

ÇALDAĞ NICKEL LATERITE ATMOSPHERIC HEAP LEACH PROJECT

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ABSTRACT

European Nickel (EN) constructed a heap leach demonstration plant (3 heaps and precipitation plant) to prove both technically and economically the success of leachability for Çaldağ Nickel laterites using atmospheric heap leaching (AHL) by sulphuric acid and to produce saleable products. Heap 1 (average Çaldağ ore) underwent leaching for 548 days extractions were 79.4%Ni, 82.7%Co, 30.0%Fe, 78.9%Mn and 37.1%Al. The heap is in its final rinse stage. The precipitation plant produces 2 nickel products, primary (24-35%Ni) and secondary (15-30%Ni & 2.5%-11%Mn). Products have been sold to various refineries for evaluation. This paper presents the first heap AHL performance.

Key words: Nickel Laterite, Caldag Heap Leaching, Cobolt, Sulphuric Acid, Precipitation

INTRODUCTION

European Nickel mined approximately 20,000 dry tons of ore from the Çaldağ deposit constructed heaps and has demonstrated both technologically and economically nickel heap leaching as a low cost alternative to conventional nickel processing at Çaldağ, Turkey.

Ore Preparation & Material Properties. The material for the Çaldağ Heap Leach Trial Heap 1 was selected to be representative of the entire Çaldağ ore body, 5,247 wet tonnes of ore were screened and crushed to minus 25mm. The Heap 1 nickel content averaged 1.15% with 11.03 % moisture.

Table 1. Heap Chemical Analyses and Moisture Content and Çaldağ Average

	Ni %	Co %	Fe %	Fe ₂ O ₃ %	SiO ₂ %	Al ₂ O ₃ %	CaO %	MgO %	MnO %	Cr ₂ O ₃ %	Moisture %
Heap 1	1.15	0.055	24.35	35.89	29.52	2.49	7.45	5.11	0.43	1.66	18
Çaldağ Average	1.13	0.07	21.66	30.97	30.85	1.91	5.02	3.2	0.41	1.62	15



Fig. 1. Heaps and Launderers

Heap Leach Operation. First irrigation was applied to Heap 1 on 18th October 2004. Instead of using open circuit operation, as applied in many Copper sulphuric acid AHL processes, a close circuit system is used in this project. The flow diagram of the heap leach trial operation at Çaldağ is shown in Fig. 2. The process is based on leach liquor metal concentration build-up in ponds through recirculation of the PLS over fresh ore. This process neutralises some acid without losing any extracted Nickel and Cobalt prior to processing to a MHP product. This system helps reduce not only acid consumption and water usage in the main leach period but also decreases limestone consumption in iron removal circuit in the precipitation plant.

As can be seen in the flow diagram below, Heap 1 and Heap 3 have been irrigated continuously by Pond 1 and Pond 2 solutions respectively. Acid concentration of the solution has been adjusted to 75 g/L according to daily determination of the free acid in the solution; all heap underflow solutions have been collected in the launders and transferred to ponds, heaps or the precipitation plant. A bleed from the underflow of Heap 1 or Heap 3 has been fed to heap 2 to reduce the acid content of PLS from 50 g/L to 5-20 g/L, this low acid PLS has been collected in the Pond 3 as precipitation plant feed (process liquor).

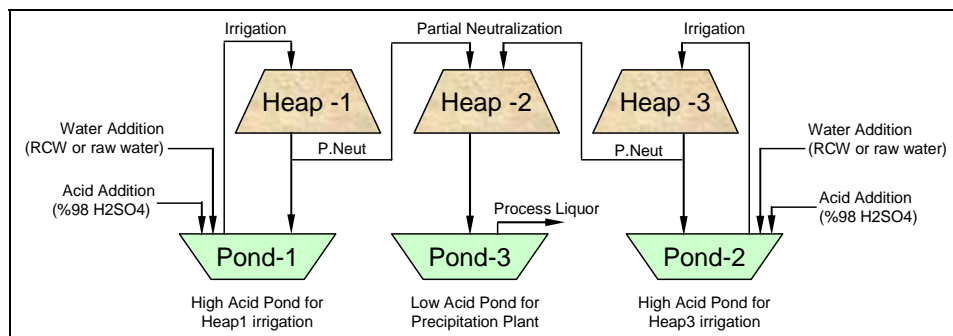
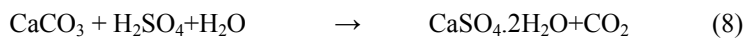
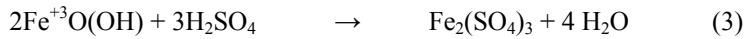


Fig. 2. Flow Diagram of Çaldağ Nickel Laterite Atmospheric Heap Leach Trial

During the complete leach period, the extraction of the metals, acid consumption and moisture of the heaps has been monitored and calculated.

Leach Kinetics. This section covers the leach kinetics of heap 1 for Nickel, Cobalt and Iron, vs. time, acid consumption, and solution flux.

The main reactions for the heap leaching are assumed as shown overleaf :



After 548 days, Heap 1 reached an extraction of 79.4%, 82.7% and 30.0% for Ni, Co and Fe respectively. Daily extraction rates for eight metals with solution flux (m^3/t) for the heap are shown in Fig. 3.

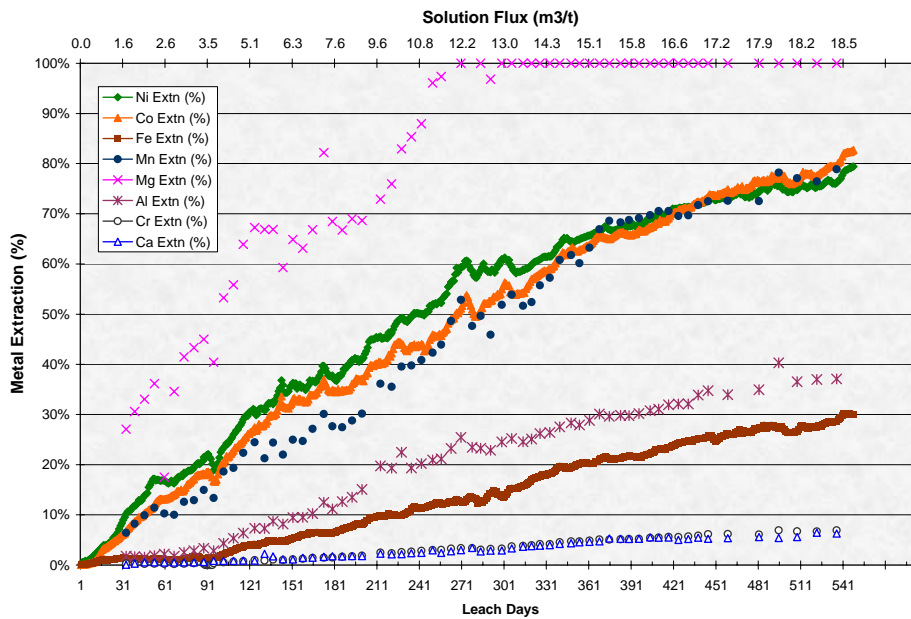


Fig. 3. Daily Metal Extractions (%) of Heap1 and Solution Flux (m^3/t)

It can be seen from Fig. 3; that after approximately 350 days the extraction of Ni, Co and Mn is in the region of 62% and that all 3 extractions increase to about 70% in 60 days and then to 80% in another 148 days.

Leach rates of Ni & Fe and Ni & Co, compared to solution flux (m³/t) for Heap 1 are shown in Fig. 4 and Fig. 5.

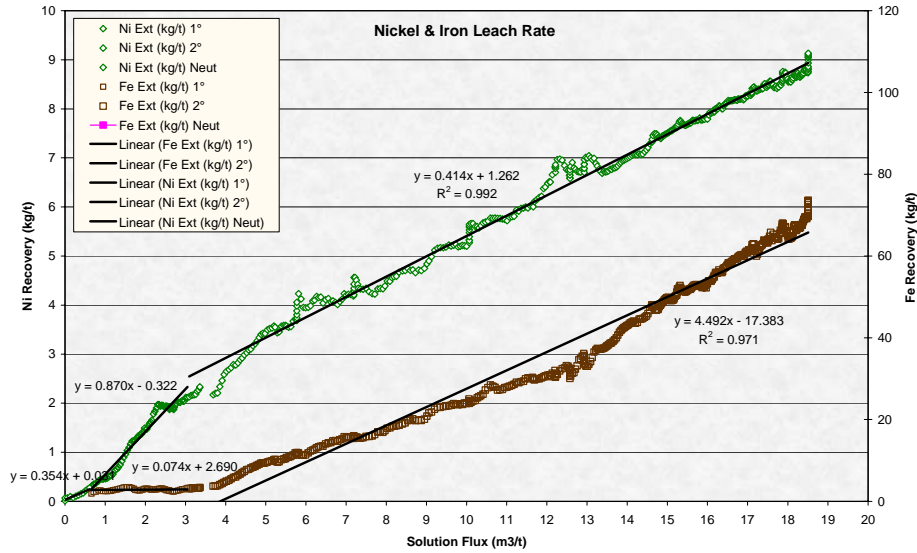


Fig. 4. Nickel and Iron Leach Rates

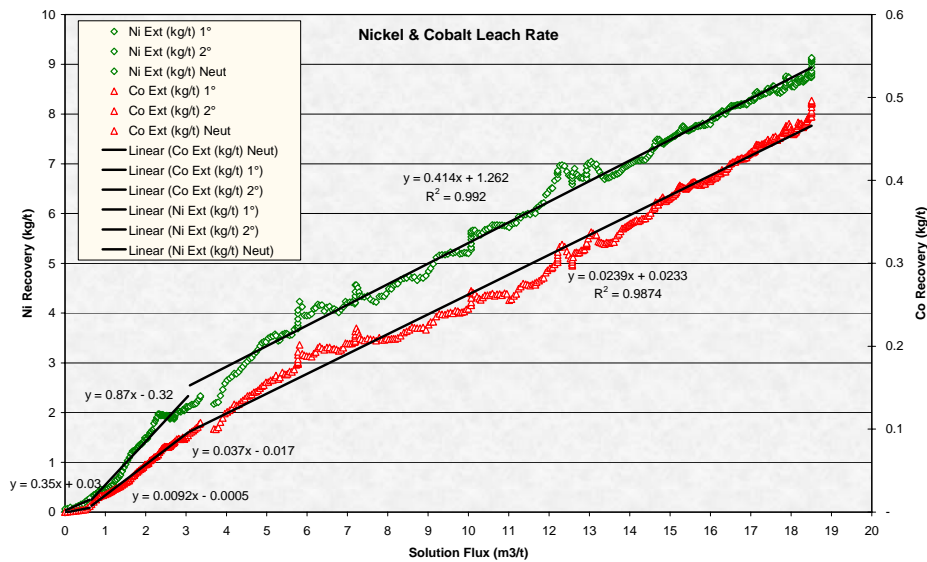


Fig. 5. Nickel and Cobalt Leach Rates

Each element's leaching rate is also tabulated below in Table 2.

Table 2. Leaching Rates of Each Element for Heap 1

Element	Ore Assay	Metal (kg/t ore)	Leach Rate(kg/m ³ liq)			Extractions				Leached Metal (kg/t ore)			
			NEUT	1 st Stage	2 nd Stage	NEUT	1 st Stage	2 nd Stage	Total	NEUT	1 st Stage	2 nd Stage	Total
Ni	1.15%	11.5	0.3540	0.8700	0.4140	1.88%	23.41%	54.12%	79.4%	0.216	2.161	6.754	9.13
Fe	24.35%	243.5	2.5300	0.0740	4.4920	0.63%	0.08%	28.43%	29.1%	1.543	0.184	69.235	71.0
Co	0.055%	0.6	0.0092	0.0370	0.0239	1.02%	16.71%	66.98%	84.7%	0.006	0.092	0.368	0.5
Mg	3.08%	30.8	9.8210	2.7430	1.6790	19.45%	22.12%	58.43%	100.0%	5.991	6.814	18.001	30.8
Al	1.32%	13.2	0.2290	0.0659	0.2970	1.06%	1.24%	34.69%	37.0%	0.140	0.164	4.578	4.9
Cr	1.13%	11.3	0.0120	0.0120	0.0489	0.06%	0.26%	6.64%	7.0%	0.007	0.030	0.754	0.8
Mn	0.34%	3.4	0.1380	0.1380	0.1380	2.50%	10.20%	63.27%	76.0%	0.084	0.343	2.127	2.6
Ca	5.32%	53.2	0.1540	0.1540	0.1540	0.18%	0.72%	4.46%	5.35%	0.094	0.383	2.374	2.9
Solution flux (m³/t)			0.61	3.09	18.51								
Total Leach Days			12.0	76.0	548.0								

The Heap 1 leaching rate data indicates the following:

- There are 3 distinct leach phases: Neutralisation, primary and secondary. The primary leaching stage is an accelerated leach where the easily accessible Ni is leached. After this the leach rates become stable as seen in the charts.
- The total extraction for nickel, cobalt and manganese in the total period is approximately 80%.
- The leaching rates of nickel, iron and cobalt per m³ of solution in second stage are 0.414 kg of nickel, 4.492 kg of iron, 0.0239 kg of cobalt and 0.297 kg of aluminium and they are stable between 3.09 and 18.52 m³/t ore solution flux.
- The nickel leach rate increases in the first stage from 0.216 kg to 2.161 kg per m³ of solution and the trend continues to rise in the second stage.

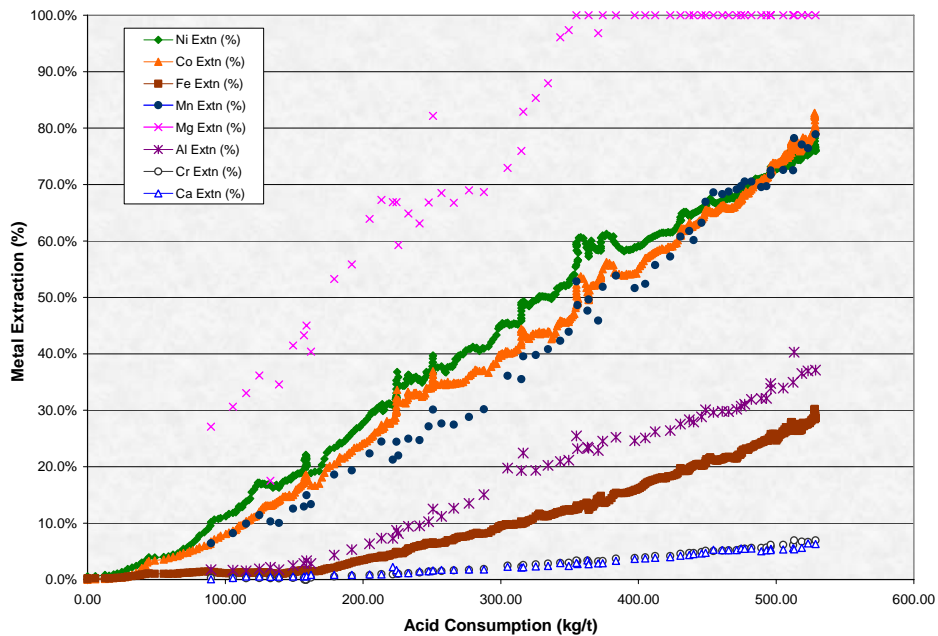


Fig. 6. Metal Extractions (%) of Heap1 v Acid Consumption (kg/t)

To achieve approximately 80% Ni and Co extraction from heap 1, acid consumption has been calculated as 528 kg per ton dry ore according to flows in and out of the system.

Following the 548 days (including drainage) of leaching for Heap 1, the heap is currently undergoing its final rinse with a 10 g/L acidic solution, next the heap will be drained and then washed until the pH of the heap underflow liquor is neutral. A final reconciliation will then take place.

CONCLUSION

Turkish and Balkan laterites are amenable to heap leaching due to very low amount of clay content. The Çaldağ Nickel leach characteristics have now been demonstrated in a large scale pilot plant by European Nickel.

The leach period of the trial heaps has been monitored and leach kinetics have shown that there are three phases in the leach cycle, neutralisation, primary and secondary leach stages.

In the neutralisation period, the first 12 days of acid treatment, Calcium precipitates as gypsum. Magnesium extracts at a high rate, as high as 20%. Nickel, Cobalt, Iron, Aluminium and Manganese begin to extract but with slower rates.

After the neutralisation period, the extraction rate of Nickel and Cobalt increases while iron, magnesium and aluminium have lower or steady state extraction. This higher extraction for Nickel and Cobalt after initial neutralisation resulted in the naming of this stage as primary leach. In this stage extraction of Nickel, Cobalt, Iron, Aluminium and Manganese reached up to 23.4%, 16.7%, 0.08%, 1.25% and 10.2%, respectively for heap 1.

In the secondary stage, which started on 76th day of leaching, all metals have constant leach rates which differ from the primary leach. Nickel, Cobalt, Iron, Aluminium and Manganese have achieved extractions of 79.4%, 82.7%, 30.0%, 37.1% and 78.9%, respectively after this stage of leaching. The Chromium has the lowest extraction with 7% in the whole leach period.

The acid consumption for neutralisation, primary and secondary stages per ton of dry ore has been calculated as 35 kg, 116 kg and 377 kg. This resulted in approximately 80% Nickel extraction, a total of 510 kg per ton of dry ore was calculated for 72% extraction.

The final stage of the demonstration plant is the precipitation area where the two nickel cobalt hydroxide products are produced from process liquor, with the primary product being approximately 33% Nickel and 1.5% Cobalt, and the secondary 25% Nickel, <1% Cobalt and 7% Manganese. The product has been sold and shipped to various refineries worldwide for evaluation.

The demonstration plant at Çaldağ has proved that Nickel and Cobalt can be extracted by means of atmospheric heap leaching and that saleable product can be produced.