Instances

In this study, we utilized 10 randomly generated instances with predefined range values to reflect real-world scenarios of the Sossego open-pit copper mine, operated by Vale S.A. in Brazil. Table 2 displays stockpile data, which serve as input parameters for both the mathematical formulation and the ILS Algorithm. Column 1 lists the characteristics of the stockpiles, and Column 2 provides the range values for these characteristics. The first line shows the range valeu of maximum production rate that can operate. Line 2 shows the range valeu of minimum production rate to recover ore due to operating costs. The range valeu of the quality parameters grade are reported in the last five lines.

Table 1.: Stockpile characteristics.

Parameters	**Description**	**Step**	**Range values**
Mu	Maximum production rate (t/h)	1	[305 ; 1,050]
Ml	Minimum production rate (t/h)	5	[100 ; 140]
G_{Cu}	Quality Parameter of copper (%)	10^{-9}	[0.25 ; 1.4]
G_{Ni}	Quality Parameter of nickel (%)	10^{-9}	[0 ; 0.049]
G_{Cl}	Quality Parameter of chlorine (%)	10^{-9}	[0 ; 7×10^{-4}]
G_F	Quality Parameter of fluorine (%)	10^{-9}	[0 ; 0.17×10^{-4}]
G_{Au}	Quality Parameter of gold (%)	10^{-9}	[0 ; 8.3×10^{-4}]

Table 2 reports the shovels' characteristics in Column 1 and their range values in Column 2. The first line lists the range value of productive capacity of each shovel. The second line indicates the range value of maximum number of stockpiles or fronts that each shovel can operate during a work shift. The third line provides the range value of minimum productivity required for each shovel when assigned to ore removal. The fourth line specifies the range value of minimum usage rate for all operations within the work shift, as allocating idle equipment is not economically viable. Finally, the last line details the range value of fuel consumption for each shovel.

Table 2.: Shovel characteristics.

Parameters	**Description**	**Step**	**Range values**
SC	Productive capacity (t/h)	10	[840 ; 1,850]
SNu	Maximum number os stockpiles	1	[1 ; 3]
SPl	Minimum productivity (t/h)	0	[100 ; 100]
SRl	Minimum usage rate (%)	0	[10 ; 10]
SFC	Fuel consumption (l/h)	5	[160 ; 400]

Table 3 summarizes the penalties for the objective function components in each instance.

Table 3.: Penalidades das parcelas da função objetivo

Instances	Production target ($\bar{\alpha}$)	Quality parameters target (β)	Fuel consumption (γ)
1, 2, 4, 5, 6 and 7	0,333	0,333	0,333
3, 8, 9 and 10	0,200	0,600	0,200