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VIEWS

GRADE IS KING

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We are pleased to respond to Jeff Hedenquist and John Thompson's request for a brief piece on the current state of the exploration business, how MAG Silver has continued to thrive in such lean times, and especially how and why economic geologists should refocus on what "economic" means. Sig Muessig's excellent column on exploration canons in the April 2014 *SEG Newsletter* outlined many tenets we have followed (knowingly and otherwise) and we urge you to (re)read that paper now, whether you read more here or not.

The current market conditions reinforce MAG's underlying philosophy that "Grade Is King." MAG was formed in 2002 when silver was \$4.50/oz, gold was at \$350/oz, and lead and zinc were under \$0.25/lb; we set out to seek deposits that would not only be profitable at those prices, but large enough to produce for a minimum of 10 years. We have been fortunate to have made two major discoveries, both of which should do just that: Juanicipio, in the shadow of the headframe of the world's largest primary silver mine (with our partners Fresnillo plc), and Cinco de Mayo, a blind discovery in the middle of nowhere. In both cases we believed in the geology and our Board believed in us enough to allow us to continue drilling to discovery.

It is the quality of what we found that keeps investors investing and sleeping comfortably at night, but this article is not about our discoveries. Rather, this article is about how many highly experienced mining people got seduced by quantity (cf. net present value, NPV) during a runaway bull market and how hard-learned lessons about profitability (cf. internal rate of return, IRR) got forgotten during the "irrational exuberance."

The bull market in metal prices that began around 2005, driven (among other things) by hyperinflationary concerns, massive infrastructure

construction in China (and to a lesser extent in India and Brazil), and the bursting of real estate and financial market bubbles, lost momentum after a high-flying recovery in 2010–2011 from the 2008 Global Financial Collapse, leaving a number of junior and major mining outfits in precarious positions. This is not news to SEG members who have seen massive layoffs (again) and/or severely straitened exploration budgets...but neither should it have been a surprise. Predictions of metals prices rising to astronomical levels (\$5,000 gold; \$250 silver; \$10 copper), coupled with exhibitor inflation at major trade conferences (e.g., PDAC exhibitors grew from 200 to over 1,000 companies, with many booths manned by people with little or no technical or mining background) and resuscitation of projects long ago consigned to the kennel, were alarming warning signs as far back as 2007. By 2010 it seemed there were multiple companies dedicated to each and every element in the periodic table, and investors willing to back them, apparently believing that all laws of economics and gravity had been suspended. The fact that the number of companies that had been created in five years was greater than the number of geologists who graduated in 20 was perhaps scariest of all to the few who thought about who was actually handling the technical aspects of all these projects.

Now that the bubble has burst, million-dollar geologic exploration budgets, which potentially generate a company's future, are being sacrificed to rebalance ledgers driven billions of dollars into the red by build-out development teams that misforecast operating-cost escalation and grossly miscalculated capital expenditures (CAPEX) on gigantic mining projects worldwide. The mass-balance problems with this are indicative of the short-term perspective of corporate management in many companies, but the fact that there were multiple failed projects in various jurisdictions



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worldwide suggests that something systemic and internal is amiss. We argue that this is most critically a failure to maintain focus on quality. We are afraid that many corporate boards, management teams, investors and, sadly, even exploration teams lack the fundamental ability to discriminate quality (an ore deposit) from dross (a geochemical anomaly). Despite the harsh pullback in our industry, it is worth noting that silver is still over \$20/oz; gold is over \$1,250; and lead and zinc remain at nearly historic highs, so the Darwinian thinning of the herd may not be over.

As we suggested earlier, much of the failure stems from a focus on NPV, often unwittingly mistaken as the number of contained ounces per ton multiplied by the number of tons, with no eye to profitability (which is actually incorporated into complete NPV modeling). This tended to be combined with the ideas (often pushed by investors and analysts alike and not resisted by technical management) that low grade would become profitable once a metal price rose sufficiently and that high metal prices allow one to mine large amounts of low-grade

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¹ Available at www.segweb.org/views

ore to make some profit as opposed to mining high-grade ore and making sizable profits while the sun shines. They've learned the hard way that the old saw "when metal prices are low you mine the high grade to keep the lights on and when they are high...you mine the high grade to make a ton of money" still holds true.


Size is good, but we'd argue that making money (profitability measured by IRR) should be the metric by which decisions are made by both mining companies and investors alike. We may be considered dinosaurs (we prefer to think of ourselves as experienced), but we came up in the days when economic geologists ran exploration and brought some basic economic rules of thumb to the table. One we find especially applicable, which we learned as Archie's Rule (for Archie Bell, Vice President of Exploration for Noranda, who led discovery of Gaspé Copper and Babine Lake deposits) but which doubtless had other names in other outfits. Archie's Rule neatly provides a yardstick for measuring whether or not a project makes real sense, regardless of commodity, mining method, or cost environment. It very simply establishes the threshold that you must recover twice your all-in operating costs (net smelter return [NSR] = 2× operating costs). So, if it costs you \$20/t all-in in a big open-pit operation, or \$100/t underground, you must recover \$40 and \$200/t, respectively. What does this doubling cover? Recovery of CAPEX, amortization, depletion and depreciation, taxes, ongoing exploration, a little breathing room for metal price and cost fluctuations, and a minimum 15% IRR. Special circumstances might allow quibbling with some of these, but, historically, if you can cover the double you're in good shape. However, note that special circumstances do not change the fundamentals of how Archie's Rule works when you compare grade and metals price.

Figure 1 shows the break-even solution for Archie's Rule for underground mining of silver in Mexico (we emphasize that you can concoct the same graph for any commodity and cost environment; the geometry is the same), with each line reflecting 2× operating cost (OC). Profitable projects lie above the lines, and the farther to the upper right of the lines the better. The solutions are not straight lines, reflecting the fact that at higher grades you are averaging your costs over more grade units, and that at lower grades

you have fewer units to support your costs. The graph also allows a rapid determination of the effects of increased costs (10–15%/yr cost increases have been common recently) or a decrease in metal prices. For example, compare the \$40/ton operating costs line (\$80 recovered) to the \$50/ton OC line (a 20% increase in costs). Note that at 400 g/t Ag, it takes a silver price increase of \$1.50 (\$7.00–\$8.50) to stay profitable, whereas at 200 g/t Ag, it takes a \$3.50 increase (\$13.50–\$17.00) to stay profitable. This differential gets more extreme at lower grades and higher prices. Above \$25/oz the lines of this diagram become increasingly closer to horizontal, meaning that not only are margins here very tight but that it takes huge increases in metal prices for something to become (or stay) economic; very slight price decreases or cost increases will put you permanently on the wrong side of the line. You can examine the lines in reverse for falling prices or costs.

The slope starts to flatten significantly for our base case (OC = \$40/t) at about 300 g/t Ag, so MAG focuses its exploration on properties that can equal or better this average grade—notably, not many can.

A related fundamental error is the belief that, as metal prices increase, it is possible to increase NPV by using a lower cutoff grade and bring in more ounces or pounds. From the graph it is easy to see how this results in a drop in profitability and how very low cutoff values put you below the Archie's Rule line completely for a given operating cost. Counterintuitively, once sufficiently below the line you will never get above it and into profitability no matter how high the metal price goes, because the lines are nearly horizontal toward higher prices. Many outfits bought into this NPV fallacy and spent billions of dollars developing deposits with infrastructure (mine development) that cannot be readily changed to reflect or react to a sharp drop in metal prices. This leaves no alternative but to mine at lower grades and suffer the inherent loss of profitability, more so if metal prices decline further.

We repeat, size is good, but making money (profitability measured by IRR) is what economic geology is all about; it is incumbent on exploration geologists to always keep this concept front and center. Remember: Not all ounces (pounds) are created equal. 

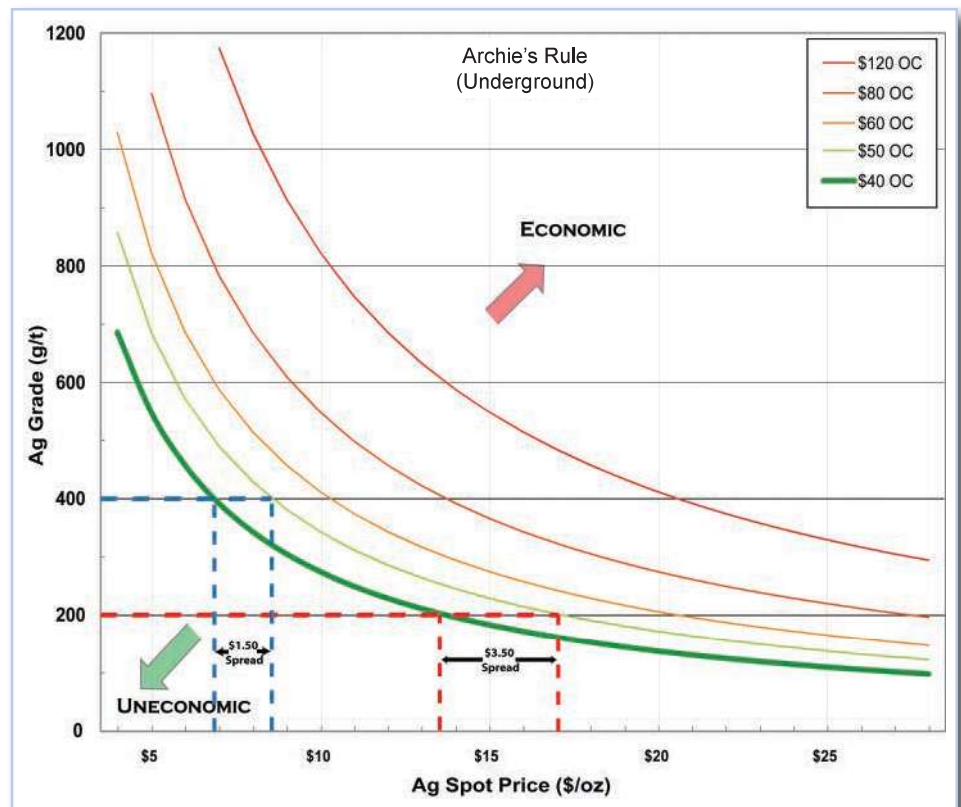


FIGURE 1. Graph of solutions to Archie's Rule (NSR = 2× OC) for a range of underground mining situations with respect to silver grade and silver price. Similar plots can be made for any commodity and mining scenario. NSR = net smelter recovery; OC = all-in operating costs.