Short-Term Geometallurgical Program Salobo Copper-Gold Mine

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Coordenação de Geociências Salobo

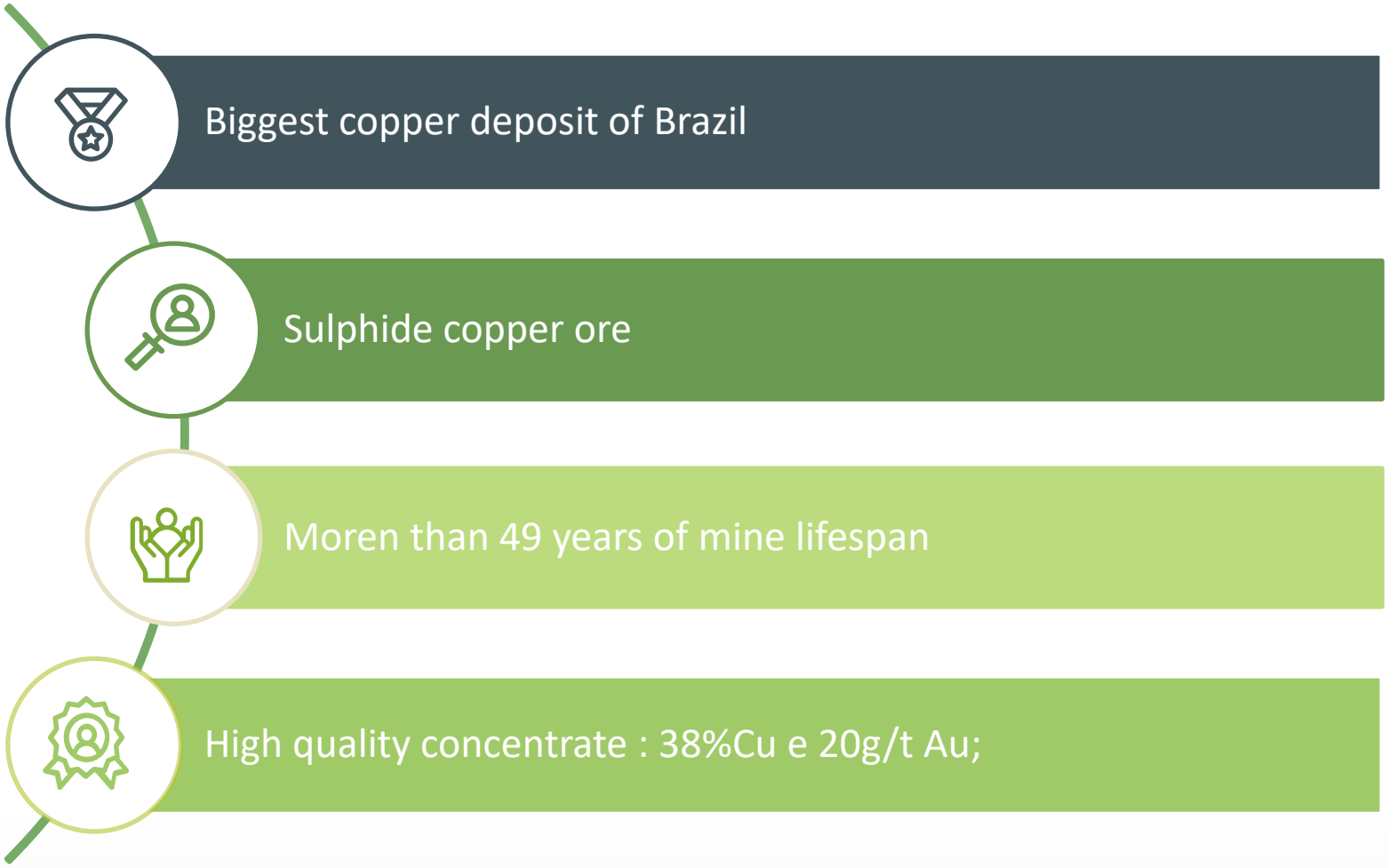
SUMMARY

LOCATION

DISTANCE
Salobo-Parauapebas:
100 km

Location Map - The Salobo operation is located along the Southern margin of the Amazon Basin, Northern central Brazil, in the Southeastern part of the State of Pará

OVERVIEW

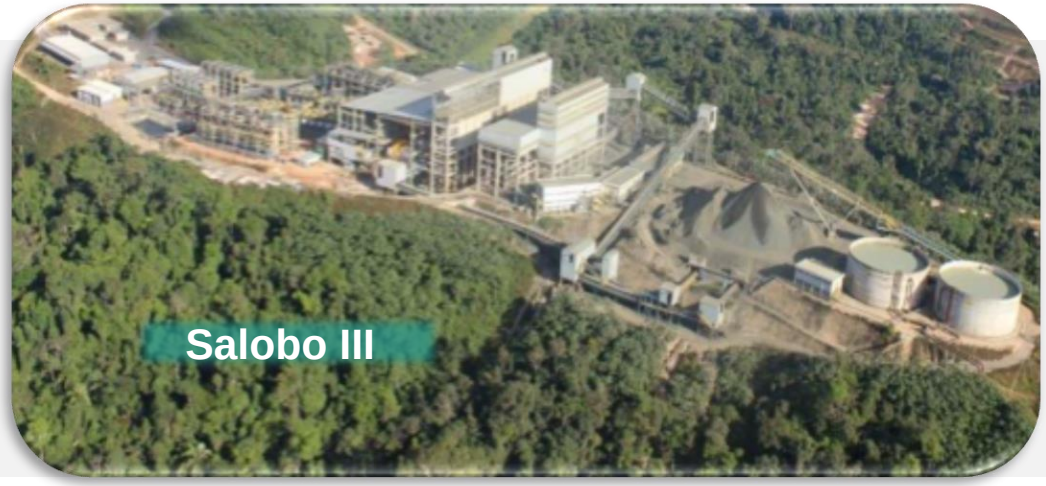

Biggest copper deposit of Brazil
Sulphide copper ore
Moren than 49 years of mine lifespan
High quality concentrate : 38%Cu e 20g/t Au;

SALOBO OPERATION

Salobo I e Salobo II

- Investment: US$4.1Bi
- Start of the operation: 04/2012
- Process capacity : 24Mt/year (SLB I + SLB II)
- Annually average production of 540 thousand of concentrated (Cu)
- Long-term contract for all production sales with anticipated sales for Gold.

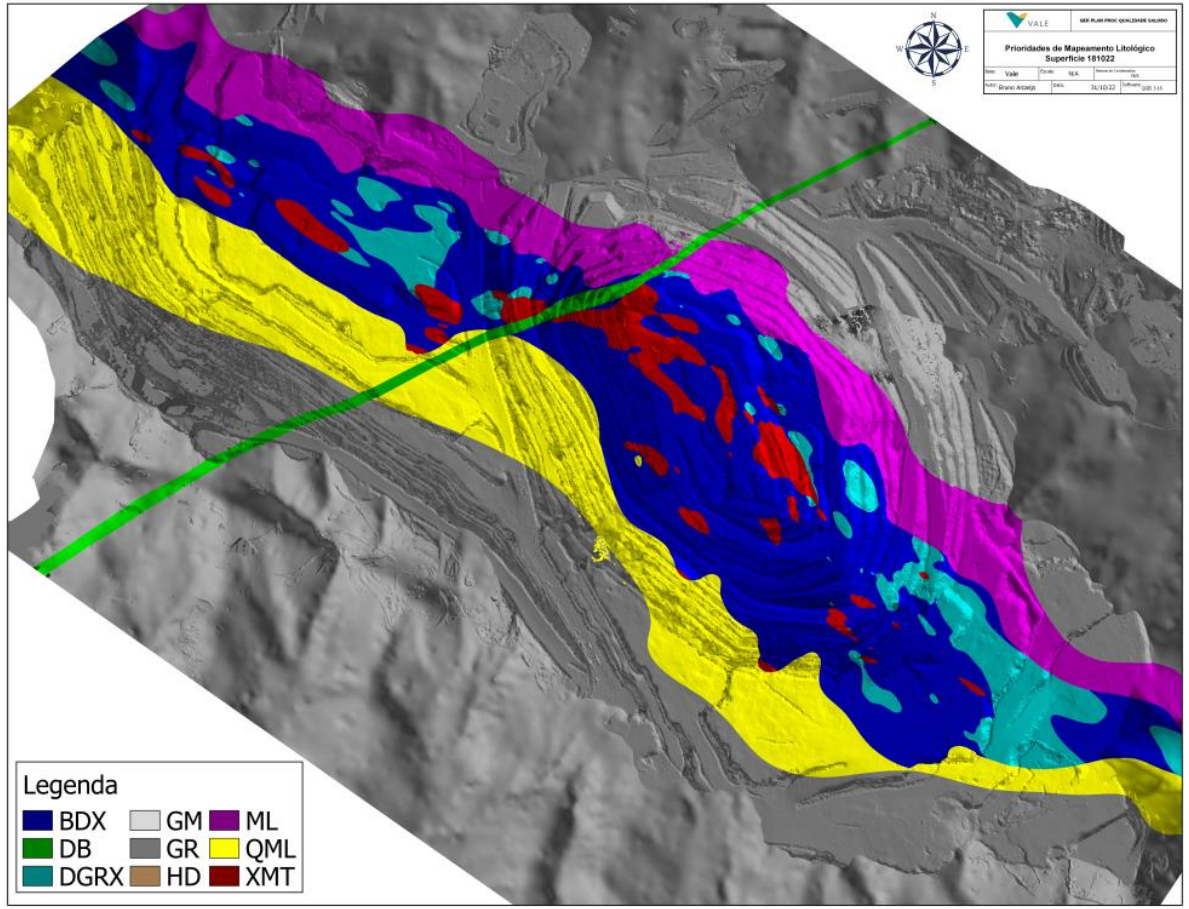
- Vale initiated construction of Salobo III
- Process capacity: 36Mt/year (SLB I + SLB II + SBIII)



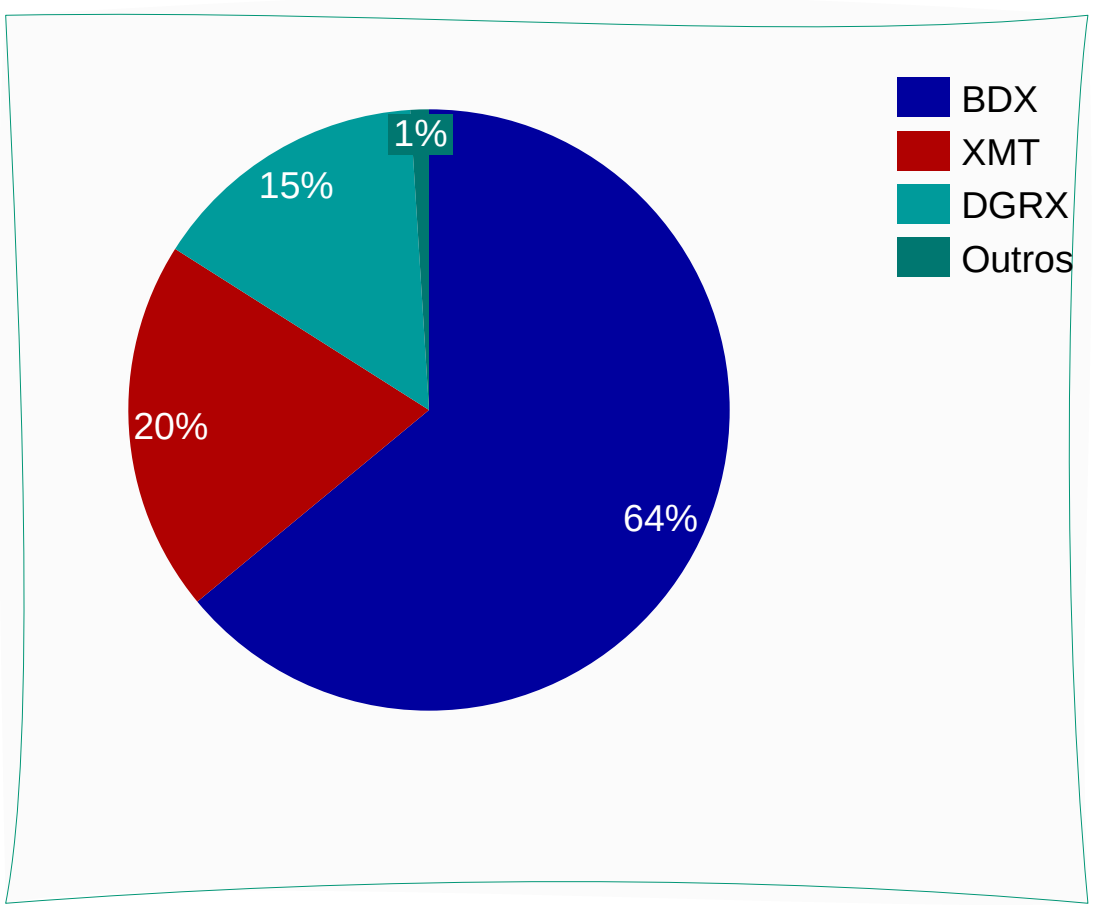
Salobo III

Salobo Deposit

SOLOBO MINE – GEOLOGICAL DOMAINS



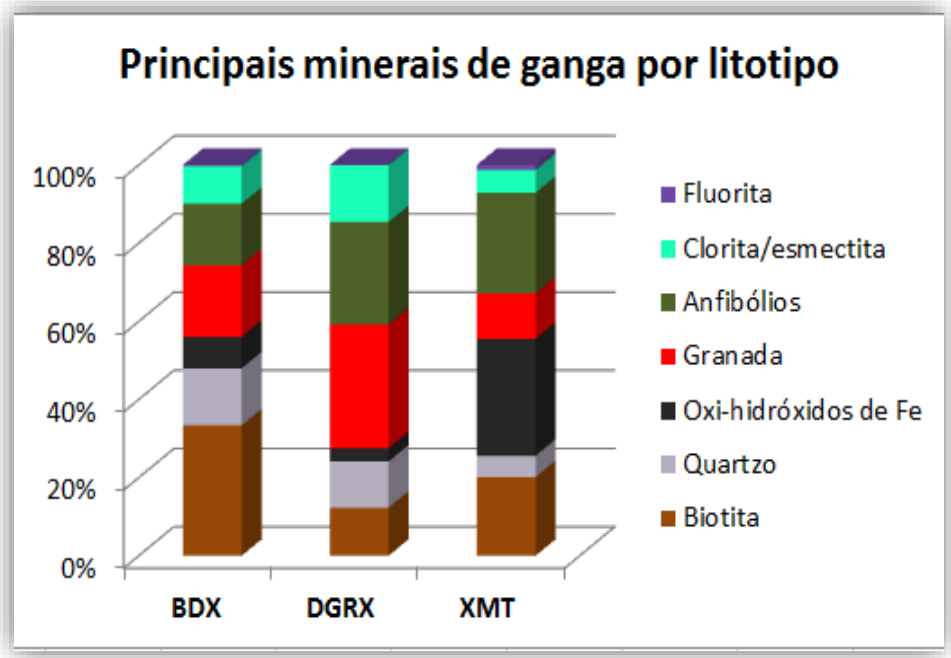
Geological map - Salobo Mine



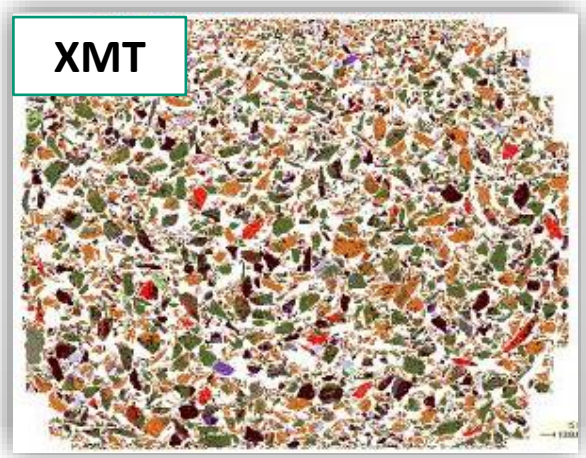
Proportion of geological domains: The major host units are biotite (BDX) , magnetite schists (XMT) and garnet-grunerite schist (DGRX)

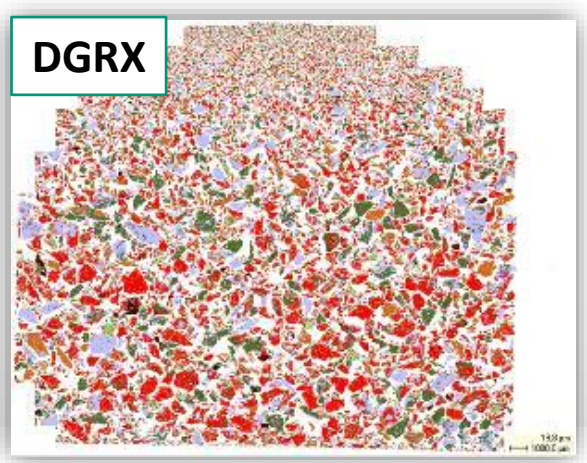
SOLOBO MINE – GEOLOGICAL DOMAINS

BDX	The main minerals arebiotite, quartz, amphibole (mainly grunerite), chlorite, garnet (almandine)
XMT	Amphibole (mainly grunerite), biotite, garnet and magnetite are the main minerals,
DGRX	Garnet dominant, quartz, grunerite, biotite and chlorite.



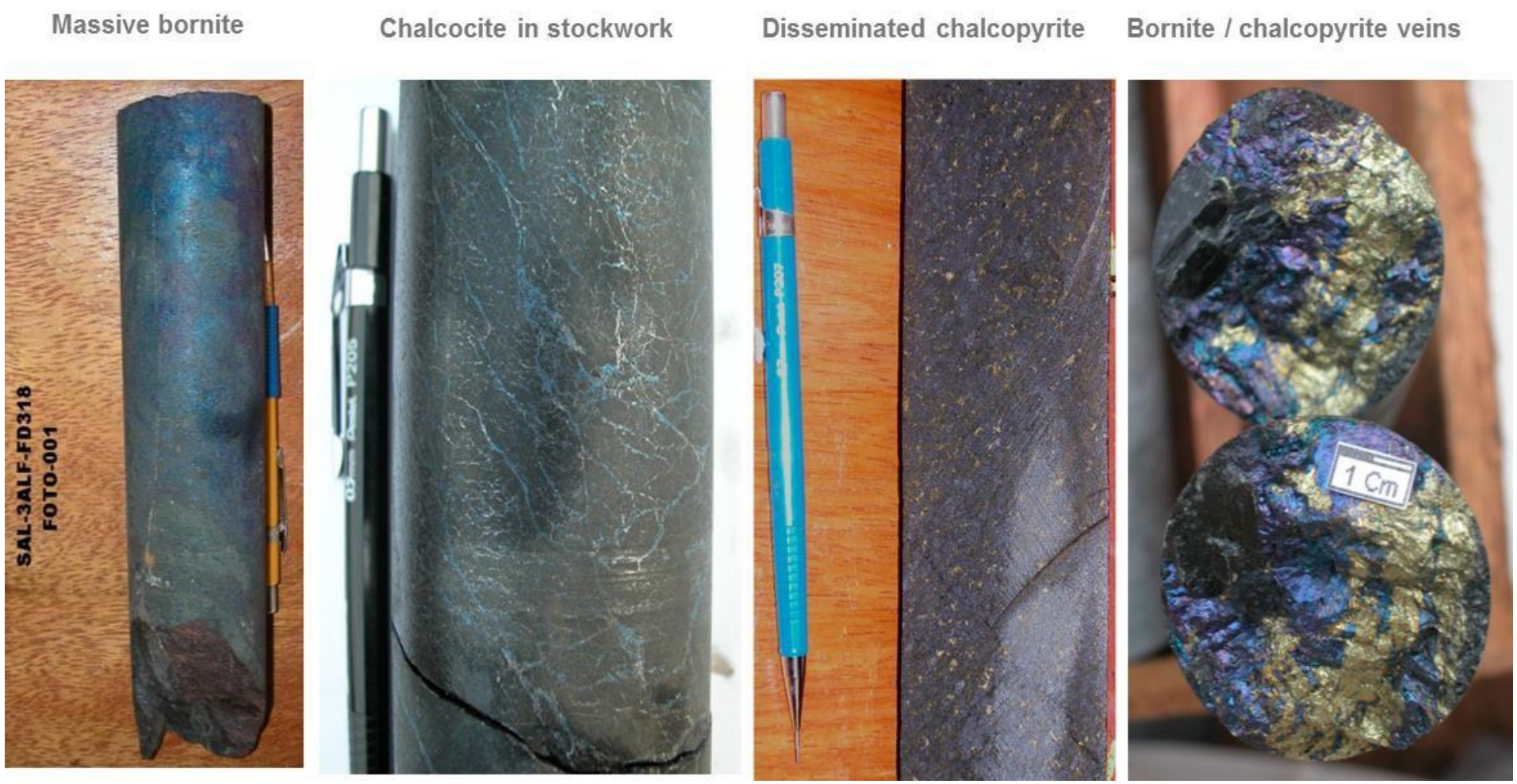
Quantitative evaluation of minerals by SEM





Mineralogical characterization by Qemscan

COPPER MINERALIZATION STYLES AT SALOBO



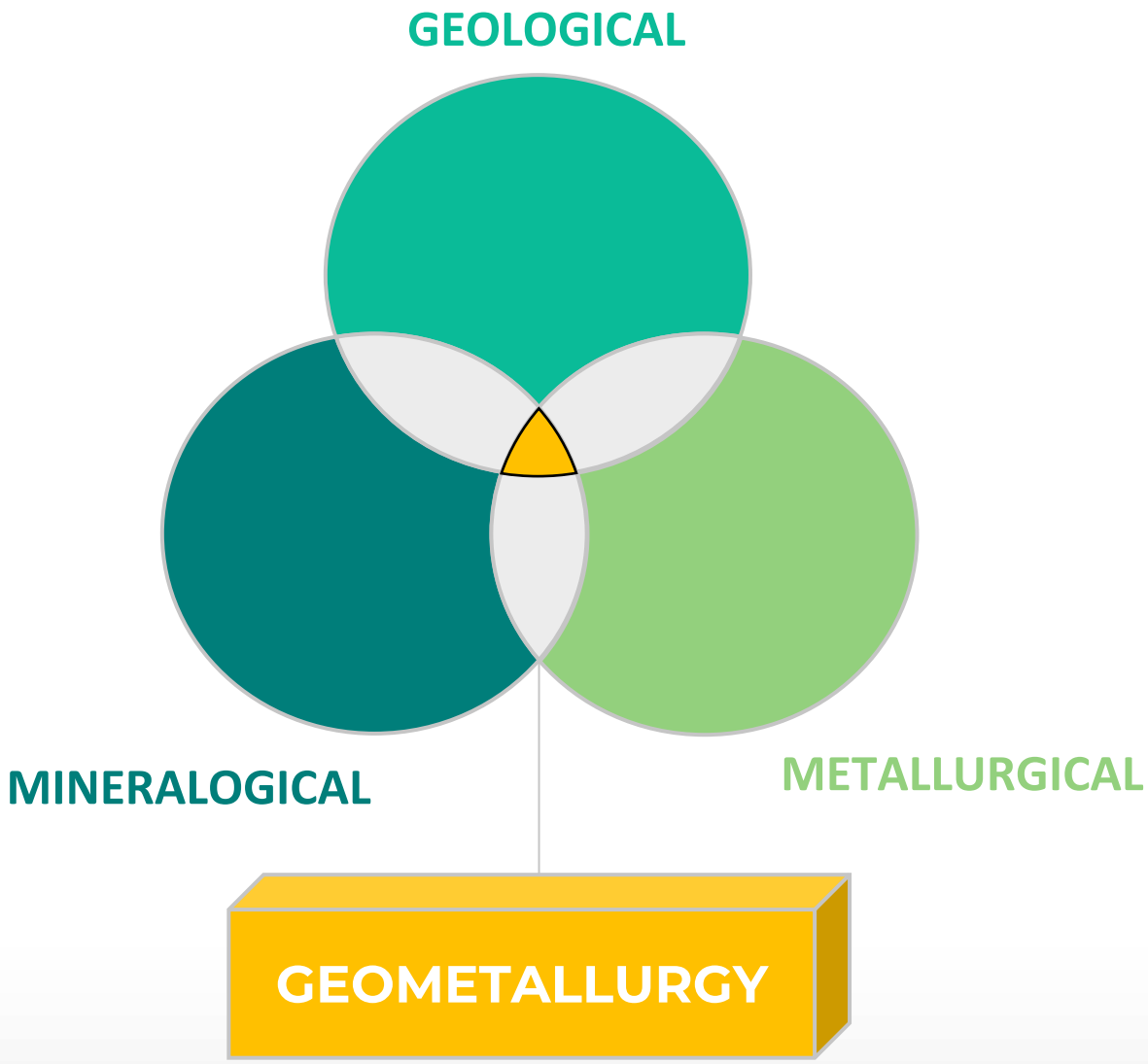
Technical Report (2019)

Copper Mineralization Styles at Salobo

- The mineral assemblages can be found in a number of styles: disseminated, stringers, stockworks,massive accumulations, filling fractures, or in veins associated with local concentrations of magnetite and/or garnet filling the cleavages of amphiboles and platy minerals and remobilized in shear zones. Bornite and chalcocite are the dominant copper sulfides with subordinate chalcopyrite.

Geometallurgy

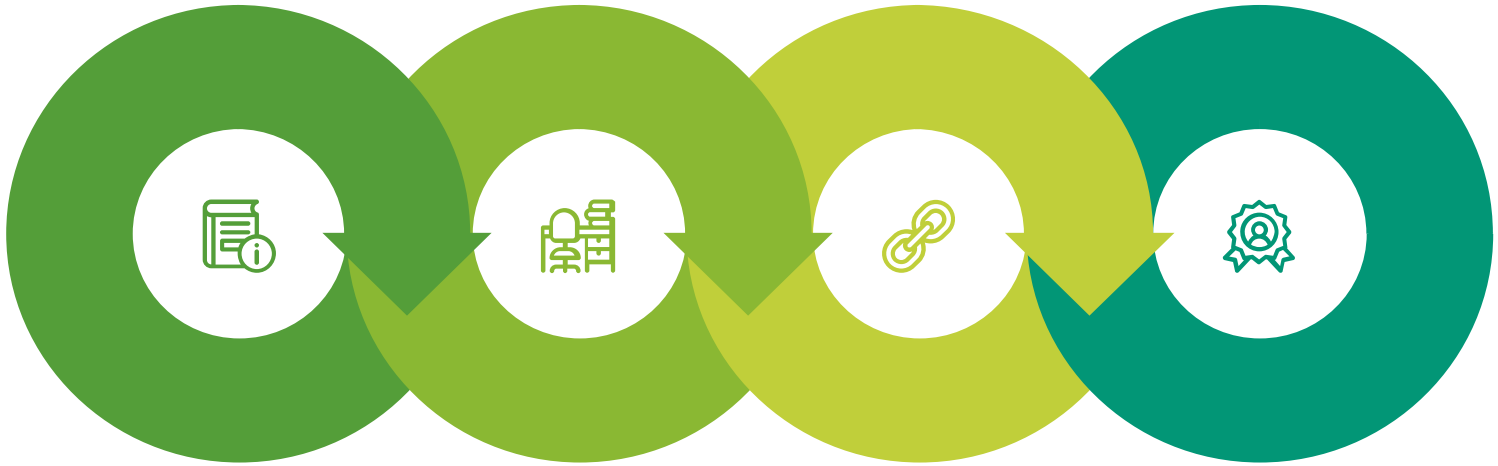
WHAT IS GEOMETALLURGY?



Short term geometallurgical objectives include: **to understand the impact of geological variability on processing activities to guarantee the optimization of the results.** Obtained through an interdisciplinary approach, to identify, correct and prevent processing and quality problems.

The geometallurgical program offers invaluable benefits by providing relevant information and connecting all stakeholders.

MAIN STAGES OF A GEOMETALLURGICAL PROGRAM



TO IDENTIFY

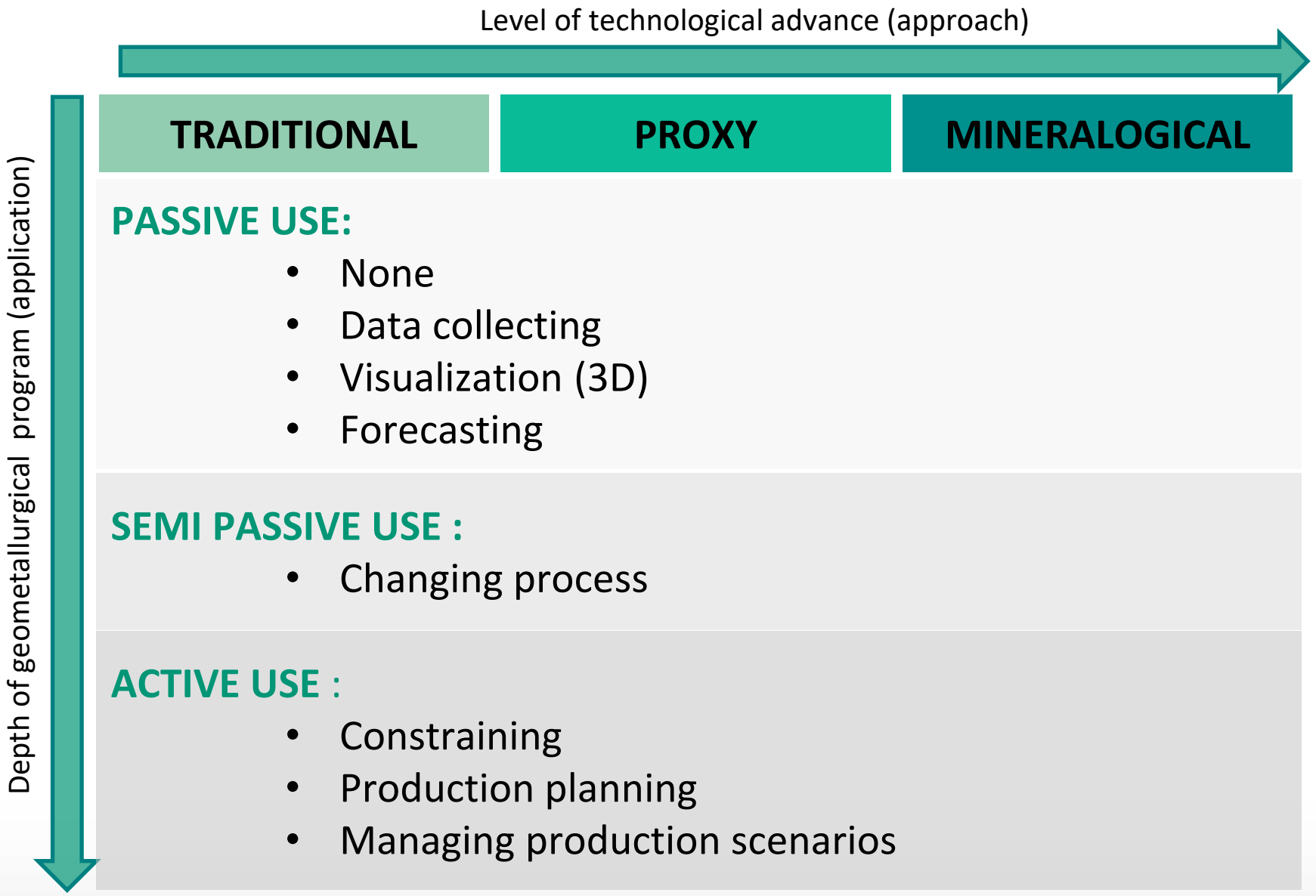
TO CORRECT

TO PREVENT

TO OPTIMIZE

Lishchuk, V,. (2016).

CLASSIFICATION MATRIX

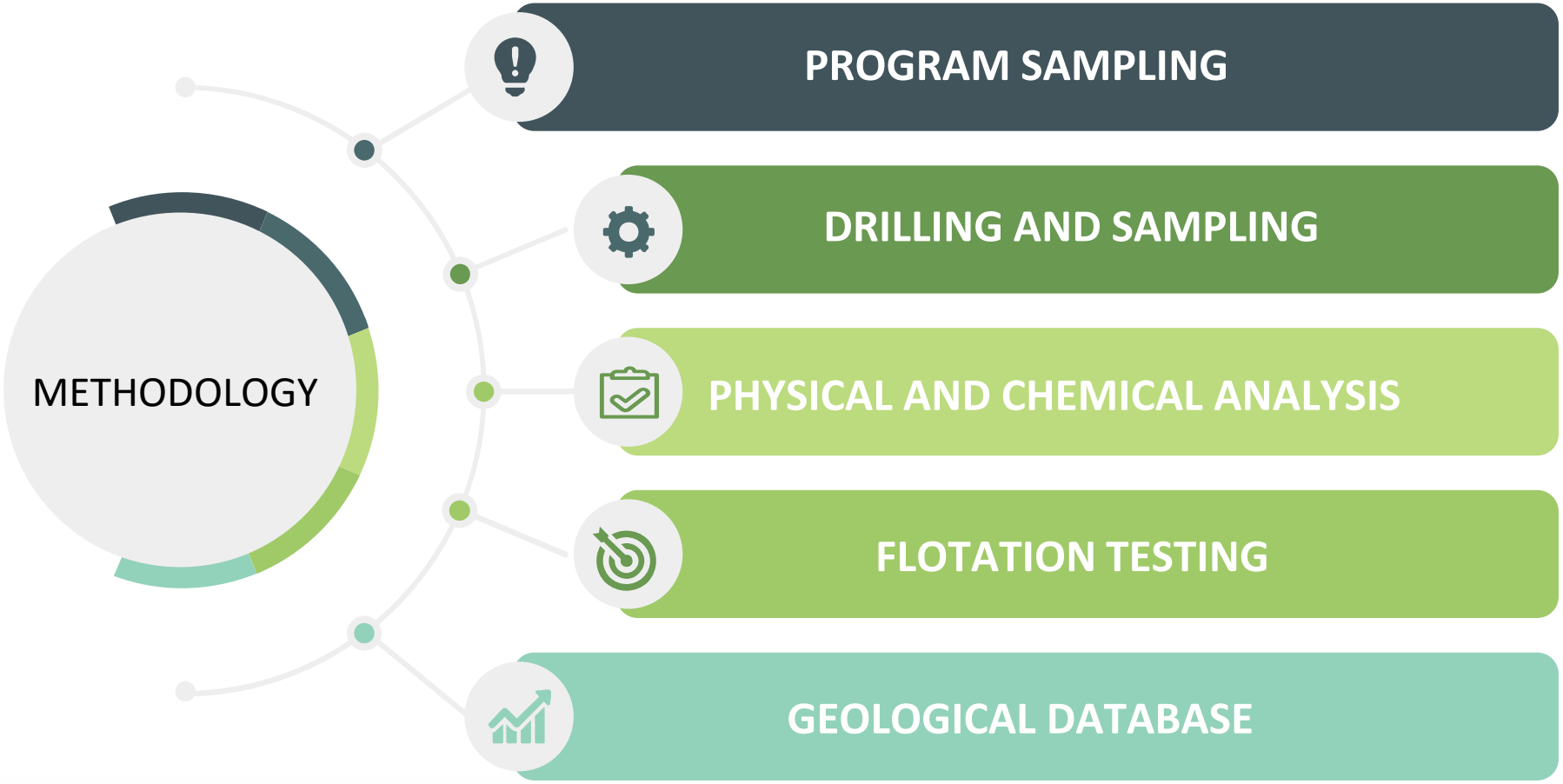


Lishchuk, V., Pettersson, M. (2021).

Classification matrix of the geometallurgical programmes

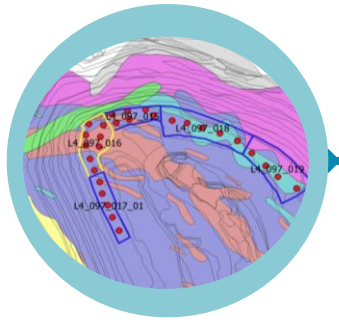
Methodology

GEOMETALLURGY PROGRAM STEPS



PROCEDURE

01



PROGRAM SAMPLING

All ore polygons are sampled. For the planning, the parameters considered are: Cu content (0,3 > ✖ > 1,6) and lithology

02

DRILLING AND SAMPLING

Cross-shaped channels are excavated into the cone and the residual dust is collected from the four exposed section.

03

PHYSICAL AND CHEMICAL ANALYSIS

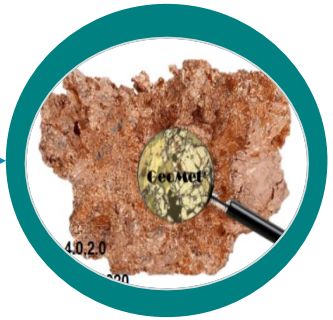
In the physical laboratory, samples are crushed, sieved, homogenized, chemically analyzed and fractionated for the next steps.

04

FLOTATION TESTING

Grinding, granulometry test, flotation and filtering of concentrate and tailings are executed for the samples.

05

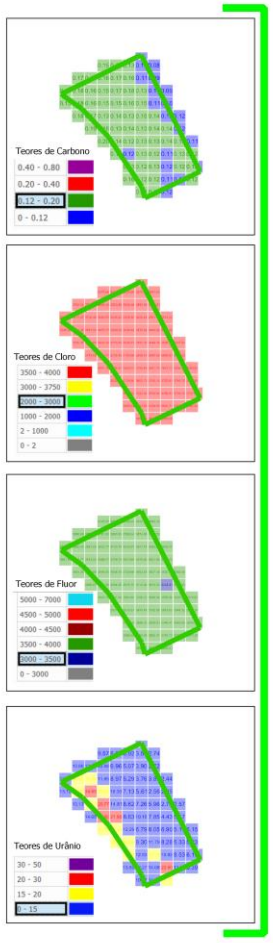


GEOLOGICAL DATABASE

Chemical results and metallurgical variables are validated and stored within the GEOMETAL database.

Results

METALLURGICAL PERFORMANCE OF THE POLYGON

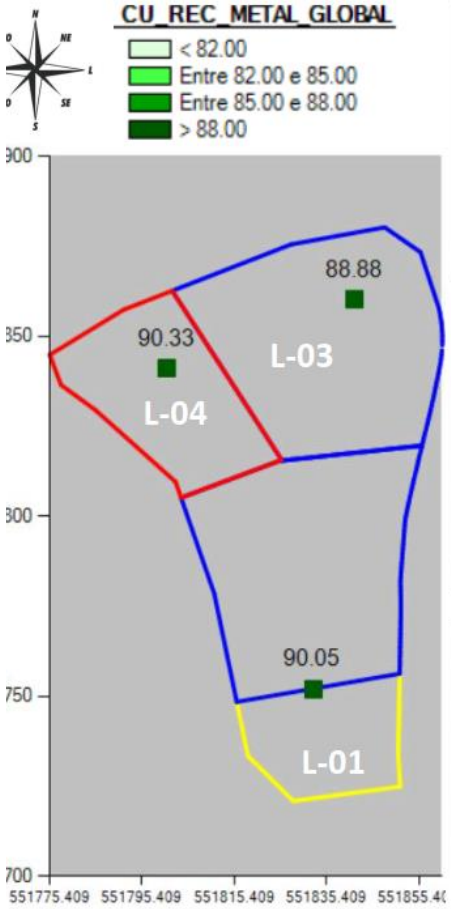


Rockcode: BDX
TONNAGE: 76.17 (x1000)
DENSITY: 3.48
CU: 0.522
AU: 0.241
U: 10.940
CL: 3,668.1
F: 3,735.0
CU_EQ: 0.660
AG: 2.250
L4_097_022L-04/MSMT
C: 0.137

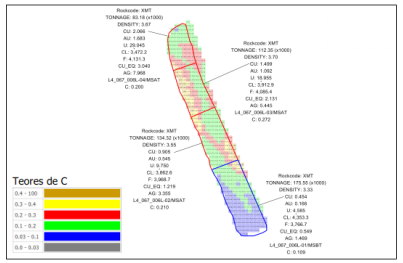
Rockcode: DGRX
TONNAGE: 128.22 (x1000)
DENSITY: 3.22
CU: 0.326
AU: 0.211
U: 3.710
CL: 3,359.5
F: 3,606.5
CU_EQ: 0.446
AG: 1.824
L4_097_022L-03/MSBT
C: 0.088

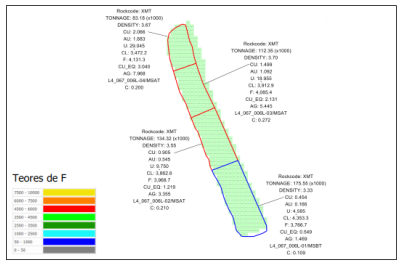
Rockcode: BDX
TONNAGE: 137.55 (x1000)
DENSITY: 3.45
CU: 0.415
AU: 0.173
U: 8.403
CL: 3,599.2
F: 3,734.6
CU_EQ: 0.513
AG: 2.381
L4_097_022L-02/MSBT
C: 0.113

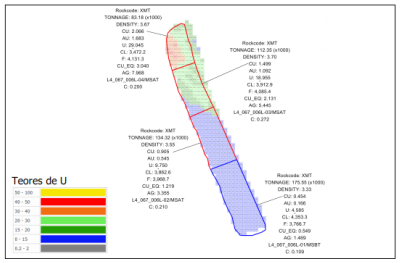
Rockcode: DGRX
TONNAGE: 49.72 (x1000)
DENSITY: 3.49
CU: 0.944
AU: 0.420
U: 15.253
CL: 3,358.8
F: 3,764.9
CU_EQ: 1.186
AG: 3.206
L4_097_022L-01/MSAT
C: 0.247

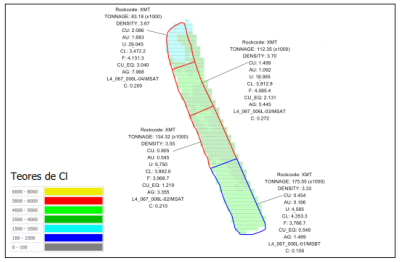


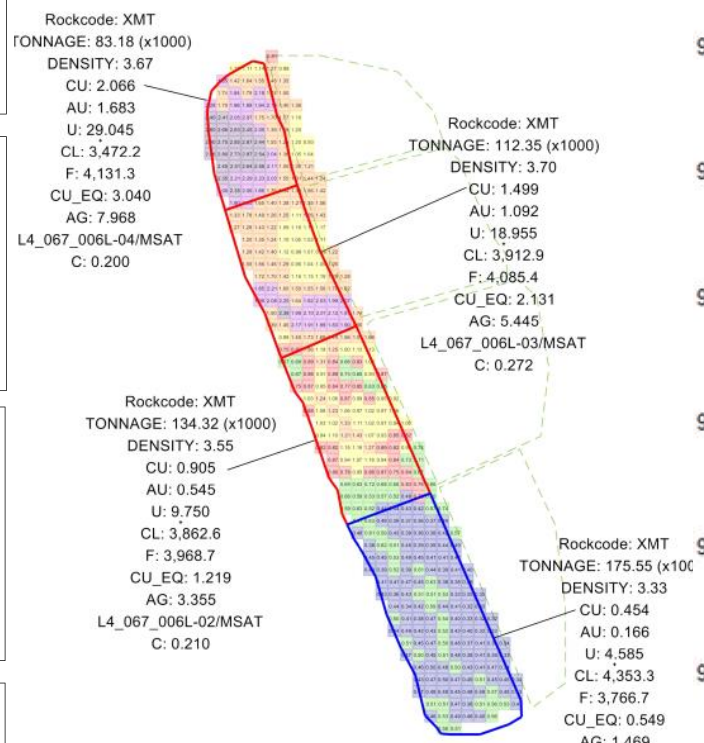
METALLURGICAL PERFORMANCE OF THE POLYGON

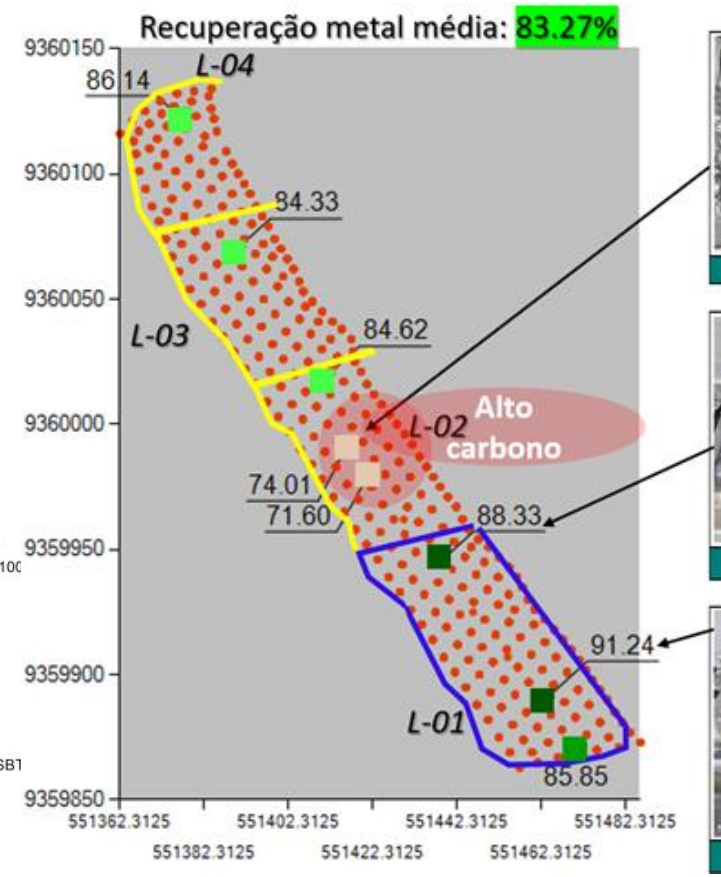


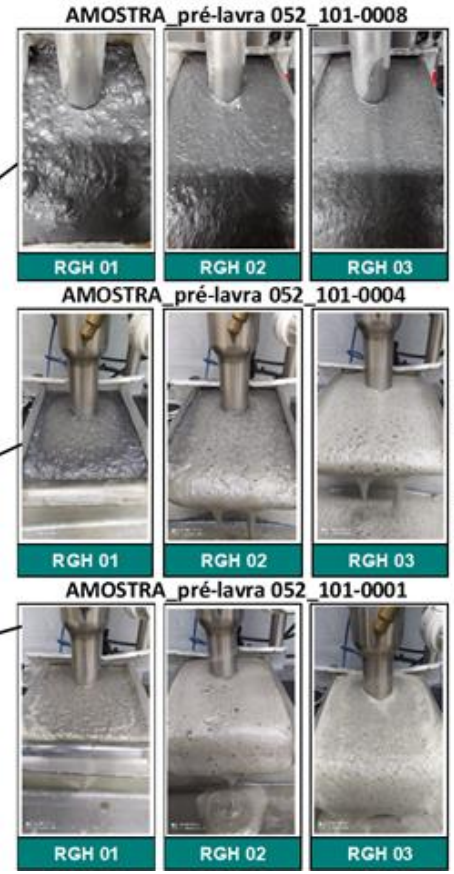








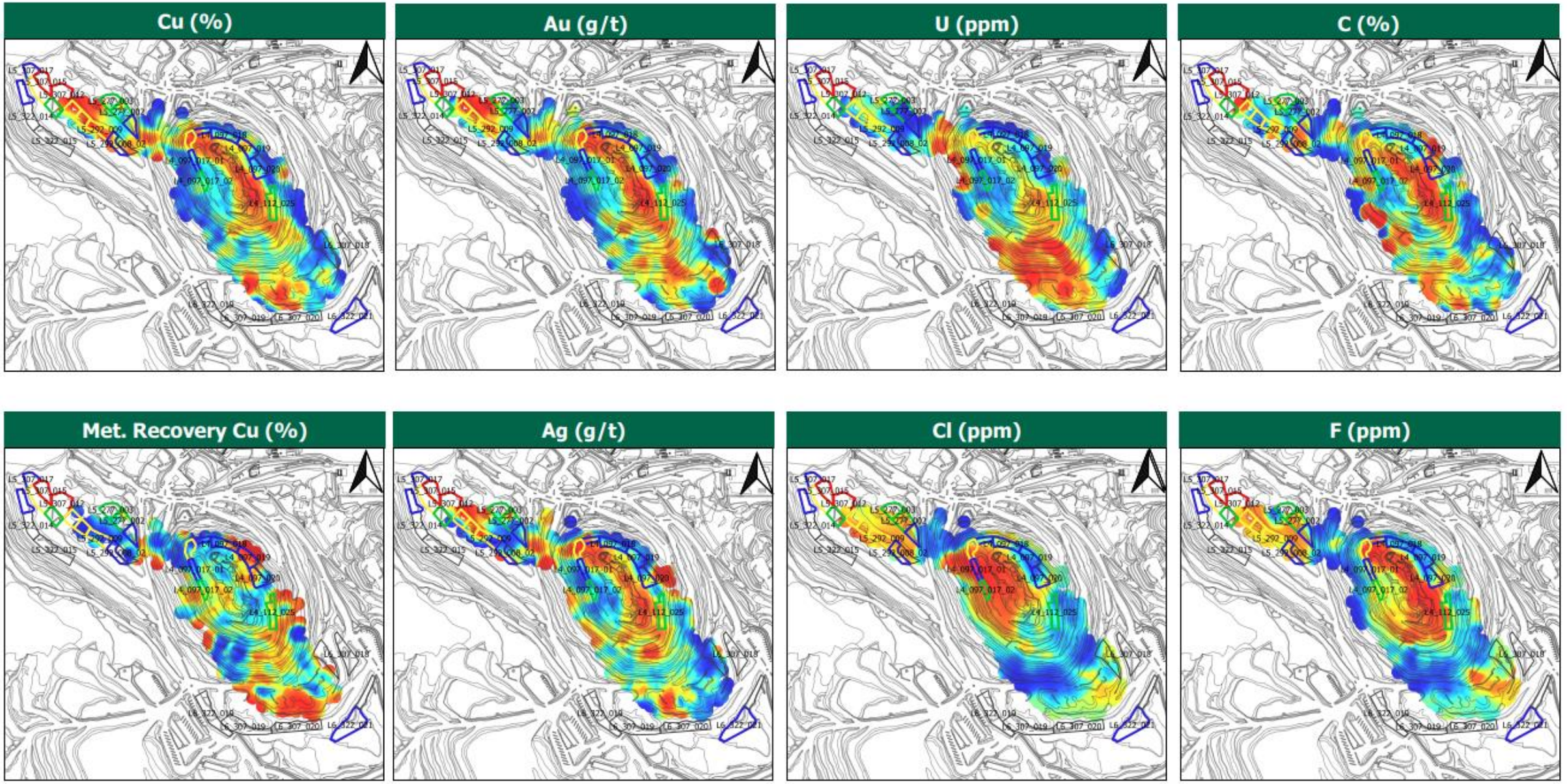




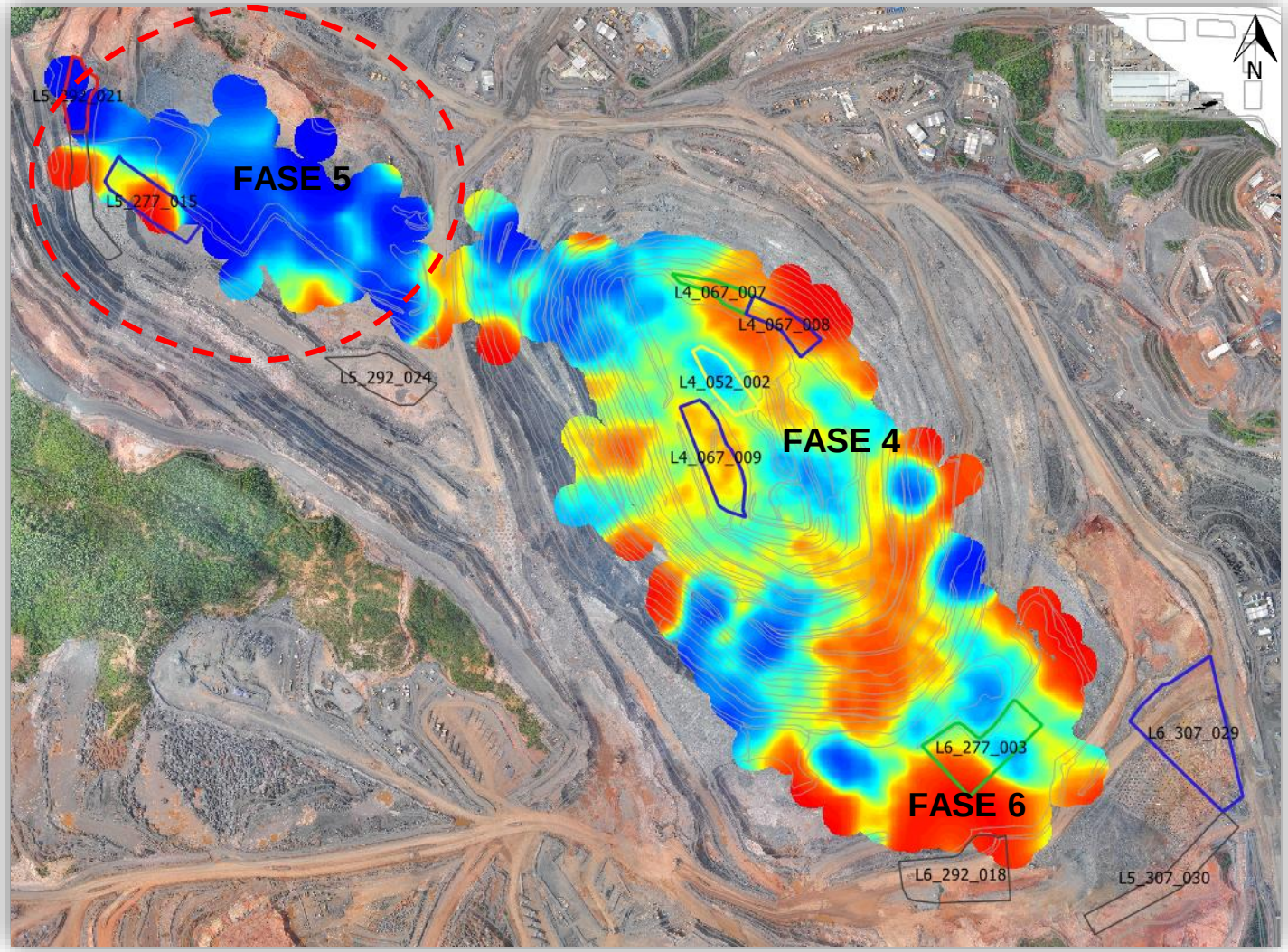
Massa total de 505.400 tons.
Teor do polígono 1,074% Cu.

Rec_metal: *L-01*; **88.47**
Rec_metal: ***L-02***; **76,74**
Rec_metal: *L-03*; **84,33**
Rec_metal: *L-04*; **86,14**

MONTHLY HEAT MAPS



MONTHLY HEAT MAPS



LEGENDA

PL (Teor de Cu - %)

- 0,00 – 0,20
- 0,20 – 0,50
- 0,50 – 0,75
- 0,75 – 0,90
- 0,90 – 1,20
- 1,20 – >

Topografia

Atualização 30/09/2022

Mapa Calor (Rec. Met. Glob)

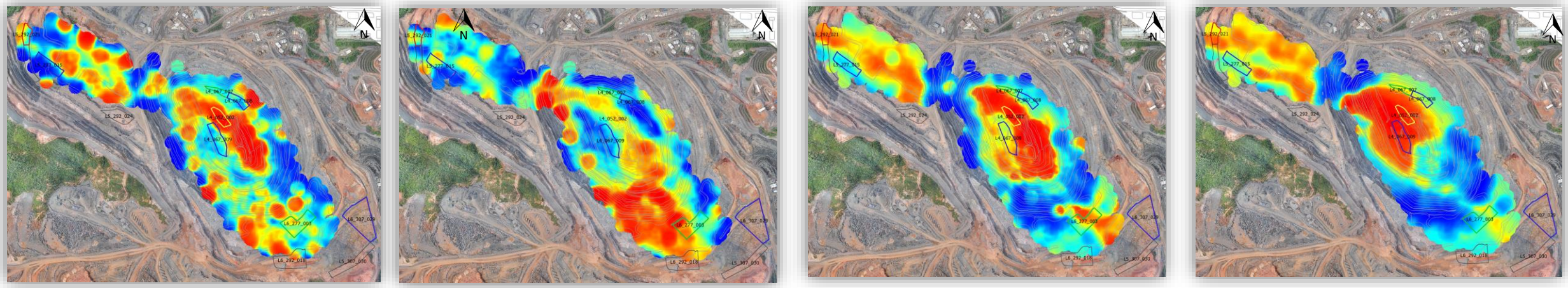
95.14
89.88
88.59
87.79
87.16
86.5
85.62
84.4
82.51
61.22
CU_REC_MET

Copper metallurgical recovery

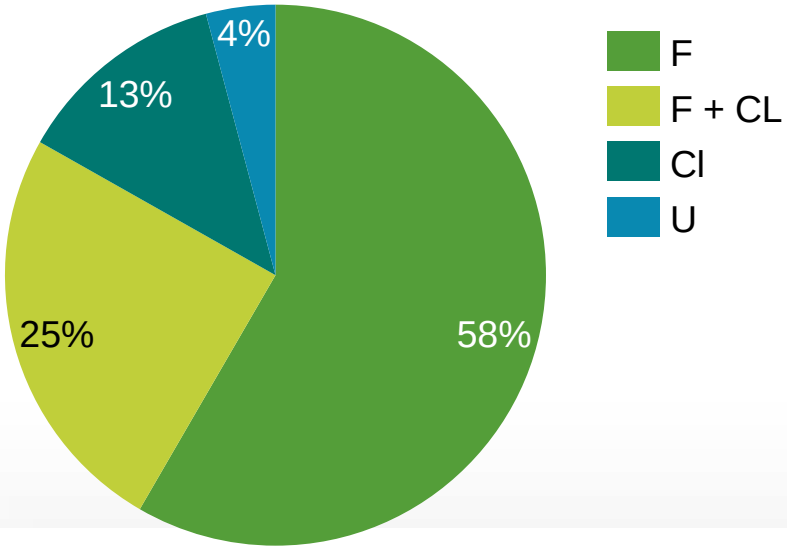
- Phase 5 has the lowest copper metallurgical recovery (less than 86%)
- We combine polygons from different phases and the polygons are used to feed the plants

MONTHLY HEAT MAPS - DELETERIOUS

Carbon	Uranium	Fluorine	Chlorine



Heat map of deleterious elements



Proportion of deleterious elements that we paid financial penalties in the last 4 years

- **Implications:**

✓ **Operational:** Carbon impacts plant operation (saturation of filter fabrics and flotation overflows).

There are three deleterious elements of potential concern in the copper concentrate, named: fluorine, chlorine and uranium. Of these, fluorine is the most significant.

✓ **Financial:** F, C, U: We pay penalties (>$40 Mi since 2019)

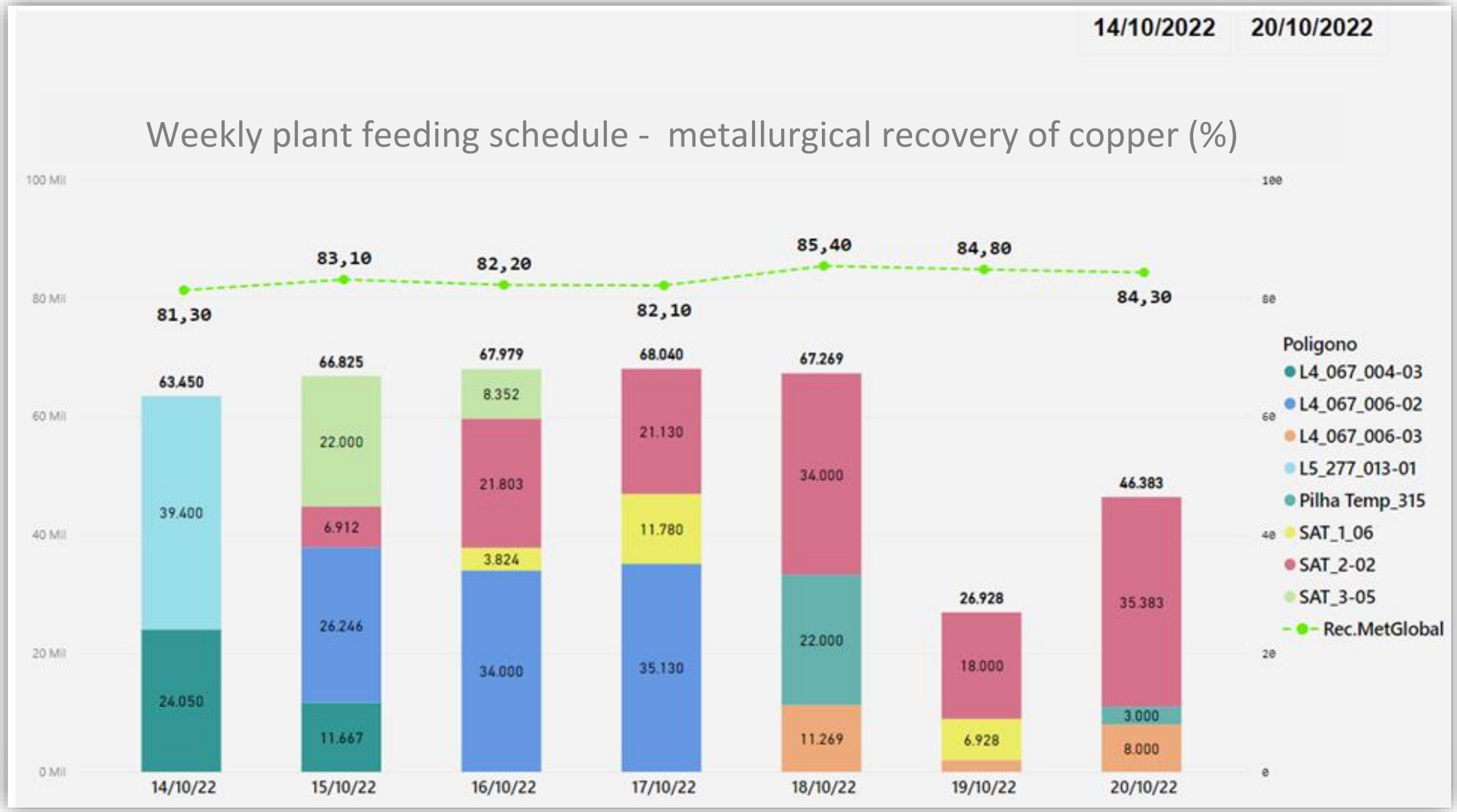
✓ **Environmental:** U, if not managed, can cause environmental damage

WEEKLY PLANT FEEDING SCHEDULE

OUTUBRO	Polígono	Massa (Kt)	Cu %	Au (ppm)	F (ppm)	Cl (ppm)	C%	U (ppm)	Rec. Met. Cu (%)
28-out	L3_052_001-01	14,599.00	0.67	0.41	3,927.00	4,129.00	0.19	12.00	86.60
	L5_277_014-01	51,900.00	0.97	0.41	3,734.00	3,397.00	0.15	13.50	87.79
	Total do dia	**66,499.00**	**0.90**	**0.41**	**3,776.37**	**3,557.70**	**0.16**	**13.17**	**87.6%**
29-out	SAT_2-02	22,000.00	0.77	0.30	2,965.95	2,251.46	0.13	23.96	86.73
	L5_277_014-01	45,628.00	0.97	0.41	3,734.00	3,397.00	0.15	13.50	87.79
	Total do dia	**67,628.00**	**0.90**	**0.37**	**3,484.15**	**3,024.35**	**0.14**	**16.90**	**87.5%**
30-out	SAT_2-02	22,000.00	0.77	0.30	2,965.95	2,251.46	0.13	23.96	86.73
	L5_277_014-01	45,628.00	0.97	0.41	3,734.00	3,397.00	0.15	13.50	87.79
	Total do dia	**67,628.00**	**0.90**	**0.37**	**3,484.15**	**3,024.35**	**0.14**	**16.90**	**87.5%**
31-out	SAT_2-02	21,371.00	0.77	0.30	2,965.95	2,251.46	0.13	23.96	86.73
	L5_277_014-01	45,128.00	0.97	0.41	3,734.00	3,397.00	0.15	13.50	87.79
	Total do dia	**66,499.00**	**0.91**	**0.37**	**3,487.17**	**3,028.85**	**0.14**	**16.86**	**87.5%**
1-nov	SAT_2-02	11,371.00	0.77	0.30	2,965.95	2,251.46	0.13	23.96	86.73
	L4_067_004-03	5,000.00	0.60	0.39	4,023.00	4,359.00	0.34	7.30	83.14
	L4_067_004-06	5,000.00	0.66	0.40	3,965.00	4,344.00	0.27	10.70	88.78
	L5_277_014-01	45,629.00	0.97	0.41	3,734.00	3,397.00	0.15	13.50	87.79
	Total do dia	**67,000.00**	**0.88**	**0.39**	**3,642.46**	**3,345.05**	**0.17**	**14.60**	**87.5%**
2-nov	SAT_2-02	11,371.00	0.77	0.30	2,965.95	2,251.46	0.13	23.96	86.73
	L4_067_004-03	5,000.00	0.60	0.39	4,023.00	4,359.00	0.34	7.30	83.14
	L4_067_004-06	5,000.00	0.66	0.40	3,965.00	4,344.00	0.27	10.70	88.78
	L5_277_014-01	45,629.00	0.97	0.41	3,734.00	3,397.00	0.15	13.50	87.79
	Total do dia	**67,000.00**	**0.88**	**0.39**	**3,642.46**	**3,345.05**	**0.17**	**14.60**	**87.5%**
3-nov	SAT_2-02	11,371.00	0.77	0.30	2,965.95	2,251.46	0.13	23.96	86.73
	L4_067_004-03	5,000.00	0.60	0.39	4,023.00	4,359.00	0.34	7.30	83.14
	L4_067_004-06	5,000.00	0.66	0.40	3,965.00	4,344.00	0.27	10.70	88.78
	L5_277_014-01	45,629.00	0.97	0.41	3,734.00	3,397.00	0.15	13.50	87.79
	Total do dia	**67,000.00**	**0.88**	**0.39**	**3,642.46**	**3,345.05**	**0.17**	**14.60**	**87.5%**
	Totalda semana	**469,254.00**	**0.90**						**87.5%**

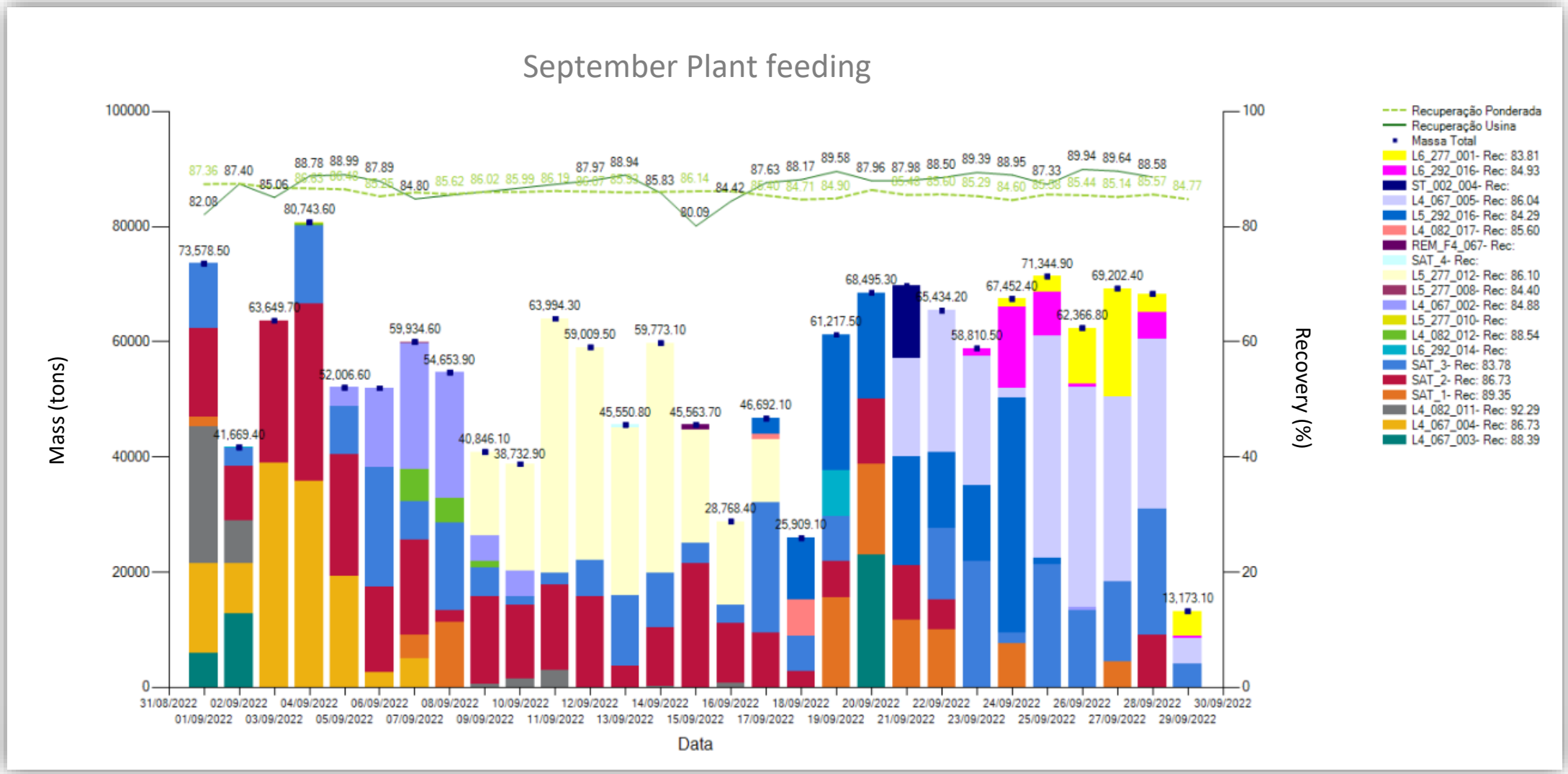
Limit	
F (ppm)	6700
Cl (ppm)	3750
C (%)	0.17
U (ppm)	15

WEEKLY PLANT FEEDING SCHEDULE

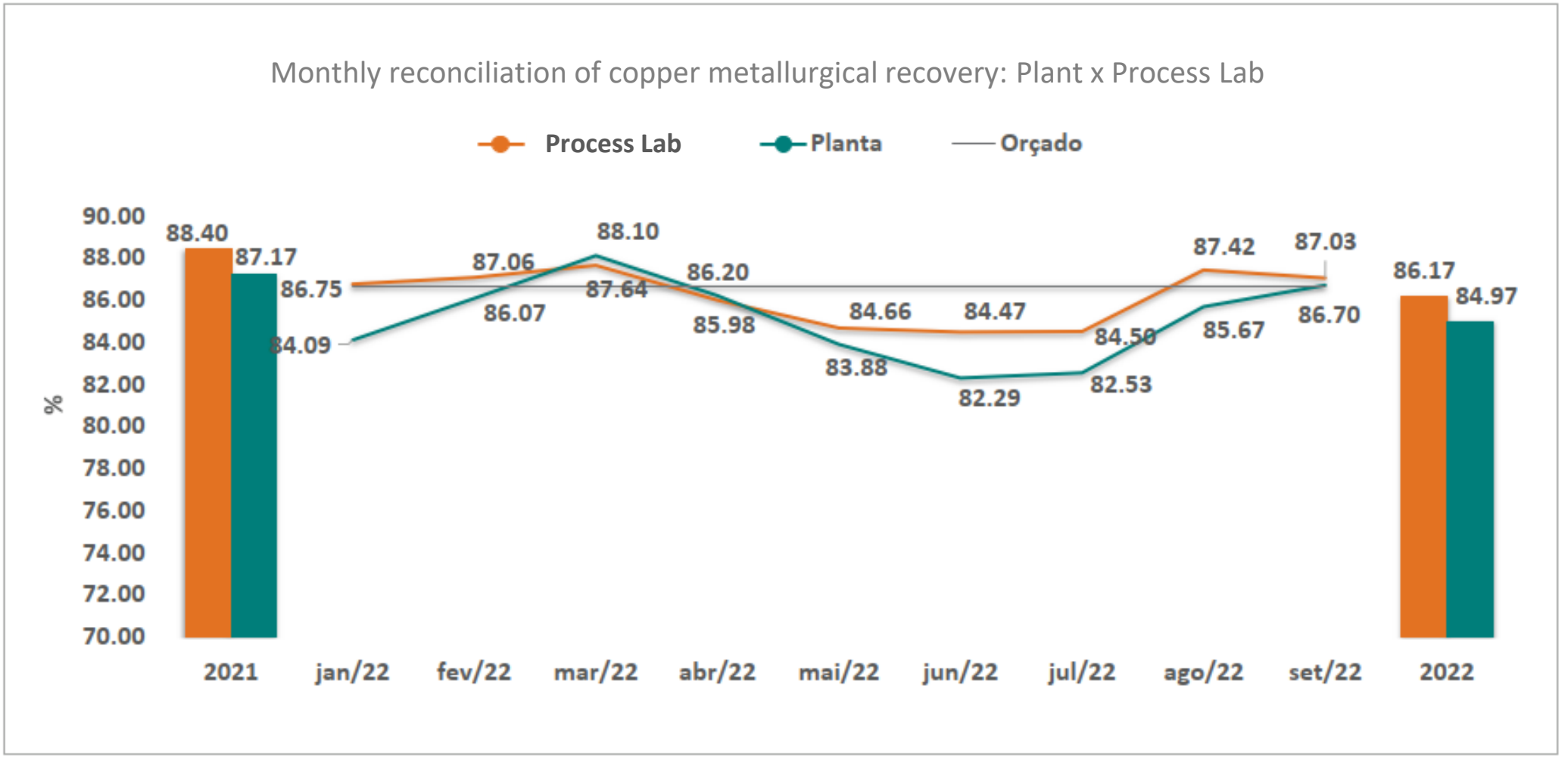


Reconciliation

DAILY METALLURGICAL RECOVERY (PLANT VS LABORATORY)



RECONCILIATION OF COPPER METALLURGICAL RECOVERY (PLANT VS LABORATORY)



Monthly reconciliation of copper metallurgical recovery

Conclusions

CONCLUSIONS

- Tests were produced to represent more finely the plant development;
- Better understanding of the geometallurgical performance within each area of the mine;
- Opportunity to improve the geometallurgical performance of the plant, based on the laboratory tests/samples observations;
- Integration within geology, mine planning, process and production areas;
- Better technical basement for the Salobo production plans..

REFERENCE

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2. Lishchuk, V., Pettersson, M. (2021). The mechanisms of decision-making when applying geometallurgical approach to the mining industry. *Miner Econ* 34, 71–80

3. Neil Burns, P.Geo., Chris Gauld, P.Geo Marcos Dias Alvim, P.Geo., FAusIMM(CP),Maurice Tagami, P.Eng (2019). Technical Report – Salobo IIIExpansion - Salobo Copper-Gold Mine -Carajás, Pará State, Brazil.

4. Relatório Interno: Equipe de Geometalurgia, 2015: Projeto de Geometalurgia, Mina do Salobo.

5. Relatório Interno: Diretoria de Exploração e Projetos Minerais e Diretoria de Metais Básicos Atlântico Sul (2021): Mapeamento e modelamento geometalúrgico de longo Prazo para Mina de Salobo

THANK YOU!

#SIMEXMIN2022