The sky is the limit, unfortunately…

by Michael Neale

Mankind has already proven that the sky need not be the limit, but for all practical purposes it still is. We have set foot on another world. We continuously have people in orbit. We probe other worlds. We position telescopes in space and have even seen space tourists. However, all of these activities that prove that we can overcome the sky as a limit drain the earth of valuable resources: resources that might be better spent on building houses, creating jobs and saving the environment.

The sky is not the limit, merely an extremely expensive barrier to cross. To make the giant leap for mankind truly count, we need a way to traverse the barrier without gutting Planet Earth. We must find the resources we need in space and live off them; do what is called "in situ space resource utilisation" (ISRU).

Jan van Riebeeck and his settlers did not come to South Africa and expect constant supplies to be shipped from Europe. The early settlers had to farm to survive. They had to chop their own wood to repair ships, they had to mine to build our country, and our fellow countrymen had to earn our independence. And look at us now…

True, living off the land on a completely foreign and sometimes hostile piece of ground is more feasible than living off space. In space, one cannot find a food source, or breathe, for that matter. For example, it would be a daunting and long-term challenge to create the infrastructure needed for a self-sustained lunar colony. Yet, it is also a challenge that is exhilarating, stimulating and – most importantly – achievable through innovation.

Why bother?

There are numerous reasons for wanting to develop space resources, including the following:

- **Space exploration.** Earth cannot fund and supply a human presence across the solar system. It is vital to develop space resources for a sustainable human presence in space.
- **Human survival.** As long as humans are bound to a single planet, our fate depends on that of our vulnerable planet.
- **Scientific opportunities.** ISRU would go hand-in-hand with scientific advances. Once resources in space can be exploited, advanced research bases could be built, for example, telescopes on the far side of the moon could be constructed from lunar material.
- **Earth benefits.** ISRU would benefit the earth in terms of job opportunities, advances in technology, electricity supply from space-based solar panels, the supply of high-value materials and relief of the strain on earth's industries and environments.

In his book, *Mining the Sky*, JS Lewis describes the vast resource potential of our solar system. The moon has oxygen, iron, titanium, water, volatiles and a future fuel source, Helium-3. Although mineral concentrations comparable to those of the earth have not yet been found, this shows that the moon has the potential to be an industrial space port.

Metals and gases are abundant on asteroids, many of which come closer to the earth than the moon. Mars and its moons could also be sources of minerals and fuel, as well as being attractive targets for colonisation. Further away, the gas giants of our solar system harbour unimaginable amounts of valuable gases.

We are destroying the earth and the life on it to get to mineral resources, yet the resources on earth are insignificant compared to the riches available to us within our solar system. If we were to mine the mineral resources from space instead of on earth, it would help us protect the most valuable resource in our solar system, namely life.

Space Resources Roundtable

I recently had the honour of being awarded a scholarship by the Space Resources Centre at the Colorado

School of Mines. The condition of the scholarship was that I had to present a student paper at the first joint meeting of the Space Resources Roundtable and the Planetary and Terrestrial Mining Sciences Symposium (SRR & PTMSS).

This annual conference is a gathering of professionals from different fields, all interested in "living off the land" in space, or ISRU. The presentations revolved mainly around proposals and experimental results on how to explore, extract, beneficiate and utilise the wealth of resources found in space.

I attended this conference at the Colorado School of Mines from 8 to 10 July 2010 and intend going back every year.

An important aspect touched on at the conference was how to inspire young minds to get an education in science, technology, engineering or maths. One of the speakers does this by showing sixth graders how, with a proper education, they might one day be involved in building space colonies.

On a higher level of education, one presentation was on the lessons learnt by mechanical engineering students who had to build a robot capable of excavating lunar soil. A few universities in the USA have some final-year engineering students doing their design projects on building such lunar excavators. These robots eventually compete against each other at the NASA lunabotics competition.

A number of the speakers presented results from different aspects of one large experiment. This was NASA's lunar base analogue experiment, which was held early in 2010. In this experiment, scientists and engineers tested proposals for different components of a lunar base. This was done at a test site in Hawaii, where the inorganic, basaltic soil simulates important aspects of lunar soil. Some of the experiments were concentrating solar heat, melting soil for construction, incorporating hydrogen fuel cells, extracting oxygen from soil and self-thinking construction robots.

A definite highlight of the conference was the half-day technical demonstrations. This is where the speakers could demonstrate their projects and experiments. Most of the lunar base analogue experiments and a number of the student-built lunar excavators were showcased.

One of the main speakers presented his results on finding water ice on the moon. The Indian probe Chandrayaan-1 is currently busy mapping the lunar poles. The preliminary data from a NASA instrument on board confirmed that there is a lot of water ice on the moon. Previous studies, like the Lunar Crater Observation and Sensing Satellite (LCROSS) and the Lunar Reconnaissance Orbiter (LRO), showed that lunar water exists in some form, but the new results indicate that the ice is much more abundant and pure than previously expected. My presentation was a conceptual proposal on mining this ice.

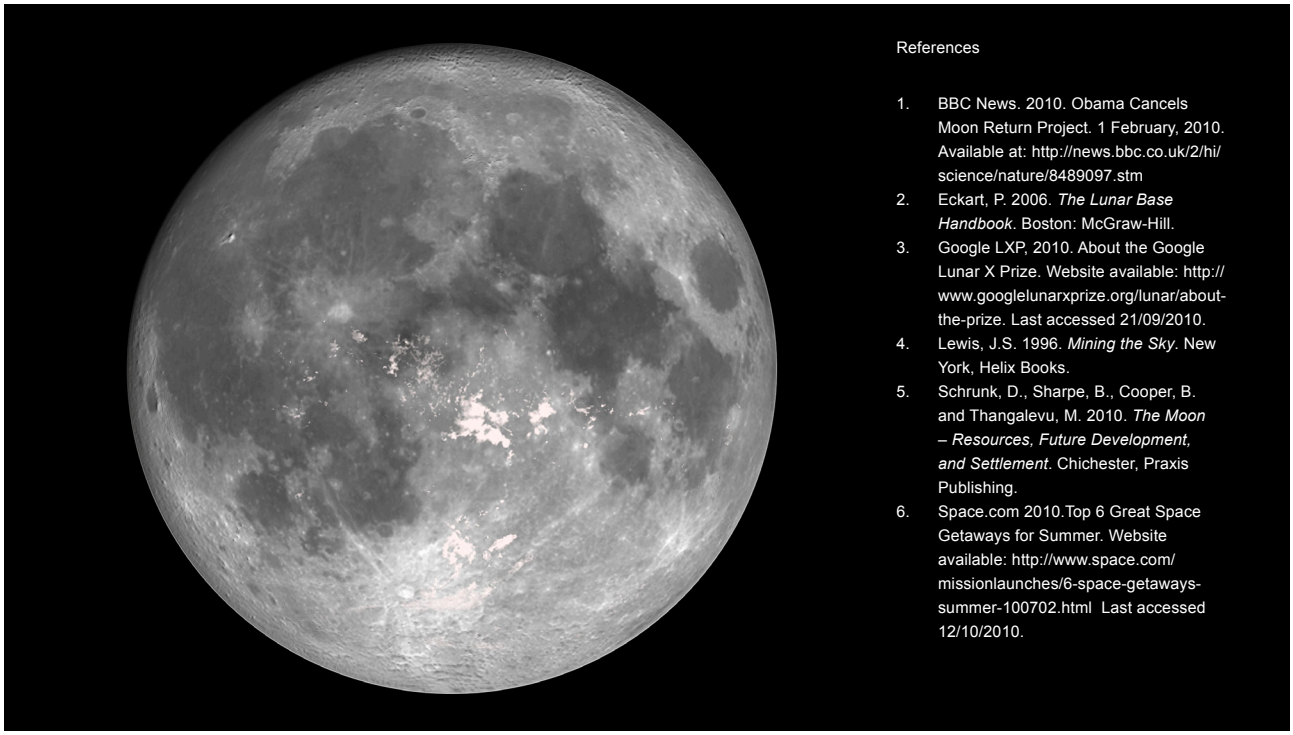
The ice is found in permanently shadowed craters, the slopes of which can be utilised to reduce ice transport. I showed three mining layouts, developed with assistance from VB Kom Consulting, that will channel the mined ice from the mining face towards a central point. The technical feasibility of the proposals is yet to be tested (and might result in a master's degree).

Mobilisation

In 2004, President Bush gave NASA the order to return humans to the moon by 2020, with the aim of extending the human presence to the rest of the solar system. When Obama assumed presidency, he supported this decision. However, the project was recently cancelled due to "lack of innovation". Instead, the plan is to put humans on asteroids and Mars. There is a lot of dispute over whether this is a good idea or not, as a sustainable moon base could have acted as an industrial outpost to supply material for Mars missions.

In the words of Jim Kohlenberger, "While we're cancelling Constellation [the lunar return project], we're not cancelling our ambitions." The cancellation of Constellation merely means that those who want to see ISRU operations on the moon will have less government money and will therefore have to obtain commercial support. This is arguably a good thing. If space missions could be more commercial and less governmental, the industry could be profitable. Profits could be ploughed back to develop the industry further.

There is already a growing awareness of and interest in commercialising space and its resources. At the moment, tourists can pay to go on zero-gravity flights, suborbital flights to space, time aboard the international space station and space walks. There are even offers to take tourists around the moon, although this has not happened yet.



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→ *There is vast resource potential in the solar system.*

These tourist excursions are far above the normal tourist's pay grade, but at least the seeds of a new industry have been sown.

Another example of commercialising space is the Google Lunar X-prize competition. Google is offering $30 million to the first commercial company to launch a rover to the moon and land it on the moon. Currently, 21 companies are competing to launch their rover to the moon first. Developing space in a commercial and industrial way as a platform for a space-faring human race is something that will happen. The question is just this: will we make it happen in our lifetimes?

A role for South Africa

Where does South Africa fit into the picture? We are not part of or able to compete with the supernations in a space race, but we can contribute. Dr Kris Zacny was born and raised in South Africa. To my mind, he is one of the champions of ISRU research, specifically in extraterrestrial robotic drilling. He works for Honeybee robotics, a company that does a lot of work for NASA. He has proven that South Africans are capable of making a contribution to this field.

This does not mean that all able South Africans should immigrate to the USA. South Africa is a strong mining country and has a number of astronomical facilities and experts. This, combined with our top-quality tertiary education, gives us the potential for substantial involvement in ISRU development. If we can get our academics educated about and interested in ISRU, there will be no need to leave the country.

ISRU development will require a multinational effort and I believe that South Africa can and should take up the challenge to overcome the limit we know as the sky. We must do what great minds do when confronted with an inconvenient barrier… innovate!

Michael Neale *is an honours student and academic instructor in the Department of Mining Engineering. He has had an interest in astronomy since he can remember and is a member of the Space Resources Roundtable. He intends establishing the South African Space Resources Association (SASRA) in the near future.*