



SDA Bocconi | SEE Lab  
School of Management | Space Economy  
Evolution

Space Policy Institute  
THE GEORGE WASHINGTON UNIVERSITY

## **“Mining the Moon for Profit” Workshop**

# **Financing Mining Projects on the Moon**

## **Key Considerations - An Industry Perspective**

**Pierre Larroque**

*International Finance & Resources Development*

Milan, March 11, 2019

## “Mining the Moon for Profit” Workshop – Financial Considerations

---

- **Mining on Earth - *A Unique Industry / Lessons***
- **“Moon-like” Mining Projects on Earth – *The Experience***
- **Mining the Moon for Water – *Impetus and Ideas***
- **Mining the Moon for Profit – *A Path Forward***

## “Mining the Moon for Profit” Workshop – Financial Considerations

---

### Mining on Earth Entails Unique Challenges

- **Mining presents unique, significant, risks**
  - Reserve definition - *what is really in the ground?* **resources vs. reserves**
  - Metallurgical recoveries & mine design - *can we extract the metals economically?*
  - Mining rights and permitting - *can we secure rights to explore and exploit the deposit?*
  - Political and social risks - *we will be expropriated during the 20+ years mine life?*
- **Value is generated at exploration, confirmation and expansion stages**
  - Mining is a a long-horizon, capital intensive industry - **10-15 years before operations start**
  - Value spikes for discovery, confirmation and expansion - **operations generate less value**
  - Mining companies are price takers - **only value defense is low cost**
- **Make no mistakes**
  - **Reserve definition and metallurgical recoveries work absolutely critical**
  - Need for exceptional geologists, experienced with similar deposits
  - Need for proper detailed feasibility study, including execution plan
  - **Only go ahead when you are in a position to reach a predictable outcome**
  - Tight project execution, de-risked through stage-gates assurances reviews
  - Tight controls of always-risky operations (technical, social, environmental aspects)

## “Mining the Moon for Profit” Workshop – Financial Considerations

---

### “Moon-like” Mining Projects on Earth

- **Deep sea mining for high-value nodules**
  - Nodules of high value metals near deep sea vents (PGMs, nickel, cobalt, etc.)
  - No precise definition of “reserves” and no serious metallurgical work
  - Mining method easy (scooping up), but projects did not go ahead
- **Minera Yolanda, Atacama desert, Northern Chile – 1997-1998**
  - A regolith-like deposit in high altitude desert, driest place on earth, sandy soil
  - Clumps of rich valuable sodium nitrate in unconsolidated layer just below surface
  - No understanding of how the Yolanda deposit came to be formed
  - Discrete boulders of ore seemingly randomly distributed in a 3-5 meters layer
  - A few trenches & random holes dug to get statistically significant resource estimate
  - Easy way to scoop up and screen the clumps of ore from the sandy regolith
  - Simple leaching process to concentrate the nitrate into high value commercial product
  - Crushers clogged up by sand, broken by hard pebbles, dust, leaching in 9 months not 2
  - Company ran out of cash, project abandoned, private sponsors wiped out
  - **You MUST fully understand the deposit and prove the technology, not wish them**

## “Mining the Moon for Profit” Workshop – Financial Considerations

---

### Mining for water in the moon’s shadowed regions

- **Why mining for water on the moon?**
  - Water may be of high value in space - manned outposts, propellant, etc.
  - Mining / producing water on the moon from shadowed regions’ ice may thus be attractive
  - Mankind’s future space activities would possibly be facilitated by such successful mining
  - Studying mining the moon for water must thus be one of mankind’s priority long-term project
  - Should governments / international institutions undertake such study? Role of private sponsors
- **Are the technologies here, or near here?**
  - Well ... yes ... we have identified promising, apparently appropriate, near-now technologies
    - “Commercial Lunar Propellant Architecture” – *Collaborative Study of Lunar Propellant Production*
    - “Opportunities for Space Resources Utilization” – *SpaceResources.Lu*
    - “Towards the Use of Lunar Resources” – *European Space Agency*
  - But ... will they work in practice?
- **Do we understand the mineralizations / reservoirs?**
  - No

Thus, next steps?

## “Mining the Moon for Profit” Workshop – Financial Considerations

---

### “Mining” the moon’s water for profit

#### What path forward?

- **Ascertain society’s investment / risk appetite to develop moon water mining**
  - Define the value proposition: why mining for water on the moon? **What value creation?**  
What priority / support from governments, international institutions and private players?
  - How much capital can be raised to design and execute a moon water mining program?  
**Explicitly stage-gate risk taking to solidify sponsorship**
  - Design a detailed, executable, program to garner societal endorsement
- **Focus all available resources on understanding the deposits**
  - Design, cost and implement a complete resources definition program
  - Do not try to develop any “appropriate technology” if you don’t fully know the deposit
  - Test mining technology and process in situ (scaling, impurities control, low gravity?)
- **Sequentially define and test each and all processing technology steps**
  - Stage-gate design and test all process steps, scope, costs and risks, in situ
  - Do not shortcut process design and verification work to save time or money

**Only move to develop mine when you have a predictable outcome**



SDA Bocconi | SEE Lab  
School of Management | Space Economy  
Evolution

Space Policy Institute  
THE GEORGE WASHINGTON UNIVERSITY

## **“Mining the Moon for Profit” Workshop**

# **Financing Mining Projects on the Moon**

## **Key Considerations - An Industry Perspective**

**Pierre Larroque**

*International Finance & Resources Development*

Milan, March 11, 2019