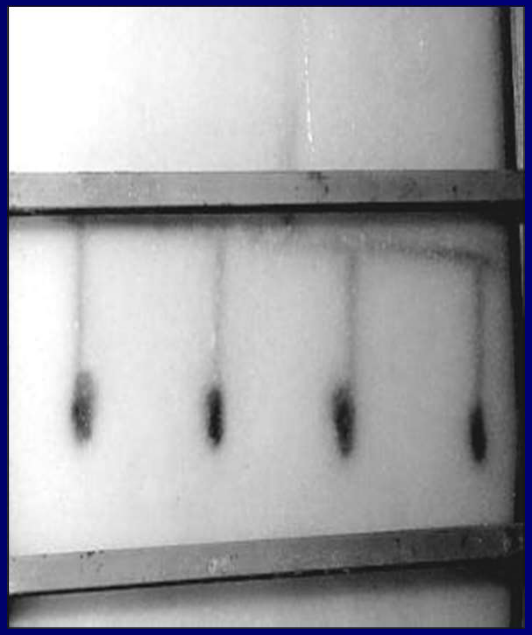
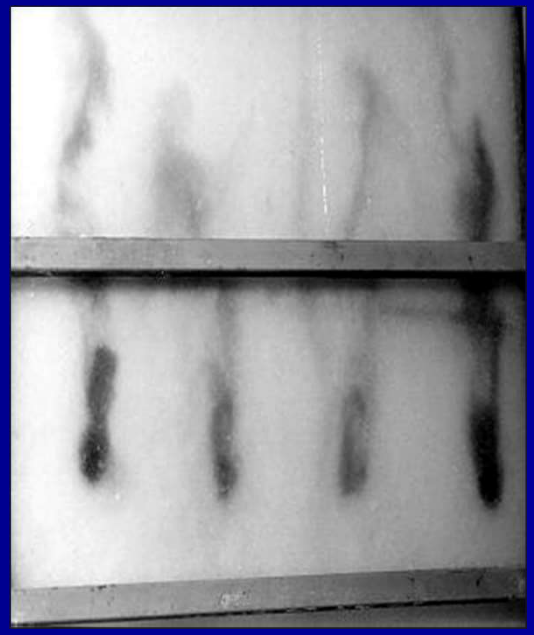
Hydroextraction works only with plug flow of salt



Picture 1: Injection of black ink into brine flowing upwards through salt flowing downwards in plug flow

Picture 2: Black ink flows upwards with brine in counter-current flow



Picture 3: Second black ink injection. There are no traces of black colour in the salt flowing downwards in plug flow

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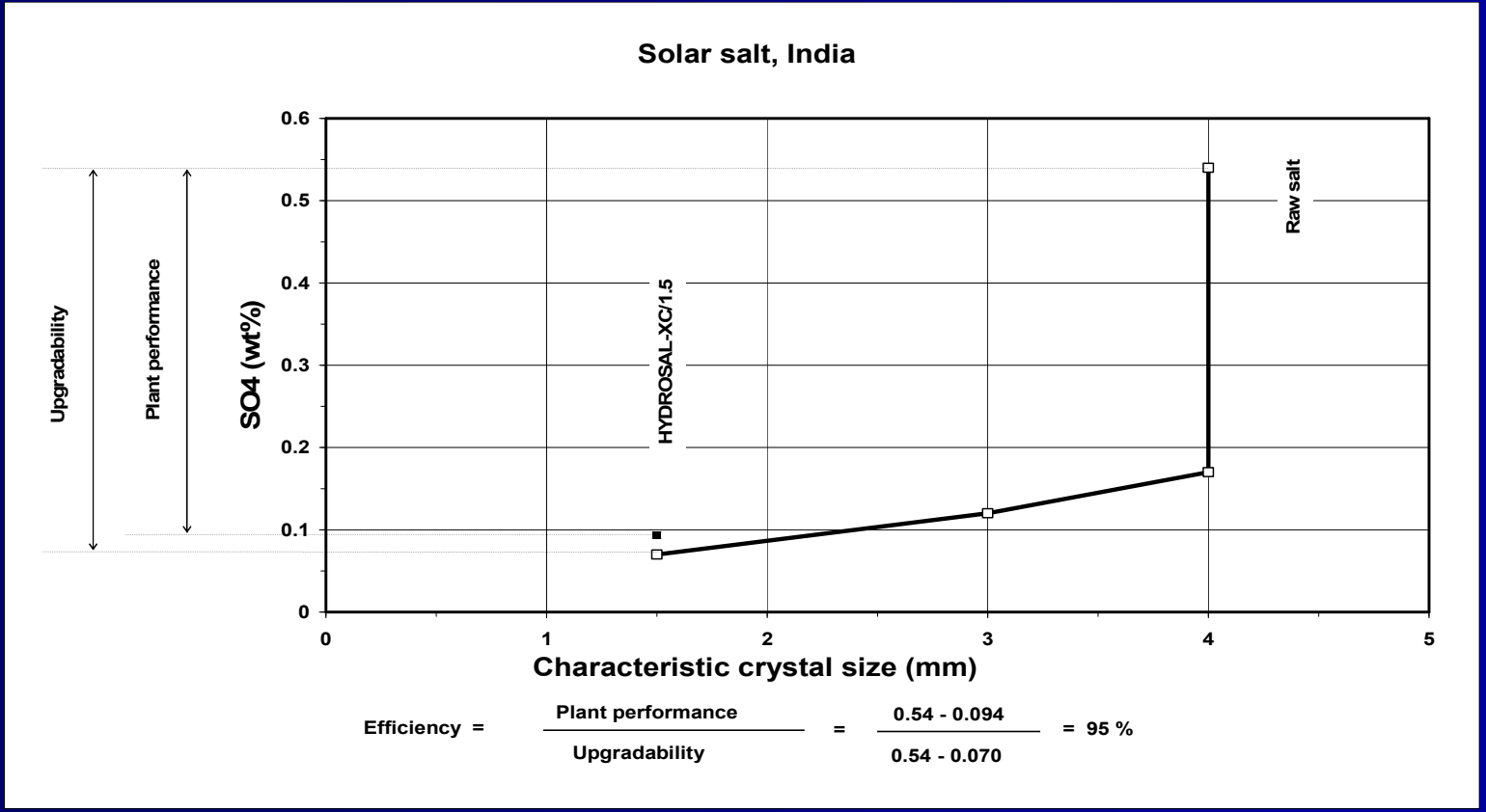
Plant efficiency calculation, sulphate



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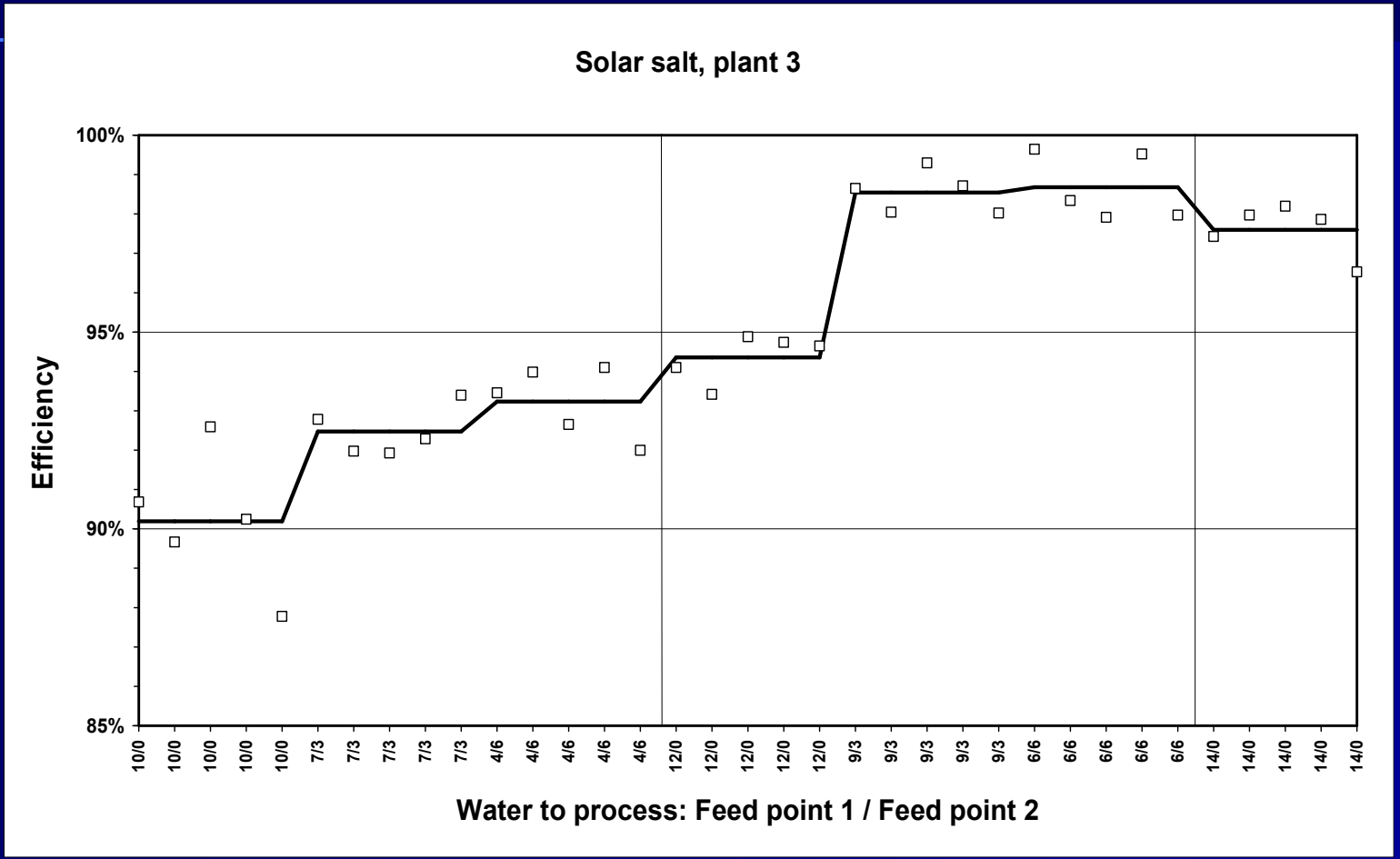
HYDROSAL optimisation test, NaCl efficiencies



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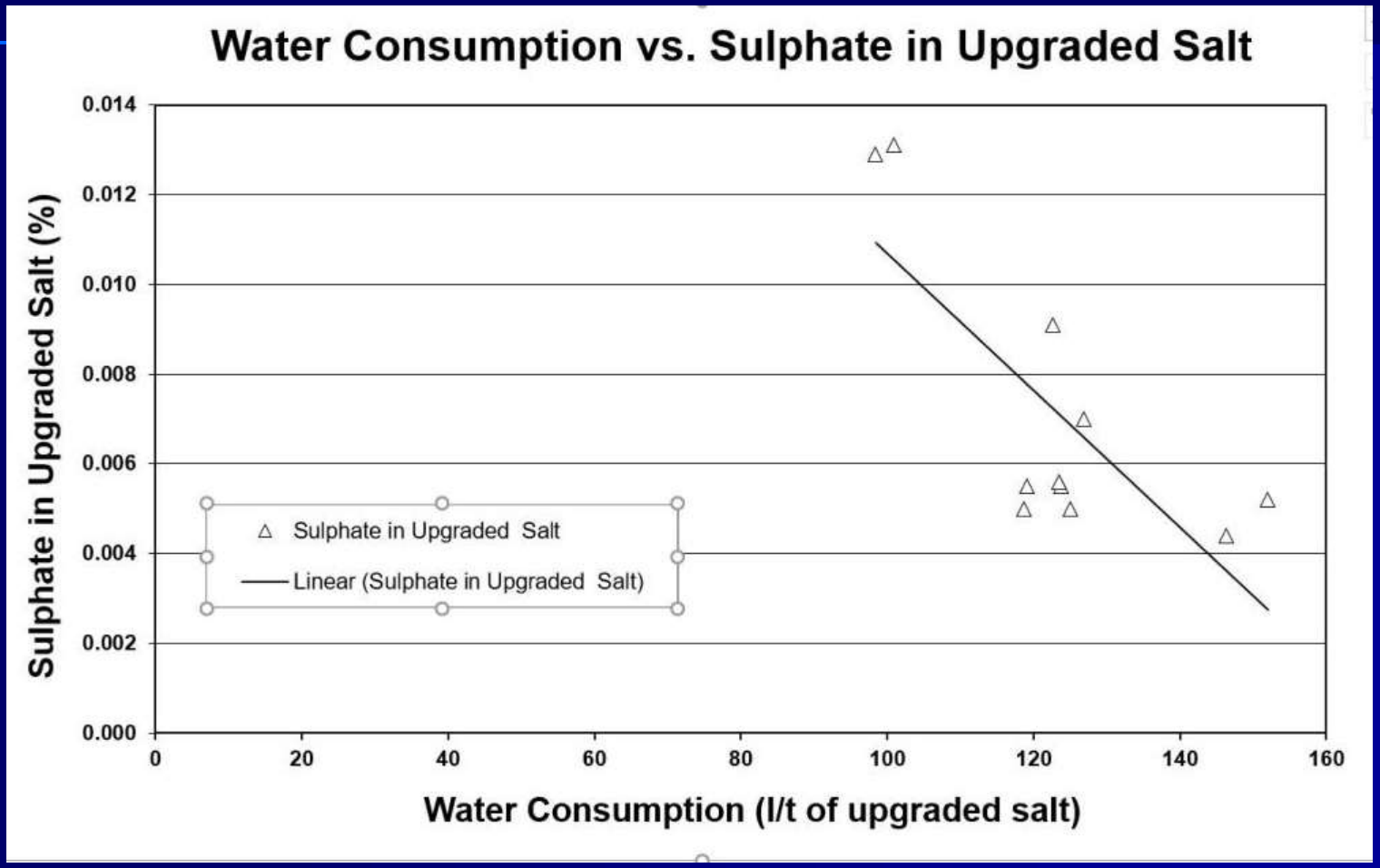
HYDROSAL optimisation test, water vs. SO4



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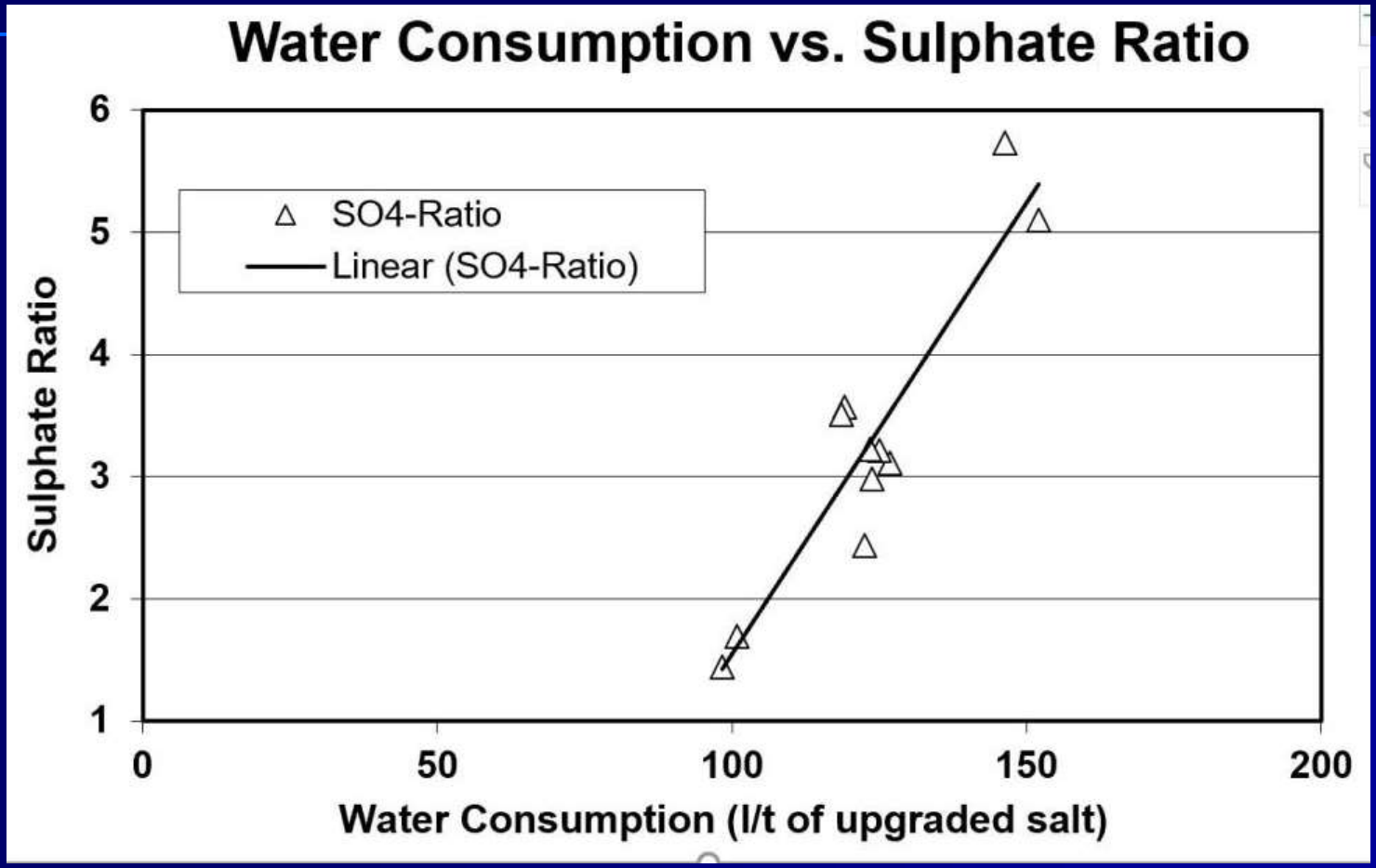
HYDROSAL optimisation, water vs. SO4 Ratio



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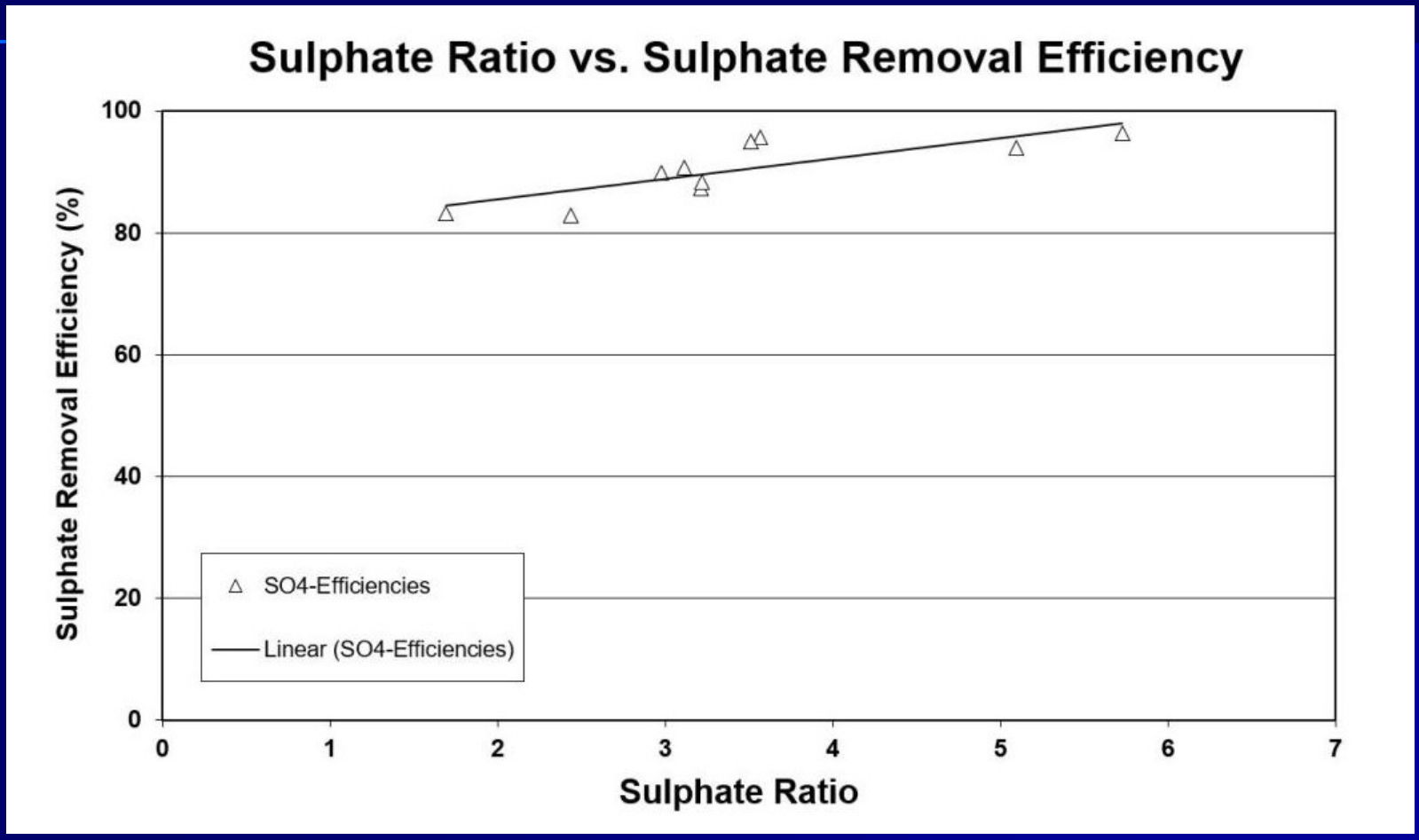
HYDROSAL optimisation, SO4-ratio vs. SO4 efficiency



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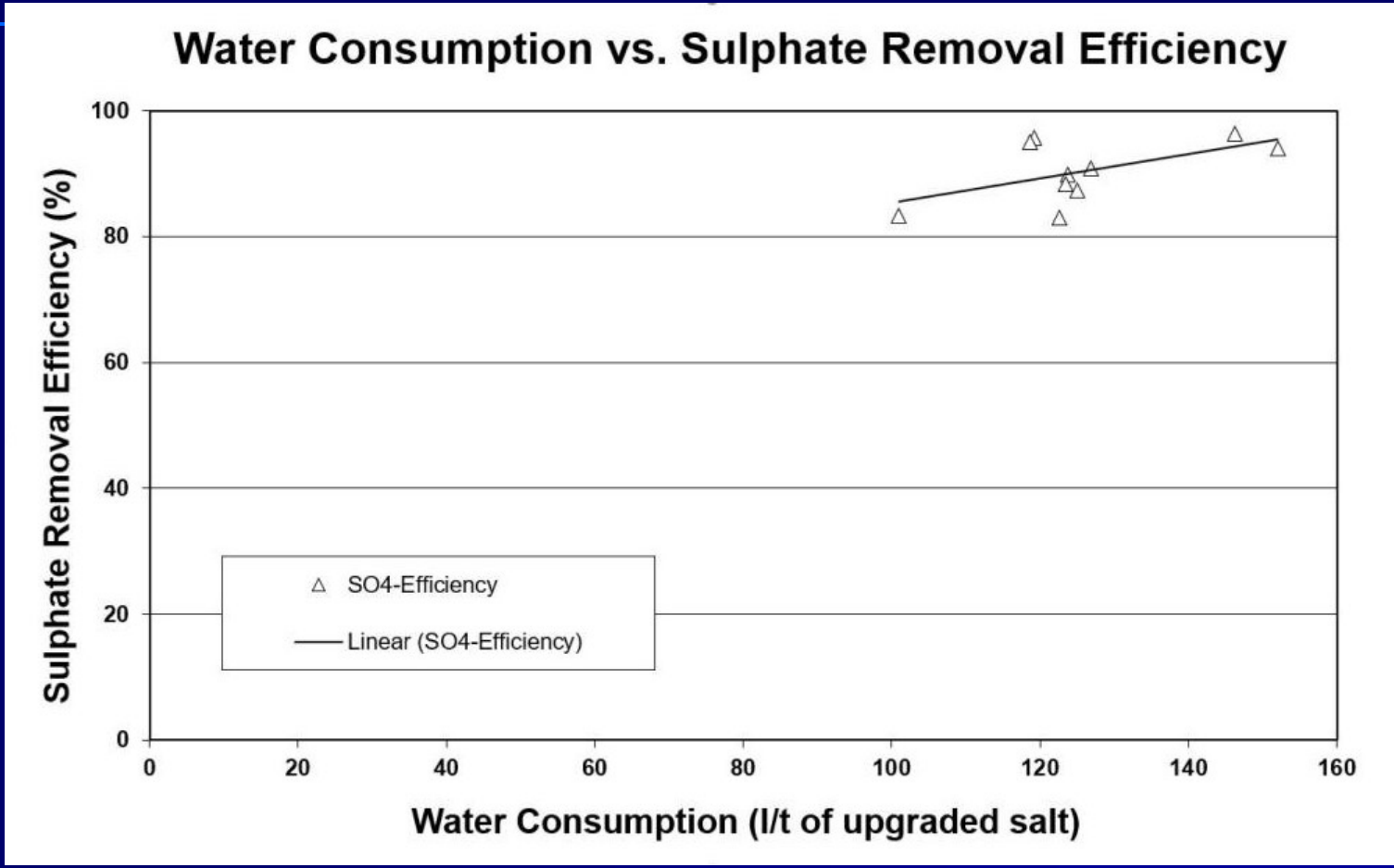
HYDROSAL optimisation test, H2O vs. SO4 efficiency



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Salt for chloralkali manufacture, specification

Component	Units	Content
Calcium	%	< 0.04
Magnesium	%	< 0.02
Sulphate	%	< 0.12
Insolubles	%	< 0.02
Ca : Mg ratio		> 2 : 1
Crystal size	mm	> 5

Salt must be free of potassium ferrocyanide, soluble silica, iodine, bromine, etc. This specification is the bases of Salt Partners performance guarantees.

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Roskill Salt 2018 Conference, 10.- 11.4.18, Tower Hotel, London, UK

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HYDROSAL refined solar salt vs. Swiss vacuum salt

		HYDROSAL refined solar sea salt	Swiss vacuum salt
CaSO4	ppm	136	17
MgSO4	ppm	55	5
MgCl2	ppm	74	
Na2SO4	ppm		420
Insolubles	ppm	20	20
NaCl	%	99.972%	99.954%

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SALEXPOR 15 t/h solar salt refining plant in Portugal

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Industrial salt upgrading plant in Cardona, Spain.

Hydroextractor diameter 10 m

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Solution mining for natural gas storage, co-generation, brine purification, salt crystallisation and refining plant in Portugal

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40 t/h salt upgrading plant in Portugal producing purest industrial salt in Europe

		Performance test
Ca	ppm	0.6
Mg	ppm	0.2
SO4	ppm	53

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Why not turn your salt into gold?

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