

MINING PMGS TO BOOTRAP COMMERCIAL SPACE

Christine Hansen, Ph.D.

PTMSS, May 2013

"KISS MY ASTEROID"

Unofficial Title



The history of NEOs is not always
inspiring...

The future is another story!

- ◎ In the future, NEOs will play a crucial role in providing resources for human civilization.



Human life is tied to minerals

- ◎ It's worth noting that:
- ◎ The living human body consumes minerals.
- ◎ The minerals we take in multivitamins show the close linkage between human beings and mineral resources.
- ◎ Unlike tourism or specialized manufacturing, a human being could not live without mineral consumption. Minerals and their consumption is a tangible part of human life.

Mining as a part of the biogeochemical cycle

- ◎ Mining is a natural part of the survival process of human beings. But supplies on the Earth are limited, whereas human population is continuing to grow.
- ◎ As human beings, we want to be able to *grow past the mineral carrying capacity of the Earth*
- ◎ Put more broadly, we need to extend the biogeochemical cycle of the Earth, so that it is able to absorb our waste into its sinks, and to provide our chemical nutrients.

We are almost out of waste sinks...



Space offers obvious waste sinks, even
in orbit!



But how do we get the “system inputs” – the minerals of life?

- ◎ Space offers these elements. But in many ways, the problem is to reconcile the availability of the resources with the structure of our economic investment.
- ◎ Yes, water ice is a mineral. And ice is a great thing to mine as propellant. But ice is not going to get investors excited. If you tell the public that you are planning to go into space to mine water, they will probably send you off into space involuntarily! Woosh...

Woosh...

- © That would be one way to get a ride into space.
“Ha, ha, did you see that Bozo go up??”



We need to sell a business plan

- ◎ Without being catapulted into space, we need to sell a business plan for commercial space.
- ◎ Water may be the most important resource to mine, but it is not necessarily the best one to talk about in order to bootstrap commercial space investment.
- ◎ Let's take a moment to look at why we need to bootstrap commercial space investment in the first place.

The Commercial Space Frontier

- ◎ Most of us recognize that we are poised on the edge of a frontier. Government-led space is increasingly yielding ground to commercial entrepreneurs, although partnerships will still be important. But just as the civilian airline sector eventually became more pervasive than the government-led sector, so commercial space appears to be increasing its impact on the industry.



The Dragon Capsule – a milestone in commercial space

Problem: How do you sell an object like an NEO to an investor?

- ◎ At first glance, nothing might seem more ludicrous than an idea that an NEO—thought to have been responsible for the demise of the dinosaurs—could be sold as a focus of investment. But it is quite a sensible idea. The concept of space mining in general is viable, and space mining is the best way to bootstrap the development of commercial space infrastructure.
- ◎ However, we will never build a popular groundswell of support without careful consideration of people's perceptions.

Too hard to understand

- ◎ Although water is the most important thing to mine, this is like telling people that environmentalism is important because we need to preserve dirt (e.g., agricultural soil). This may be quite true, but it works a lot better to tell people about the rainforest or that cute little baby seals are being clubbed. Telling people that we need to go into space to mine water sounds lame to some people.

Too hard to understand

◎ Remember our friend?



But people understand THIS





“There was no license you had to buy. There was no central authority. This was one of the most remarkable examples of the democratization of the economy.” - **Malcolm J. Rohrbough**, author of *Days of Gold: The California Gold Rush and the American Nation*

Wanted: A Psychological Catalyst

- Commercial space is at a key point where something more is needed as a psychological catalyst. Like an old “Wanted Poster” from the Gold Rush days, commercial mining of PMGs seems to fit the bill as a useful catalyst.



Resource-rich “nuggets” of precious metals have a special psychological investor allure

- ◎ Plucking the low-hanging fruit in a precious metals mining operation is an iconic example of economic freedom.
- ◎ Low-hanging economic fruit is available to those first on the scene. In 1848 in California, near John Sutter’s mill, “fourteen pounds of ...[gold] had been taken from the North Fork the previous week by Indians working for John Sinclair, one of Sutter's neighbors.” But after 1850, major engineering was required to extract most of the gold.

(Of course this would be in Canadian dollars, since Canada will own the moon...)

- ◎ The idea of being early on the scene to pluck the low-hanging economic fruit of space is a no-brainer. Anyone can understand it.



The problem of long time horizons

- ◎ But the money tree doesn't look good if you have to wait too long to pick the fruit. So in commercial space project management, this becomes a problem.
- ◎ Even if the fruit of investment can be sold, long time horizons in a venture are a deterrent to investment. No one wants to wait thirty or forty years for a return on their initial investment.

Adding human psychology to science

- ◎ So if time horizons for commercial space projects are notoriously long, can they possibly be compatible with “get rich quick” allure? Yes.
- ◎ Gradual accumulation is not as exciting as the prospect of a large mineralogical find.
- ◎ Commercial space requires such allure to bootstrap infrastructure quickly
- ◎ Investment amounts in commercial space are large and time horizons are large

Reconciling two very distinct time frames

- ◎ It's just a human characteristic to be attracted to the “quick fix” to life's economic problems.
- ◎ But space investment faces a particular challenge of misaligned time frames. Barring time dilation effects at the edge of a black hole's event horizon, how can we reconcile an investor's time frame with commercial space time frames? (Hint: this is where project management comes in).



Seeking a more practical reconciliation of time frames...

The stages of a commercial space venture

- ◎ Project management of very long term (VLT) time horizons is usually staged. The idea is to break the project up into manageable pieces and to provide an economic return at each stage or gate.
- ◎ The first stage is typically to make a business case establishing that the project is viable. In many ways, this is the biggest hurdle for commercial space management. Because the commercial space era is just dawning, proposals concerning commercial space tend to be met with incredulity.
- ◎ It is at this stage that many space mining projects sometimes falter.



INCRECULITY

He beat me again! By Suraki I'm going to kill him!
I'll contact T'Poling right now. She'll know what to do.

If asked to be an investor angel for some of today's commercial space projects, even Mr. Spock might express incredulity

Selling the project idea

- ◎ Even if a later stage returns profit in a reasonable time, the project idea must still be sold. A hard-headed business plan has to be in place. Returns have to be something a potential investor can imagine and understand.
- ◎ Speeches about the glory of space won't cut it. These methods have not even succeeded with government over recent decades.
- ◎ To sell the project idea commercially, the investor should be able to create a virtual picture of the return in the imagination, and feel that it is something solid.

Stage One Separation

- ◎ Some of the space mining proposals out there have well-conceived later stages of the project, such as in deliverables. For example, the remote-sensing stage of the mining cycle becomes a marketable product that can be spun off for applications in forestry and other earth-based industries under the Planetary Resources model. But science needs to mesh better with human psychology in some portrayals of the project idea.

Mining: A practical endeavor

- ◎ Although space mining seems more unlikely at first than winning the lottery, this is not true. According to a 2012 NPR broadcast on the odds of winning the Mega Millions lottery jackpot, “the odds [of winning] are about one in 175 million. So, that means that you're about 100 times more likely to die of a flesh-eating bacteria than you are to win the lottery.” These odds were calculated by Aaron Abrams, a mathematician from Emory University.
- ◎ Yet, riches are made routinely from asteroid and comet impacts. Sudbury has long been one of the most profitable mines in Canada, and is thought to have derived its bounty from a bolide impact.

Risk vs. Imagined Risk

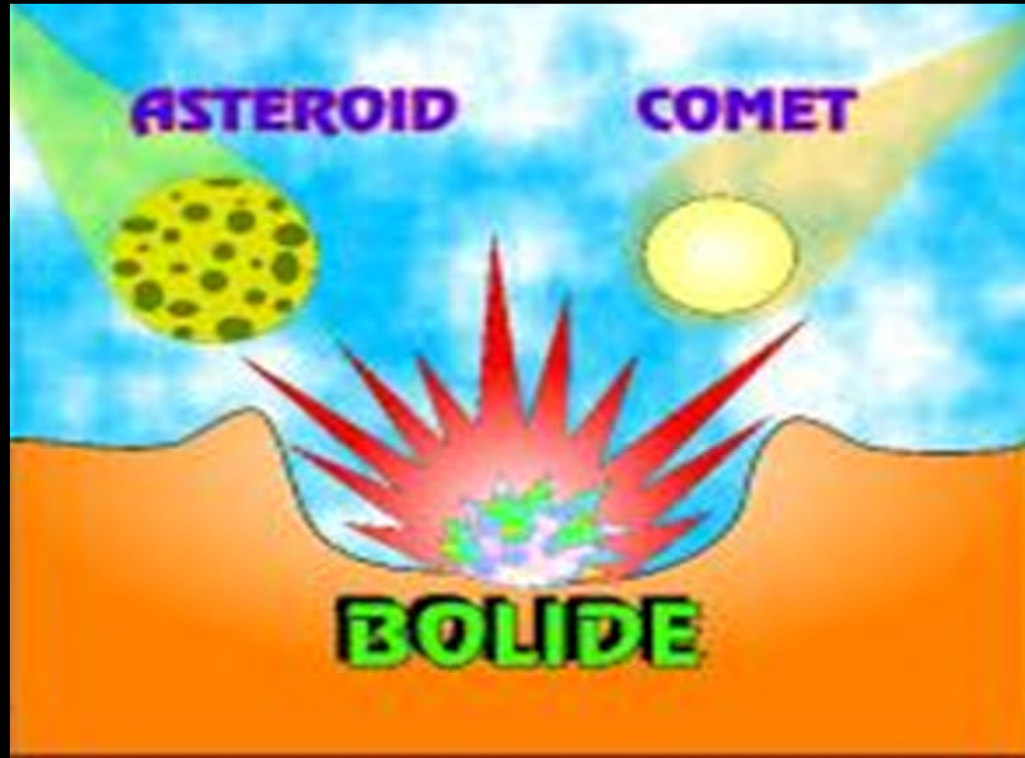
- ◎ The example of the lottery shows us it is not the risk that deters some potential investors. It is the *imagined* risk. People have difficulty imagining returns from space because such returns have not happened to their knowledge in the past. They have not yet developed a habit of associated space with large financial returns. This is one of the primary challenges to commercial space ventures.



A paper receipt would hardly be the same at Las Vegas

The Lucky Strike

- ◎ Casinos in Las Vegas do not print out a paper receipt. The falling of coins or tokens into the tray in vast quantities, and the idea of a “lucky strike,” are integral to human psychology.
- ◎ All commercial space needs to do is to create the habit of associating what is already here on Earth— mining being integrally tied to NEOs— and form the habit of thinking this way in people’s minds. Then extend the idea to space.
- ◎ The facts are already in place, but have just not been articulated vividly enough.



A “bolide” is defined as an extraterrestrial body of between 1-10-km, impacting the earth at velocities greater than Mach 75, explodes upon impact, and leaving a large crater. This is a generic term, “used to imply that we do not know the precise nature of the impacting body . . . whether it is a rocky or metallic asteroid, or an icy comet, for example.” [Woods Hole]

“The Richest in North America”

- ◎ Sudol (2004) has called Sudbury mine “the richest in North America” and claims it that supplies 15% of the world’s nickel, as well as gold, platinum group metals, copper, and cobalt.
- ◎ In a 2005 review article, “Economic Mineral Deposits in Impact Structures: A Review” Reimold¹, Koeberl, Gibson, and Dressler argue that “ Undoubtedly, impact structures -- at least those in excess of 5-10 km diameter -- represent potential exploration targets for ore resources of economic magnitude. This important conclusion must be communicated to exploration geologists and geophysicists.”

A practical idea

- ◎ In addition to ideas of capturing or in-situ processing of asteroid or comet NEOs, the notion of impact craters on the surface of the moon or Mars therefore also merit careful consideration as potential mining sites with substantial “low hanging fruit.”
- ◎ This type of venture is not based on idle dreams, but on solid, proven associations between precious terrestrial mining resources and bolides.
- ◎ Which is more practical: Playing the lottery or space mining? After due consideration, anyone would have to answer that space mining is probably the more practical of the two endeavors.

Making a better human connection

- ◎ But as Reimold, Koeberl, Gibson, and Dressler noted, even geologists and geophysicists don't believe it yet. So why would potential investors? We need to make a better association in the public mind between terrestrial mining and extraterrestrial objects. Once this can be done, the true practicality of space mining ventures will begin to become apparent.
- ◎ This is why mining water ice might not be the best thing to focus on from a publicity standpoint. There is no impressive history of mining water; but everyone has heard of the California Gold Rush.

Why Platinum?

- ◎ Very few single returns could rake in a profit after paying for launch. But platinum apparently can. Eric Anderson (2012) of Planetary Resources claims PGMs "are some of the most expensive metals known to man. We're talking about \$1,500 an ounce. The cost of a pound of platinum is actually far more expensive than the cost to put that pound into space" (2012). And Peter Diamandis has claimed that, "One asteroid may contain more platinum than has been mined in all of history" (2012).

Other Riches

- ◎ Aside from PMGs, are there other possibly very valuable materials connected to NEOs that could be profitable to asteroid miners? Ohtani et al. (2013) report finding a “huge” single crystal diamond recently in Ureilite meteorite. Diamonds could also be present in asteroids, and like precious metals, diamonds have a huge psychological allure for investors.

Increasing profit

- ◎ Of course, to bring back profitable mining products, we also need to drive down launch costs to lower the cost of the mining operations. If propellant can be found in space, and launch does not need to occur from Earth's gravity well, this would be a huge factor in driving down costs.
- ◎ But meanwhile, we need to also focus on driving down launch costs.

How Commercial Space Can Take Off

- ◎ So the perception that space is expensive is more important than the actual costs of undertaking space projects. This needs to be changed.



We Need a 'Fordism' of Space

- ◎ We need a Fordism of space. The “space is expensive” idea is really just a perception.
- ◎ Investors don't invest in space because we have not done a good enough job of creating a useful perception of space. We have not shown that space is not expensive, and we have not shown that mining profits have always been closely linked to space. Therefore, investing in space mining is sometimes perceived as risky.

Another perception we need to change

- ◎ In *Space: The Free-Market Frontier*, Hudgins discusses the perception that “space has to be expensive. Most in the private sector believe that our current space program and NASA projects are costly because space is and always has been costly.” But the cost per pound of launch does not have to be so expensive.

A great but costly program

Space-X claims that as of March 2013, the cost per pound to LEO of the Falcon 9 Heavy is \$4,109 per kilogram, compared to some estimates that the Space Shuttle cost about \$18,000 per kilogram to LEO.



Commercial space needs the equivalent of a winning Lotto ticket

- ⊙ Mining profits are already connected to space, but people don't know it.
- ⊙ Water is the best thing to mine, but people may not care.
- ⊙ Commercial space needs a psychological catalyst to bootstrap it
- ⊙ This all comes back to Stage One of the project, making the business case. We have failed to make a proper business case. We have not connected the proper dots in people's minds.
- ⊙ We need to think more about human psychology. If people are willing to play the lottery, despite such long odds, space mining needs a dash of Las Vegas.