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Peak Oil, Peak Gold, Peak Whatever … Phooey!

A Monday Morning Musing from Mickey the Mercenary Geologist

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Non-renewable natural resources (e.g., industrial metals, precious metals, agricultural minerals, industrial minerals and rocks, energy fluids, and energy solids) are extracted from Earth's surface and its depths. Exploitation of these resources naturally leads to depletion and more must constantly be found, developed, and mined. In our economic system, unit prices of commodities reflect current supply and demand fundamentals.

There are two distinct and diametric philosophical positions on availability of adequate supplies required to meet future demand of non-renewable natural resources.

On one side are the optimists, i.e., those who generally view a glass as half-full. These folks are called "cornucopians". They surmise that Earth contains an abundance and in fact, a bounty of all resources that mankind requires for his well-being, prosperity, and longevity as a species. Furthermore, they postulate that we will never run out of a critical resource, will find a substitute, or will invent a technology to get what we need when we need it.

The basis of cornucopian philosophy is capitalistic; i.e., as a resource becomes scarcer its price will rise. Stimulated by higher value, more will be found, developed, and produced, more will be recycled, new technologies will require less of it, and if beneficial or necessary, a substitute will be found.

Inhabiting the other side are the pessimists, i.e., those who view the very same glass as half-empty. They are the malthusians, disciples of Thomas Malthus, a late 18th to early 19th Centuries English cleric, professor, and economist who predicted the pending decline of mankind due to rapid population growth that unless controlled, would outpace agricultural growth. He postulated that cycles of population growth in times of plenty beget famine, disease, and war in times of scarcity.

The malthusian philosophy looks at increasing demand as a negative. It universally predicts supply deficits, critical shortages, and economic crises leading to catastrophic cultural and societal declines in the human condition or even our extinction as a species.

Avowed iconoclast George Carlin added a bit of levity to this dichotomy by observing that the glass is twice as big as it needs to be. He had a point.

But I digress…

As an economic geologist and analyst, I am by nature an optimist (though always skeptical). With that philosophical mindset, I embrace the cornucopian viewpoint.

And today, I will unequivocally illustrate in a series of facts, figures, and graphs why the malthusians and other assorted pessimists and nihilists of their ilk (e.g., the religious enviro-fundamentalists and the eco-socio-fascists) have been, are, and will always be …

Absolutely WRONG in their cynical, gloom and doom opinions of humankind and the bountiful planet on which we live and breathe.

In a think-piece a few years ago, I responded in print to a media query of whether Earth has ever run out of a natural resource. Based on my unabashedly cornucopian views, you may be surprised by the reply (**Mercenary Musing, March 19, 2012**). I answered yes but could only come up with one example and there were unique circumstances that led to its near exhaustion.

Read this short essay to learn the particular commodity and why it was all but used up in less than 35 years. Quite predictably, a substitute was soon discovered, a war was fought to control the new commodity, and the industry that needed it continued to prosper. Since that period over 140 years ago, a second substitute that is man-made now supplies the exponentially growing world demand.

Let's flesh out the meat on the bone now. To establish my cornucopian case, I present evidence from four of the world's most valuable and essential commodities: Oil, iron ore, copper, and gold.

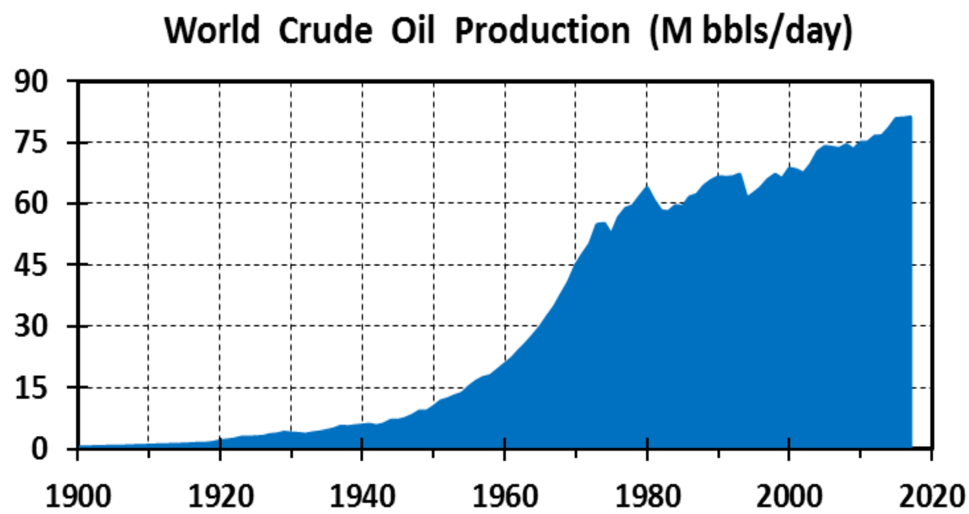
Oil is the most important natural resource exploited by modern man. The world's economy literally runs on oil and it supplies 33% of our annual energy needs. World oil production has long been predicted to decline in the near- to intermediate future. This platform grew out of a misappropriation of the thesis of a brilliant geologist and geophysicist, King Hubbert, in the late 1950s. Dr. Hubbert studied and wrote about giant oil fields and districts in the United States. Because all oil and gas fields have a natural and significant decline curve, Hubbert used historical data to predict that US oil production would peak in 1970.

And he was right on the money: US oil production did indeed peak in November 1970 at 10.0 million bbls/ day. It then fell off dramatically and dropped to little more than half that amount 30 to 40 years later.

"Peak oil" production for the world was in particular favor by the malthusians in the mid-2000s given rapidly increasing demand from China and other historically poor countries as they assimilated into the modern global economy.

Despite an exponentially growing population and worldwide increases in the standard of living in the 20th and 21st Centuries, we have nevertheless constantly and continuously produced more oil to meet burgeoning demand.

In this graph, I illustrate world oil production in millions of barrels per day from 1900 to 2017:



Annualized growth in crude oil production has averaged a whopping 4.7% since 1900. Note the overall steady increase in demand thru 1920, the production surge as the automobile became a way of life in the US after WWI, the drop off during the 1930's depression, and a steep rise during and after WWII that continued thru 1960.

The latter 60-year period shows the accelerating increase in demand that continued until the first Middle East oil embargo and recession of 1973-1974. This was followed by robust growth until the second oil embargo and another recession in the early '80s. Overall demand has continued to increase over the past 35 years but with numerous perturbations that reflect geopolitics in the Middle East, the rise and fall of OPEC's power over world oil markets, accelerating demand from China and other developing countries, and most recently, the shale oil revolution in the United States that has more than doubled domestic production since 2008.

The relative flattening in the world production curve from 2015-2017 reflects a price crash in late 2014 largely driven by the phenomenal increase in US production. It hit an all-time record level in November 2017, 47 years after the prescient Hubbert was proven right.

Indeed, there has been a vast oversupply of crude oil for the past four years. It first resulted in weak prices and was followed last year with voluntary cuts by OPEC and Russia, in whole amounting to about 1.5% of annual production. These cuts were designed to stimulate prices and reduce record oil inventories. But domestic shale production just keeps going up, despite bottlenecks in pipelines to refineries and inadequate export capacities. Production is 11.7 million bbls/day and is projected to average over 12.0 million in 2019.

Folks, the malthusian prediction of peak oil that came across so loud and so vociferously ten to fifteen years ago was just a bunch of malarkey. In fact, the exact opposite has occurred: we have found, developed, and produced way too much oil over the past few years and have overwhelmed a yearly growth in world demand of 1.3-1.5%. All our numbers are from the US Energy Information Agency (EIA) and do not include natural gas liquids or condensate production. That said, crude oil production will be very near 30 billion bbls in 2018.

As an aside, note that 70% of the oil contained in fields discovered throughout the world remains in the ground and awaits development of the ways and means to extract economically.

Meanwhile, technological advances such as horizontal drilling and fracking have enabled additional production in old fields and basins from tight shales that until a decade ago, were viewed only as the source rocks for oil and not as potentially productive reservoirs. These new recovery techniques have been applied extensively to US onshore basins but at this juncture, nowhere else in the world to any extent.

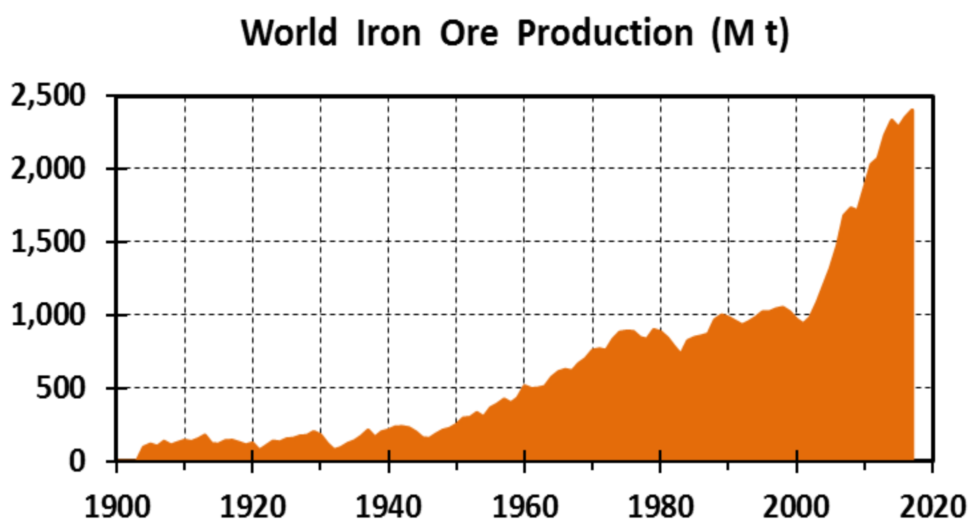
Offshore exploration, development, and production technology has also made significant advances over the last few years with drilling in much deeper water and more remote targets now feasible.

There are oil-bearing sedimentary rocks all around the globe and they are scattered throughout 500 million years of the geological record. Oil production is geographically diverse: Three countries currently produce more than 10 million barrels per day and another 17 produce more than 1 million barrels. In total, 41 countries produce greater than 100,000 barrels of oil each and every day.

You say, "Peak Oil." … I say, "Phooey!"

Iron is overwhelmingly the most important metal consumed on Earth, comprising about 95% (as iron ore) of the total annual output from mining of metals. Iron ore is a very low value bulk commodity priced by the tonne. Unlike most other major metals, it is not traded on world exchanges or derivative markets but instead is priced mostly by annual contract negotiations between miners and consumers and a spot market.

The world mine production chart for iron ore since 1904 (1900-1903 are not available from our USGS source) is again a story of increasing demand for over 110 years:



From 1904 to 2017, the worldwide mining of iron ore increased over 25 times, from 95.5 to 2400 million tonnes for an annualized growth rate of 2.9%. On a yearly basis, production increased and declined in a volatile fashion, affected by both macroeconomics and armed conflict thru the middle of World War II.

With a post-war economic boom first driven by the United States and then by the rebuilding of Western Europe and Japan, iron ore production surged in a steep line thru the late 1970s. From the early '80s recession until the late '90s, growth was uneven but production grew to over a billion tonnes per year.

Then in 2002, demand for iron ore rose dramatically when China embarked on by far the largest program of industrialization and infrastructure build out in history. Over the past 15 years, iron ore production has gone from 1100 to 2400 million tonnes per year.

This rampant growth is slowing now but has shown little evidence of regressing. Shy of a major world economic recession, iron ore production is expected to remain strong with India and other countries in eastern Asia next to assimilate into a modern market economy.

The Earth is geologically endowed with vast quantities of near-surface iron ores in bulk mineable accumulations. Most of them formed from 2.4 to 1.8 billion years ago as sedimentary rock deposits when photosynthesis by blue-green algae caused the oceans to become oxidized. Dissolved iron in the water was precipitated as iron oxides and accumulated in massive deposits on the sea floor called banded iron formations.

The USGS lists current iron ore resources at 800 billion tonnes. Given 2017's record production at 2.4 billion tonnes, these resources constitute over 330 years of supply at current mining levels and grade requirements. Many giant deposits of lower grade material are known but are not presently economic.

Note also that iron is the fourth most abundant element in Earth's crust, behind only oxygen, silicon, and aluminum. The possibilities for iron ore resources are endless. In addition, a significant percent of annual iron and steel production is from recycled materials.

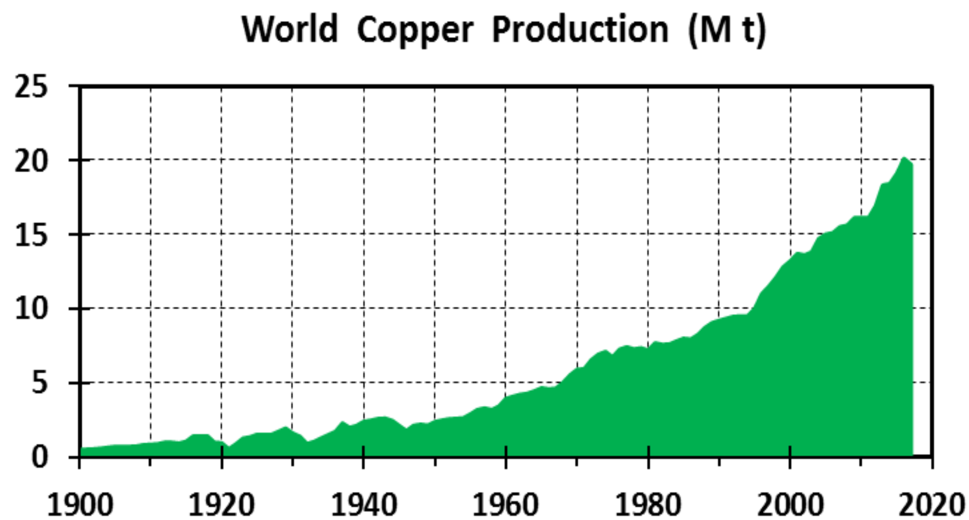
So folks, I think we can rest assured that the world is not going to run out of iron ore.

Next on the agenda is copper, aka the metal with a PhD in economics. Copper is required for everything electrical and is used extensively in building materials and alloys. As such, it is the third most utilitarian metal, behind only iron and aluminum.

Since 1900, annual mine production of copper has increased quite systematically from slightly less than half a million to over 20 million tonnes per year (>40 times) for annualized growth of 3.2%. Annual worldwide consumption is best reflected by refined copper that includes scrap and recycled materials; it now amounts to over 24 million tonnes.

The rapid growth in copper consumption is driven mostly by electrification. World population and per capita consumption has grown from 2.6 billion people at 1.2 kg each in 1950 to 7.3 billion people at over 3.2 kg each in 2017. That, my friends, is astounding.

A graph of mine production from 1900 to 2017 follows:



The connection of copper production to world macroeconomics and geopolitical events is well-documented by this graph. There was a steady increase in mined copper from 1900 to WWI, then a steep drop off as the economy recessed after the war. In the Roaring ‘20s, production soared until the crash of 1929. It bottomed at the depth of the depression in 1932 and took until the late 1930s to recover.

From the advent of WWII to the height of the war in 1943, copper mining peaked. Although it did not recover that level again until the early 1950s, production has been on the uptick constantly from 1946 to the present with hardly a respite as the world has and continues to become increasingly electrified. Brief perturbations occurred during periodic recessions over this 70-year interval.

The emergence and rapid industrialization of China starting in the mid-1990s is marked by a much steeper curve of increasing mine production. In fact, world copper production doubled from 10 million tonnes in 1995 to over 20 million tonnes in 2016. China now accounts for about 45% of annual copper demand.

There is a dearth of new copper projects on the near-term horizon. I submit this has mostly to do with four years of low copper price and a concomitant lack of new development. It is generally accepted by analysts that a long-term base price of $3.30/lb is required to stimulate financing and development of new copper mines.

Average mine grades for copper have declined dramatically in recent years. But that is the general nature of all metals extracted over time. Easily discovered, surficial, high-grade deposits are exploited first. The history of mining for all metals has been one of larger tonnages, declining grades, and lower prices on a constant dollar basis.

Be aware that there are thousands of known, drilled-out copper deposits in the world that are currently too low grade, too deep, too difficult to process and recover, too remote, too climate-challenged, too far from infrastructure, too large, too small, and/or too geopolitically risky to attract capital for development and mining in today’s macroeconomic and nationalistic climate.

If supplies become short and insufficient to meet demand, then the price of copper will go up, new technologies will be developed, and some of the many known deposits will become economically attractive.

That said, recall that the definition of ore is *rock that can be mined at a profit*. A corollary acknowledges the importance of economics over time: *What was ore yesterday is not always ore today and may or may not be ore tomorrow* (**Mercenary Musing, August 25, 2008**).

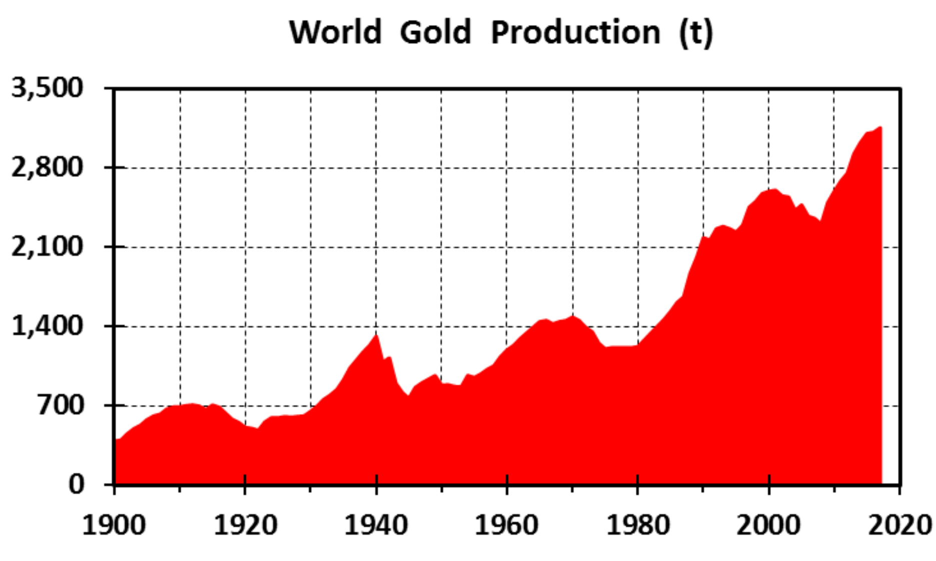
But folks, here's an ace in the hole: The USGS estimates there are 2.1 billion tonnes of known copper resources and another 3.5 billion tonnes of "undiscovered resources" in the ground. At current mine production levels, these numbers equate to a ready supply for the next 280 years.

As with iron ore, a significant and growing amount of copper is recycled. In 2016, it comprised 29% of global usage according to the ICSG.

Plus substitution is always looming. For instance, remember back when phone and cable TV signals were carried in thick copper wires strung overhead on big wooden poles? Then along came underground fiber optic lines that transmitted much cleaner and clearer signals several orders of magnitude faster for phone, television, and internet. That once big demand for copper was soon kaput.

Finally, let's look at money, i.e., gold. I recently wrote about the flawed premise of peak gold and will not rehash my position in detail here (**Mercenary Musing, December 3, 2018**). Suffice it to say that the price of gold is not governed by usual supply and demand fundamentals: 85% of gold is stored or hoarded in jewelry and bullion as a store of wealth and a safe haven against financial calamity. Because it is so valuable and does not corrode or oxidize, an estimated 98% of all the gold ever mined is still above ground and available for trade, barter, and recycling.

Annual gold production since 1900 is shown below:



World gold production increased from 386 tonnes in 1900 to 3150 tonnes in 2017. That is an eight times increase for an average gain of 1.8% per year.

The above chart of the118-year record of increasing gold production is a strong argument against peak gold. Gold demand is driven by geopolitical unrest and economic duress. If global tensions and more importantly, the potential for world financial collapse are high, then the demand for gold as a safe haven and insurance policy will increase. Price will follow suit, gold mining will remain profitable, and robust production will continue.

I have shown that mining of four of the world's most important natural resources, namely oil, iron ore, copper, and gold, has increased steadily and relentlessly with few pauses over 118 years from the early industrial age to the present.

This is the strongest argument for a cornucopian outlook of Earth. Assuming past is prologue, the history of our industrialized age repeatedly shows us that as the world population increases and standards of living improve, resource demand increases at higher rates. That said, we have without fail found, developed, and extracted the supplies required for all of these heightened demands. I find no reason to think that paradigm will not continue.

As further evidence, let's revisit some infamous curmudgeons of the malthusian camp and their false narratives. My arguments against this cabal are exemplified by two notable and failed predictions made during the social and political turmoil of the late 1960s and early 1970s.

The Population Bomb (1968) was a best-selling book written by Stanford University Professor Paul Ehrlich and his wife Anne in 1968. Its alarmist predictions were based on a premise of overpopulation that would spawn mass starvation and other societal upheavals in the 1970s to 1980s. It called for shocking and draconian actions to limit populations, such as cutting off of food supplies to countries that refused to address population growth. Among Dr. Ehrlich's more ridiculous predictions of the time: all important animal sea life will die off in 10 years; India will not be able to feed another 200 million people by 1980; and England will not exist as a country in 2000.

The Club of Rome's *Limits to Growth* (1972) used computer modeling to generate a collection of charts predicting serial resource depletion, economic and societal collapse, and a sudden decrease in population and industrial capacity within 100 years. The authors proposed that the only solution to the presumptive dilemma was to immediately stop population growth and to restrict industrial output per capita at then present levels. Their idealized world would be accomplished via a no growth scenario and exist in a state of global equilibrium with a self-sustaining society. The overall birth rate would equal the death rate and capital investment would equal the depreciation rate.

However, their dubious World3 computer model was based on flawed assumptions that resource use would grow exponentially while technological advances to increase resources would only increase linearly, that all non-renewable resources had a 110-year lifespan, and that the present amount of agricultural land was at its ultimate limit.

Included among its misfit projections: the world would run out of oil in 20 to 50 years (1992-2022) and gold would be mined out in 9 to 29 years (1981-2001).

The work faced immediate ridicule and had lost all credibility by the 1990s. Its methodology has been described by the old computer maxim, "garbage in, garbage out" and the overall work as "Chicken Little with a computer".

The catastrophic forecasts made in these seminal books, the first written by a self-described malthusian and the second by a collective of environmental scientists and computer jockeys with a socialist agenda, have not approached any semblance of reality in the intervening 45-50 years.

Yet we as logical, rational, and practical scientists are repeatedly inundated with such dire and catastrophic forecasts by government-supported PhDs with malthusian bents. Furthermore, their inane doomsday prophecies are then promulgated as sure-fire scenarios by the popular mainstream media.

Other notable examples that have lost all credibility over the last half century include: global cooling that would initiate a new Ice Age (1965-1975), acid rain that would kill all the fish and denude all the forests in northeastern North America and Northern Europe (1972-1983); ozone hole layer that would cause a worldwide outbreak of human skin cancers and cataracts (1976-1989); and the global warming hockey stick that would result in a “20-foot sea level rise in the near future” (Al Gore, 2006).

Well, that’s enough of that; let’s get back to the “peak whatever” discussion.

I have shown in a series of facts, figures, and graphs that peak oil, peak iron, peak copper, and peak gold are all figments of imagination in the minds of malthusians. As these are four of the major and essential non-renewable resources that run our industrialized society, I can extrapolate and state that we are equally as unlikely to exhaust other commodities.

Mankind inhabits a beautiful and bountiful Blue Marble that has, does, and will supply us with what we need and what we want on demand:

That said, science is always a serial exercise of experiment, hypothesis, theory, and principle. It can never be exact, stagnant, or settled.

So perchance that we do in some future century or millennia eventually exhaust one or more of our essential natural resources on Earth: What then?

As a geologist, a cornucopian, and an optimist, I am convinced that humans will live on and will mine other rocky bodies in our solar system in the 21st Century, whether they are asteroids, moons, or planets. And we will undoubtedly transport some of what we extract back to Earth.

Looking to the longer term and a worst-case scenario, I opine that we will have migrated to another blue-green planet in the Milky Way long before any catastrophic, malthusian-style socio-economic event could possibly extinguish our by then significantly evolved species:

All hail science, reason, and logic and the driver of human evolution and progress: Optimism!

Ciao for now,

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Mercenary Geologist

Acknowledgment: Troy McIntyre is the research assistant for **MercenaryGeologist.com.** Sources of data for this musing include the USGS, EIA, and ICSG.

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Mickey worked for junior explorers, major mining companies, private companies, and investors as a consulting economic geologist for over 20 years, specializing in geological mapping, property evaluation, and business development. In addition to Mickey's professional credentials and experience, he is high-altitude proficient, and is bilingual in English and Spanish. From 2003 to 2006, he made four outcrop ore discoveries in Peru, Nevada, Chile, and British Columbia.

Mickey is well-known and highly respected throughout the mining and exploration community due to his ongoing work as an analyst, writer, and speaker.

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