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PUBLISHED SINCE 1912

## MINING REVIEW

FEBRUARY 2014 VOL. 103 NO.02



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INTERVIEW WITH  
**BILL RADVAK**  
THE PRESIDENT, CEO  
AND DIRECTOR OF

## American Vanadium

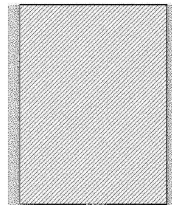
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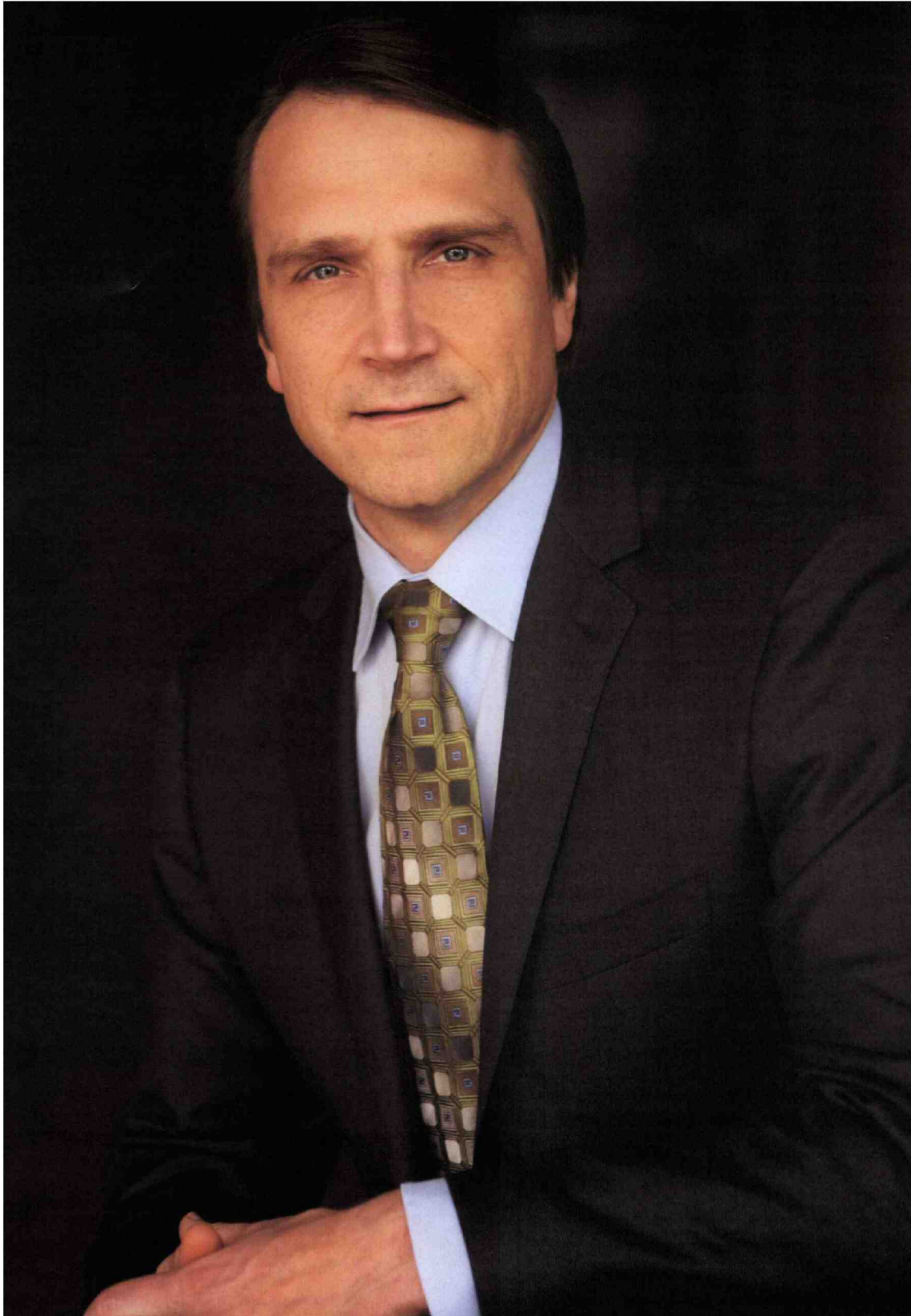
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### **Mr. Bill Radvak**

President, CEO and Director of American Vanadium

#### **SMR: What are the commercial uses and benefits of Vanadium?**

**BR:** Approximately 90% of vanadium produced globally is used as a steel additive. Vanadium forms stable nitrides and carbides, resulting in a significant increase in the strength of steel. When as little as two pounds of vanadium is added to a ton of steel, the overall strength is increased by up to 100%.

The first high profile commercial user of vanadium was Henry Ford who added it to the Model T to make it lighter and stronger. High strength, low alloy (“HSLA”) steels containing vanadium are used for the construction of buildings (rebar), bridges, pipelines, cranes, ships, rail cars, truck bodies, and auto and truck parts.

Vanadium also plays a crucial role in many titanium applications where it is used at a much higher addition rate than in steel (4% compared to 1% in HSLA steel). With its large aerospace industry, the U.S. share of vanadium consumption devoted to titanium alloys is more than double that in the rest of the world. Approximately 9% of annual vanadium use in the U.S. is used for titanium applications and these uses are growing at a faster rate than many other applications, particularly now with Boeing’s 787 Dreamliner beginning full production. More importantly due

to the critical nature of the applications, the vanadium used must be of high purity and traced back to the source making most source of vanadium unusable and creating an excellent market opportunity for the value-added, high purity product that will be produced by American Vanadium.

Uses of vanadium in various chemical processes, mostly as a catalyst then in small applications like the vitamin market round out the balance of global demand for vanadium. Uses in various chemical applications account for approximately 4% of global vanadium demand.

Vanadium is the 23rd element on the periodic table, and is classified as a soft silver-grey ductile transition metal. It is vanadium’s status as a strategic metal with “green energy” applications that has excited the renewable energy world.

Leading the way in new grid scale renewable energy storage solutions are vanadium flow batteries. These batteries allow inherently intermittent energy supplies to be regulated from moment to moment. The electricity industry refers to such energy as ‘dispatchable energy’ or ‘dispatchable power’, which enables the grid to balance the amount of energy being put into the wires with the demand arising from consumers. These mass energy storage solutions are designed

to help America deliver on its objectives for clean energy, energy independence and self-sufficiency, as well as targets for the reduction of CO2 and greenhouse gases.

Vanadium flow batteries utilize vanadium's unique characteristics for rechargeable energy storage, which is critical to renewable and dispatchable power systems. The vanadium flow battery has virtually unlimited storage capacity with the ability to scale the batteries. As a result, the vanadium flow battery's value to the emerging renewable energy technology sector is compelling for many utility companies and grid operators.

**SMR: How is American Vanadium able to produce solid vanadium pentoxide (for steel applications) and vanadium electrolyte (for batteries), and why is that proprietary to the industry?**

**BR:** American Vanadium's 100% controlled, open pit, heap leach Gibellini Project represents one of the most simple vanadium operations to be developed in the world. The abovementioned heap leach process to recover vanadium allows electrolyte to be produced earlier in the plant flow-sheet giving Gibellini a unique flexibility to produce both electrolyte and vanadium pentoxide at low cost.

The Nevada project's NI 43-101 compliant resource represents 131.369 million pounds of measured and indicated vanadium (i.e., vanadium pentoxide or V2O5) and an additional 48.96 million pounds of inferred vanadium.

The Gibellini Project delivered a positive feasibility study and is solidly tracking towards production, which would make American Vanadium the only primary vanadium mine in the United States. Production is projected to average 11.4 million pounds of vanadium pentoxide per year. This will enable Gibellini to potentially supply 4% of current global vanadium demand.

**SMR: The solar energy sector is expected to reach \$19 billion by the year 2017 however its intermittency makes it unreliable. How will Vanadium factor into making solar energy dependable and a principal source of power in the future?**

**BR:** It is widely acknowledged that the intermittency of solar energy makes it unreliable as a primary source of power. Yet, the penetration of the PV on the grid continues to increase, multiplying the challenges.

Long duration and intelligent energy storage solves the intermittency challenges of PV by absorbing the excess generation and dispatching it when required. With the right energy storage system, solar energy can be stored during the middle of the day and shifted for use whenever it is needed. In remote microgrid and island grid systems, PV energy generation combined with energy storage can become the primary source of



**Bill Radvak** at American Vanadium's Gibellini Vanadium project in Eureka County, Nevada.

power, relegating diesel generators to a back-up role and resulting in an energy ecosystem that is more reliable, sustainable and affordable.

Vanadium flow batteries have a unique ability to safely store up multi megawatts of power for multiple hours – perfect for storing wind and solar power for electric power grids and for setting up micro grids where main power sources fail to reach in commercial, industrial and military applications.

**SMR: Do you consider the energy storage affects photovoltaic (PV) business as a growth industry or is it decades away from maturity?**

**BR:** Energy storage is the glue that can hold the grid together, and the PV business leaders understand it is vital. More and more companies are looking to combine solar and energy storage technologies. As reported by USA Today, "the global market for storing power from solar panels is forecast to explode, from less than \$200 million in 2012 to \$19 billion by 2017, according to IMS Research. One factor driving this growth is the plummeting price of renewable equipment, especially solar panels that have fallen at least 60% since the beginning of 2011. As a result, industry groups report historic growth as U.S. electric capacity from solar panels jumped 76% and from wind turbines, 28%, last year alone."

**SMR: What do you anticipate will be the ratio of solid vanadium oxide to vanadium electrolyte produced?**

**BR:** The Gibellini mine has the ability to change the ratio of vanadium pentoxide to vanadium electrolyte production. The goal is to dedicate the majority/entirety of the vanadium output as electrolyte, as it commands a superior price. According to the growth rate expected in the North



**CellCube FB 200-400 - Vanadium Redox Flow energy storage system with 200 kW power and 400 kWh capacity.**

American energy storage space American Vanadium expects to dedicate 100% of its output to the electrolyte battery market not long after commencing production.

***SMR: The base metals industry was impacted by China's demand, which rose and fell through 2013. How much influence does China have on Vanadium's future growth and success?***

**BR:** It is important to understand that current market forecasts do not yet include any future demand coming from the adoption of grid scale energy storage and the related use of vanadium in flow batteries for mass power storage, which could dwarf all other uses combined. In that market, China is leading the charge to adopt energy storage for renewable energy applications and is specifically investing in vanadium flow batteries. China has set a target of 15% of their energy supply coming from renewable resources by 2020, a target they will likely surpass. In one project alone they will invest \$2 billion into 600 MW of renewable energy coupled with 110 MW of energy storage.

In the past 10 years, world vanadium consumption has grown at an annualized rate of approximately 6.4% while in China alone the growth has been 20.5% per year. With the BRIC countries widely expected to significantly increase their specific use of vanadium and even without including demand from vanadium battery applications, global vanadium consumption is predicted to double by 2020. Vanadium consumption growth is fuelled by use of high strength low alloy steels, which are replacing low strength carbon manganese steels in many applications due to economic drivers (lower total cost, less energy consumption, less pollution, less capital employed).

International competition for vanadium is climbing, the global demand for vanadium is approximately six times that of the U.S., and growing at a faster rate as emerging economies realize the value of using vanadium alloys and as they develop their own renewable energy economies. As recently as 2005, a simple change in building codes turned China from the world's largest vanadium exporter to a net importer, causing a 450% increase in vanadium prices in less than a year.

To date, China has regarded vanadium as a strategic national interest while being quite restrictive and protective in terms of vanadium exploration and mining. Currently, around 85% of vanadium consumption demand in China stems from the steelmaking process. A major pillar of China's 12th five-year economic plan, meanwhile, is the production of higher quality steel, which will further increase that nation's demand for vanadium. In the future new buildings designed in China will no longer be able to utilize Grade II rebar, which does not include vanadium in its composition.

While China's current rebar products include Grade II, Grade III and Grade IV, the most widely used rebar in China remains Grade II, a trend that is behind that of other advanced economies such as the U.S., Japan, and the U.K., which use Grade III and Grade IV rebar. By taking China's current production level of Grade II rebar, and then calculating the amount of vanadium required to

replace that production with Grade III and Grade IV rebar, an additional 27,000 MT of vanadium demand will exist per year. Forecasted vanadium production won't be able to meet the forecasted consumption levels until 2017.

The vanadium market has been in a state of oversupply and is now expected to transition into a period of undersupply, which is coincidentally around the anticipated time American Vanadium expects to reach production.

**SMR: With renewable energy penetration, what other electric powered essential devices beside vehicles will become more common?**

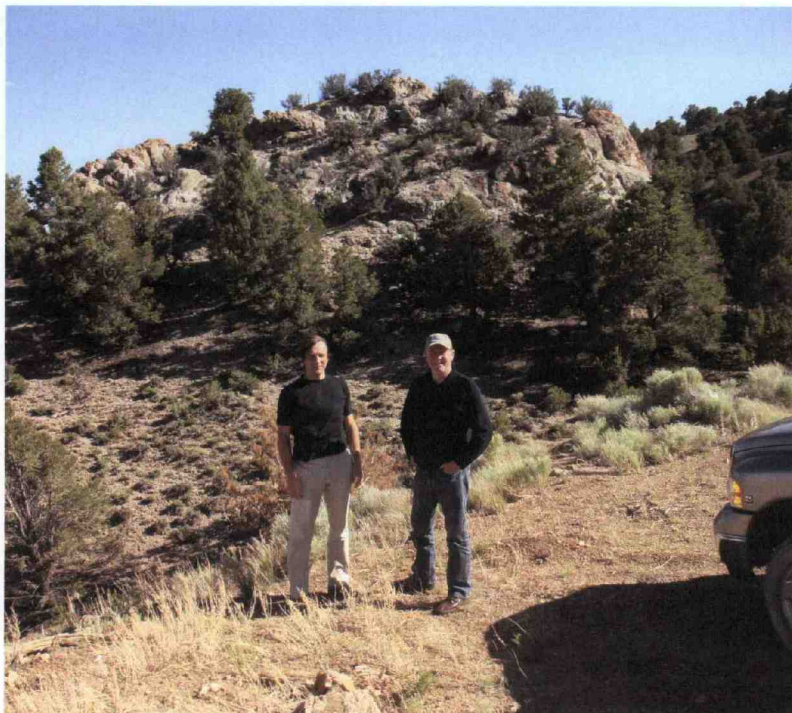
**BR:** As discussed grid energy storage will become more common; particularly across North America as Europe has been ahead of the curve. Renewable energy products will expand with more solar energy (photovoltaic panels), solar hot water tubes, wind energy turbine systems, and portable power options taking hold.

**SMR: With a 10-year mine life for the project, what kinds of options might American Vanadium have in the future assuming energy storage really takes off as a business?**

**BR:** It is important to understand that we have transitioned from a mining company to an integrated energy storage company. Last year, American Vanadium announced a deal with Gildemeister AG to market and sell the German company's vanadium energy storage battery and penetrate the storage market in North America. We have a number of important milestones we expect to deliver in the coming months – most related to recently becoming a sales organization.

Our job is to sell energy storage and microgrid solutions to parts of the world where energy is most valuable whether the need is for military installations or to fuel water treatment facilities in third world countries. Our expectation is to announce new sales of CellCubes in North America this year.

Gildemeister's CellCube redox flow battery uses vanadium, and it can recharge electric vehicles, store wind and solar power for electric power grids and set up micro grids where main power sources fail to reach in commercial, industrial and governmental applications. Over 50 CellCube systems are in use in Europe since the beginning of last year. Our goal is to replicate that success here in the North American marketplace.



**Bill Radvak** and colleague at American Vanadium's Gibellini Vanadium project in Nevada.

**SMR: It's interesting to see a company that bets so heavily on renewable energy that also plans to derive sales revenue from mining operations. What sustainability standards will the Gibellini Project follow?**

**BR:** We are putting our money where our mouth is in terms of setting sustainability standards. We are not only building a vanadium mine in Nevada but we are also powering the operation with solar power, using vanadium redox flow batteries for storage.

Sustainability standards for vanadium mining at our Gibellini project in Nevada are very high. The mining operation is less energy intensive and environmentally disruptive due to the deposit's proximity to the surface; very few deep drills are needed. We often call the process the "Fischer Price of mining" because we are operating more like a quarry within a very shallow deposit. We even put the rock back when we are done.

The heap leach process is set up as a closed loop system at Gibellini Hill. The rock is placed on a leach pad which is then coated in hydrochloric acid. Once the leaching process is completed, the acid is reclaimed, cleaned and reused. Overall, the mine will use one tenth the amount of water of a traditional mine, and all of that water is being recaptured as well.

**SMR: Seeing that American Vanadium is the only vanadium mine in the United States, what is the production of vanadium's impact on the environment?**

**BR:** American Vanadium completed a Feasibility Study on its Gibellini Project and is now engaged in the environmental permitting process. Once in production, the Gibellini Project will be the only vanadium mine in the United States, able to produce approximately 20% of the U.S. needs and 4% of the world's current vanadium supply. The US currently imports 100% of its vanadium from sources like Venezuela, China Russia and South Africa.

The production of vanadium will have a very positive impact on our environment. The U.S. Department of Energy's (DOE) Office of Electricity

stated its goal of increasing energy storage capacity 10-fold to improve grid reliability and facilitate the adoption of such variable and renewable generation resources as wind and solar.

Renewable energy supplies such as wind and solar continue to emerge while meeting an increasing percentage of today's electricity demands. But yesterday's grid was never designed to handle the intermittent power supplies these clean energies represent; simply put, we can't expect the wind to blow or the sun to shine based on when or how much electricity we need.

***SMR: What about the Gibellini Project's geology and composition makes it so simple in operational terms?***

**BR:** While many other vanadium deposits are found in magnetites where there are a high percentage of heavy ferrous metals, the American Vanadium resource is a clean sedimentary shale deposit where the strip ratio is less than 0.2. It is this heavily oxidized sedimentary deposit that makes it amenable to a simple and cost effective heap leach process.

The Feasibility Study's base case scenario also places the Gibellini Project's after tax IRR at 43%, and after tax NPV at \$170.1M

at a 7% discount. The project is comprised of 232 unpatented lode claims and 7 placer claims totaling approximately 4,254 acres in U.S. state of Nevada, which is ranked among the world's top 10 mining jurisdictions.

***SMR: American Vanadium describes itself as an energy storage company rather than a vanadium mining company, and it has partnered with the company Gildemeister as NAFTA sales agent of its vanadium flow battery production capabilities. What is the general outlook for bringing Gildemeister operations to the US, closer to the mine?***

**BR:** Gildemeister is a German based company and as we represent Gildemeister in energy storage related sales, it is not necessary for Gildemeister to move their own operations closer to our Nevada mine. Using Gildemeister's commercialized CellCube energy storage system and American Vanadium's stably priced supply of high purity vanadium electrolyte, the companies together present a unique opportunity to cooperate to supply the world's growing energy storage and renewable energy markets with a tremendous solution. At some point in the future it is likely that a CellCube assembly plant will be built in America, but for now we can compete globally with the European operation and our American vanadium supply.

***SMR: What is the timeline for entering mining operations; what phase of the permit process are you in currently?***

**BR:** We are fortunate to have the support and pleasure to work with the U.S. Bureau of Land Management (BLM), the Nevada Division of Environmental Protection and Eureka County to provide both regulatory and technical direction which enhance the project's environmental protection measures and streamline the permitting process. While the timeline is not under our direct control due to the regulatory process, our hope is that we will be fully permitted this calendar year.