5-3-2018

Milling of the Phosphate Rock Flotation Circuit Circulating Load Aiming Production Increase and Iron Content Reduction in the Final Concentrate

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PHOSPHATE ROCK PRODUCTION INCREASE THROUGH THE MILLING OF THE APATITE FLOTATION CIRCULATING LOAD

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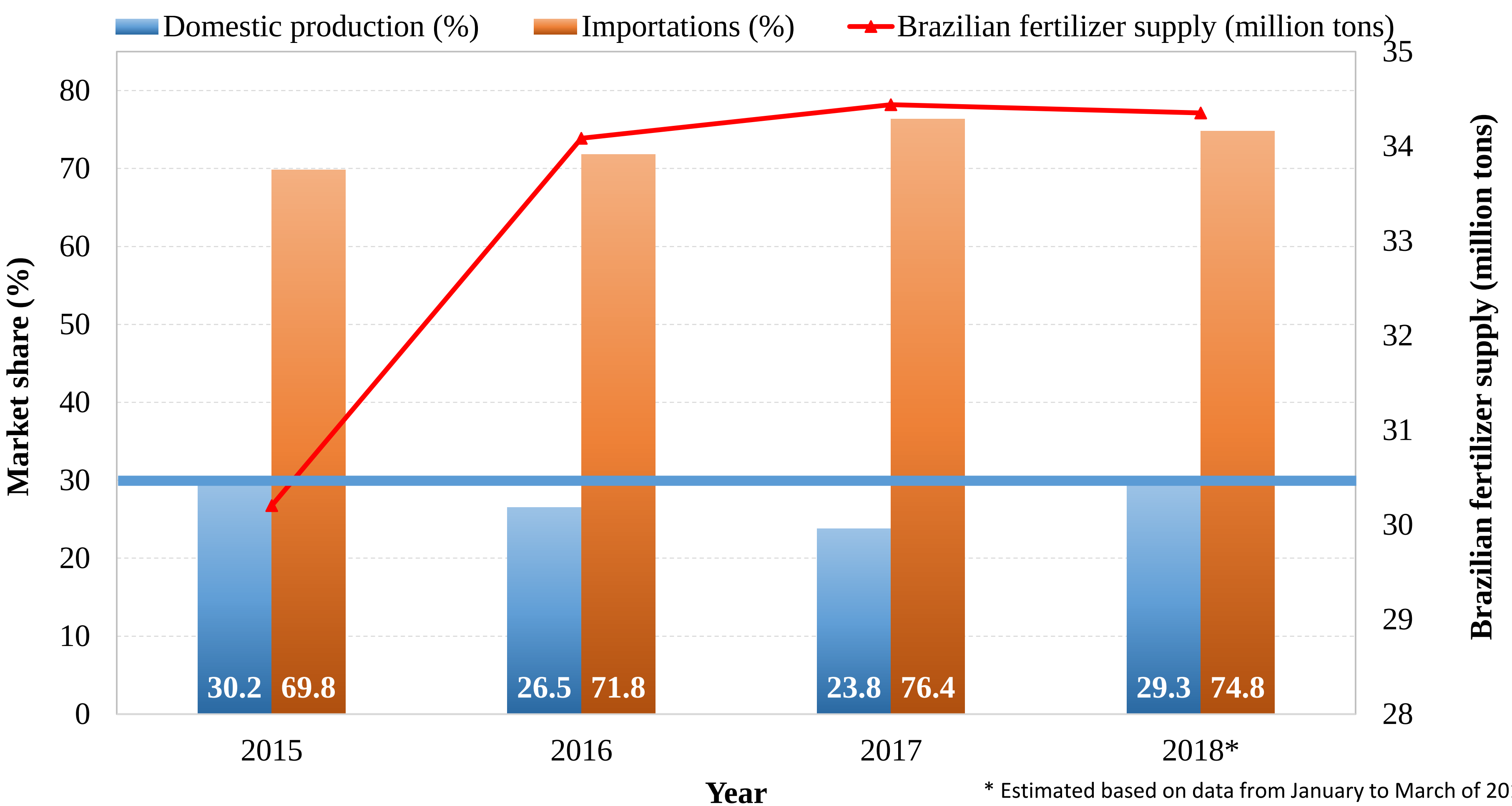
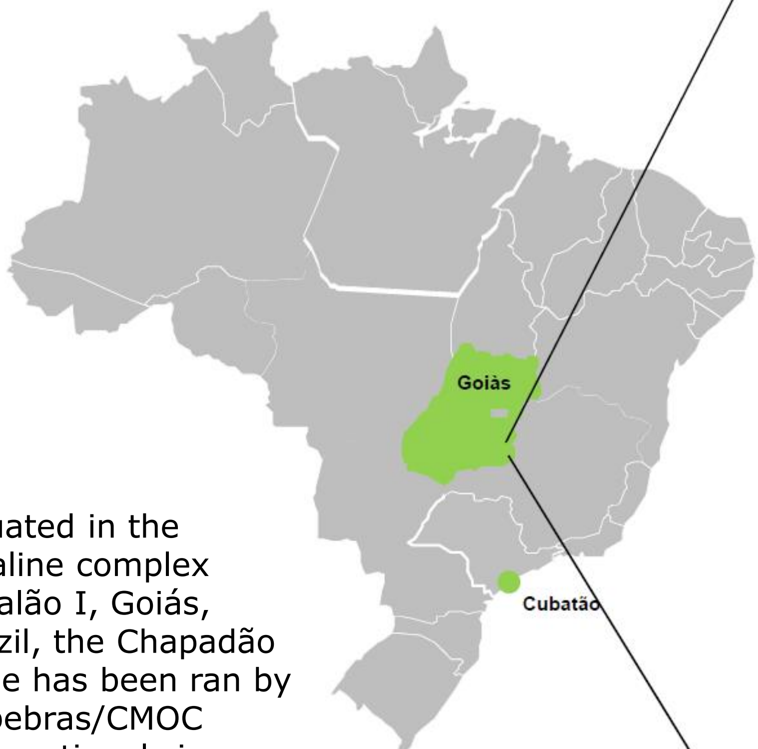
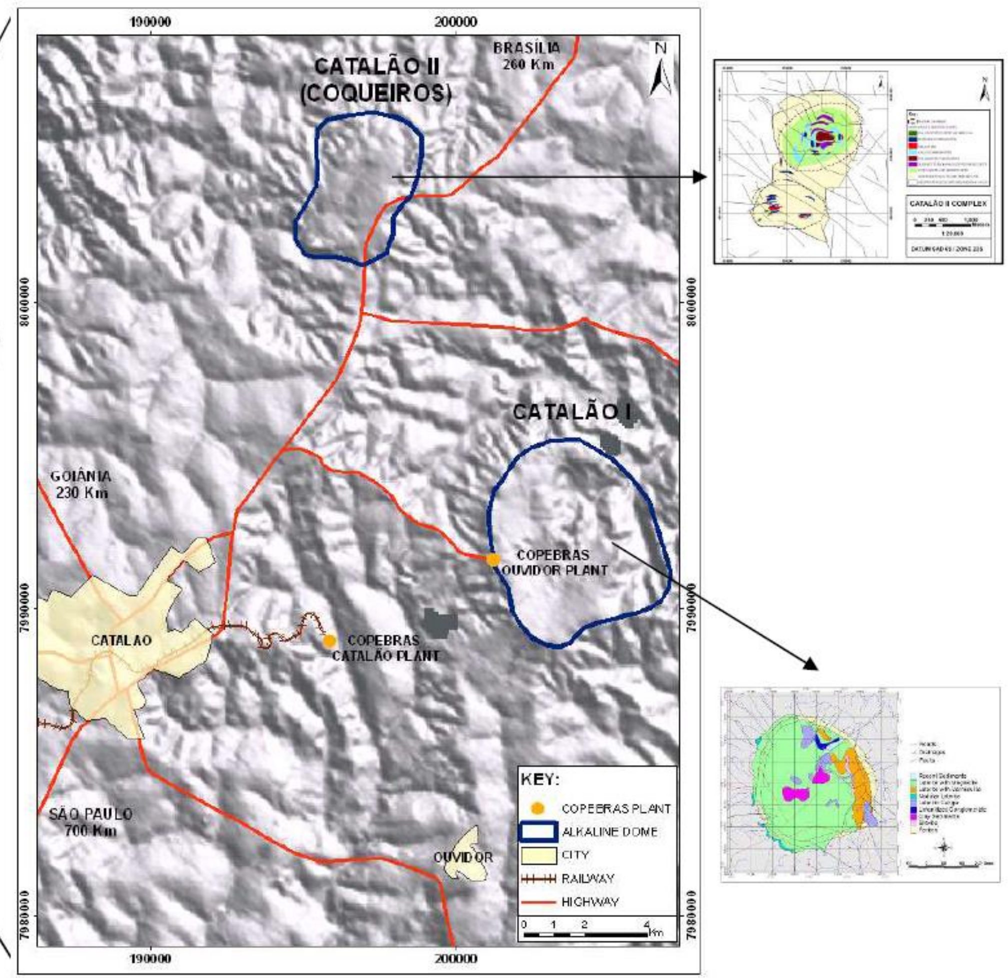
Brazilian fertilizer supply from 2015 to 2018. Adapted from ANDA, 2018



* Estimated based on data from January to March of 2018.

Copebras/CMOC





Situated in the alkaline complex Catalão I, Goiás, Brazil, the Chapadão mine has been ran by Copebras/CMOC International since 2016

CMOC International Brasil

The Chapadão Mine has being in operation since 1976 and in 2014 was responsible for 21% of the Brazilian phospha-te rock production

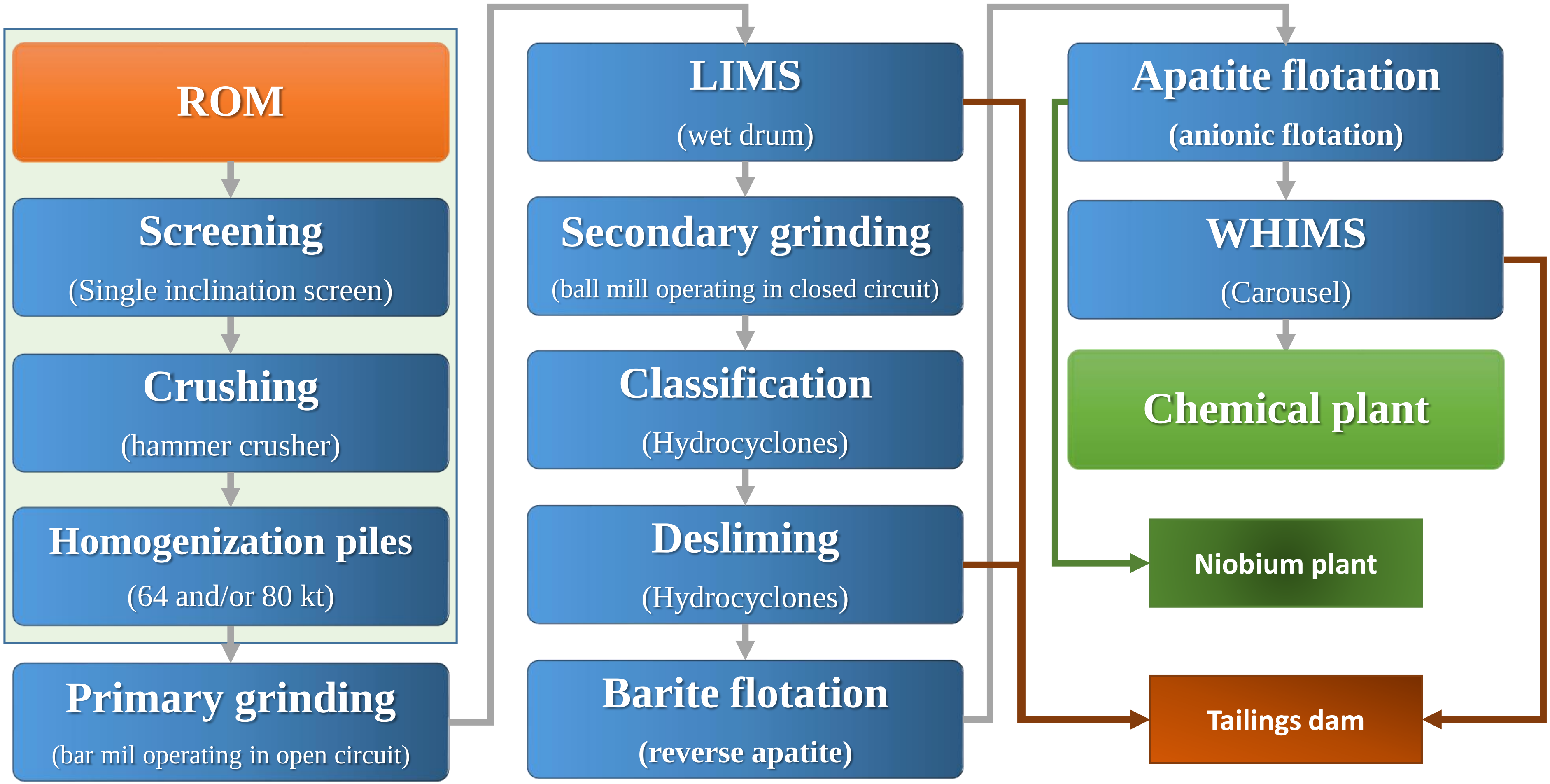
In 2015, the company produced 1.1 million tons of phosphate fertilizers, 265 kt of phosphoric acid, and 147 kt of dicalcium phosphate (DCP) for animal supplementary feed.

The company products portfolio is composed in addition by sulfuric and hexafluorosilicic acids.

CMOC International Brasil

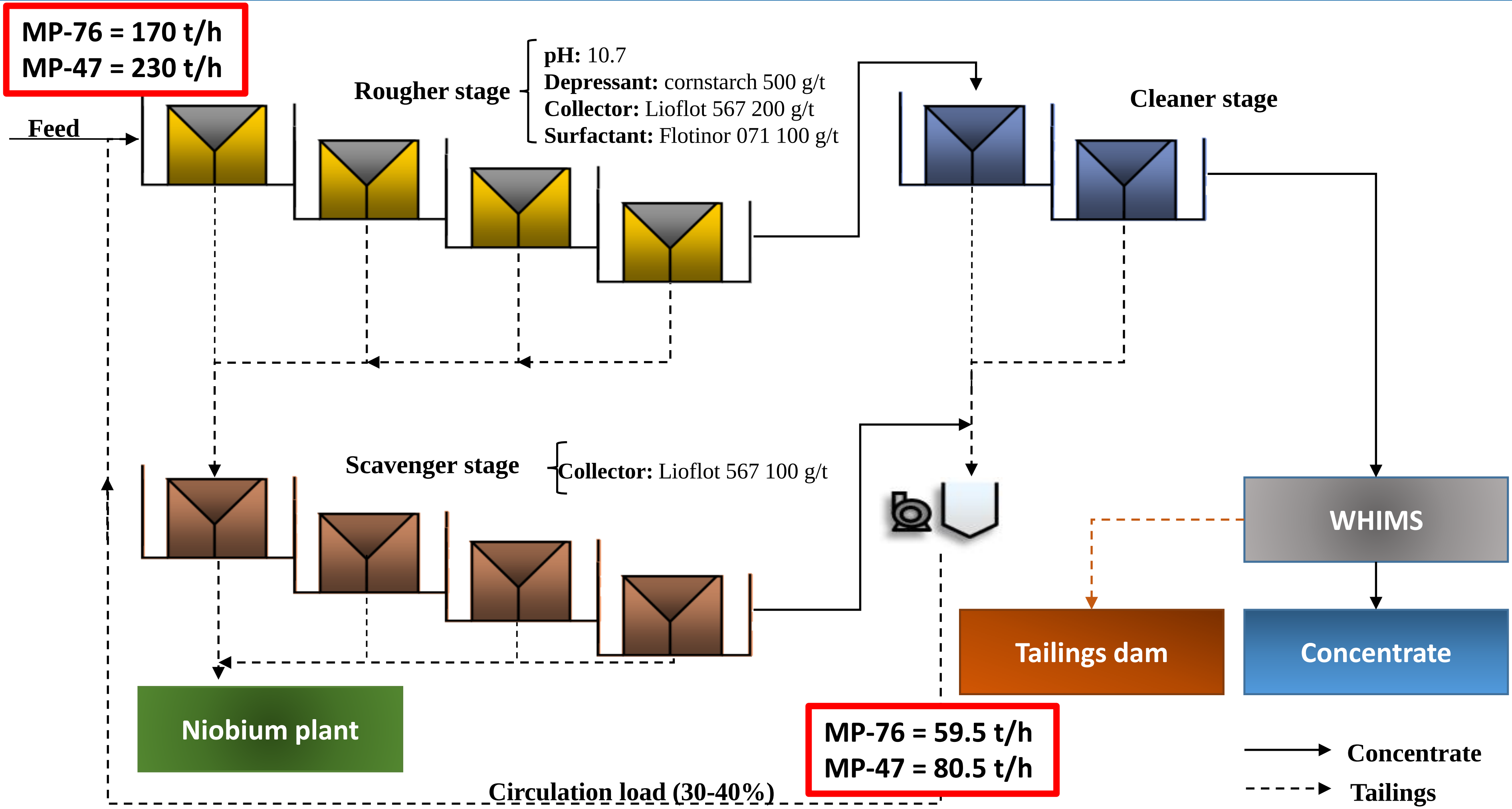

VILLARES

Phosphate rock processing flowsheet at Copebras/CMOC in Brazil

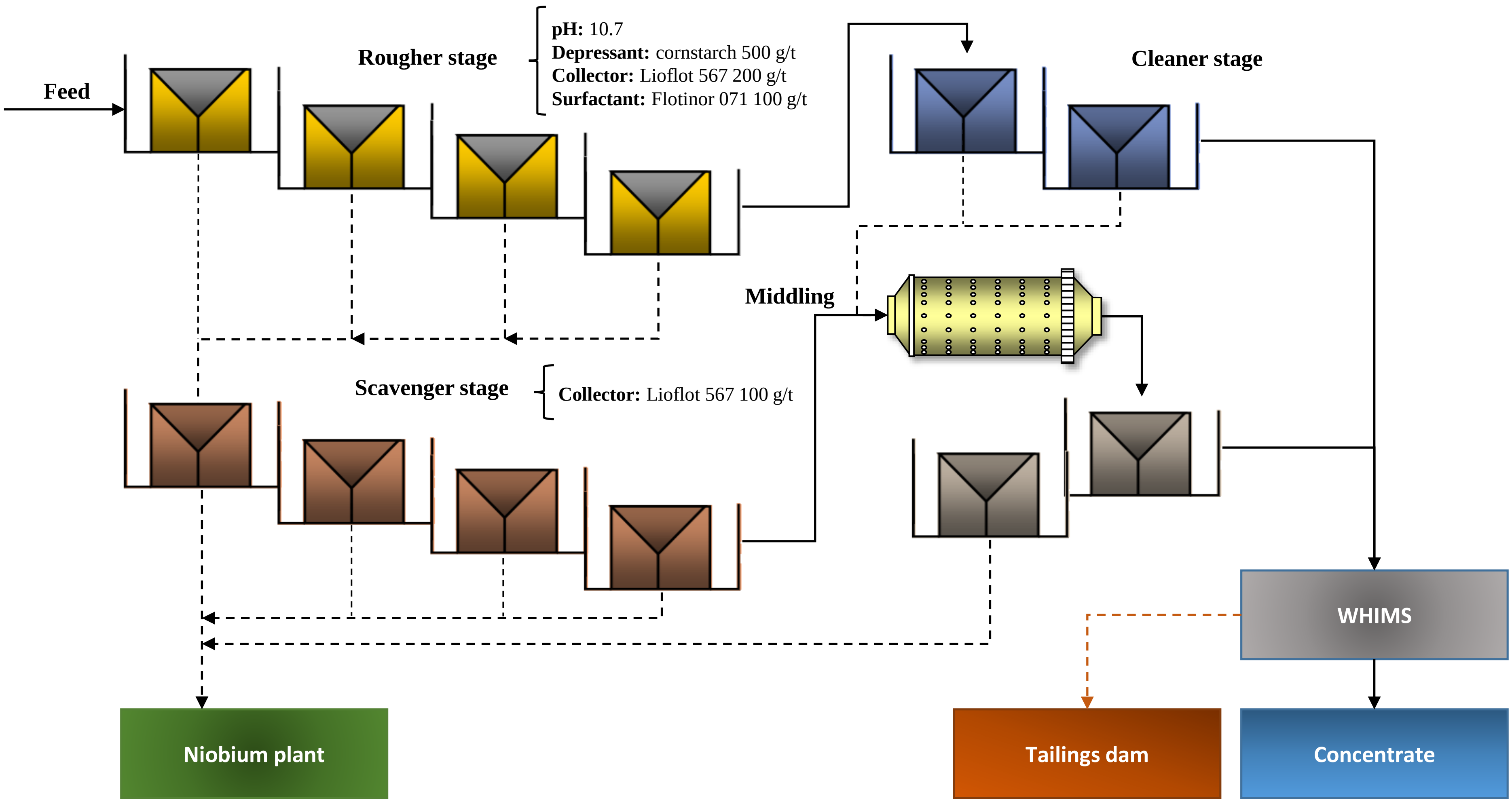


*Nowadays barite concentrate is sold as a coproduct

Phosphate rock processing flowsheet at Copebras/CMOC in Brazil



Do we need a circulating load?



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Mineralogical characterization

XRD
Bruker D8 Discover

XRF
Bruker S8 TIGER WDXRF

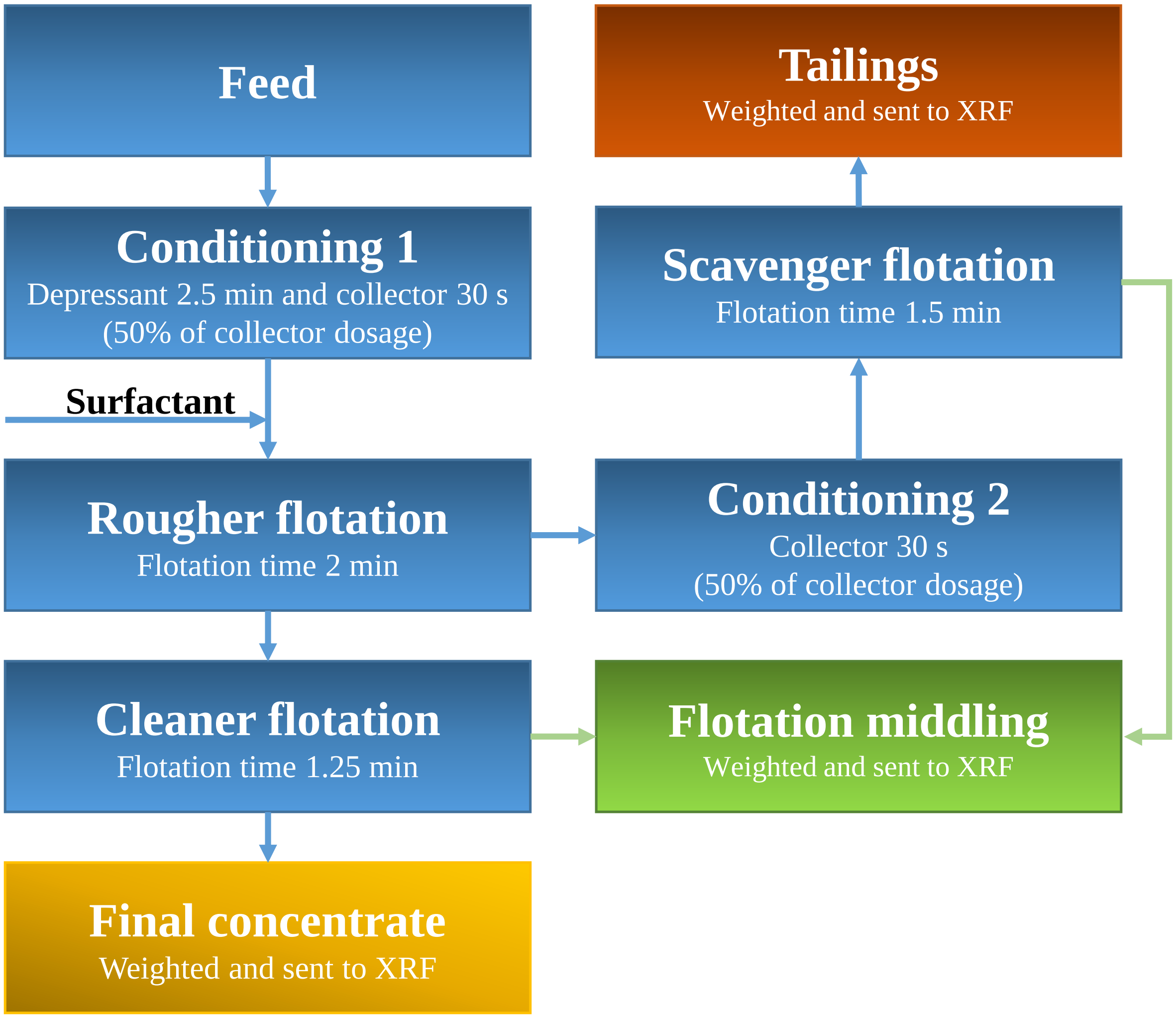
SEM
JEOL JSM-IT300

EDS
Oxford Instruments X-MaxN

LOI
Calcined at 900 ^{o}C for 2 hours

Flotation tests at bench scale

Copebras/CMOC internal procedure PCT.13.001.050 for apatite flotation tests in bench scale

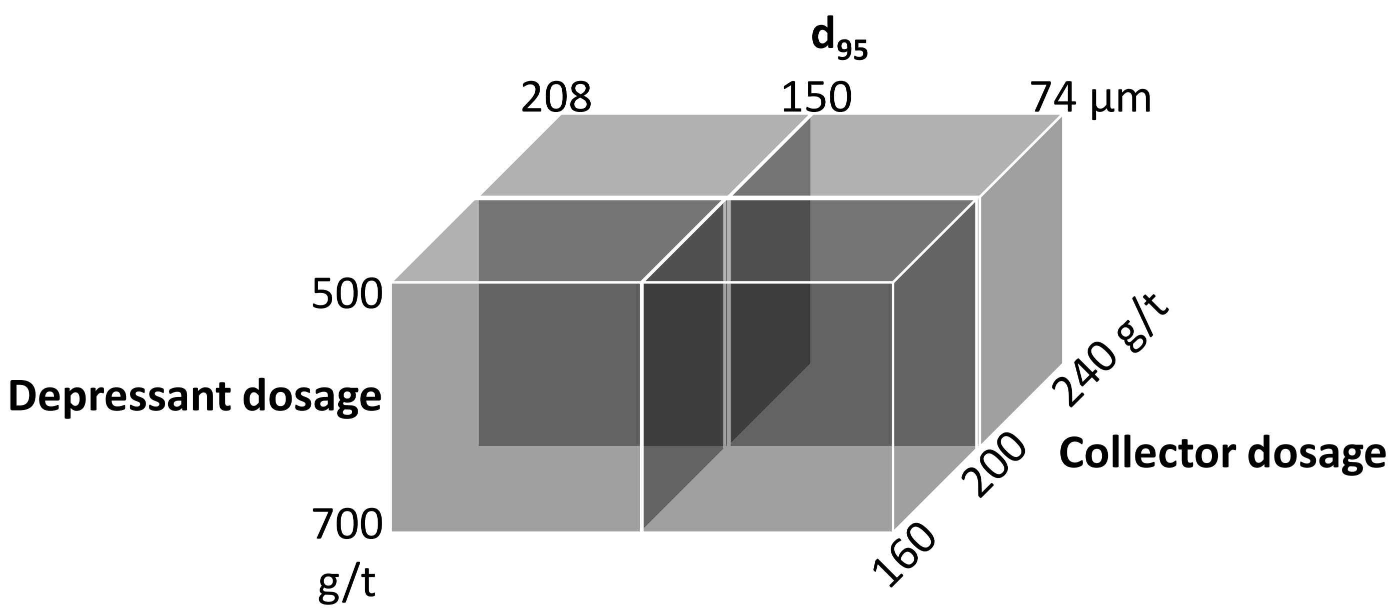


Operational parameter	Value
Starch (g/t)	500
Lioflot 567 (g/t)	320
Flotinor 071 (g/t)	20
pH	10
Impeller speed (rpm)	1100
Solids (%)	
Conditioning	50
Flotation	35
Conditioning (min)	
Depressor	2.5
Collector – rougher	0.5
Collector – scavenger	0.5
Flotation (min)	
Rougher	2
Cleaner	1.25
Scavenger	1.5

Methodology

Experimental design for the middling rougher flotation tests

Factors	Levels
d_{95}	**3** (208, 150, and 74 µm)
Collector dosage	**3** (160, 200, and 240 g/t)
Depressant dosage	**2** (500 and 700 g/t)



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Methodology

Experimental design for the middling rougher flotation tests

Sample	Test	Solids % during the conditioning	Collector (g/t)	Depressant (g/t)
Middling without milling d_{95} = 208 μm	1.1	49.4	160	500
	1.2	48.8	200	500
	1.3	49.1	240	500
A After milling d_{95} = 150 μm	2.1	46.4	160	700
	2.2	46.9	200	700
	2.3	46.1	240	700
	3.1	50.8	160	500
	3.2	49.6	200	500
	3.3	52.4	240	500
B After milling d_{95} = 74 μm	4.1	55.1	160	700
	4.2	38.9	200	700
	4.3	39.6	240	700
	5.1	51.1	160	500
	5.2	49.8	200	500
	5.3	49.1	240	500

Methodology

Average XRF results for the feed of the tests 1 (middling without milling) and the industrial threshold for the oxides in the final concentrate

Feed	P_2O_5	CaO	Fe_2O_3	SiO_2	Al_2O_3	MgO	BaO	CPR
Average	22.85	29.30	18.81	18.62	0.95	0.83	0.58	1.28
St. Dev.	0.09	0.09	0.27	0.24	0.02	0.01	0.01	0.00
Ind. thres.	≥ 37	-	≤ 0.82	≤ 2.90	≤ 3	≤ 0.50	≤ 0.50	≤ 1.32

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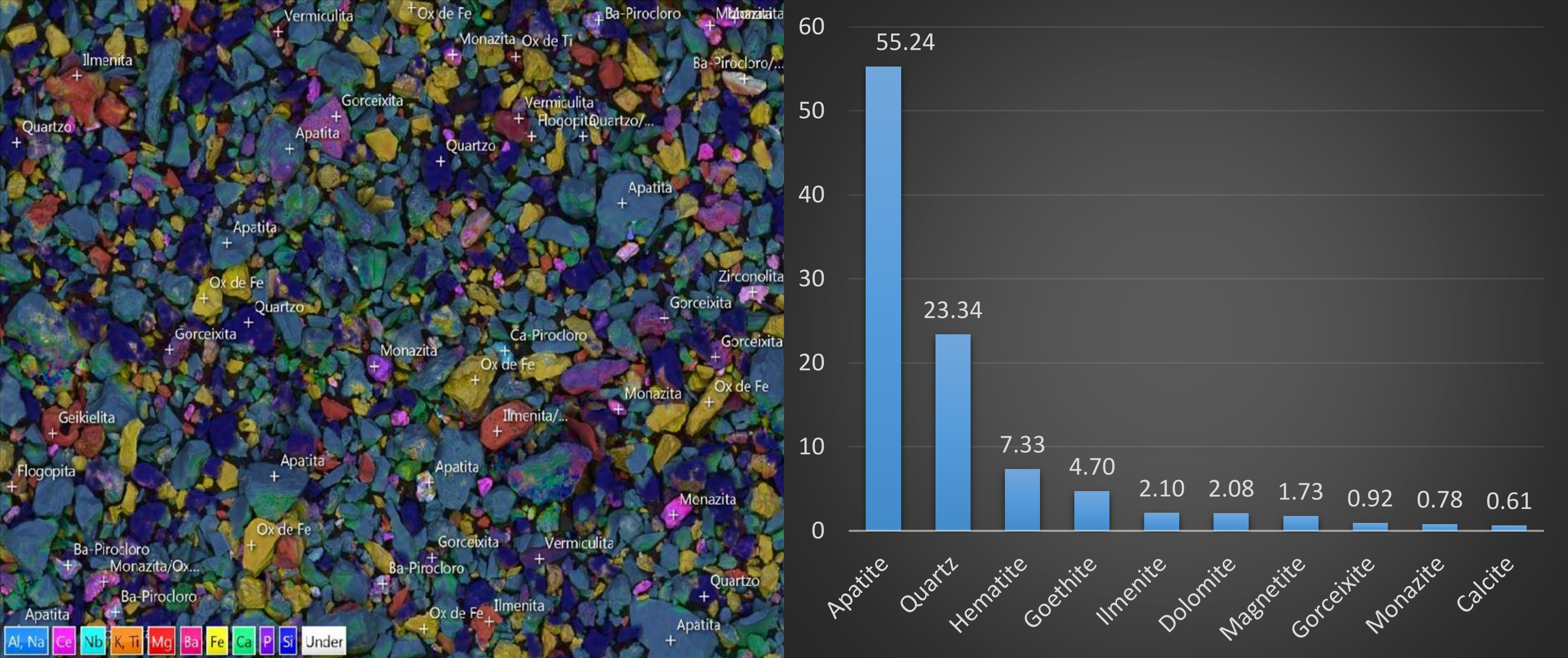
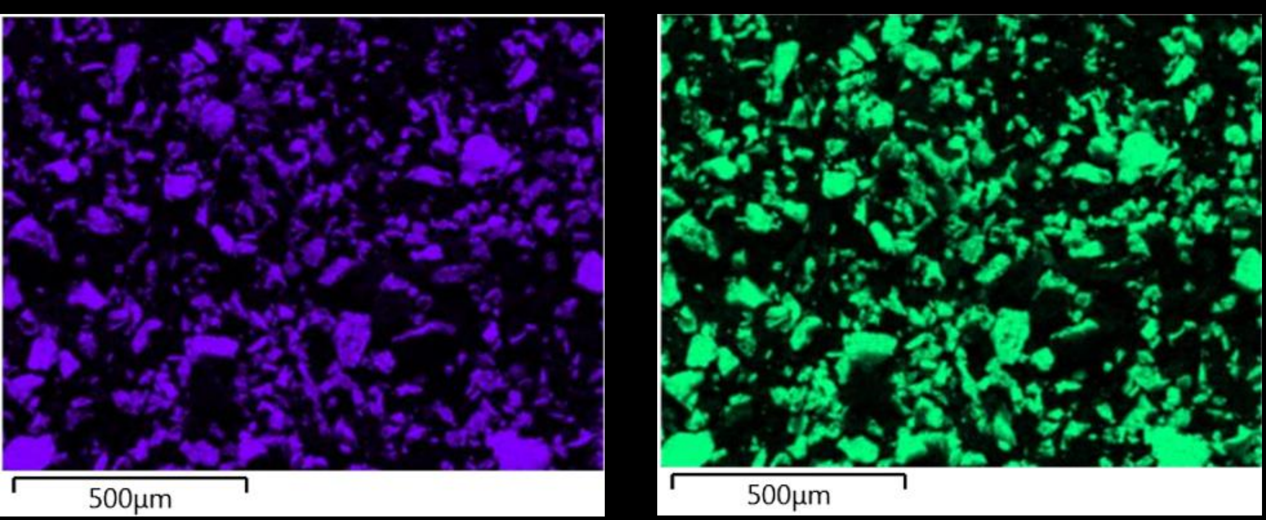
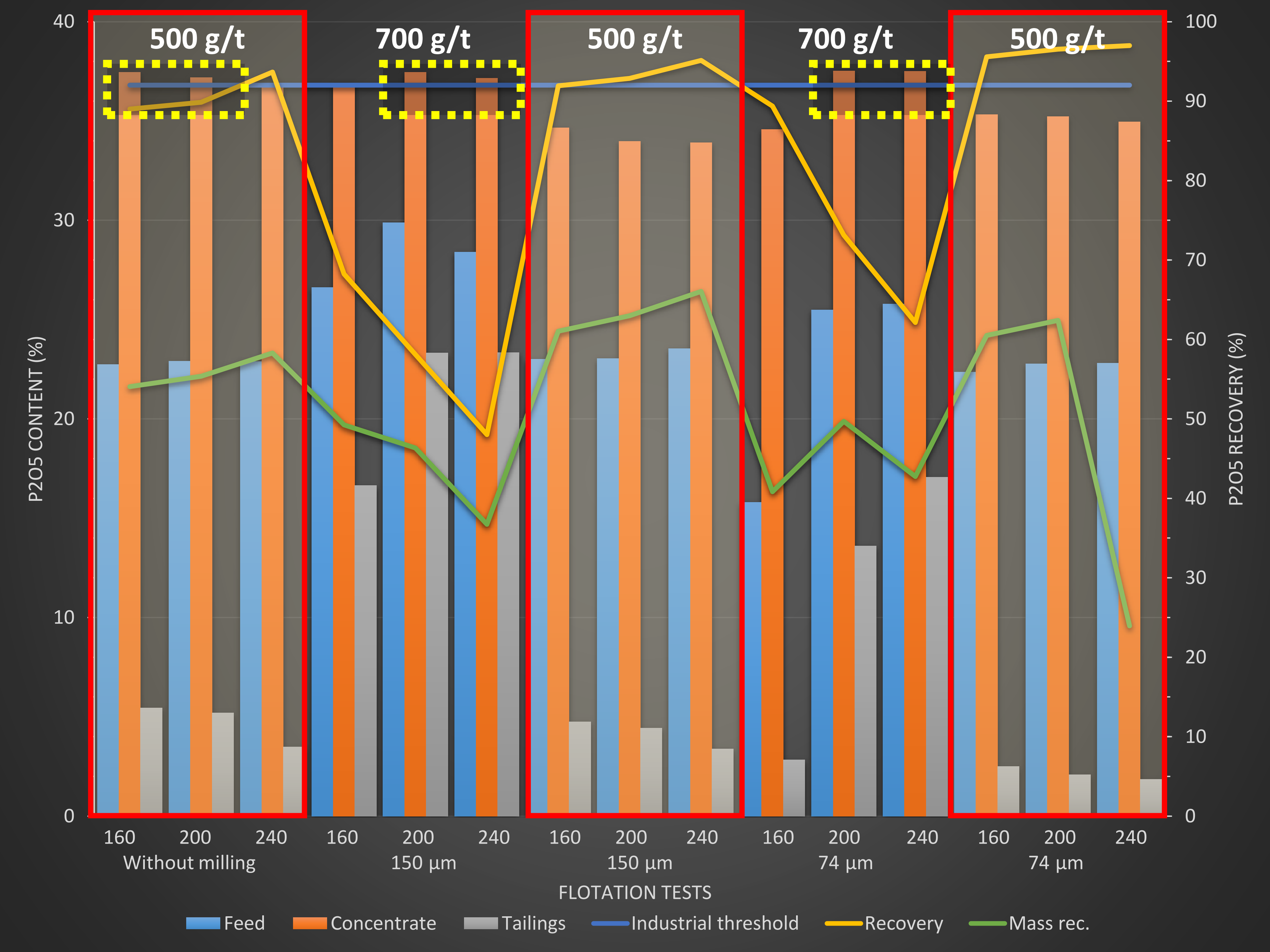
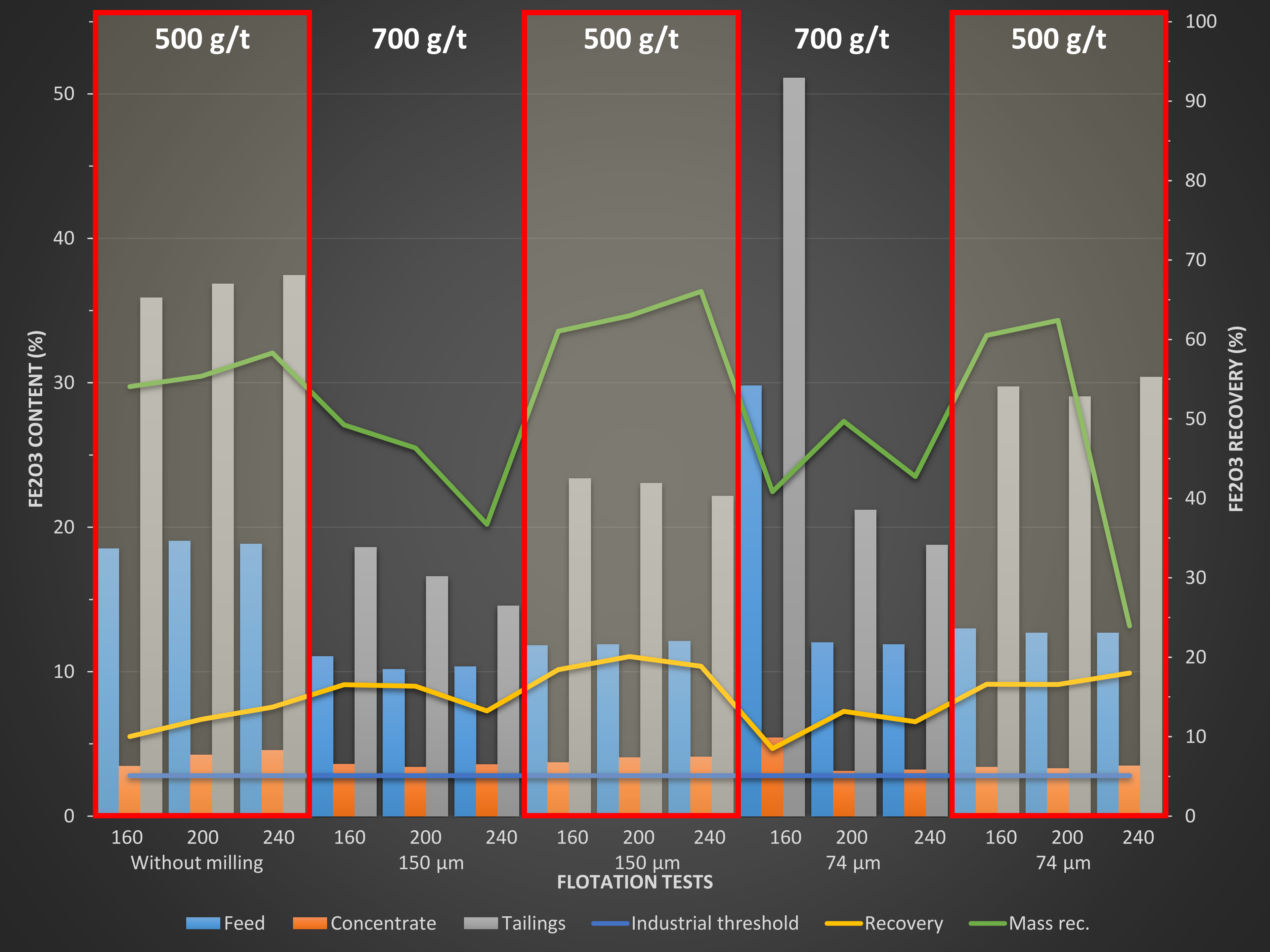
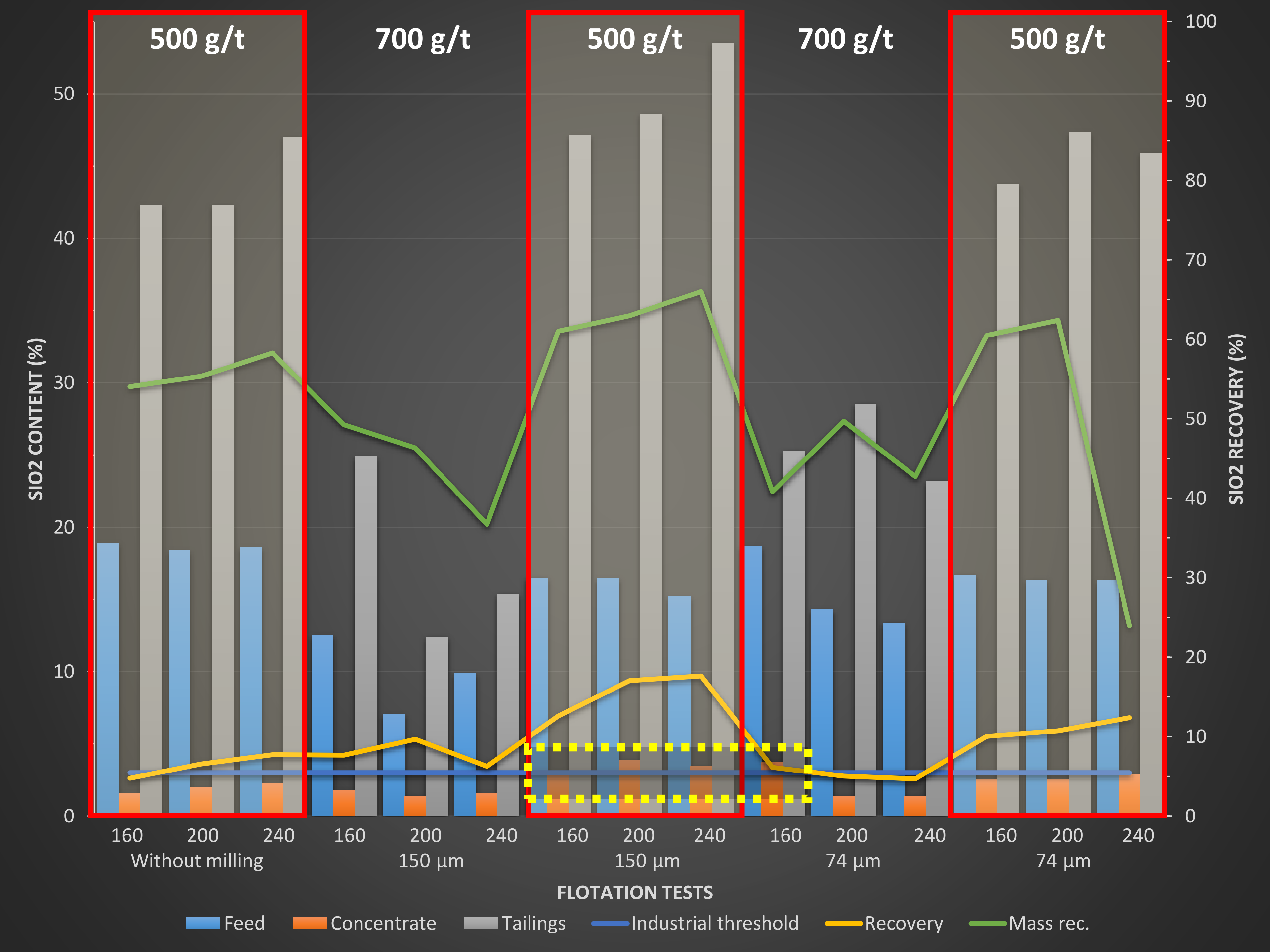


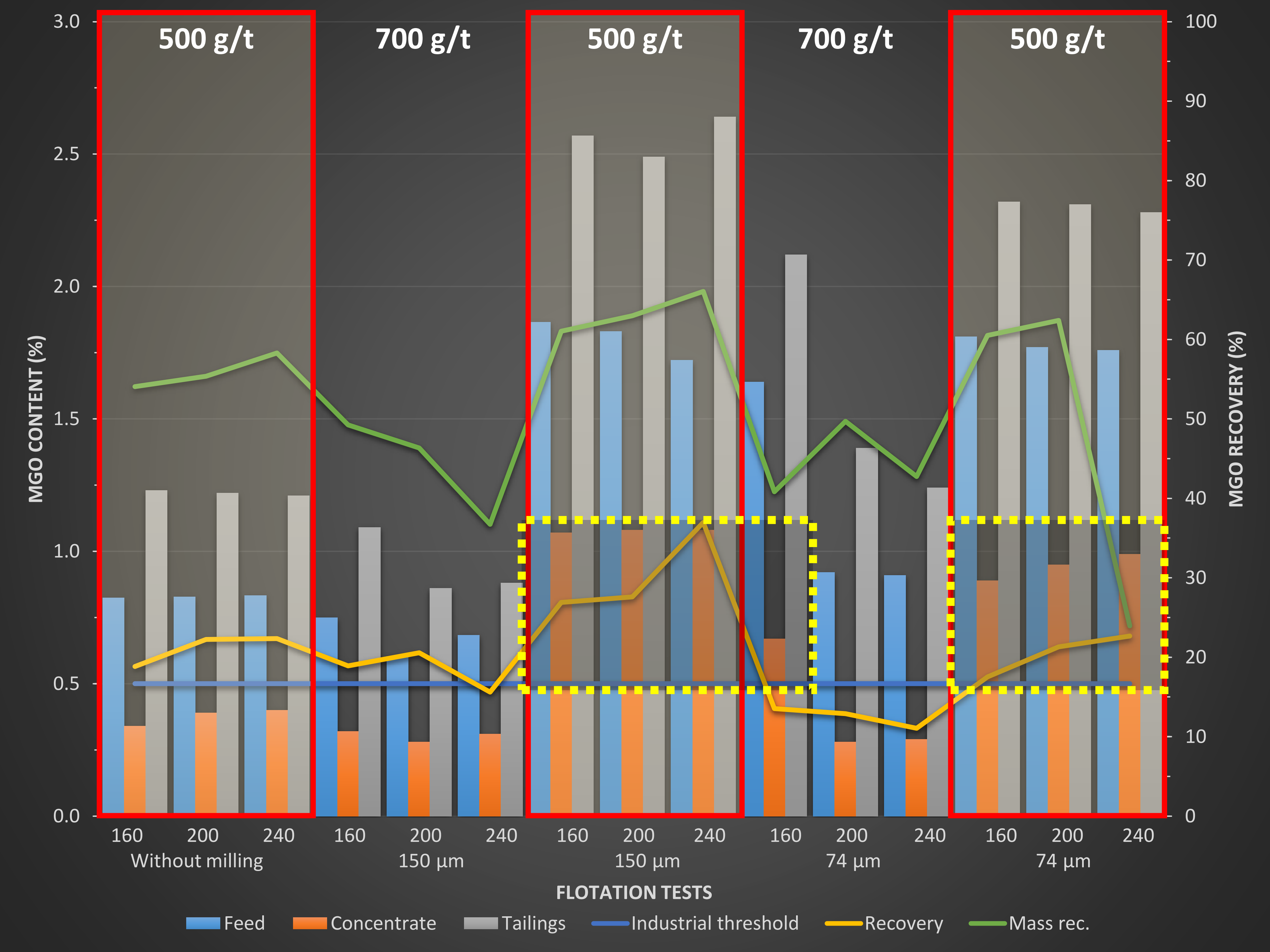
Mineralogical characterization of the flotation feed. (a) Quantitative analysis by the Rietveld Method. Compositional map obtained by EDS from SEM image: (b) global, (c) P, (d) Ca and (e) Fe.



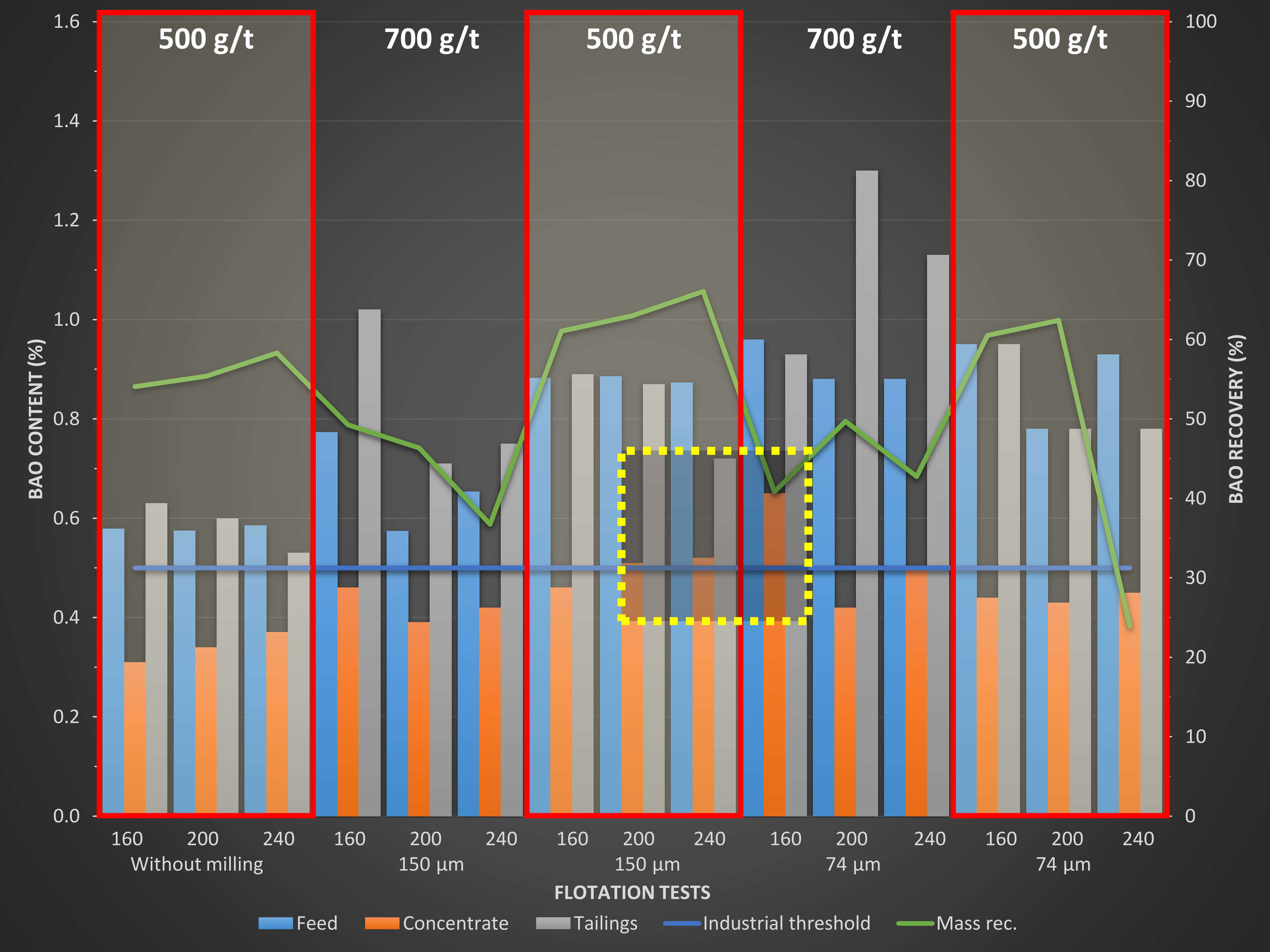

500 g/t
700 g/t
500 g/t
700 g/t
500 g/t
P2O5 CONTENT (%)
P2O5 RECOVERY (%)
0
10
20
30
40
0
10
20
30
40
50
60
70
80
90
100
160
200
240
Without milling
150 µm
150 µm
74 µm
74 µm
FLOTATION TESTS
Feed
Concentrate
Tailings
Industrial threshold
Recovery
Mass rec.


500 g/t
700 g/t
500 g/t
700 g/t
500 g/t
FE2O3 CONTENT (%)
FE2O3 RECOVERY (%)
0
10
20
30
40
50
60
70
80
90
100
160
200
240
Without milling
150 µm
150 µm
74 µm
74 µm
FLOTATION TESTS
Feed
Concentrate
Tailings
Industrial threshold
Recovery
Mass rec.

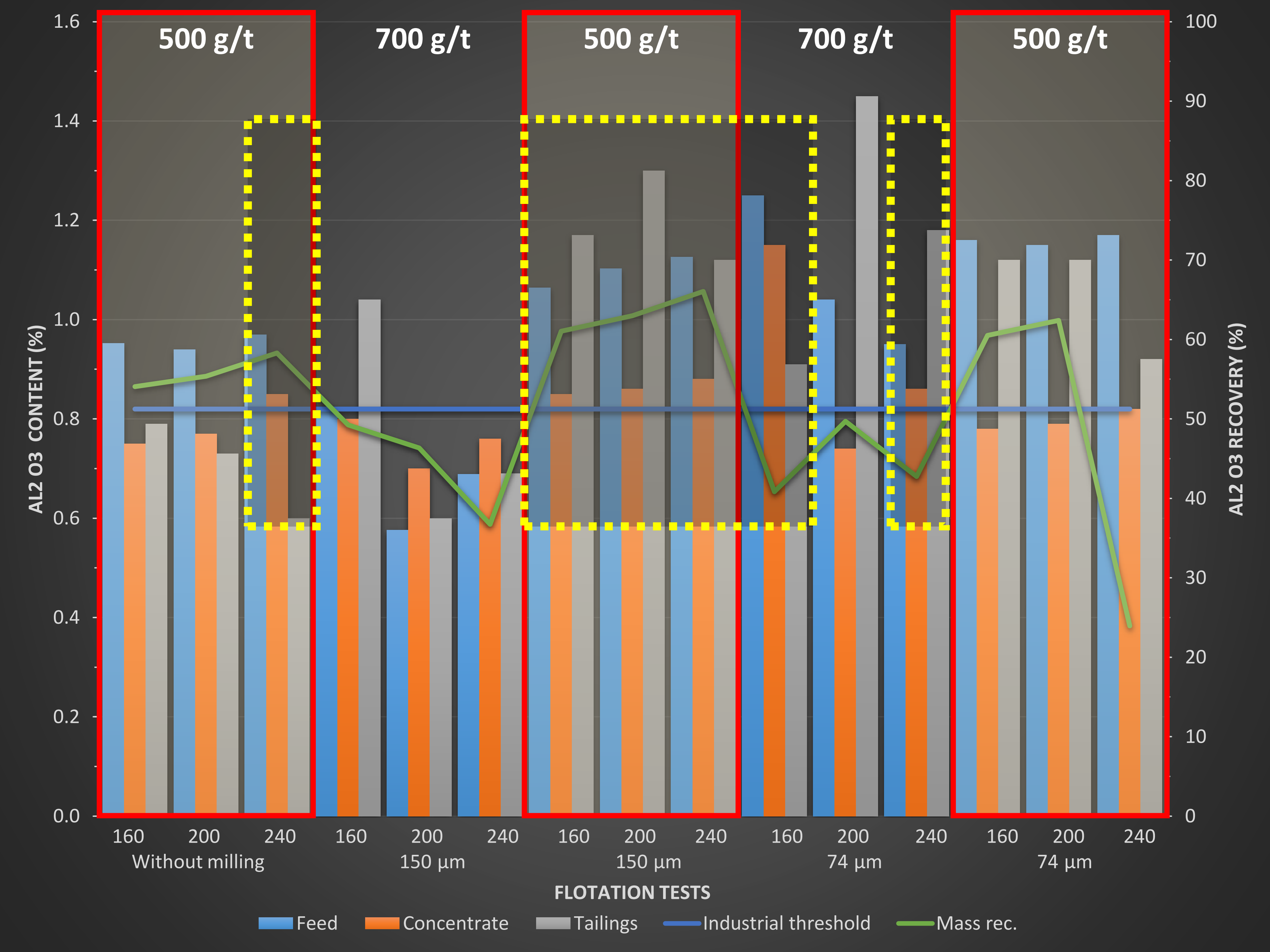

500 g/t
700 g/t
500 g/t
700 g/t
500 g/t
SIO2 CONTENT (%)
SIO2 RECOVERY (%)
0
10
20
30
40
50
0
10
20
30
40
50
60
70
80
90
100
160
200
240
Without milling
160
200
240
150 µm
160
200
240
150 µm
160
200
240
74 µm
160
200
240
74 µm
FLOTATION TESTS
Feed
Concentrate
Tailings
Industrial threshold
Recovery
Mass rec.



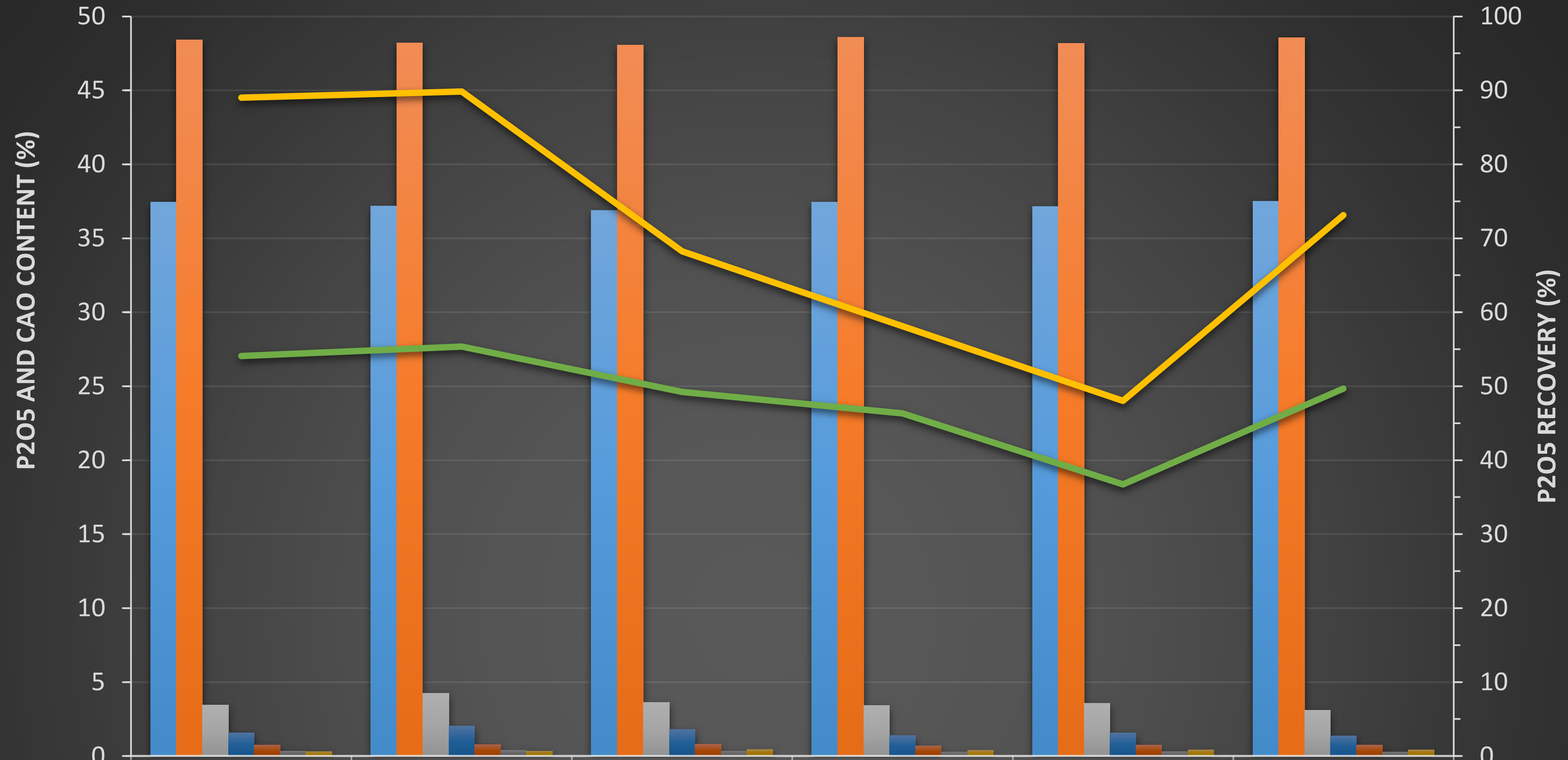
500 g/t
700 g/t
500 g/t
700 g/t
500 g/t
MGO CONTENT (%)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
MGO RECOVERY (%)
100
90
80
70
60
50
40
30
20
10
0
160
200
240
Without milling
160
200
240
150 µm
160
200
240
150 µm
160
200
240
74 µm
160
200
240
74 µm
FLOTATION TESTS
Feed
Concentrate
Tailings
Industrial threshold
Recovery
Mass rec.



500 g/t
700 g/t
500 g/t
700 g/t
500 g/t
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
BAO CONTENT (%)
100
90
80
70
60
50
40
30
20
10
0
BAO RECOVERY (%)
160 200 240
Without milling
160 200 240
150 µm
160 200 240
150 µm
160 200 240
74 µm
160 200 240
74 µm
FLOTATION TESTS
Feed
Concentrate
Tailings
Industrial threshold
Mass rec.



500 g/t
700 g/t
500 g/t
700 g/t
500 g/t
AL2 O3 CONTENT (%)
AL2 O3 RECOVERY (%)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
100
90
80
70
60
50
40
30
20
10
0
160 200 240 160 200 240 160 200 240 160 200 240 160 200 240
Without milling
150 µm
150 µm
74 µm
74 µm
FLOTATION TESTS
Feed
Concentrate
Tailings
Industrial threshold
Mass rec.



	1.1	1.2	2.1	2.2	2.3	4.2
P_2O_5	37.45	37.18	36.89	37.46	37.15	37.52
CaO	48.42	48.22	48.08	48.58	48.19	48.57
Fe_2O_3	3.46	4.25	3.62	3.41	3.58	3.12
SiO_2	1.57	2.03	1.79	1.40	1.56	1.38
Al_2O_3	0.75	0.77	0.80	0.70	0.76	0.74
MgO	0.34	0.39	0.32	0.28	0.31	0.28
BaO	0.31	0.34	0.46	0.39	0.42	0.42
Recovery	89.00	89.85	68.24	58.11	48.01	73.14
Mass rec.	54.07	55.36	49.23	46.34	36.72	49.69

FLOTATION TESTS

Conclusions

- Samples from Copebras/CMOC mineral processing plant were collected and mineralogical characterized.
- The results showed that the main phase present in the middling sample was ***apatite*** (55.24%), followed by ***quartz*** (23.34%) and ***hematite*** (7.33%).
- This result was double-checked by the XRF results.

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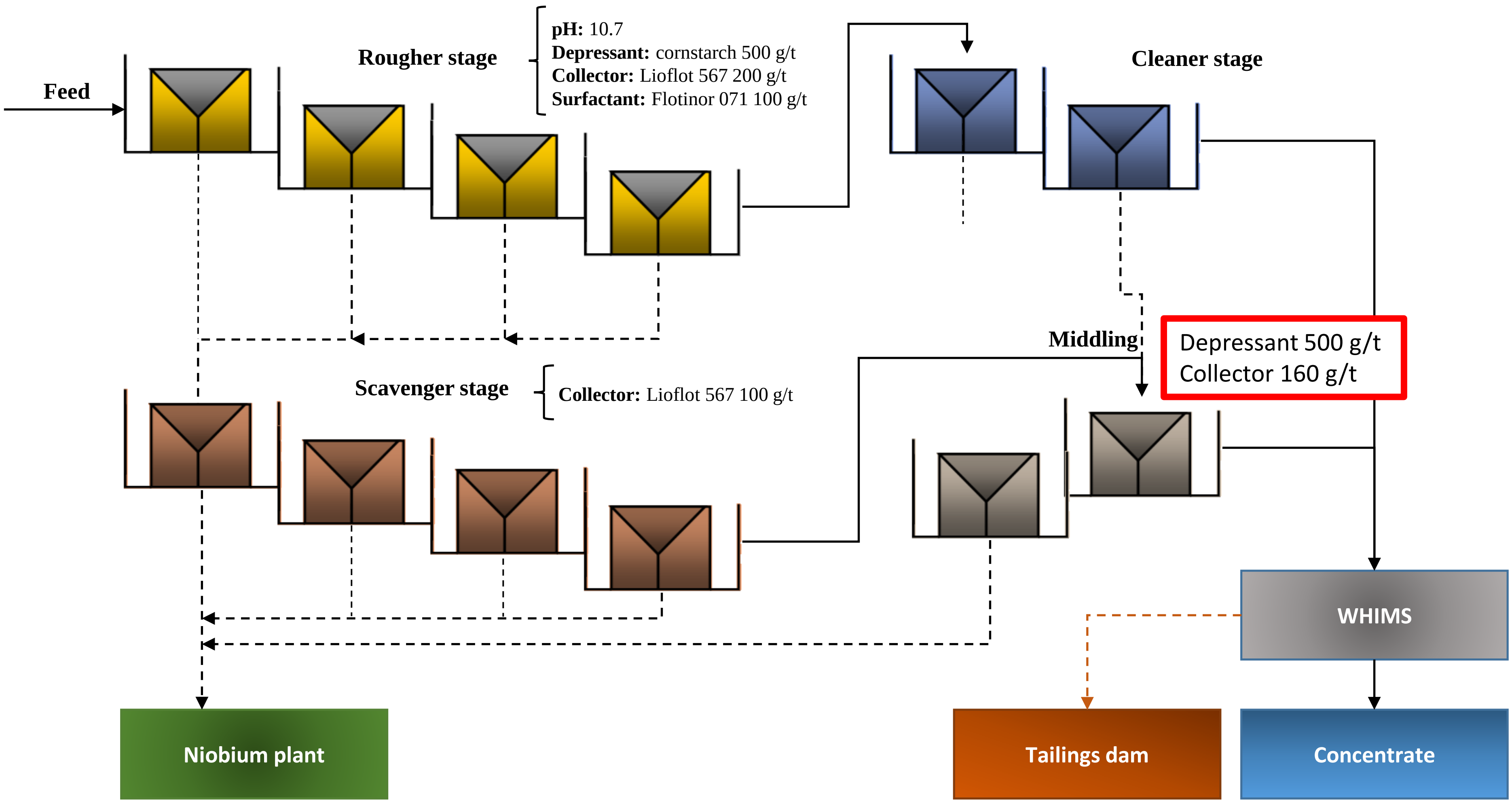
Conclusions

- Two attractive scenarios were found.
  - The first one, for the non-milled middling, was obtained for the test ***1.1***, which produced with grade concentrate with ***low levels of contaminants***.
  - This test was carried out with the industrially adopted depressant dosage (500 g/t), but a considerably lower collector dosage (160 g/t instead of 320 g/t).

Scenario 1

No milling
Depressant 500 g/t
Collector 160 g/t

Scenario 1: Proposed flowsheet



Conclusions

- The second scenario, for the ***milled middling***, was obtained for test 4.2.

- Even operating with particle size relatively smaller than the other tests a high recovery (mass and metallurgical) and relatively low level of contaminants were found.

- In this particular test, a higher depressant dosage (700 g/t) and lower collector dosage (200 g/t) were used.

Scenario 2

Middling milled (d_{95} = 74 µm)
Depressant 700 g/t
Collector 200 g/t

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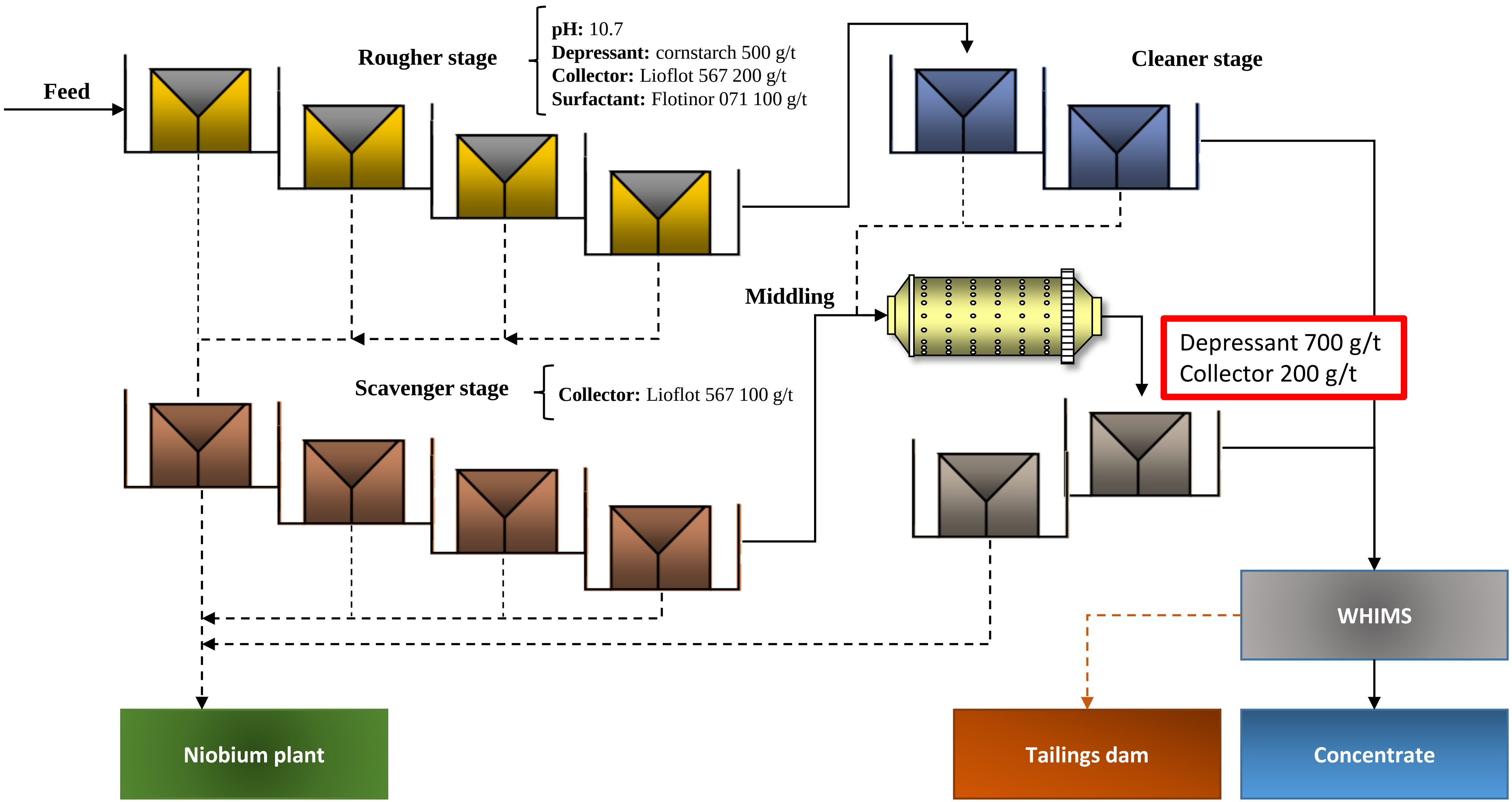
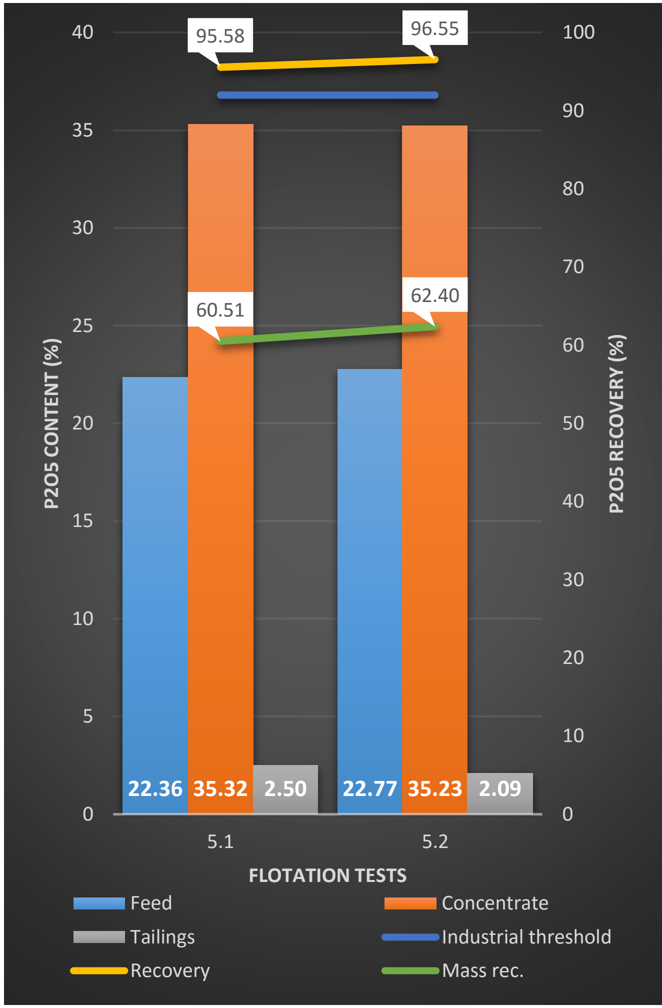
Phosphate rock processing flowsheet at Copebras/CMOC in Brazil



Conclusions

- The tests 5.1 and 5.2 (middling B) did not reached the industrial threshold for ***P_2O_5 content***, but they showed high metallurgical and mass recoveries and considerably low P_2O_5 content in the tailings.

- Therefore, this sample is suitable to an ***additional cleaner stage***, which could raise the P_2O_5 content in the concentrate, which will be made in a future work.



Conclusions

- The industrial implementation of a milling stage for the flotation circulation load and a subsequent flotation of this material has the potential to ***increase the overall process efficiency by approximately 5.5%***, resulting in a production increase of ***62 kt/year of phosphate rock concentrate***, with P_2O_5 content similar to the one currently produced.

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Acknowledgements

- The authors gratefully acknowledge the financial support from the Brazilian agencies **CNPq**, **CAPES**, **FAPEG** and **FUNAPE**.

- In addition, we would like to thank the **Copebras/CMOC** to allow this study, **CRTI** and **UFG**.

Influence of the impeller speed on phosphate rock flotation

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