Presented at Alta 2018 NCC, Perth, Australia, May 2018

LATERITE AND THE COMMODITY PRICE CYCLE

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ABSTRACT

In spite of recent commercial failures involving HPAL processing of laterite, the extraction of nickel and cobalt from laterites is inevitable if supply is to meet demand into the future. The commercial failures have been attributed, largely, to insufficient process development and excessive optimism in scaling up the autoclave and other technology. Additionally, there is a commodity price cycle that affects both input costs and revenues.

This paper examines the impact of the commodity price cycle on the economics of a hypothetical laterite project using HPAL technology to produce a mixed hydroxide precipitate containing nickel and cobalt.

Almost a century's worth of commodity price data, converted into inflation-adjusted currency, is used to examine the cash flows associated with the construction, commissioning and operation of the project for 20 years. The project is assumed to begin at various points in the commodity cycle and the resulting cash flows are examined.

The commodity price cycle was found to strongly affect the 20-year process economics.

The results of this exercise indicate that 2018 and the coming years might well be very propitious for new laterite projects.

Keywords: Nickel, Cobalt, HPAL, Economics, Commodity cycle

INTRODUCTION

While metals have been mined and extracted for a long time, not all extraction projects have been successful. Harris[(1)] lists overly complex flowsheets, incorrect piloting, insufficient understanding of process chemistry and premature design changes driven by cost considerations as contributors to the failure of projects in extractive metallurgy. Benz[(2)] cites declining grades, increasing ore complexity, process safety, tightening environmental expectations, remote projects and volatility of input costs and product prices as major attributes of today's mining and metal industry that translate into formidable and increasing business risk.

While the technical factors affecting risk are at least notionally within the control of the project developers, the future cost of input reagents and the future prices of products is not. This paper presents an evaluation whether or not the commodity price cycle would be important to the success of a new laterite venture.

CASE STUDY

A case study that was developed previously entails using established HPAL technology[(3,4)] to produce mixed hydroxide precipitate (MHP) as an intermediate for further refining elsewhere from a laterite of the composition listed in Table 1.

Table 1: Laterite composition, mass %

Ni	Co	Al_2O_3	Cr_2O_3	Fe_2O_3	CaO	MgO	MnO	Na_2O	K_2O	SiO_2
1.22	0.2	5.61	3.36	64.31	0.06	1.54	1.51	0.17	0.01	7.62

Figure 1 shows the HPAL circuit. The details of this circuit have been presented previously[(3,4)]. This circuit was picked for this exercise because the associated process and cost modelling had already been done.

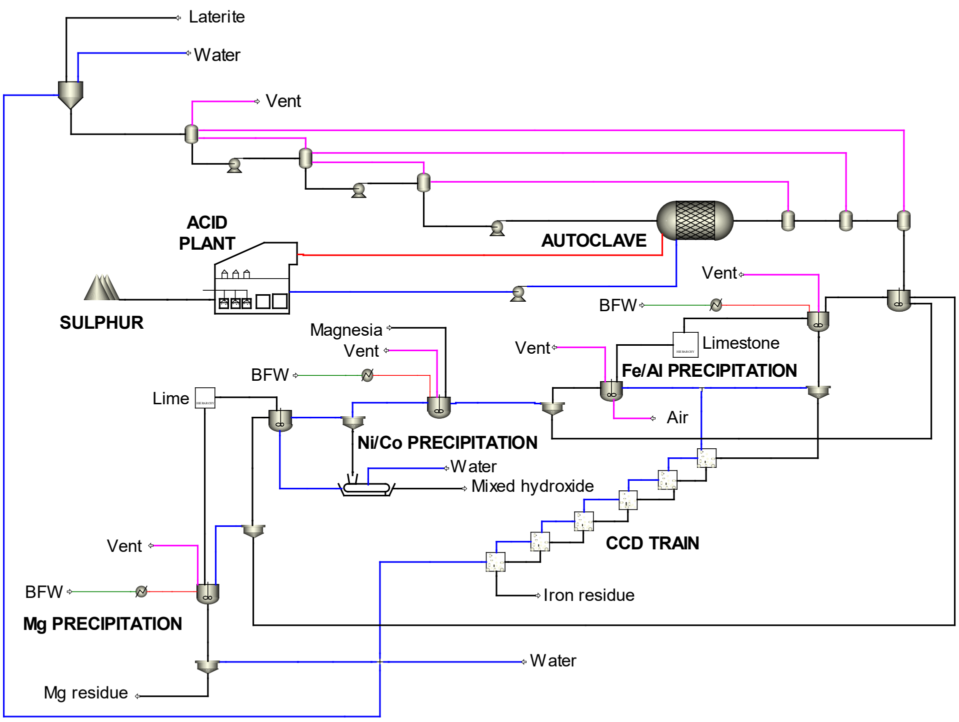

Figure 1: HPAL circuit

Table 2 shows the estimated capital and fixed operating costs for the process. For this exercise the annual maintenance cost was assumed to be ten percent of the capital cost of the process plant.

Table 2: Capital and fixed operating costs

Capital cost, mine	US$666 million
Capital cost, Process plant	US$479 million
Fixed operating cost	US$6.2 million/year

Table 3 lists the reagent and utility requirements that translate into the variable operating cost. The unit costs associated with the individual reagents and utilities, along with the amounts consumed, become the variable cost of the process. As a mining and metal extraction project would typically have a lifespan of twenty years or longer, and commodity prices are variable over time, the variable costs and the revenue associated with the project are not definitively known ahead of the decision to proceed. Rather, these numbers are projections, hopefully realistic but by nature uncertain. Overly optimistic projections of the input costs and metal selling prices, i.e. variable operating costs and project revenue, would lead to lower than anticipated returns, as either the actual selling prices would be lower or the costs for reagents and utilities would be higher than were projected.

Table 3: Reagent and utility requirements, per tonne base metal in MHP

Sulphur, as100% S	2.3 tonne
Limestone, as 100% $CaCO_3$	9.3 tonne
Magnesia, as 100% MgO	0.6 tonne
Lime, as 100% CaO	1.3 tonne
Water, m^3	19 m^3
Electricity	4.2 GJ

COMMODITY PRICE CYCLE

One way of accommodating price and cost uncertainty in evaluating a potential project is to require its economics to remain acceptable for all combinations of cost and revenue between selected upper and lower bounds. The challenge lies in selecting appropriate bounds. Figure 2 shows historical price data[5] for the two metals and the four main reagents of interest to this exercise.

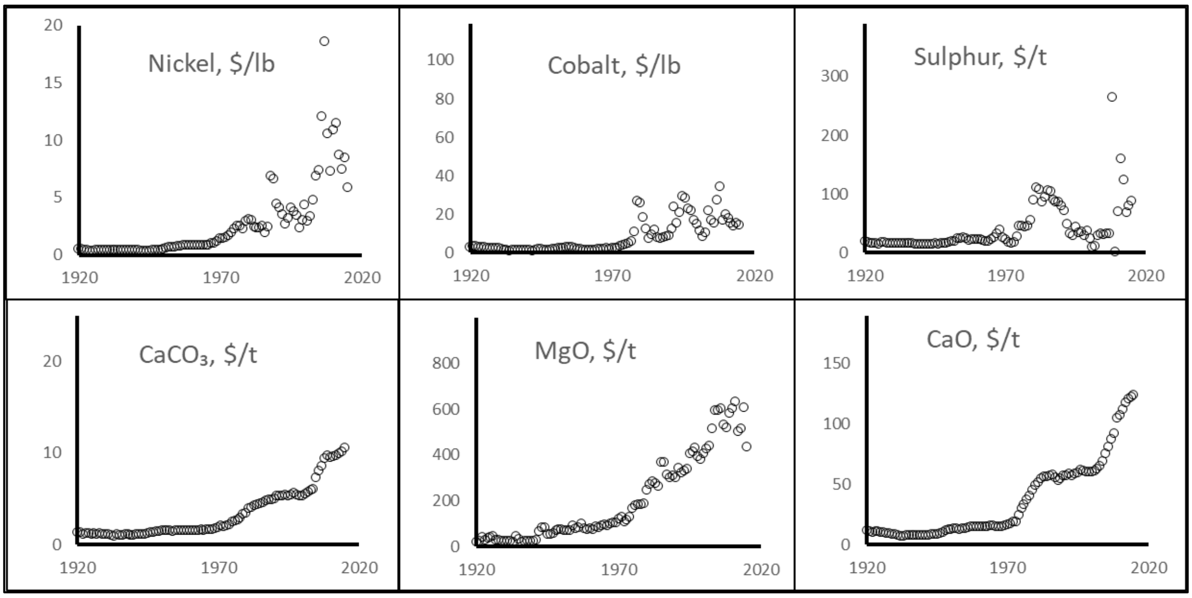

Figure 2: Historical price data

It might seem very difficult to use these charts to project realistic prices up to twenty years hence. However, the data points in Figure 2 are in the historical currency. Using historical data on inflation[6] enables us to convert the raw historical prices into the inflation-adjusted values shown in Figure 3. In these plots, the horizontal dashed lines are the arithmetic mean of the inflation-adjusted prices over the entire period spanned by the horizontal axis, plus or minus one standard deviation. (The vertical solid lines mark 1973, the year in which United States President Nixon removed the US dollar from the gold standard. Whether or not that event links in any way to the increased volatility in the post-1973 prices of nickel and cobalt is left to others to debate.)

Two things can arguably be seen in these graphs:

- for most of the past century, these inflation-adjusted commodity prices have stayed within channels bounded by one standard deviation above or below the long-term average (the arithmetic average of the prices over the period covered);
- when a price strayed above or below the channel defined by one standard deviation above or below the long-term average, it invariably reverted to back inside the channel.

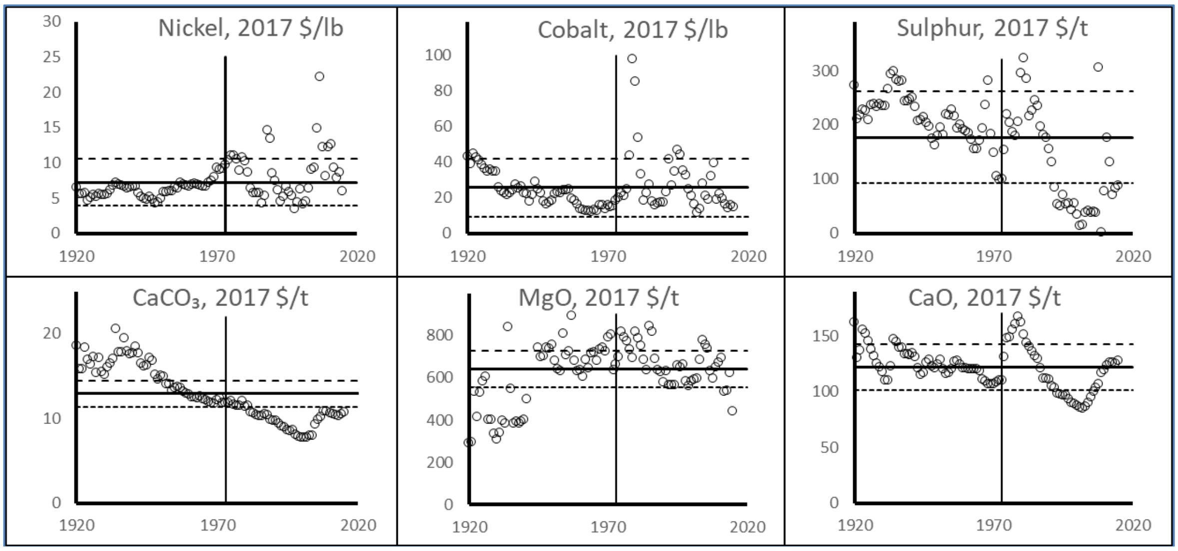

Figure 3: Inflation-adjusted price data

Further examination of the inflation-adjusted historical price data shows that as nickel and cobalt prices move up and down, the prices of the major reagents used to extract the nickel and cobalt also move up and down in a manner not totally divorced from the movement of the prices of nickel and cobalt. Figure 4 plots the inflation-adjusted prices of nickel and sulphur together. Although the correlation is far from perfect, these two prices follow similar trends. There are similar broad correlations between the nickel price and the prices of the other major reagents used in HPAL processing of laterite.

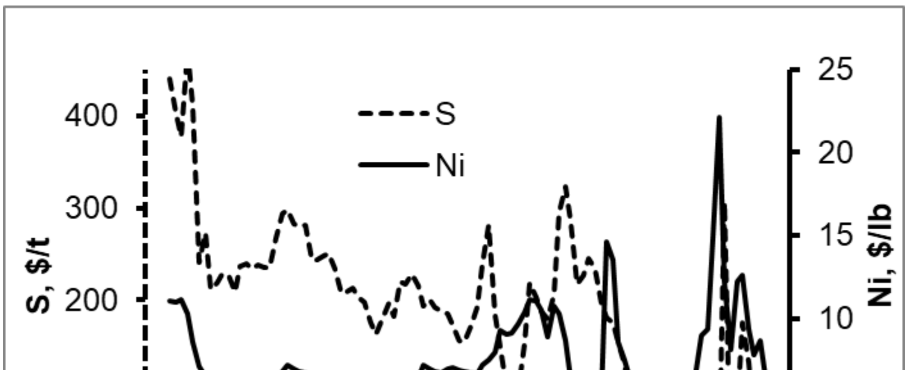

Figure 4: Inflation-adjusted prices of sulphur and nickel

An argument has been made[3,4] that the impact of rising input costs on the overall economics of the project should, to some extent at least, be countered by the rising prices of the metals in the intermediate product. Similarly, the negative impact of falling metal prices should be countered, at least somewhat, by falling input costs.

In the exercise presented here, this hypothesis was tested via a set of cash flow calculations in which the yearly historical prices of nickel, cobalt and the various major reagents were used to calculate revenue and variable cost over a set of 20-year periods at five-year intervals, beginning at 1921, i.e. 1921 to 1942, 1926 to 1947, etc., plus a latest period beginning in 1994 and ending in 2015 (the latest year of commodity price data[5]). Figure 5 shows the results of this exercise as the internal rate of return (IRR) versus project life, using the assumptions listed in Table 4.

Table 4: Assumptions used in the cash flow calculations

Operating hours per year	8400
Product value, percent of metal price	85%
Capital expenditure, year 1	50%
Capital expenditure, year 2	50%
Depreciation, starting in year 3	5%
Production in year 3	50%
Production in year 4	75%
Production in year 5	100%
Production after year 5	100%
Corporate tax rate	30%

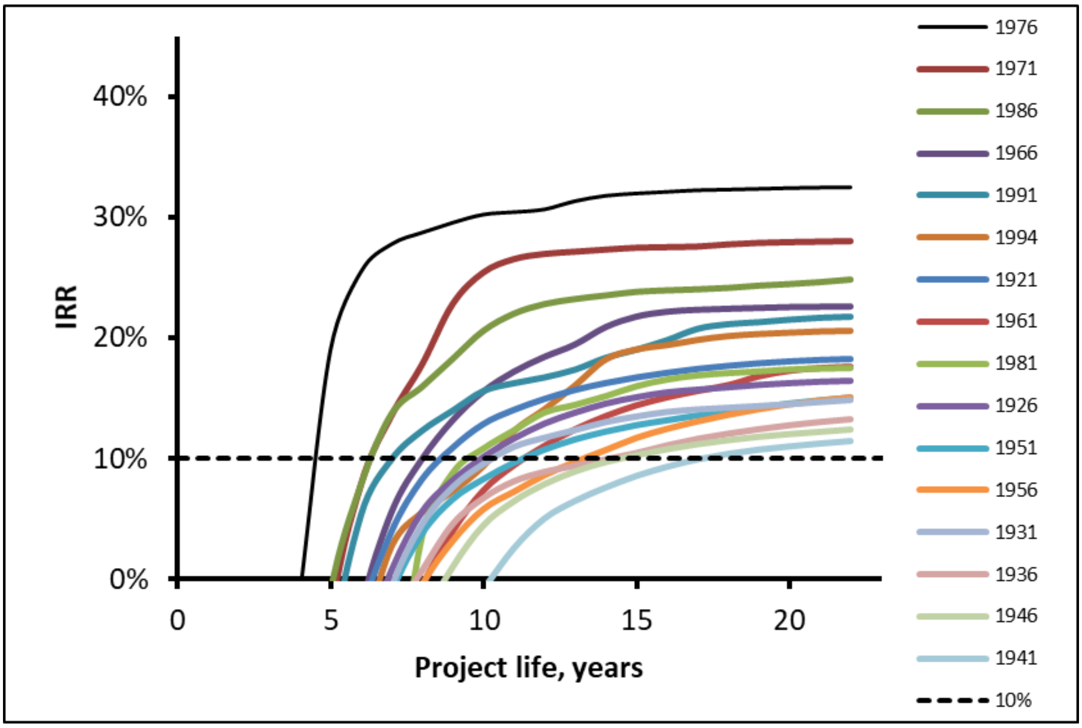

Figure 5: IRR calculations using historical price data

The necessary assumption in this exercise is that while history may not repeat itself exactly, it does tend to rhyme, in that it repeats similar patterns over time. The argument is that, in lieu of an accurate crystal ball, assuming similar price-time cycles in the future to those seen in the past is as good a way as any to project the economics of a process into the future. A variable is at what part of the cycle the project would begin, hence the taking of 20-year time slices over the range of the available (inflation-adjusted) historical price data.

Clearly, any correlation between metal prices and the input commodity prices is not strong enough to appreciably dampen the effects of the commodity price cycles. The suggestion that long-term average prices are a good proxy for predicting the 20-year economics of projects[3,4], therefore requires further scrutiny. Figure 6 shows the best (1976) and the worst (1941) two IRR curves based on the historical price data (inflation-adjusted), along with IRR curves calculated using the long-term average prices (A), long-term average prices minus one standard deviation (L) or long-term average prices plus one standard deviation (H). In the legend, the first letter refers to the metal prices and the second letter refers to the reagent prices. Two things are apparent:

- Using the long-term average metal prices plus or minus one standard deviation produces IRR curves that are outside the range of the IRR curves calculated from the inflation-adjusted historical data.
- The prices of the input reagents have much less impact on the IRR than those of the metals.

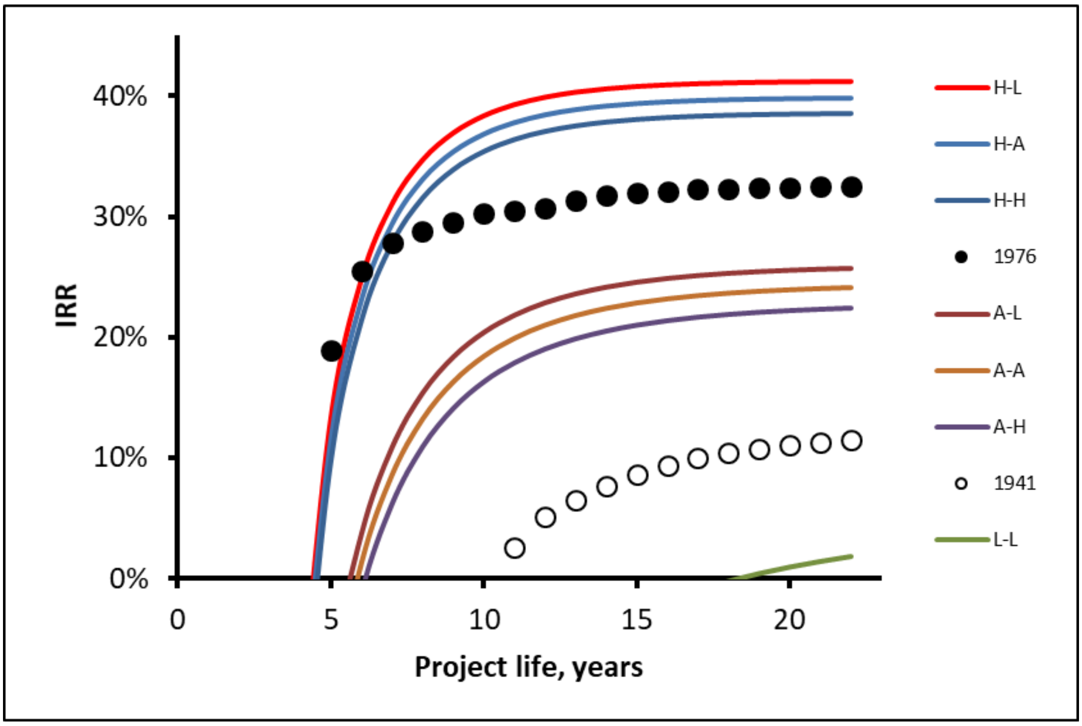

Figure 6: IRR calculations using average long-term price data

The IRR curves calculated using the average long-term metal prices and the long-term average prices (or the long-term average plus or minus one standard deviation) for the reagents, lie roughly in the middle of the range found using the actual historical prices. This would indicate that, while any correlation in the commodity price cycle does not appreciably diminish the impact of the commodity cycle, the long-term averages are reasonably plausible proxies for future prices, when used to predict project economics two decades out.

PROJECTION USING THE COMMODITY PRICE CYCLE

Since the commodity price cycle does affect the economics of projects such as the one assumed for this exercise, a logical question would be whether or not it is possible to use that concept to predict good and bad times to begin such a project.

Figure 7 shows the historical prices of nickel and cobalt, inflation-adjusted to 2017 currency. The horizontal solid lines are the long-term averages and the horizontal dashed lines are the long-term averages plus or minus one standard deviation. The solid vertical lines mark 1973, the year in which the US dollar was removed from the gold standard.

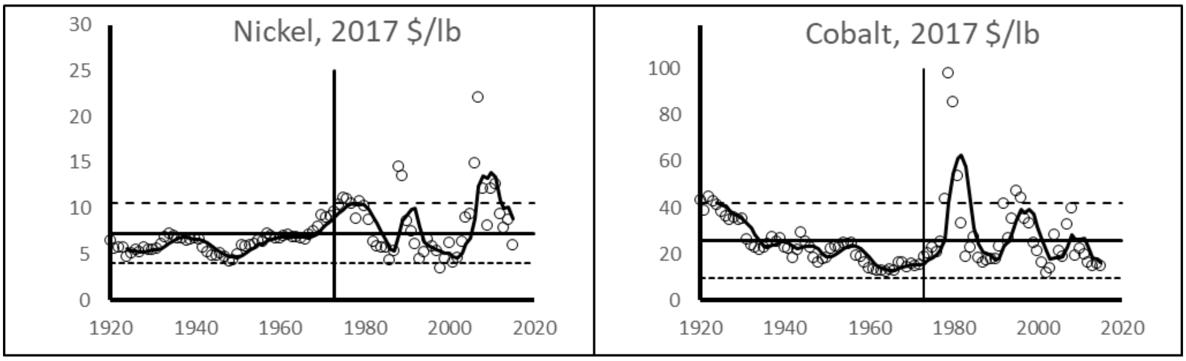

Figure 7: Nickel and cobalt price data

The solid curves in the two graphs in Figure 7 are five-year moving averages that somewhat smooth out the price-time data. Note that, over the past century, neither of these moving averages has gone below the long-term average price minus one standard deviation.

One seemingly logical assumption might be that the higher the average margin (difference between revenue and costs), the better the overall economics. Figure 8 shows the IRR versus the margin for the project used in this exercise. It would be a stretch to ascribe any strong correlation to this plot.

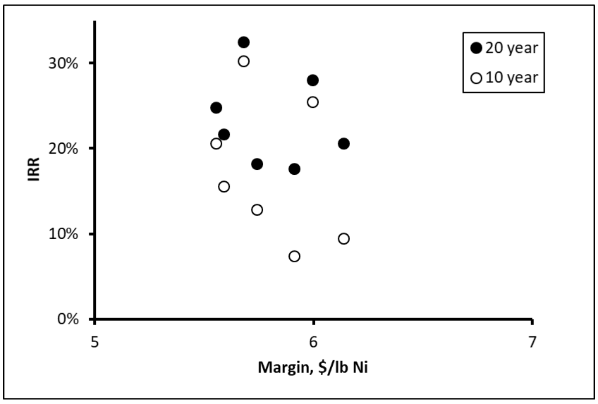

Figure 8: IRR versus margin

Another logical assumption might be that the better the price of nickel and cobalt, the better the project economics should be. Figure 9 plots the IRR against the average price of nickel or cobalt over the 20-year time slice represented by each data point. While there is a lot of scatter in these plots, they do seem to support the assertion that better metal prices lead to better overall project economics.

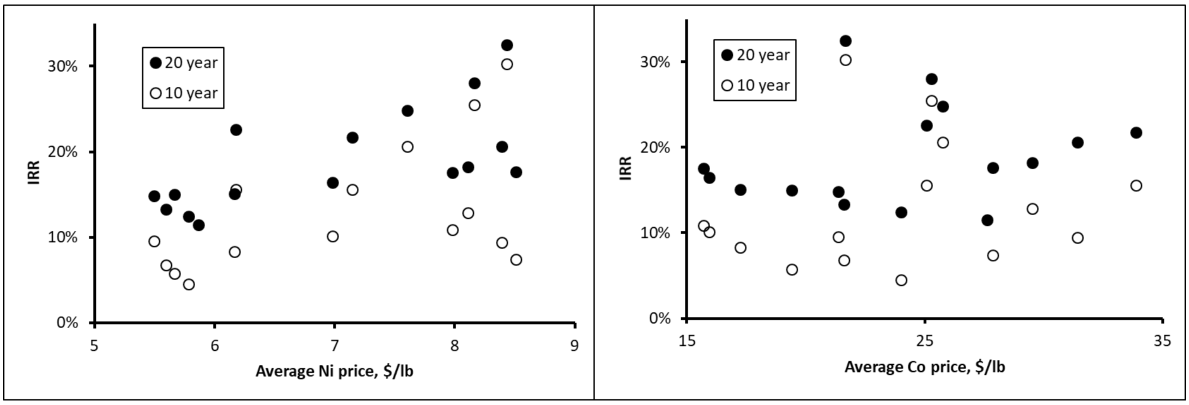

Figure 9: IRR versus metal prices

The next logical question is whether or not swings in the selling prices and input costs might make a 20-year project have better or worse economics, and if so to what extent. Figure 10 plots the 20-year IRR values calculated for each 20-year period examined, along with the five-year moving averages of the nickel and cobalt prices. Although the correlation is not perfect, when the slope of the moving average price curves changed from negative to positive, the project IRR values improved. The drop in IRR numbers calculated for after 1997 would seem to tie in with the extended drop in the prices of nickel and cobalt.

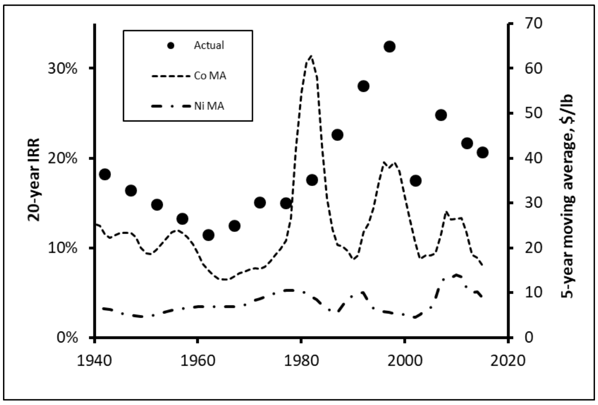

Figure 10: IRR and metal prices versus time

Although 2015 is the latest year for which historical yearly average prices are documented in the source used in this exercise[5], the cobalt price dropped from about $14.80/lb in 2015 to about $10.50 in the first quarter of 2016, but then began to rise sharply[7]. At the end of 2016 it was about $15/lb, at the end of 2017 it was about $36.20/lb and at the end of March 2118 it was about $42.60/lb. Since cobalt is a critical part of lithium-ion batteries and is widely expected to be in short supply as the production of lithium-ion batteries expands, its price is unlikely to decline dramatically in the near to foreseeable future. This means that the five-year moving average of the cobalt price is turning upwards again. In stock market parlance, at the end of 2015 the five-year moving average of the cobalt price was at a support level, i.e. at the price of its previous two turning points (1990 and 2003), at which it becomes more attractive to buyers than to sellers, and the price moves higher.

The price prognosis for nickel is not dissimilar to that of cobalt, although at the end of 2015 the five-year moving average of the nickel price was still above its long-term average. The price of nickel was at about $6.00/lb in 2015. It dropped to about $3.60/lb during 2016 but ended that year at about $4.50/lb. At the end of 2017 it was about $5.80/lb and during the first quarter of 2018 the nickel price was about $6.00/lb. While less under stress in terms of supply and percentage of the total market, nickel is also a critical metal in lithium-ion batteries.

SUMMARY AND CONCLUSIONS

The exercise presented in this paper was done to examine the impact of the commodity price cycle on the economics of processing laterite, producing an intermediate mixed nickel-cobalt hydroxide product. The technology selected for this exercise was the HPAL route, but that was merely for the convenience of already having the process and cost modelling available from previous work.

While it may not repeat itself, history does rhyme; a century of price data, inflation-adjusted to 2017 currency, for nickel, cobalt, sulphur, limestone, magnesium oxide and lime show that the prices of these commodities tend to vary cyclically between bounds determined by the relevant long-term average price plus or minus one standard deviation. At times the prices do escape this channel, but they invariably revert back to inside these bounds.

The commodity price cycle does have a substantial impact on the economics of the HPAL project used for this exercise, depending on the year in which the process was assumed to begin. The worst result, economically, was for a price cycle replicating the one that began in 1941, which gave a 20-year IRR of only 11%. The best result was for a price cycle replicating the one that began in 1976, which gave a 20-year IRR of 33%.

For the HPAL circuit and the laterite used in this exercise, the prices of the main input reagents had a much smaller impact on the overall economics than the prices of nickel and cobalt.

At present, early 2018, the prices of nickel and cobalt are on the rise and not likely to decline in the near to foreseeable future because both are important in the manufacture of lithium-ion batteries. This would make it appear that 2018 and onwards might well be a very propitious time for new laterite projects.

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