Use of radioactive tracers for measurement of flowrate distribution in industrial flotation circuits

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CONTENTS

- Introduction
- Experimental Method
- Applications
- Conclusions

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General facts of Chile

Population 2014(e):

- 17,8 million (e)

Surface territorial area:

- 756,950 km^2

GDP 2014(e):

- US$250 billion
- Mining GDP: 11%

Sources: Central Bank of Chile, National Statistical Institute

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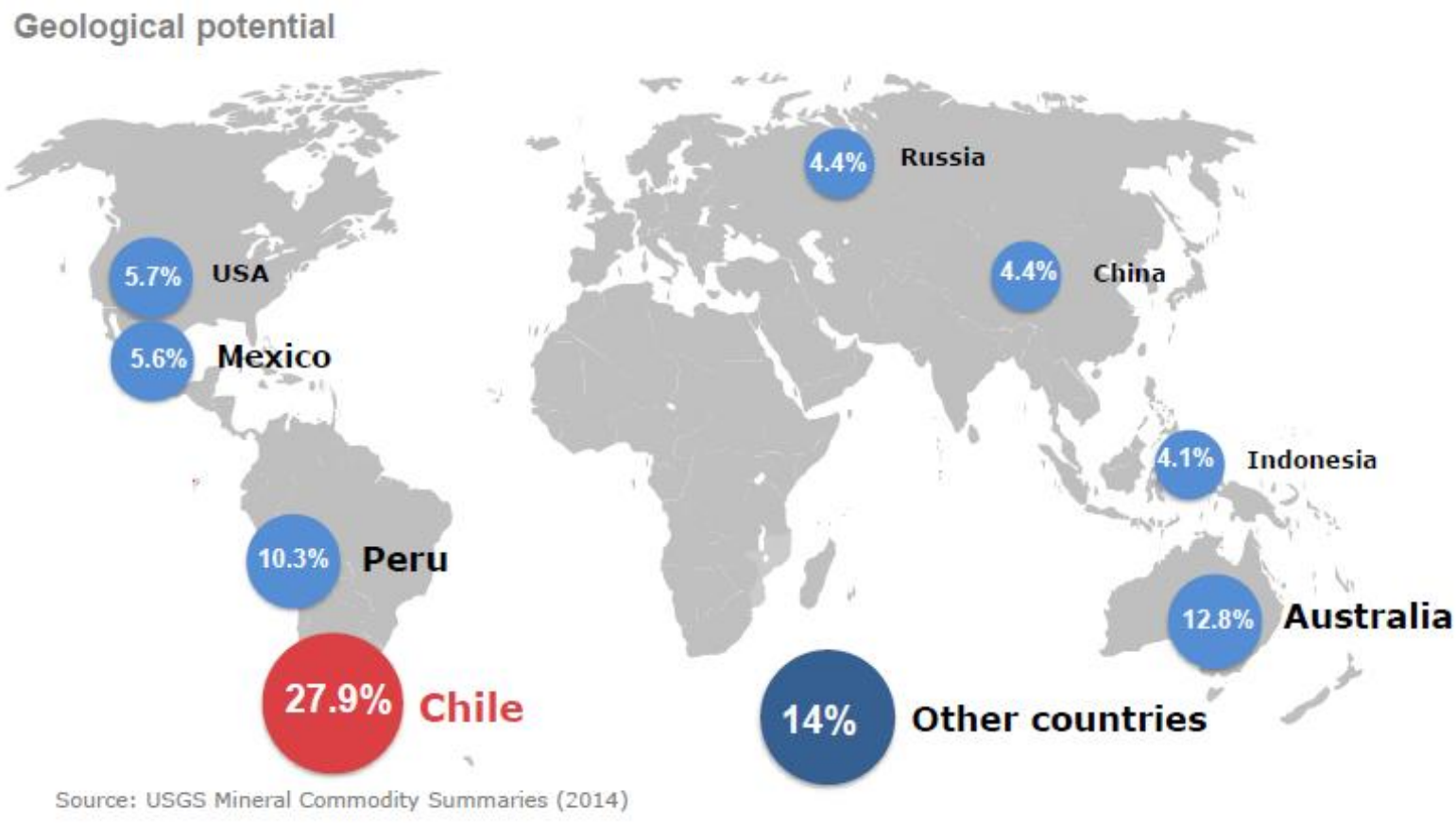
Geographical distribution of copper reserves worldwide



Source: USGS Mineral Commodity Summaries (2014)

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INTRODUCTION

- Pulp distribution to parallel rougher rows:

✓It is typically unknown and commonly unbalanced, because of design as well as operating conditions.

✓For this reason, an even distribution is often assumed for mass balance purposes.

✓The uneven distribution of the feed pulp between parallel flotation lines has detrimental effects for both lines, because they are either over loaded or under loaded with respect to the mean flowrate conditions.

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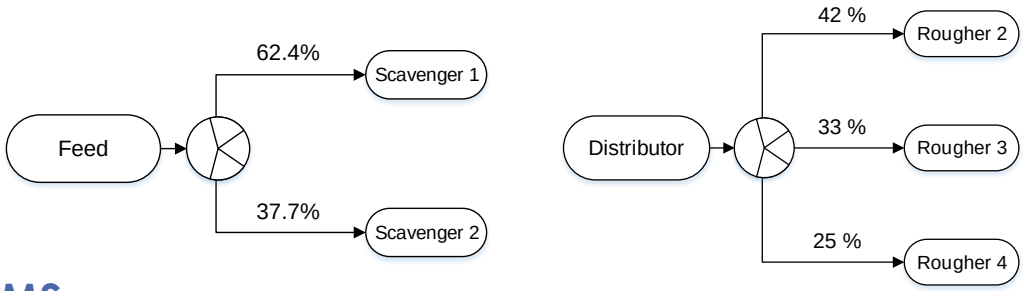
INTRODUCTION

- Pulp distribution to parallel rougher rows:

✓From previous studies, unbalanced flowrate distribution has been observed in rougher and scavenger parallel rows.



❖ **PROBLEMS:**

- ✓ Segregation of solids, grades, etc. could be presented.
- ✓ Control systems become less stable, because pulp levels and manipulated variables, such as opening of dart valves, advance reagents will operate in different ranges.
- ✓ Consequently, the recovery and/or grade are negatively affected.

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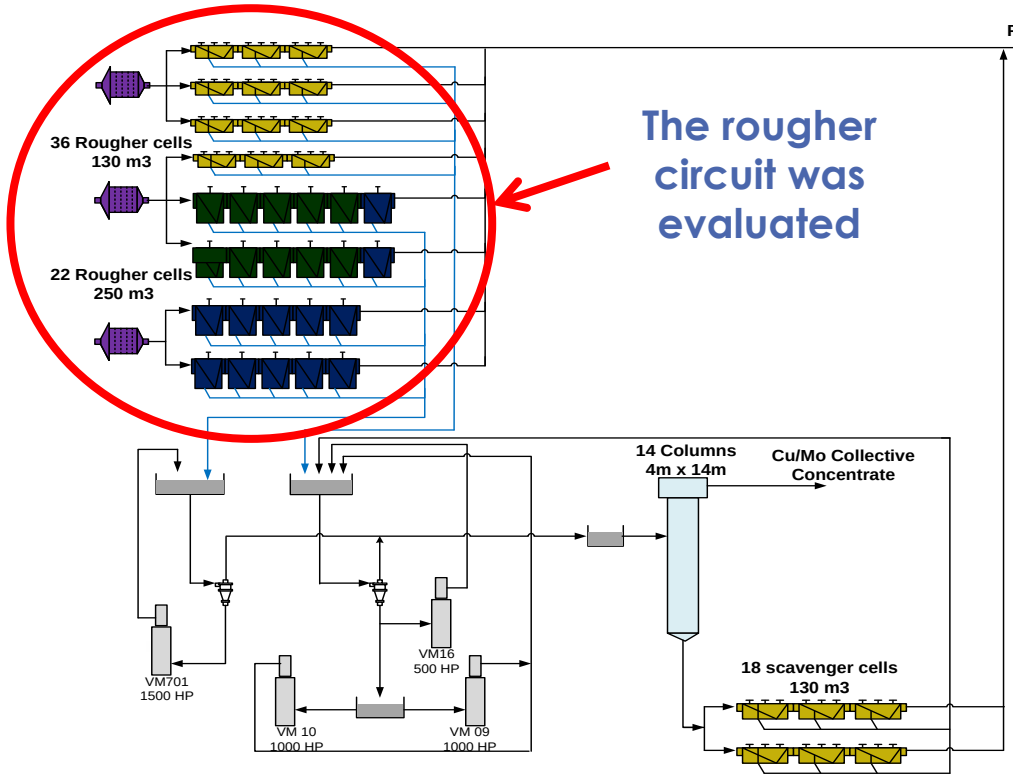
INTRODUCTION

- Flotation plant of Los Pelambres Mining:



- ✓ Mineral feed: 6500 tph.
- ✓ Copper feed grade: 0.7%.

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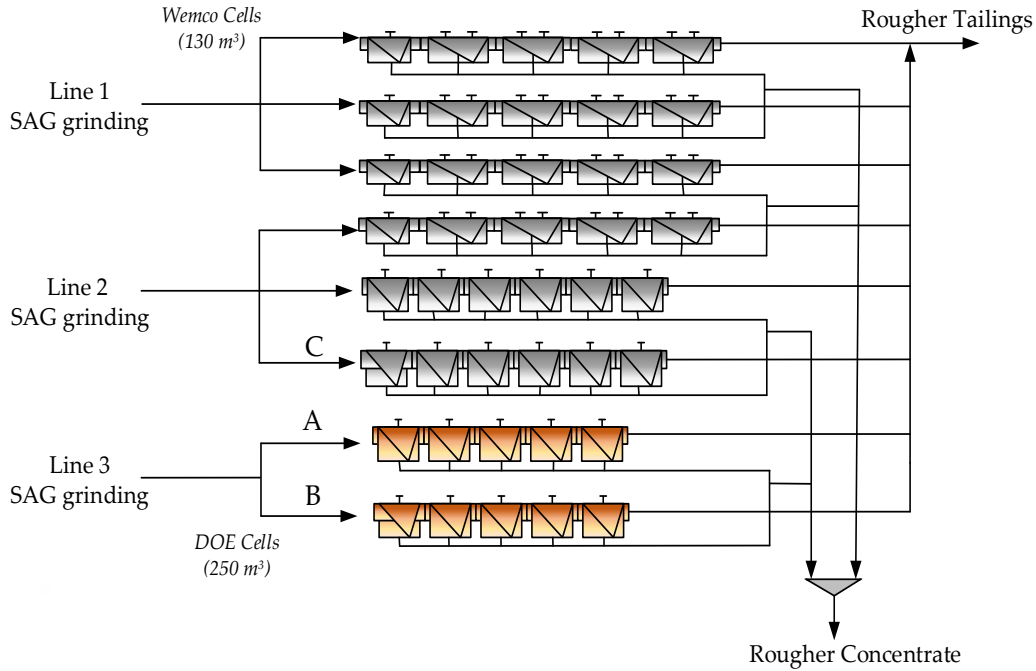
INTRODUCTION

- Rougher flotation circuit:



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CONTENTS

- Introduction
- **Methodology**
- Results and discussion
- Conclusions

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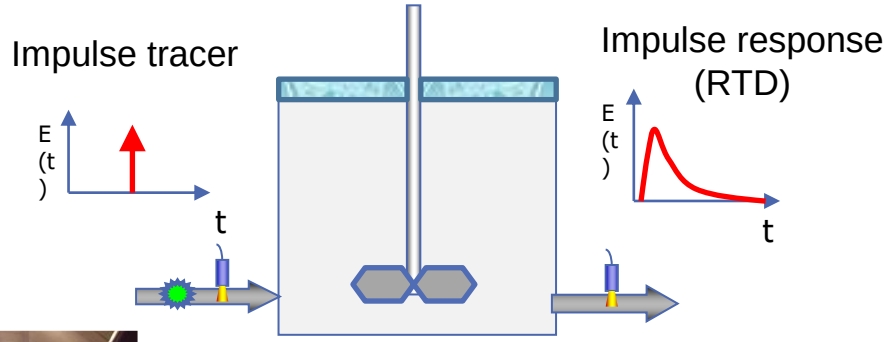
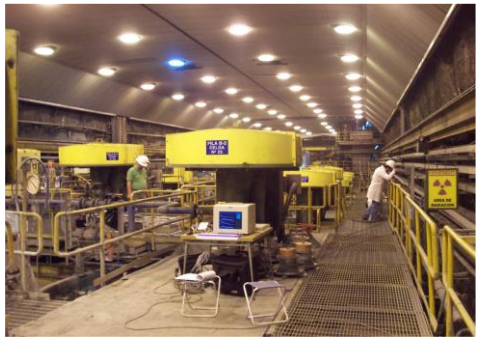
METHODOLOGY

Radioactive tracer tests

✓Radioactive tracer technique.





- ✓ Liquid : Br-82
- ✓ Solid : non-floatable
  floatable
  size classes
- ✓ Gas : Kripton-85
  Freon 13B1

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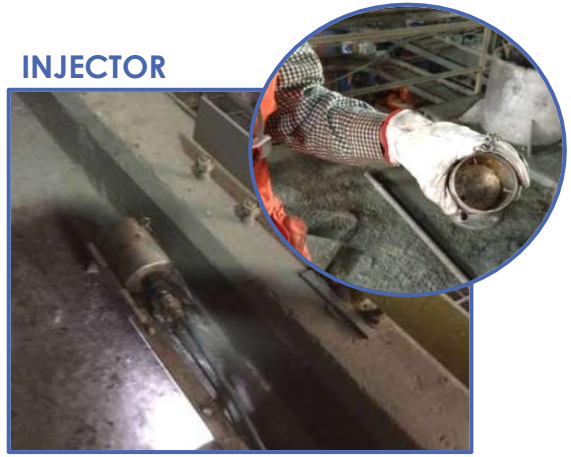
METHODOLOGY

Radioactive tracer tests

✓The tracers used in this study were prepared at CCHEN, Santiago:

- Liquid radioactive tracer (Br^{82} in water solution)
- Non-floatable solids (gangue from final tailings) in 3 size classes (coarse: +150, medium: -150+45 and, fine -45 microns).



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METHODOLOGY

Radioactive tracer tests

✓Radioactive tracer sample: around 100 mL (liquid or pulp).

✓Radioactive tracer detection: on-line non-invasive sensors with a minimum period of 50 ms.

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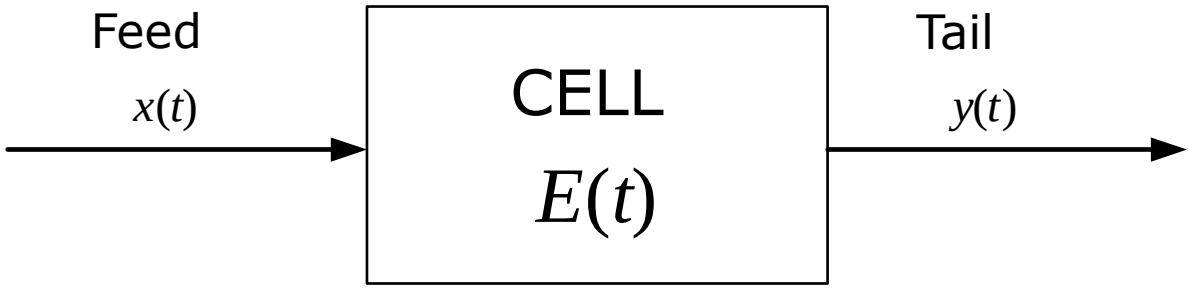
METHODOLOGY

Radioactive tracer tests analysis

✓Parametric deconvolution, fitting the normalized output signal.



$$y(t) = E(t) \otimes x(t)$$

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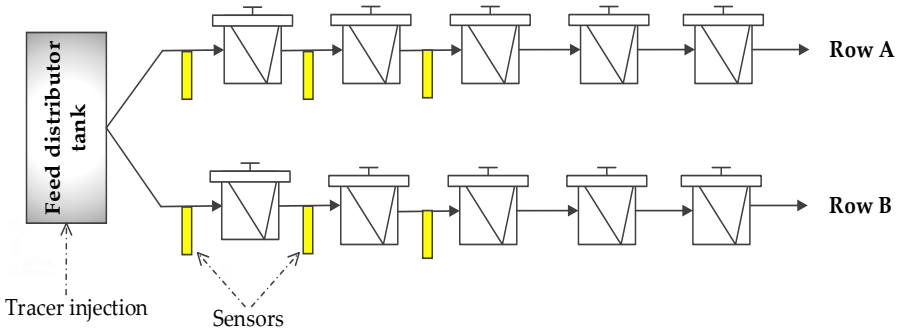
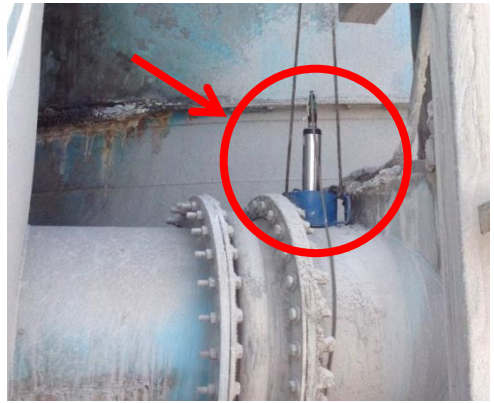
METHODOLOGY

Radioactive tracer tests

✓Liquid and solid tracers were injected in the feed distributor tank and sensors were located at the input and output streams of cells 1 and 2 of each row.

✓The sensors were collimated to measure the tracer transport in the pipelines, decreasing the interference with other radioactive sources.





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METHODOLOGY

Radioactive tracer tests

✓The first condition is the typical plant operation, Test 1 (Baseline).
✓Tests 2 and 3 refer to the operational changes performed to enhance the pulp distribution.

✓ Note that the residence time of row C was not significantly affected by the operational conditions of Tests 2 and 3.

Tests	Operational condition
Test 1 (Baseline)	Two open valves to each of rougher rows A and B.
Test 2	Two open valves to each rougher row A and B. One open valve to rougher row C.
Test 3	Two open valves to each rougher row A and C. One open valve to rougher row B.

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- Introduction
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RESULTS AND DISCUSSION

RTD measurements in rougher circuits

✓The mean residence times in Test 1 (Baseline) were significantly different, using both liquid and solid tracers.

✓These differences were slightly decreased for Test 2, particularly for the fine solids.

✓The results of Test 3 showed similar residence times for liquid and solid tracers.

Tracer type	Rougher row	Test 1 Baseline (min)		Test 2 (min)		Test 3 (min)	
		Cell 1	Cells 1+2	Cell 1	Cells 1+2	Cell 1	Cells 1+2
Liquid	A	4.8	10.8	-	-	9.5	21.9
	B	10.6	16.6	-	-	10.8	22.9
Fine solid	A	5.5	11.7	9.0	19.5	-	-
	B	15.8	21.2	13.4	22.9	-	-
Medium solid	A	6.0	12.8	5.4	13.6	-	-
	B	14.4	21.3	10.9	21.3	-	-
Coarse solid	A	6.0	11.6	-	-	10.3	21.9
	B	13.2	18.4	-	-	11.5	18.4

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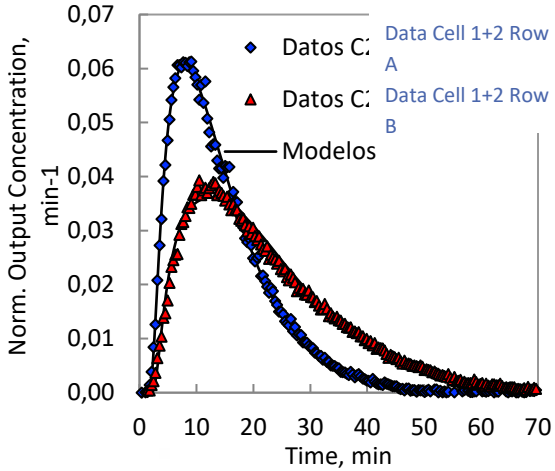
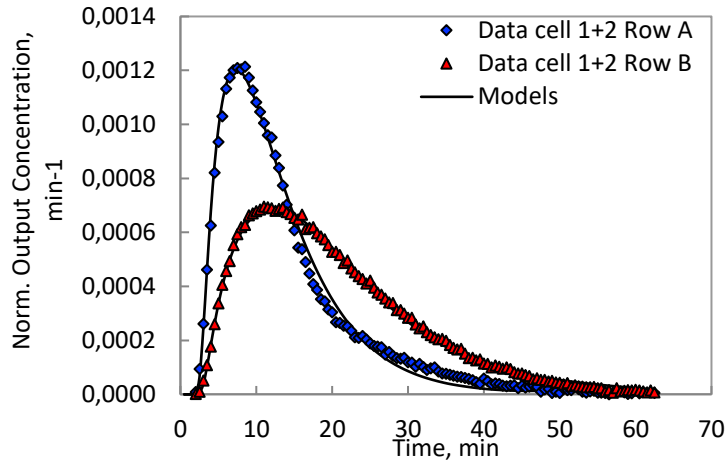
RESULTS AND DISCUSSION

RTD measurement in rougher circuits

✓For Test 1 (Baseline), the mean residence times were significantly different in
✓rougher rows A and B.



MEDIUM SOLID



LIQUID

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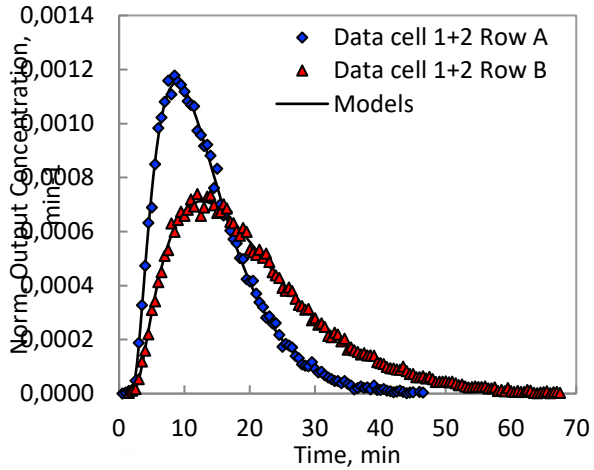
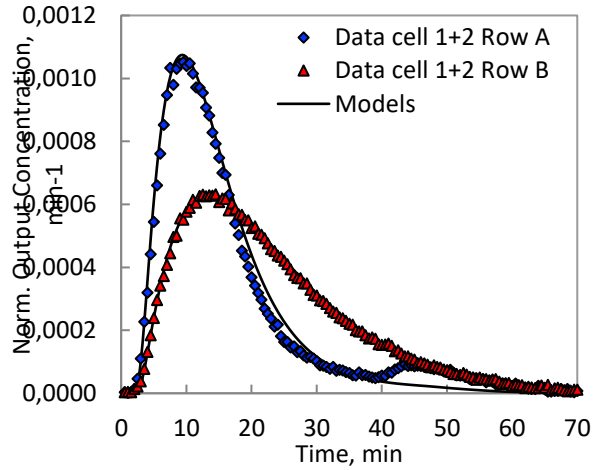
RESULTS AND DISCUSSION

RTD measurement in rougher circuits

✓For Test 1 (Baseline), the mean residence times were significantly different in
✓rougher rows A and B.



COARSE SOLID



FINE SOLID

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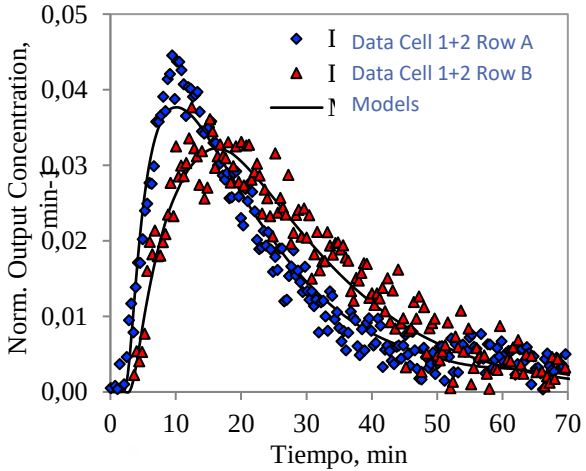
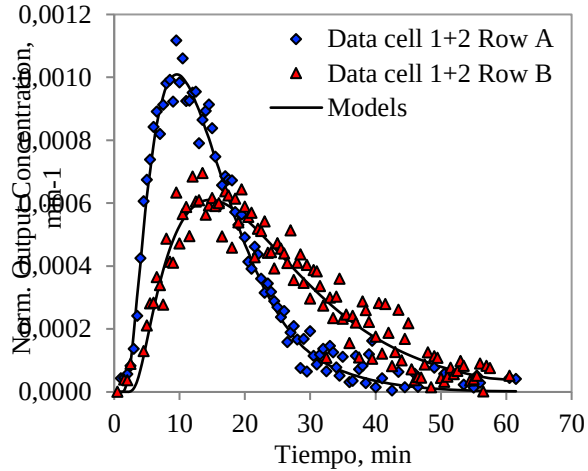
RESULTS AND DISCUSSION

RTD measurement in rougher circuits

✓Differences in mean residence time were slightly decreased for Test 2,
✓particularly for the fine solids.



FINE SOLID



MEDIUM SOLID

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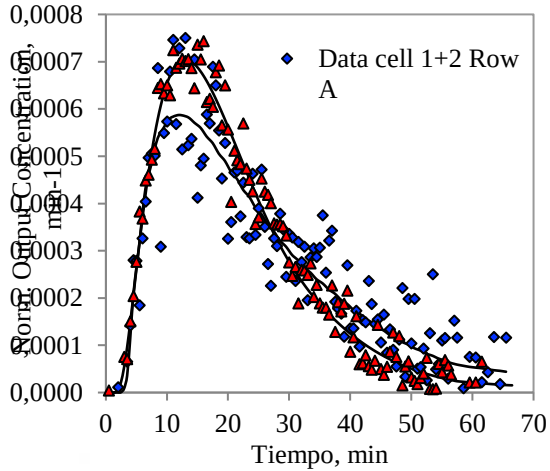
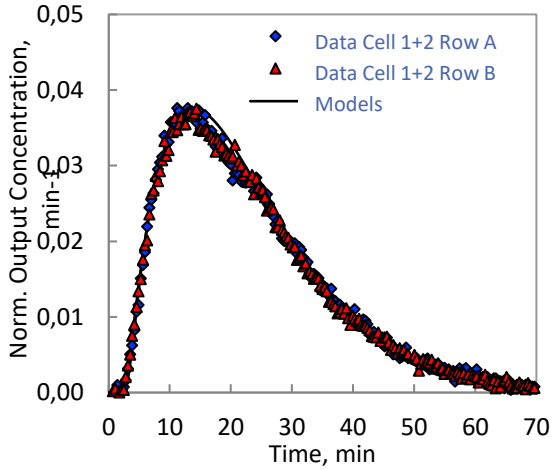
RESULTS AND DISCUSSION

RTD measurement in rougher circuits

✓The RTD as well as the mean residence times were similar for Test 3.



COARSE SOLID



LIQUID

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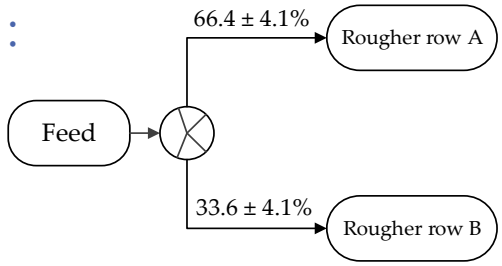
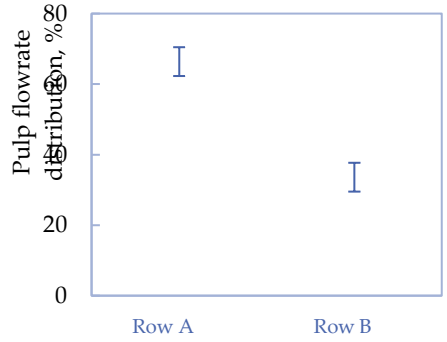
RESULTS AND DISCUSSION

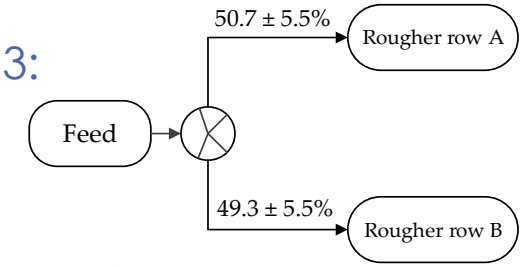
Pulp distribution to rougher rows A and B

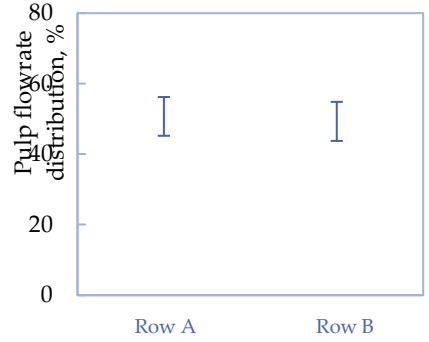
Test 1:





Test 3:





✓ No significant differences for the pulp distribution were observed, using the arrangement of Test 3 at a 95% confidence interval.

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- **Conclusions**

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CONCLUSIONS

✓The radioactive tracer technique has proven to be a suitable methodology to estimate the mean residence times of liquid and solids in flotation circuits.

✓This technique allowed on-line RTD measurements of the flowrate distribution between parallel rougher lines in an industrial flotation operation.

✓Under the typical operational conditions (normal valve setting), the pulp distribution in parallel rougher lines was significantly unbalanced.

✓After selecting a proper valves manipulation, the pulp feed to rows A and B was evenly distributed, both in liquid and solids.

✓The radioactive tracer technique allowed to identify unbalanced flowrate conditions between parallel rows as well as to evaluate their improvement.

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