

DESWIK
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2018





VALE

Carajas - Integrated Multimine Scheduling using Deswik Tools





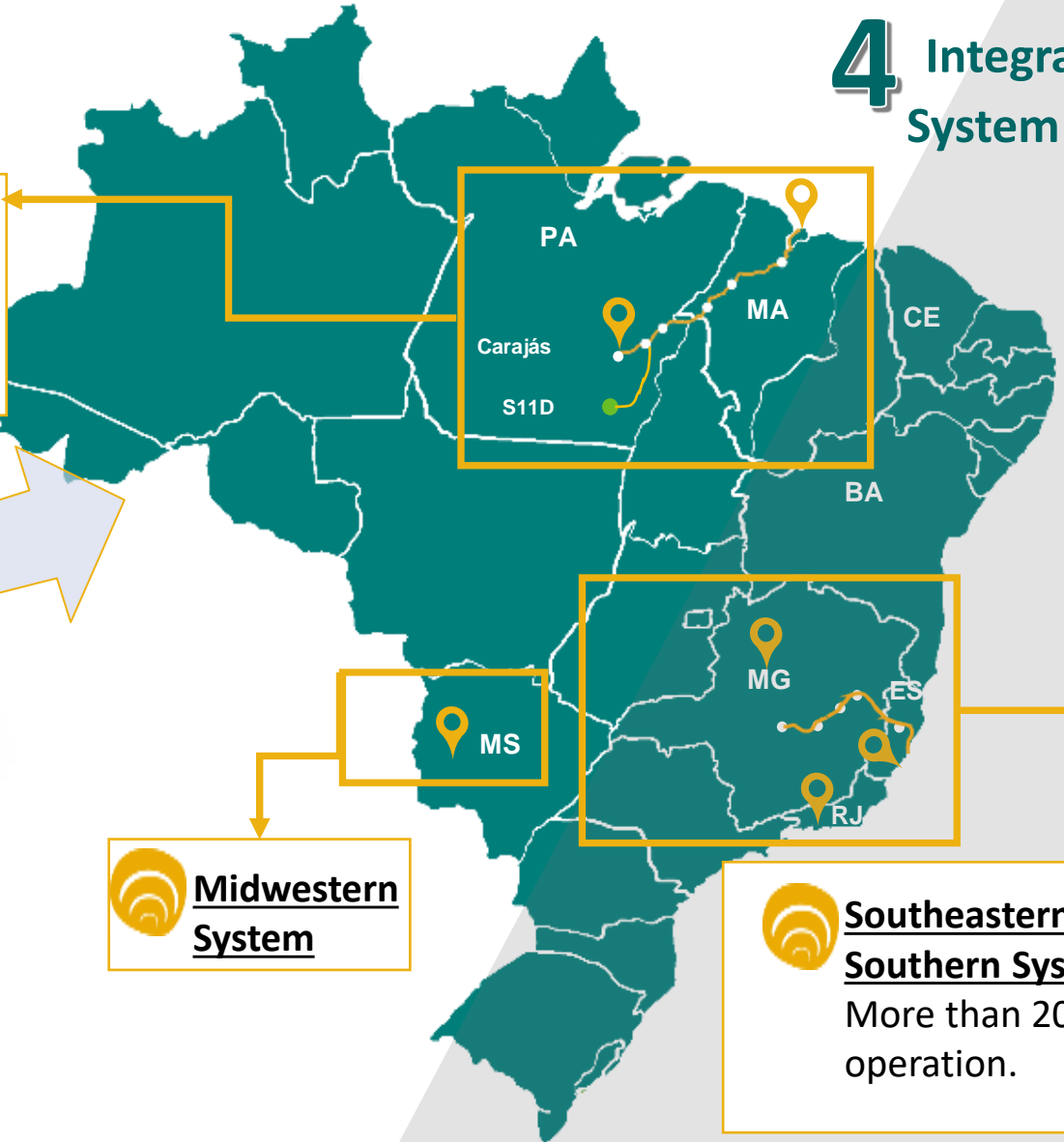
Bruno Gadelha

Date: 11/6/2018

OVERVIEW – Vale’s Iron Ore




 **Northern System:**
Carajás, S11D.
 Best Quality Ore



4 Integrated Ore System in Brazil

 **Midwestern System**

 **Southeastern and Southern System:**
More than 20 mines in operation.

OVERVIEW – Northern System

Pará and Maranhão are strategic for Vale, given the importance of their mineral resources and logistics capacity



OVERVIEW – Northern System



Ore Production Areas

The Iron Ore Geological Reserves in Northern System total 6,622 million tons, divided into:

North Range: 2,169 Mt
East Range: 258 Mt
South Range: 4,195 Mt

*Form 20-F Vale 2017

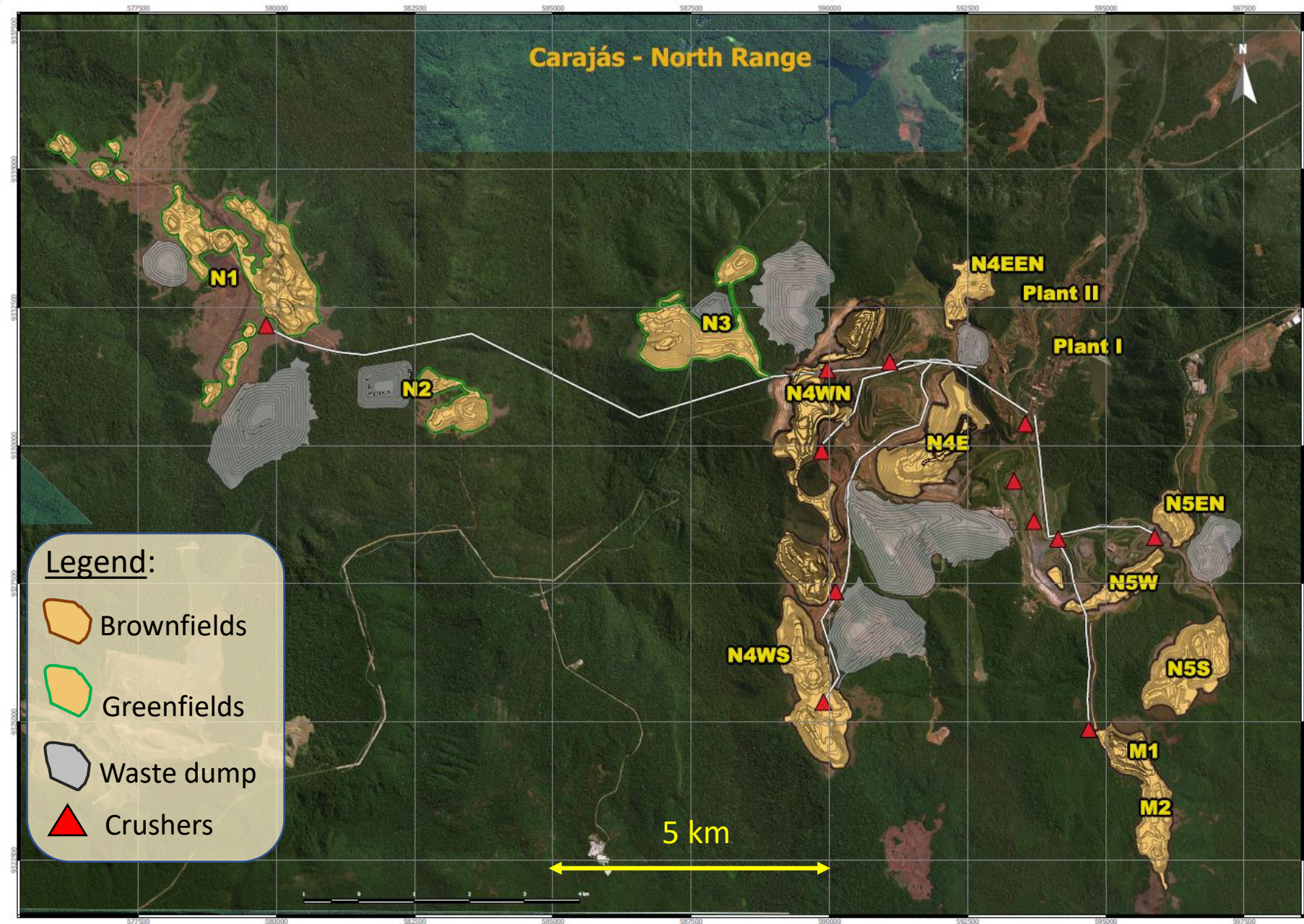


OVERVIEW – Carajás: North Range

Carajás's North Range:

There are currently 6 mines with 8 bottom pits operating simultaneously to feed 3 plants and producing around 140 Mtpy (ROM).

Until 2025 there will be 10 mines in full integrated operation.



Deswik.CAD



Deswik.IS



Deswik.Sched



Deswik.Blender



Deswik.LHS



How to do a life of mine plan (LOMP) controlling a huge mining complex with:

- 5 Block models: Over 9.5 millions blocks (*25x25m*)
- 12 Integrated mines
- 74 Stages
- 3 Plants
- 11 Crushers
- 4 Conveyors Systems
- 9 Waste Dumps



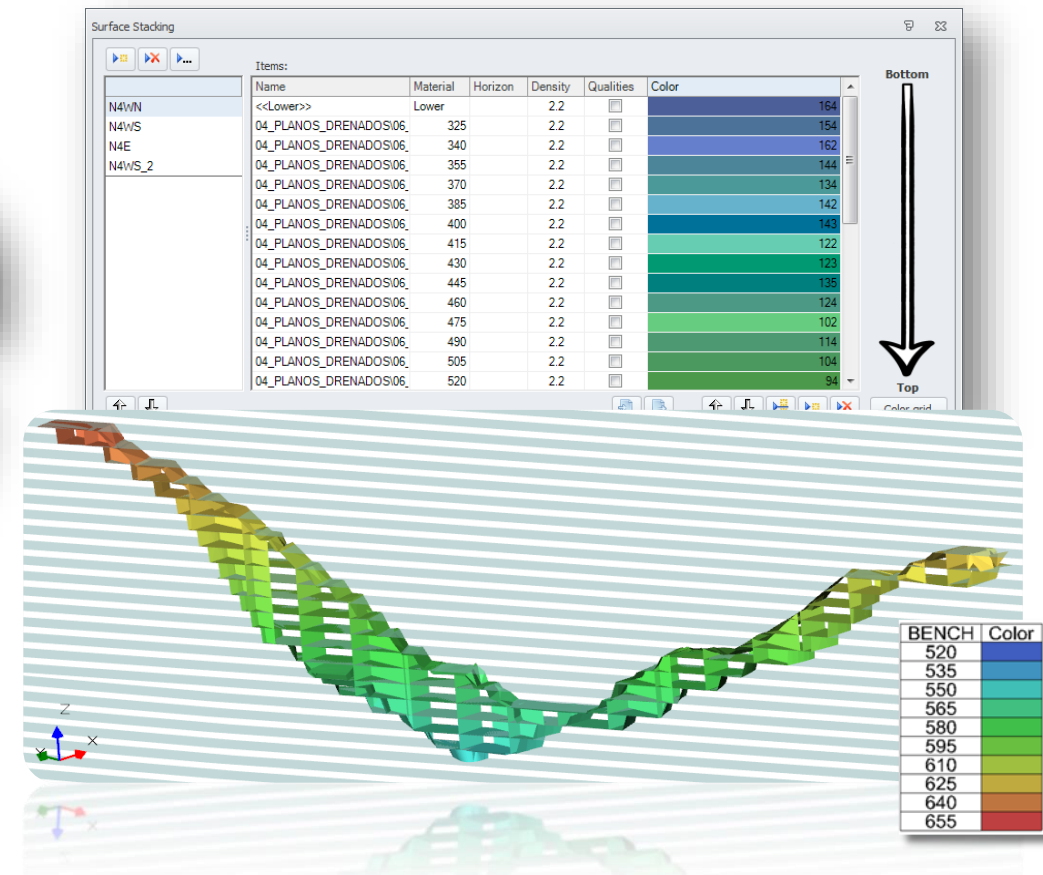
Carajás is a big rainforest with high rainfall rates. Therefore, each mine has the detailed and specific drainage operational plans.

- Pit Design of **74 Stages** following the operational drainage plans of each mine.
- Creation and organization of drainage plans in rules per mine (**Surface Stacking**).
- Use **Surface Stacking rules** to perform solid bench cutting.
- Creation Over **50.000** tasks solids (50x50m)

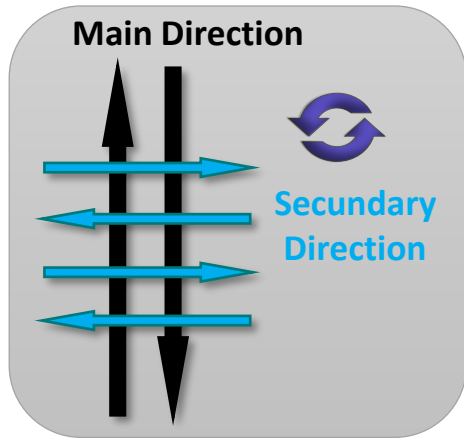


Control of Drainage

Cut benches solids by Drainage Surfaces



IS – Priorities and Dependencies

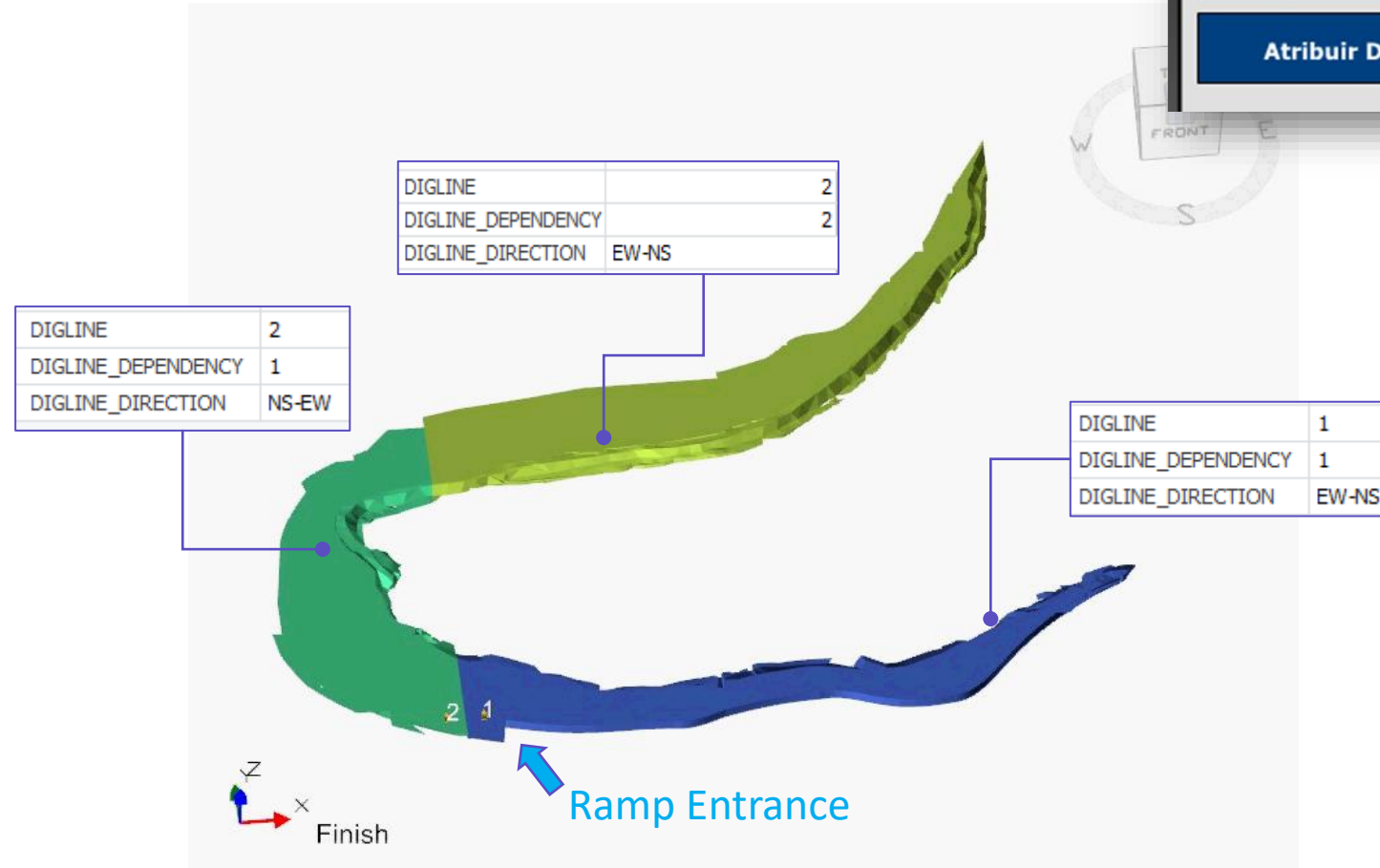


The dependency rule **MINING DIRECTION** was created for tasks when the scheduling using the RAMP PRIORITY (Radius Search) attribute results in a non operational plan, e.g: **Horseshoe** shape Bench.



MINING DIRECTION Attributes:

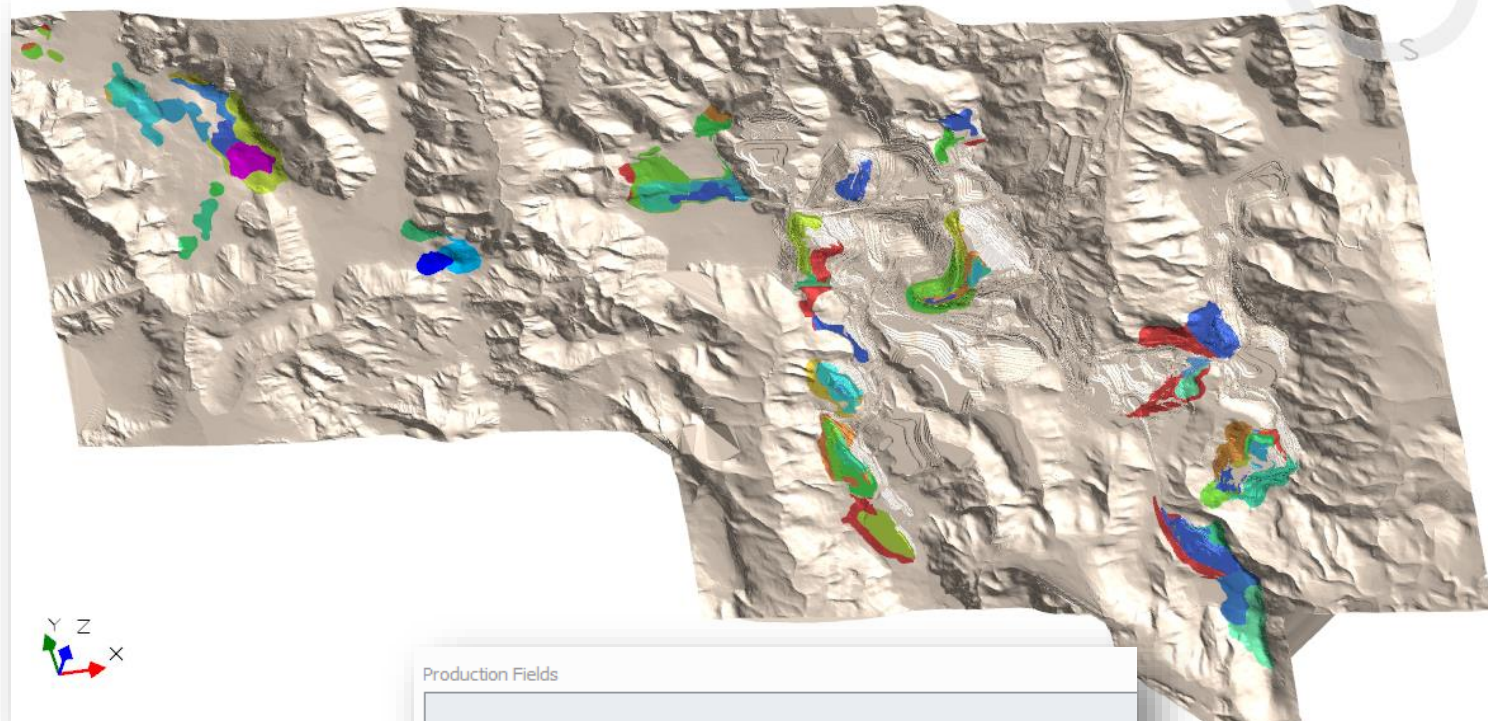
- **DIGLINE:** different areas with independent mining directions.
- **DIGLINE_DEPENDENCY:** used to create dependency between DIGLINES.
- **DIGLINE_DIRECTION:** Sets the Main and Secondary direction, e.g: **NS/SN/WE/EW**



IS – Priorities and Dependencies

Scheduling Priorities Configuration:

- **Stage Priority:** Sorted by Strip Ratio, Mining Cost or Environmental Restrictions
- **Bench:** Descending
- **Ramp Priority or Mining Direction**
- **Material:** Sorted by Ore Type (1:High Grade, 2: Low Grade, 3: Waste)



Scheduling Priorities

FASE_BENCH_RAMP_MATERIAL

FASE_BENCH_RAMP_MATE

Field	Order
FASE PRIORITY	Ascending
BENCH	Descending
RAMP PRIORITY	Ascending
MATERIAL PRIORITY	Ascending

Production Fields

Expand all Collapse all Refresh groups

Enter text to search...

Name	Abbreviation	Unit	Weight
STAGE PRIORITY	STAGE PRIORITY	N/A	None

Formula Revenue variation

Filter	Expression
FASE = M1_F02	10
FASE = M1_F01	11
FASE = M1_F03	12
FASE = M1_F04	13

Deswik.Sched: Levelling

In the North Range there are three main excavators fleets It matches from 240 to 400u.s. ton trucks, totaling around **30 units**.



7un. (47yd³) and 4un. (32yd³)



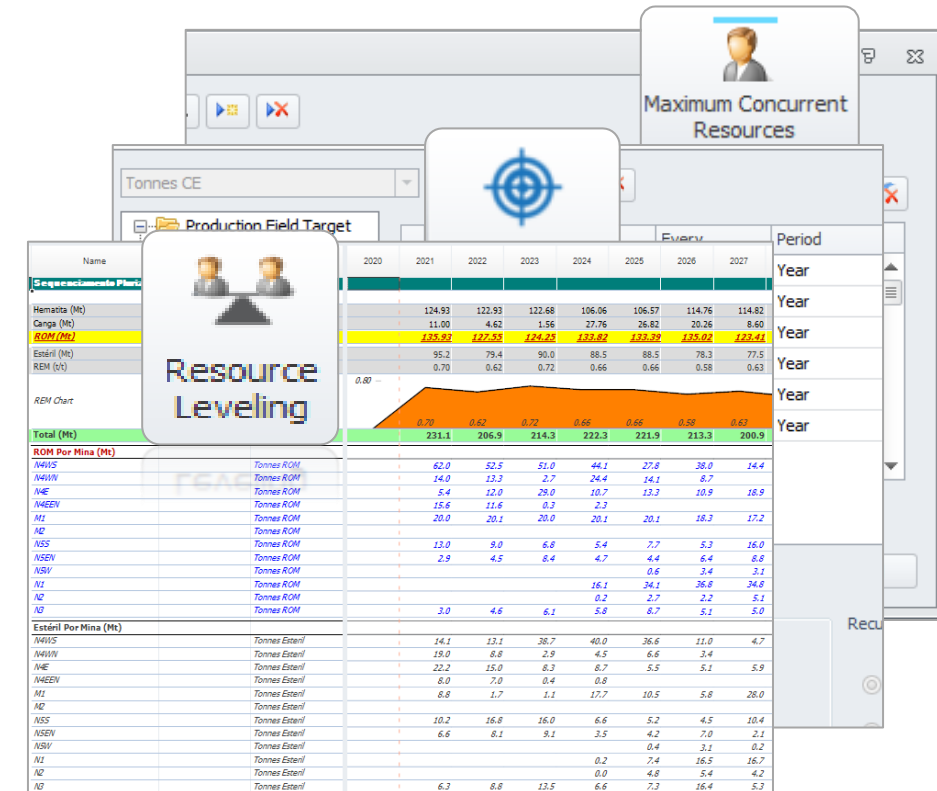
7un. (52 yd³)



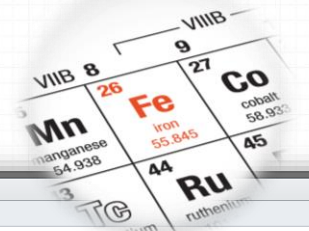
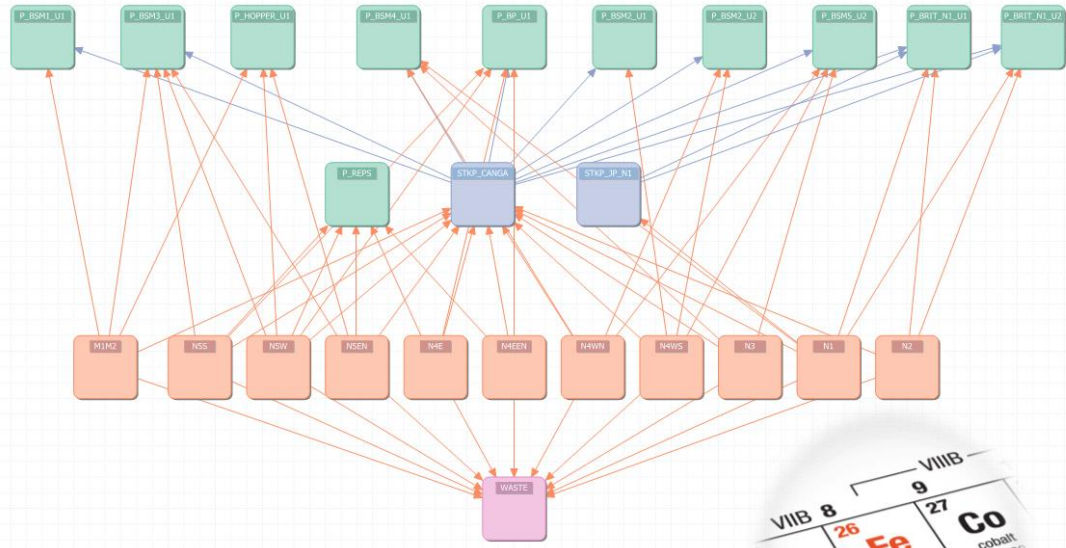
10un. (22yd³)

Through the levelling tool we could managed to control each resource and beyond:

- Maximum Concurrent Resources Rules: by (Stage and Bench)
- Productivity Resource Rate by pit: **Lookup Table**
- Possibility to apply several "targets" by Ore, Waste, Total per mine, etc.
- Standardized **reports**: improving control of the mine plan



Blender



After levelling, we blend it ...



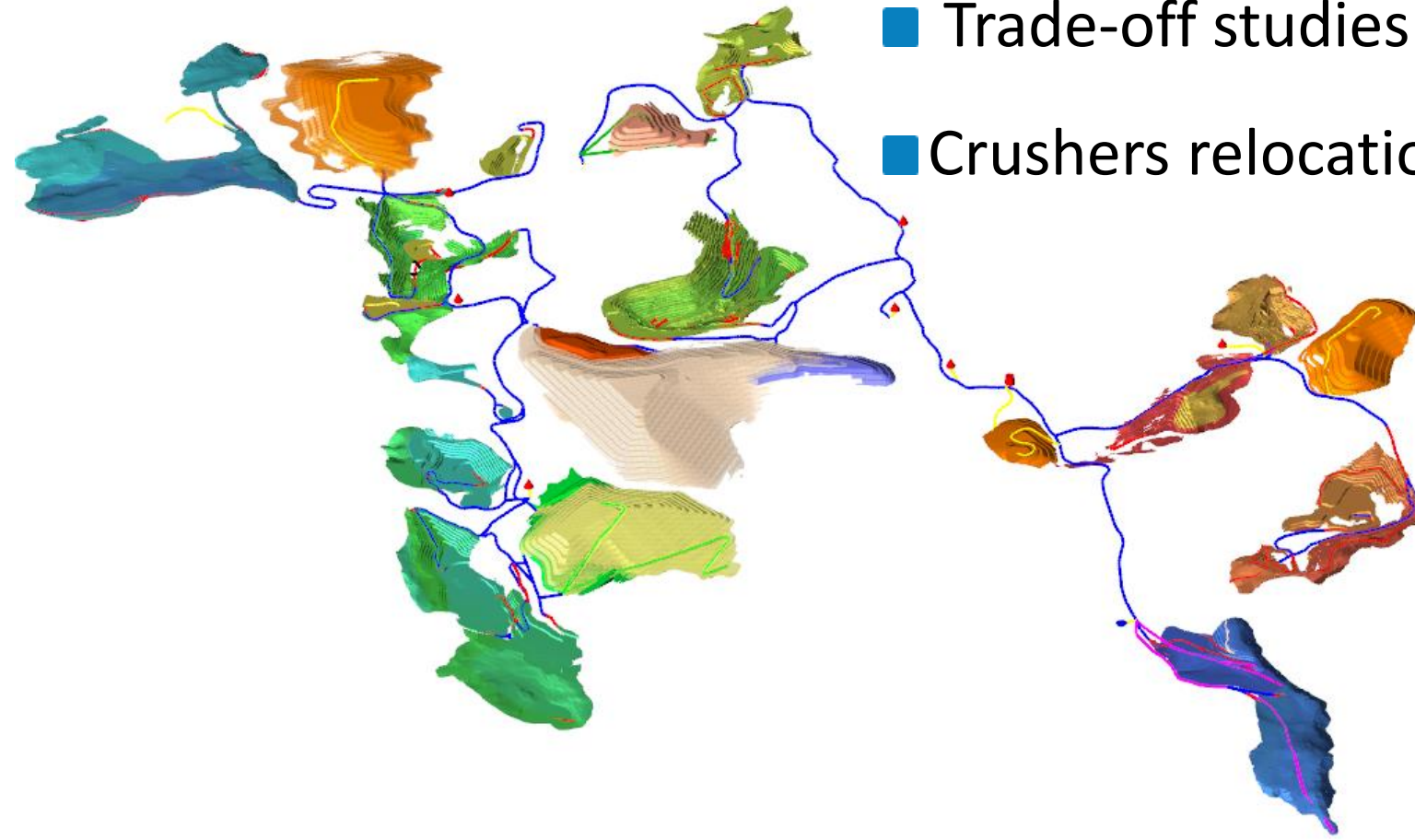
...feeding 3 plants, controlling:

- Capacities
- Averages Grades of: Fe, SiO₂, Al₂O₃, P, Mn
- Material types proportions (Ratio Constraints)

Use	Constraint Name	Filter	Flow	Material	Material Field	Constraint ...	Carry Over	1 Jan 21	1 Jan 22	1 Jan 23
<input checked="" type="checkbox"/>	Feed USINA 1	<No Filtering>	USINA 1	CE,HB,HM,P,HR,HMN,JP	Primary Quantity	Equal	<input type="checkbox"/>	90000000	73201182	
<input checked="" type="checkbox"/>	Feed USINA 2	<No Filtering>	USINA 2	CE,HB,HM,P,HR,HMN,JP	Primary Quantity	Equal	<input type="checkbox"/>	38575385	38575385	
<input checked="" type="checkbox"/>	Feed USINA 3	<No Filtering>	REPS	HB,HM,P,HR,HMN	Primary Quantity	Equal	<input type="checkbox"/>	9407429	6718952	
<input checked="" type="checkbox"/>	CE Usina 1 Max	<No Filtering>	USINA 1	CE	Primary Quantity	Max	<input type="checkbox"/>	8482818	7320118	
<input checked="" type="checkbox"/>	CE Usina 2 Max	<No Filtering>	USINA 2	CE	Primary Quantity	Max	<input type="checkbox"/>	9643846	9643846	
<input checked="" type="checkbox"/>	ROM BSM1 Max	<No Filtering>	[* -> P_BSM1_U1]	CE,HB,HM,P,HR,HMN,JP	Primary Quantity	Equal	<input type="checkbox"/>	20000000	20000000	
<input checked="" type="checkbox"/>	ROM BSM2_U1 Max	<No Filtering>	[* -> P_BSM2_U1]	CE,HB,HM,P,HR,HMN,JP	Primary Quantity	Max	<input type="checkbox"/>	40000000	40000000	
<input checked="" type="checkbox"/>	ROM BSM2_U2 Max	<No Filtering>	[* -> P_BSM2_U2]	CE,HB,HM,P,HR,HMN,JP	Primary Quantity	Max	<input type="checkbox"/>	40000000	20000000	
<input checked="" type="checkbox"/>	ROM BSM3_U1	<No Filtering>	[* -> P_BSM3_U1]	CE,HB,HM,P,HR,HMN,JP	Primary Quantity	Max	<input type="checkbox"/>	35000000	35000000	
<input checked="" type="checkbox"/>	ROM BSM4 Max	<No Filtering>	[* -> P_BSM4_U1]	CE,HB,HM,P,HR,HMN,JP	Primary Quantity	Max	<input type="checkbox"/>	50000000	50000000	
<input checked="" type="checkbox"/>	ROM BSM5 Max	<No Filtering>	[* -> P_BSM5_U2]	CE,HB,HM,P,HR,HMN,JP	Primary Quantity	Max	<input type="checkbox"/>	38575385	38575385	
<input checked="" type="checkbox"/>	ROM HOPPER Max	<No Filtering>	[* -> P_HOPPER_U1]	HB,HM,P,HR,HMN	Primary Quantity	Equal	<input type="checkbox"/>	4000000	4000000	
<input checked="" type="checkbox"/>	ROM BP Max	<No Filtering>	[* -> P_BP_U1]	CE,HB,HM,P,HR,HMN	Primary Quantity	Max	<input type="checkbox"/>	50000000	50000000	
<input checked="" type="checkbox"/>	Mov_Total Min	<No Filtering>	TOTAL	Total	Primary Quantity	Min	<input type="checkbox"/>	234692719.16	201530938.87	1977
<input checked="" type="checkbox"/>	Mov_Total Max	<No Filtering>	TOTAL	Total	Primary Quantity	Max	<input type="checkbox"/>	203553244	187758505	11
<input checked="" type="checkbox"/>	N4WS ROM	MDNA = N4WS	ROM TOTAL	HB,HM,P,HR,HMN,CE	Primary Quantity	Max	<input type="checkbox"/>	61618065.8	49516466.07	42
<input checked="" type="checkbox"/>	N4WN ROM	MDNA = N4WN	ROM TOTAL	HB,HM,P,HR,HMN,CE	Primary Quantity	Equal	<input type="checkbox"/>	13865194.73	12345087.68	374
<input checked="" type="checkbox"/>	N4E ROM	MDNA = N4E	ROM TOTAL	HB,HM,P,HR,HMN,CE	Primary Quantity	Max	<input type="checkbox"/>	5360800	10804139.95	124
<input checked="" type="checkbox"/>	N4EEN ROM	MDNA = N4EEN	ROM TOTAL	HB,HM,P,HR,HMN,CE	Primary Quantity	Equal	<input type="checkbox"/>	15587250.89	10893020.85	102
<input checked="" type="checkbox"/>	M1 ROM	MDNA = M1	ROM TOTAL	HB,HM,P,HR,HMN,CE	Primary Quantity	Equal	<input type="checkbox"/>	20000000	20000000	
<input checked="" type="checkbox"/>	M2 ROM	MDNA = M2	ROM TOTAL	HB,HM,P,HR,HMN,CE	Primary Quantity	Max	<input type="checkbox"/>	0	0	
<input checked="" type="checkbox"/>	NSS ROM	MDNA = NSS	ROM TOTAL	HB,HM,P,HR,HMN,CE	Primary Quantity	Equal	<input type="checkbox"/>	12906290.36	8840835.413	6
<input checked="" type="checkbox"/>	NSEN ROM	MDNA = NSEN	ROM TOTAL	HB,HM,P,HR,HMN,CE	Primary Quantity	Equal	<input type="checkbox"/>	3337663.453	4113035.154	908
<input checked="" type="checkbox"/>	NSW ROM	MDNA = NSW	ROM TOTAL	HB,HM,P,HR,HMN,CE	Primary Quantity	Equal	<input type="checkbox"/>	0	0	
<input checked="" type="checkbox"/>	N1 ROM	MDNA = N1	ROM TOTAL	HB,HM,P,HR,HMN,CE,JP	Primary Quantity	Equal	<input type="checkbox"/>	0	0	
<input checked="" type="checkbox"/>	N2 ROM	MDNA = N2	ROM TOTAL	HB,HM,P,HR,HMN,CE	Primary Quantity	Equal	<input type="checkbox"/>	0	0	
<input checked="" type="checkbox"/>	N3 ROM	MDNA = N3	ROM TOTAL	HR,HM,P,HR,HMN,CF	Primary Quantity	Max	<input type="checkbox"/>	5368865.614	7758007.891	874

The integrated scheduler and landform haulage ensures a dynamic analysis for strategic decision making reducing costs and risks.

- Period Variations Rules
- Trade-off studies: (IPCC x Truck and Shovel)
- Crushers relocations analysis



Scenario - CKS_02_Monthly

Advanced settings: Enabled

Settings

- Layers and attributes
- Files
- Period variations
- Dumps
- Haul roads
- Stockpiles
- Conveyors
- Destination mapping
- Destination overrides
- Fleet assignment
- Processing parameters

Period variations

Per period: Month

Items:

Rule	Date From
Total_BP_Yearly	2016-01-01 00:00:00
Total_BSM1_Yearly	2016-02-01 00:00:00
Total_BSM3_Yearly	2016-03-01 00:00:00
Total_BSM4_Yearly	2016-04-01 00:00:00
Total_BSM5_Yearly	2016-05-01 00:00:00
Total_Hooper_Yearly	2016-06-01 00:00:00
Total_REP_Yearly	2016-07-01 00:00:00
Canga_BP_Yearly	2016-08-01 00:00:00
Canga_BSM1_Yearly	2016-09-01 00:00:00
Canga_BSM3_Yearly	2016-10-01 00:00:00
Canga_BSM4_Yearly	2016-11-01 00:00:00
Canga_BSM5_Yearly	2016-12-01 00:00:00
Canga_Hooper_Yearly	2017-01-01 00:00:00
Total_BP_Monthly	2017-02-01 00:00:00
Total_BSM1_Monthly	2017-03-01 00:00:00
Total_BSM3_Monthly	2017-04-01 00:00:00
Total_BSM4_Monthly	2017-05-01 00:00:00
Total_BSM5_Monthly	2017-06-01 00:00:00
Total_Hooper_Monthly	2017-07-01 00:00:00
Total_REP_Monthly	2017-08-01 00:00:00
Canga_BP_Monthly	2017-09-01 00:00:00
Canga_BSM1_Monthly	2017-10-01 00:00:00
Canga_BSM3_Monthly	2017-11-01 00:00:00
Canga_BSM4_Monthly	2017-12-01 00:00:00
Canga_BSM5_Monthly	2018-01-01 00:00:00
Canga_Hooper_Monthly	2018-02-01 00:00:00
	2018-03-01 00:00:00
	2018-04-01 00:00:00
	2018-05-01 00:00:00
	2018-06-01 00:00:00

4365000

4346496

4546432

4276800

4497856

4322139

3916528

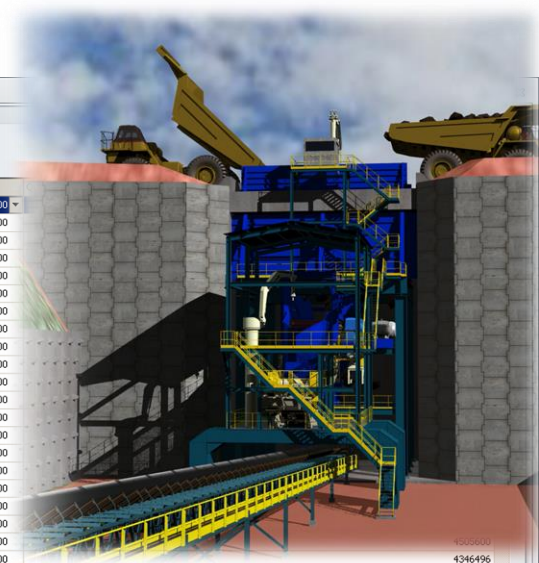
1988800

3462536

4367810

3597440

OK Cancel



Goals and Challenges Overcome

Integrated Project

Before there were **9 mines** projects working seperatedelly.

Deswik works in an integrated project way, including **All block models.**




Operational Constraints

Optimize design and scheduling of the mines respecting operational aspects such as Drainages and Enviromental Licenses.


Pit Design Tools 

 Cut Benchs By Surface Stacking Rules.

 Constraints dates (Delay Dates)

Scheduler /Blender +LHS

Integrated Mining planning with operational detailed controlling of excavation, haulage and Ore quality.

 Scheduler: Resources Levelling

Blender Strategies 

 Landform and Haulage

Reports And Outputs

Reduction of manual labor work for generation and result analysis.

Dynamic Reports, Pivot Tables and Period Maps



Thank You!



Bruno Gadelha
Senior Engineer
bruno.gadelha@vale.com
Vale

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