MODULE 1- HOW MUCH IS THE ORE WORTH?

This is the first of hopefully a series of periodic modules discussing the zinc mining industry. The author, now retired and with some time on his hands, spent approximately eight of his 30+ years in the mining business working as an engineer at zinc mines including Noranda's Geco copper/zinc/silver mine in northern Ontario and Glencore's George Fisher and McArthur River zinc/lead/silver mines in northern Australia. It was at these operations where I slowly developed a keen sense for what was and was not an economic mining proposition.

Zinc is unique in the fact that the percentage of the zinc mined by underground methods is steadily increasing as open pits such as Century and Rampura Agucha are exhausted. Even Teck's Red Dog open pit mine will commence a production decline shortly (without a mill expansion) as grades to the mill drop steadily.

One of the key roadblocks to understanding the economics of a zinc deposit is to understand its revenue potential.

This is often complicated by:

1) the fact that the mine may produce multiple concentrates;
2) precious metals reporting to various concentrates;
3) the grades and recovery factors for each concentrate must be known;
4) whether there are any elements the will result in penalties or rejection of concentrates;
5) not knowing where the concentrates will be processed. This impacts transport costs which are paid by the miner;
6) not knowing long term representative treatment charges.

Revenue must be related back to the cost of mining, milling and all other site and corporate charges on a tonnage mined basis in order to determine what the potential margins will be.

The example below is for a base metals mine producing multiple concentrates shipped to numerous smelters.

Red Sky Mines mills ore grading 6% Zinc, 5% Lead, 1% Cu, 4 oz/t Ag, 0.03 oz/t Au. What is the revenue per tonne of ore?

Three concentrates are produced:

	Zinc Concentrate	**Lead Concentrate**	**Copper Concentrate**
Grade	51% Zn	60% Pb	25% Cu
Recovery	85% Zn	88% Pb	75% Cu
	15% Ag	65% Ag	50% Au

Doug Beattie, Mining Engineer (Retired)

Existing commodity prices- $1 /lb Zn, $1 /lb Pb, $2/ lb Cu $20/oz Ag, $1,000/oz Au

Treatment Terms

Zinc Concentrate

Units Deduction-	8% Zn
	3 oz/t Ag
Treatment Charge-	$200/t concentrate
Price participation-	$0.10/t for every $1.00 change in price basis $2,000/t SHG Zinc
Silver refining charge-	$1/oz

Lead Concentrate

Units Deduction-	2% Pb
	1 oz/t Ag
Treatment Charge-	$200/t concentrate
Price participation-	$2/t for every 1 cent change in price above $1/ lb Pb. No de-escalator.
Silver refining charge-	$1/oz

Copper Concentrate

Units Deduction-	1% Cu
	0.04 oz/t Au
Treatment Charge-	$90/t
Refining Charge-	$0.09/lb Cu
	$6/oz Au

Zinc Revenue

Tonnes of ore mined to produce one tonne of zinc concentrate:

51%/ (6% x 85%) = 10 tonnes

Ag grade in zinc concentrate = 10 tonnes ore/ tonne concentrate x 4 oz/ tonne of ore x 15% recovery

= 6 oz/tonne concentrate

Zinc concentrate revenue:

51%-8% = 43% Zn payable

2204.5 lb/t conc x 43% x $1/lb. = $947.94 /t concentrate

6 oz/ t- 3 oz/t = 3 oz/t Ag payable

3 oz/t x $20/oz= $60 /t concentrate

Minus:

Treatment charge: $200 + ($2,204.5-$2,000) x $0.10 =$222.05

Ag refining charge: 3 oz/t x $1/oz = $3.00

Net revenue/ tonne zinc concentrate: $947.94+ $60-$222.05-$3 = $782.89

Net revenue/ tonne ore mined: $782.89/10 = $78.29

Lead Revenue

Tonnes of ore mined to produce one tonne of lead concentrate:

60%/ (5% x 88%) = 13.6 tonnes

Ag grade in lead concentrate = 13.6 tonnes ore/ tonne concentrate x 4 oz/ tonne of ore x 65% recovery

= 35.4 oz/tonne concentrate

Lead concentrate revenue:

60%-2% = 58% Pb payable

2204.5 lb/t conc x 58% x $1/lb. = $1,278.61 /t concentrate

35.4 oz/t – 1 oz/t = 34.4 oz/t Ag payable

34.4 oz/t x $20/oz = $688 /t concentrate

Minus:

Treatment charge: $200 /t concentrate

Ag refining charge: 34.4 oz/t x $1/oz = $34.40 /t concentrate

Net revenue/ tonne lead concentrate: $1,278.61 + $688 -$200- $34.4 = $1,732.21

Net revenue/ tonne ore mined: $1,732.21/13.6 = $ 127.37

Copper Revenue

Tonnes of ore mined to produce one tonne of copper concentrate:

25%/(1% x 75%) = 33.3 tonnes

Au grade in copper concentrate= 33.3t ore/t conc x 0.03 oz/t x 50% recovery

= 0.5 oz /tonne concentrate

Copper concentrate revenue:

25%-1% = 24% Cu payable

2204.5 lb/ t conc x 24% x $2/lb = $1,058.16 / t concentrate

0.5 oz/t – 0.04 oz/t = 0.46 oz/t Au payable

0.46 oz/t x $1,000 /oz = $460/ t concentrate

Minus:

Treatment charge: $90/t

Copper refining charge: $0.09/lb x 2204.5 lb/t conc x 24% = $47.61 / t

Au refining charge: 0.46 oz/t x $6/oz = $2.76

Net revenue/ tonne copper concentrate: $1,058.16+ $460 -$90- $47.61 - $2.76 = $1,377.79

Net revenue/ tonne ore mined: $1,377.79/33.3 = $41.34

Total revenue/ tonne ore mined: $78.29+ $127.37 +$41.33= $247.00

I will try to find the time to generate a spreadsheet model of the above calculations.

You may often hear the term that the zinc is “85% payable”. This is a term that is interchangeable with the 8 units’ deduction. Typical zinc concentrate grades average about 51% so (51%-8%)/51% x 100 % = 84.3% in this example.

A typical smelter may in fact recover greater than 96% of the zinc contained in the concentrate. The difference between 96% and 85% is considered to be “free metal” that the smelter sells for their own account. It therefore constitutes an important source of revenue for the smelter. The smelter may also produce byproducts such as sulphuric acid for sale.

The above example highlights that all five commodities contribute significantly and the success or failure of an operation may depend upon the price of any given commodity.

Also illustrated above is the fact that the lead concentrate has contributed more revenue than the zinc concentrate and this is largely due to the fact that silver is generally intermixed with the primary lead mineral galena so floats with it in the mill. This is a primary reason why zinc is often considered a byproduct of the silver/lead mining and copper mining. Indeed, mining in the prolific Mt. Isa and Broken Hill camps in Australia focused on the lead and silver rich areas of the mines initially.

What this has meant from a practical perspective is that lead and copper rich (zinc lean) deposits have been preferentially mined over the past decades in comparison to zinc rich (lead, copper lean) deposits. Many mines could overlook the fact that the zinc stream was not terribly profitable or a loss leader by doing so.

The fundamental problem this has created however is that many of the lead and copper rich deposits with zinc present are now mined out or near mined out and zinc must now pull its weight financially in order for the mine to survive. Copper exploration focusses on porphyry copper targets with no zinc present and few bother to explore for zinc or lead anymore.

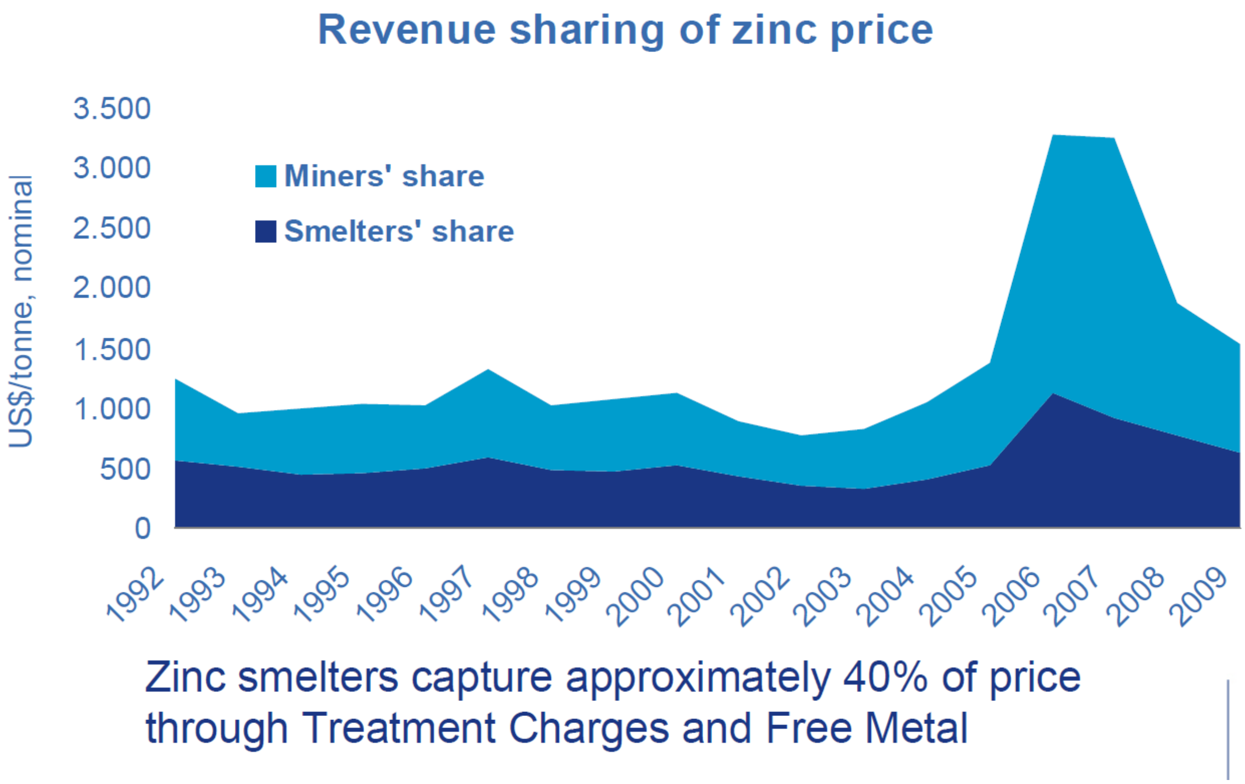
The smelters have generally not been good stewards for keeping supply and demand for slab zinc in check hence ensuring both they and the miners are making ample returns. A part of the reason for this is that they make much of their money from treatment charges and not selling the end product. They therefore encourage as many mines to enter production as possible (by signing off take agreements, providing finance etc.) knowing that the end result will be higher treatment charges due to an oversupply of concentrate. This has created an adversarial relationship at times. It has also led at other times to custom smelters having to enter the zinc mining business (Nyrstar, Glencore etc.) simply to keep feed coming to their smelters. They have bankrupted their suppliers of concentrate. They then internalize the miners' losses in order to keep their smelters running.

The problem with the zinc mining industry is that there were and are simply too many individual small miners. Historically, the miners have had no pricing power since each mine constituted only a small fraction of the overall market. This has begun to change with Glencore and Vedanta both in a position to now have some clout.

There are two supply and demand situations that concern the miner:

- the supply and demand for zinc concentrate. Treatment charges increase when there is an oversupply of concentrate;
- the supply and demand for slab zinc. If the smelters overproduce, the price decreases and the miners suffer.

The figure below amply illustrates that when zinc prices rise sharply, it is the miner who benefits most.



The worst of both worlds is when the miners and smelters overproduce. The best of both worlds is when the miners starve the smelters of concentrate by design or undercapitalization of the zinc mining industry. The latter situation is the one the zinc market has now entered.

Few probably remember but both BHP and Rio Tinto got their starts as zinc miners. Both have largely exited the business however in part due to the inability of zinc miners to be anything but price takers in an overcrowded market. Rio Tinto in fact found the Century deposit but quickly vended it away.

Known unmined zinc deposits all have some impediment that has prevented development and the project owner may also be the last to reveal what these issues are since this inhibits fund raising from retail investors in particular. The notorious and defunct Breakwater Resources simply mined the stock market to stay alive while pretending to operate viable mines. There are numerous traps for retail investors to fall into therefore and the underwriters may be the last to point them out. Beware of miners with conceivably commercial operations that continually go the market for more funds.

In most cases unmined deposits will suffer from one or more of the following issues:

- **Remoteness.** The reason many remote deposits have not been developed is that the miner must pay the concentrate transportation costs to the smelter or nearest smelter port. In most cases the miner must also pay to establish haulage roads and rail or port loading facilities. Canada Zinc's Prairie Creek deposit is about as remote as they come. The company will have to build an all season 180 km road to the site and then use it to haul concentrate by truck almost 500 km to the rail head at Fort Nelson,BC. They must then pay the cost to rail this concentrate 1,850 km to Vancouver and then by boat to smelters in Europe and Asia. Costs <u>per tonne of ore</u>

mined (not per tonne of concentrate) are estimated in their PEA at $33/t for the trucking, $24/t rail freight and $8/t ocean freight for a total of $65/t. This cost is higher than many mines mining costs. Total costs are estimated at $228/t demonstrating that remote mine sites may require the revenue per tonne mined to be in the $400 range to justify the initial capital expenditure. In other words, the ore grade must be very high. The advantage of having a smelter down the road from the mine, such as in Flin Flon, is readily apparent since it eliminates this transport cost. Remote sites also likely require high cost diesel power generation which could be 4-8 times more expensive than mines fed by industrial grids. They must also house and feed a workforce.

- **Impurities.** The Gamsberg deposit in South Africa is one of the largest known unmined deposit. Unfortunately, the zinc is intimately associated with manganese which is detrimental to custom zinc plants. Vedanta will reconfigure the Skorpion zinc plant in order to handle this ore.
- **Lack of byproduct credits.** The silver and gold content of many deposits provide the revenue to ensure profitability. For instance, the Flin Flon mining camp has had very good silver and gold credits in the multitude of deposits mined in the area to date. The nearby Hanson Lake deposit however is precious metal deficient and this lack of additional revenue has hampered development in the past.
- **Depth.** Australia's Admiral Bay deposit is a large relatively low grade resource. However, a high geothermal gradient means that the rock temperatures at the depth of the deposit could lead to severe operating problems.
- **Mining complexity.** Some deposits require higher cost underground mining methods such as cut and fill mining that render the deposits marginal due to the extra expense.
- **Low grade.** The Tennessee zinc mines have been the poster child for frequent openings and closings. Zinc grades in the 3% range simply do not provide ample revenue at times despite numerous infrastructure advantages.
- **Bad metallurgy.** Occasionally it is not possible to achieve positive metallurgical results from bench scale testing or pilot plants when scaled up to commercial production. Trevali is the latest in a long line of companies attempting to achieve suitable grades and recoveries at the fine grained Caribou zinc mine in New Brunswick.

The lack of exploration for zinc deposits in the past twenty years has meant that multiple deposits have been exhausted and many more are within five years of exhaustion. The rapid increase in zinc production in China appears to have masked this phenomena but anecdotal evidence suggests that this increase has also ceased.

What this means is that a suite of second tier deposits will likely have to be developed in order to fill the gap and the commodity price for zinc must be sufficient to provide the justification for the necessary capital expenditure. Analysts predicting a 10% rise per annum in zinc price appear to be timidly way off the mark since this will not come close to encouraging new greenfield production and the capital expenditure it entails nor provide the incentive to explore for a new suite of predominantly zinc deposits.

In subsequent modules, the zinc mining situation in individual countries will be reviewed. The aim of these modules is not to ultimately come up definitive supply and demand forecasts but to provide some insight as to who the potential winners and losers will be during the long overdue and necessary recapitalization of this industry.

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