Mineral Sands

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DATA AND ANALYSIS ON THE GLOBAL TITANIUM MINERAL, TIO2 PIGMENT AND ZIRCON INDUSTRIES.

A unique source of zircon

In the cold, northern reaches of Alberta, Canada, a new technology has been designed to extract valuable heavy minerals (VHM) from waste produced by oil sands mining operations. It is certainly unique as zircon and titanium are not minerals that are normally associated with oil sands mining.

However, Titanium Corporation has developed technology that recovers valuable mineral sands from the tailings waste of the oil sands industry.

It has been a long trek to its current position, but Titanium Corp is now poised to take its Athabasca Sands project through to commercialisation.

The Athabasca oil sands deposits are located in the Province of Alberta. They contain heavy oil called bitumen. Canada's oil sands reserves, at 175 billion barrels, rank third in the world after Saudi Arabia and Venezuela. The presence of heavy minerals also makes the Athabasca Sands one of the world's largest deposits of mineral sands. Titanium Corp said that the Athabasca Sands contain just under 1% heavy minerals in the ore body, which are then naturally concentrated during the oil recovery process to approximately 25% in the sand fraction of one of the tailings streams. Four mining sites are currently in operation and two additional sites are approved and under development.



The Athabasca oil sands region in northern Alberta, Canada (Alberta Geological Survey)



Syncrude Canada Oil Sands mining north of Fort McMurray (Pembina institute)

Titanium Corp's mantra is 'Creating value from waste' (CVW, a registered phrase), and this commitment to taking a waste product and turning it into something that can be recycled as well as extracting valuable minerals has also earned it environmental street cred.

With increased environmental concerns surrounding the oil sands industry, technology such as that developed by Titanium Corp could provide environmentally friendly solutions, while improving performance and recovering heavy minerals.

The company was recently been named a TSX (Toronto Stock Exchange) Venture 50 Company for 2012. President and chief executive officer Scott Nelson said it was nice to receive the recognition.

"By a range of measures, our company has successfully weathered some very uncertain times in the markets, and performed well relative to other firms on our exchange," he said. "It means increased investor interest and analyst coverage."

Cormark Securities and GMP Securities have provided coverage of Titanium Corp in the past year.

Oil sands mining to HM extraction

At remote mining sites in Northern Alberta, oil sands deposits closest to surface are open pit mined to recover more than 90% of the contained bitumen. Oil sand's mining is conducted at an unprecedented scale with individual sites mining up to 1 million tonnes daily using 100 tonne shovels and 400 tonne capacity trucks. Mined ore contains 8-12% bitumen. Following mining, a 'hot water' slurry, flotation and settling 'extraction' process is employed to liberate bitumen from sands into a

concentrated 'bitumen more froth' containing 60-65% bitumen. Heavy minerals are also concentrated in bitumen froth due to their oleophilic nature. Bitumen froth is then further processed in a 'froth treatment' facility where a hydrocarbon solvent is added. Froth treatment uses gravity separation processes to remove water and solids, including the heavy minerals, from bitumen froth. The tailings from froth treatment, which are the focus of Titanium Corp's technology, contain lost bitumen, solvent and valuable heavy minerals.



Syncrude Canada Oil Sands mining north of Fort McMurray (Pembina Institute)

After mining, extraction and

froth treatment, bitumen is either upgraded on site to highquality synthetic crude oil or diluted and pipelined to refineries in Canada and the USA. Canada's oil sands production currently averages about 1.4 million barrels per day. Mr Nelson said production was well on the way to doubling in the next decade and then tripling with total capital investments in excess of C\$150 billion predicted during the next decade. It only followed that the heavy minerals contained in oil sands tailings would increase significantly in the years ahead.

Oil sands miners have developed unique solutions to operating in the harsh winters of northern Alberta. Mr Nelson said during several decades, the industry had developed equipment and practices that performed very well in the mining, extraction and upgrading operations. He said the company planned to utilise similar equipment and practices.

"For minerals processing we will employ much of the same, ranging from heated, climate controlled buildings and facilities to the specialised equipment that is designed to withstand cold weather," he said.

Getting to the current stage

Mr Nelson said it had taken about seven years to move through the research and development stage and then demonstration piloting to the current stage.

"Recovering valuable heavy minerals, starting with zircon, has been a multi-year quest of Titanium Corporation," he said. "Across a period of seven years, from R&D through demonstration piloting, the company has invested more than C\$50 million to unlock this world class resource. More than 20 R&D projects were conducted by Titanium Corp in co-operation with research and testing firms throughout North America and including Australia." The Alberta Provincial and the Canadian Federal Governments have been very supportive of the initiative and have injected \$9 million of 'grant' funding into the project so far. In 2011, Titanium Corp successfully completed a 12-month, C\$15 million demonstration pilot for three of the oil sands producers which culminated its multi-year development program.

Mr Nelson said Titanium Corp's CVW[™] process employed robust, high-volume technologies including cyclone, flotation, countercurrent decantation and steam stripping which had been modified to handle complex tailings streams. The company has filed six patents for various proprietary aspects of the technology.

Getting to this stage of the project has not been without challenges. Mr Nelson said there were major challenges to overcome on the technical side, such as cleaning bitumen off of the contained minerals to enable conventional minerals separation processing and recovering bitumen from a complex tailings stream, particularly fine clays.

"On the business side, the oil sands industry has been undergoing massive expansion during this period with priorities on brownfields and greenfields projects with programs spending tens of billions," he said. "There has been a constant shortage of skilled people, so priorities have been on mainstream construction programs and operational reliability. More recently, the emergence of environmental concerns has shifted some of the focus to projects like ours. We improve environmental performance while recovering valuable commodities."

Mr Nelson said the skills shortages did pose problems during the developmental years, but there was now an established team in place.

"Within our company, we have a small team of experts in mineral sands and oil sands that has ranged from six to

twelve," he said." A number of our folks have advanced degrees in metallurgy and chemical engineering including PHDs and have worked extensively in the respective industries. A real strength and key to our success has been enlisting the services of over a dozen research, testing and engineering organisations to carry out our programs. Through that strategy we have simultaneously deployed large numbers of very smart people, successfully developed our technologies and retained ownership of the IP."

Environmental benefits

While heavy minerals recovery from tailings has been Titanium Corporation's primary objective, the company's value proposition involves a much broader spectrum. Valuable heavy minerals are just one of the commodities lost in oil sands tailings.

Mr Nelson said a typical operating site experiences 2-3% losses of high-quality bitumen, together with associated hydrocarbon solvents (used in bitumen froth treatment) in these tailings. The discharge of bitumen and hydrocarbon solvents to tailings ponds contribute to volatile organic compound (VOC) and green house gas emissions (GHG) at oil sands sites. However, he said that following remediation by Titanium's CVW™ technology, the water recovered can be improved to standards for recycle in services currently consuming fresh river water, thereby reducing river water consumption.

The oil sands industry has been widely criticised for its environmental footprint and new technology is viewed as the pathway to improved performance.

Titanium Corporation's technologies have been developed and demonstrated to recover 80% of lost bitumen and 75% of solvents which will significantly reduce emissions of VOCs and GHGs. In addition to the environmental improvements, the recovered bitumen and solvents represent increased



Source: Courtesy Titanium Corporation

valuable resource recoveries. Installation of the company's technologies at existing mining sites (*Figure 1*), has potential to annually recover more than 8 million barrels per year of bitumen and 800,000 barrels of solvent. The combined value of potential heavy mineral, bitumen and solvent recoveries exceeds C\$1 billion per year. Mr Nelson said that with planned expansions and new mines, recoveries could exceed C\$2.5 billion per year in the next decade.

Mr Nelson said Titanium's CVW[™] technologies had been designed to seamlessly integrate with oil sands operations.

He explained that new facilities are comprised of three plants: on-site concentrator to produce HMC (as well as recover highquality hydrocarbons and water); on-site concentrate upgrader to produce zircon concentrate; and an off-site MSP to produce zircon products.

During the R&D phase, Mr Nelson said it brought in SNC-Lavalin as its engineering partner to design the demonstration pilot. SNC-Lavalin is now working on full-scale, site-specific engineering and cost estimating. Combined on-site concentrator and off-site minerals separation facilities for a large oil sands operation are currently estimated in the range of C\$370 million. He said project economics are robust with recoveries of bitumen, solvent and minerals producing attractive returns. The costs associated with recovering valuable products from oil sands waste streams (green bars) are significantly lower than greenfields mining projects (grey bars) as illustrated in *Figure 2*.





Source: Titanium Corporation

Zircon the first target

At full production, each oil sands mining site has the potential to produce 60,000-70,000 tonnes per year of zircon. Mr Nelson said total zircon production could grow to 400,000 tpa from six sites during the next decade. Due to the vast size of reserves, oil sands sites are in the midst of expanding their mining operations to increase and maintain production at maximum levels for decades. While more than four times

| Economic | 2012 | | 2020 | |
|-----------------------|---------------------|----------|---------------------|----------|
| Potential | Recovery | Revenues | Recovery | Revenues |
| Zircon | 170,000 tpa | \$340 M | 400,000 tpa | \$800 M |
| Bitumen | 28,000 bpd | \$700 M | 70,000 bpd | \$1.8 B |
| Total annual | | \$1.4 B | | \$2.6 B |
| Capital investment | Total cumulative | \$1.5 B | Total cumulative | \$3 B |
| | | | | |
| Economic | 2012 | | 2020 | |
| Benefits | Reduction | Rate | Reduction | Rate |
| VOC | 60 ktpa | 80% | 151 ktpa | 80% |
| CO,e | 0.8 mtpa | 5.6% | 2.4 mtpa | 5.6% |
| NO | 1.9 ktpa | 4.2% | 5.8 ktpa | 4.2% |
| Water | 25 Mm ³ | 25% | 75 Mm ³ | 25% |
| | | | | |

TABLE 1: TOTAL ANNUAL ECONOMIC AND ENVIRONMENTAL BENE-FITS OF IMPLEMENTING TECHNOLOGY IN 2012 & 2020

Source: Titanium Corporation

this volume of titanium-bearing minerals are present at each site, the company has elected to focus on zircon first because of the high prices the mineral commands and continued demand. As titanium demand and pricing increases, he said titanium minerals would be assessed for future production.

After assembling the joint-venture stakeholders needed to execute these projects, the engineering, procurement, construction and commissioning phase will take two to three years per site, Mr Nelson said.

"It really depends on when the oil sands industry schedules the first on-site facility but you can estimate the timeframe from that point," he added.

Partnering the way forward

"The capital cost for implementation of bitumen and minerals recovery facilities utilising our technology for a single large site is estimated in the range of C\$350-\$400 million," Mr Nelson said. "As a small company, we knew that at this advanced stage we would be bringing in strategic partners to assist with these very large projects. Partnerships will involve experienced firms that have project execution, operations and in some cases marketing depth. On the financial side, like most large resource plays, the larger firms bring project funding as they earn their way into attractive opportunities that have been created by a more nimble, entrepreneurial smaller firm. Oil sands firms see partnering on the bitumen side as very compelling for both environmental and economic reasons. On the minerals side, we have unlocked a world class, decades-long, new supply of heavy minerals that will increase over time. There is understandably a great deal of interest in both the minerals industry and the larger emerging market consumption countries."

There is the potential for the Athabasca Sands project to be one of the world's largest sources of heavy minerals. Mr Nelson explained it this way, "The large sites are reporting in excess of 40 years of bitumen reserves so they will be growing and in production for a very long time and perhaps it would be illustrative to look at it this way.

"If our technology were installed today at the four oil sands mining sites, we would be producing approximately 170,000 tpa of zircon at current rates of mining and bitumen production.

"Athabasca Sands zircon production would grow to approximately 400,000 tpa over the next decade based on expansions planned at the existing sites and the addition of two new sites that are approved and under development."

Currently, Titanium Corp, oil sands companies and the Alberta Government are engaged in planning the first processing facilities to recover heavy minerals and bitumen from tailings at oil sands sites.

HMC from the company's demonstration pilot has been sent to Australia where testing is under way for the best available zircon production technologies.

Mr Nelson said the company was focused on preliminary engineering and project planning with the oil sands operators,





Titanium Corp demonstration pilot

fiscal programs with the Alberta Government and discussions with strategic partners. He said it was difficult to pinpoint the timing and location of the first project as discussions with a number of parties were ongoing. However, based on successful demonstration piloting and a strong economic and environmental value proposition, he said Titanium Corp was confident that a new minerals industry would soon emerge from Canada's Athabasca Sands.



Suncor Energy oil sands mining and upgrading complex (Pembina Institute)