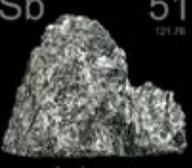
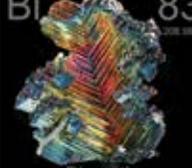
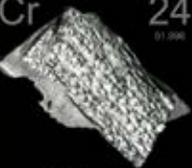
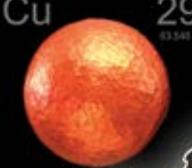
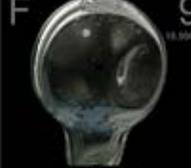
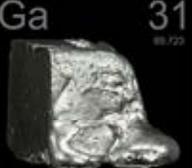
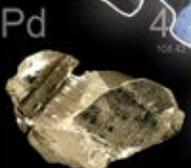
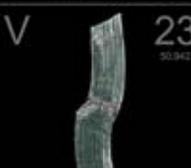


Critical Minerals

ALASKA

Sb 51 121.76  Antimony	As 33 74.922  Arsenic	Ba 56 137.33  Barium	Be 4 9.012  Beryllium	Bi 83 208.98  Bismuth	C 6 12.011  Carbon	Ce 58 140.12  Cerium
Cr 24 51.996  Chromium	Co 27 58.933  Cobalt	Cu 29 63.546  Copper	Dy 66 162.5  Dysprosium	Eu 63 151.96  Europium	F 9 18.998  Fluorine	Gd 64 157.25  Gadolinium
Ga 31 69.723  Gallium	Ge 32 72.64  Germanium				Hf 72 178.49  Hafnium	In 49 114.82  Indium
Ir 77 192.22  Iridium	La 57 138.905  Lanthanum				Mg 12 24.305  Magnesium	Mn 25 54.938  Manganese
Nb 41 92.906  Niobium	Pd 46 106.42  Palladium				Pt 78 195.08  Platinum	Re 75 186.21  Rhenium
Rh 45 102.91  Rhodium	Rb 37 85.468  Rubidium				Ru 44 101.07  Ruthenium	Sc 21 44.956  Scandium
Ti 22 47.88  Titanium	W 74 183.84  Tungsten	U 92 238.03  Uranium	V 23 50.942  Vanadium	Yb 70 173.04  Ytterbium	Y 39 88.906  Yttrium	Zr 40 91.224  Zirconium

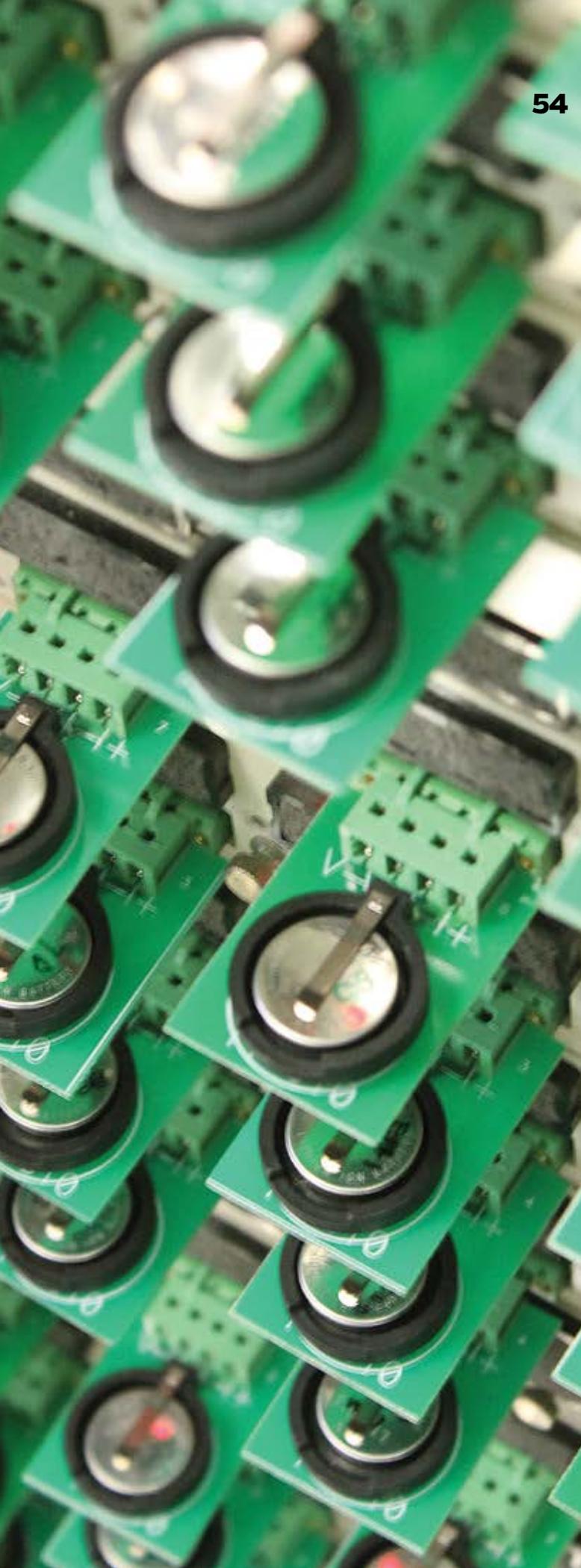


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NORTH OF 60
MINING NEWS
 The Mining Newspaper for Alaska and Canada’s North

Critical Minerals Alaska
 Released May 2019

Critical Minerals Alaska is a special magazine published by North of 60 Mining News. To order additional copies of this special publication, contact Rebecca Lasley at RebeccaL@miningnewsnorth.com

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ABOUT THE COVER:
 Photo of the Chrome Queen Mine courtesy of Bretwood Higman of Groundtruth Trekking; element symbols by Theodore Gray of Periodictable.com (Copyright 2019); and graphic design by Chris Day of Lions Light Corp.

*Printed by Century Publishing,
 Post Falls, Idaho*

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Bokan Mountain, the site of Ucore Rare Metals' rare earth element deposit on Prince of Wales Island in Southeast Alaska, looms above the American flag flying over Kendrick Bay.

UCORE RARE METALS INC.



US leaders address critical minerals

Trump executive order calls for an American critical mineral strategy

By SHANE LASLEY

Mining News

U.S. PRESIDENT DONALD TRUMP SPARKED A RENEWED interest in critical minerals and metals when he issued an executive order calling on federal agencies to devise a strategy to ensure the United States has reliable supplies of these commodities vital to America's economic and strategic security.

"It shall be the policy of the federal government to reduce the nation's vulnerability to disruptions in the supply of critical minerals, which constitutes a strategic vulnerability for the security and prosperity of the United States," reads Executive Order 13817, signed by Trump at the end of 2017.

Critical minerals strategy ordered

Trump's critical minerals executive order instructed the secretaries of Interior and Defense to identify and publish a list of critical minerals, then develop a strategy to reduce the United States' reliance on other countries to supply these increasingly important ingredients to America's defensive and economic security.

The terms critical minerals and strategic minerals were first used in the United States during World War I. Over the ensuing century, however, the definitions of these overlapping terms have been somewhat subjective and been interpreted differently by various agencies and individuals depending on their priorities.

The United States Geological Survey now considers strategic minerals a subset of critical minerals and has established criteria to determine which minerals should be considered critical.

In an 862-page report, “Critical Mineral Resources of the United States – Economic and Environmental Geology and Prospects for Future Supply”, the federal geological department defines critical minerals as “non-fuel minerals or mineral materials essential to the economic and national security of the United States; vulnerable to supply chain disruptions; and serve an essential function in the manufacturing of a product, the absence of which would have significant consequences for the U.S. economy or security.”

Using this definition, the federal geological survey has identified 35 minerals and metals critical to the U.S., at least 30 of which can be found in mines, deposits, and prospects across Alaska.

“For a number of these commodities – for example, graphite, manganese, niobium, and tantalum – the United States is currently wholly dependent on imports to meet its needs,” according to the USGS report.

In its Minerals Commodity Summaries 2019, the USGS identified 48 different minerals and metals for which the U.S. was net import reliant, 18 of which it imported 100 percent of its supply.

It is this dependence on foreign sources for minerals and metals vital to the manufacture of high-technology devices; green energy generation; and military hardware that has spurred a renewed interest in critical minerals in the United States.

Establishing a strategy

With the USGS establishing the critical minerals list, President Trump’s executive order calls for:

- a strategy to reduce the nation’s reliance on critical minerals;
- an assessment of progress toward developing critical minerals recycling and reprocessing technologies, and technological alternatives to critical minerals;
- options for accessing and developing critical minerals through investment and trade with our allies and partners;
- a plan to improve the topographic, geologic, and geophysical mapping of the United States and make the resulting data and metadata electronically accessible to support private sector mineral exploration of critical minerals; and
- recommendations to streamline permitting and review processes related to developing leases with the goal of enhancing the access, discovery, production and refining of critical minerals in the United States.

The critical minerals strategy and other directives of the executive order are being addressed in a report spearheaded by the U.S. Department of Commerce that is expected to include analyses and strategies to strengthen and sustain the supply chains for all minerals and metals, not just the 35 the USGS deemed critical based on the 2018 analysis.

Though slated for delivery to the White House by mid-November, this report had yet to land on the President’s desk at the time this article was written.

Sources told Mining News in March that the U.S. critical minerals report is going through the review process and should be available by the time this article is published.

America’s Achilles heel

While the Trump Administration is addressing critical minerals from the White House, U.S. Sen. Lisa Murkowski, R-Alaska and chair of the Senate Energy and Natural Resources Committee, is urging Congress to pass legislation that will curb the United States’ increasing dependence on foreign countries for its growing mineral needs.



EINTRAUS; CREATIVE COMMONS 2.0

A Tesla Roadster owned by Elon Musk parked at the SpaceX facility in 2010. America’s increasing reliance on foreign countries for minerals and metals comes at a time when new technologies, such as electric vehicles, are increasing the competition for global supplies.

“Over the past several years, our committee has sought to call attention to our reliance on foreign nations for minerals,” Murkowski said while chairing the first natural resources committee hearing of the 116th Congress. “The administration has taken several important steps, but we must complement their actions with congressional legislation.”

During the Feb. 5 hearing, Murkowski said the U.S. has come a long way in curbing its reliance on overseas supplies for oil and natural gas but continues to slide when it comes to the growing need for minerals.

“Whether we realize it or not, energy and minerals fuel our 21st Century economy and standard of living. Access to energy and minerals impacts everything from healthcare, to poverty levels, to defense readiness, and the strength of our manufacturing sector,” the Alaska senator said. “In the past decade, we have seen a dramatic increase in domestic energy production and a corresponding decrease in our dependence on energy imports. This remarkable shift has led to substantial economic benefits here at home, while also giving us options to help our allies to achieve a level of energy security.”

“In contrast to the energy sector, our nation is headed in the wrong direction on mineral imports,” she added.

America’s increasing reliance on foreign countries for minerals and metals comes at a time when new technologies, such as electric vehicles, are increasing the competition for global supplies.

Benchmark Mineral Intelligence Managing Director Simon Moores a global authority on lithium-ion batteries supply chains, told the resources committee that the U.S. is heavily dependent on foreign sources for the cobalt, graphite, lithium and nickel that are vital to EV batteries.

“We are in the midst of a global battery arms race in which the U.S. is presently a bystander,” he said.

“Those who control these critical raw materials and those who possess the manufacturing and processing know-how, will hold the balance of industrial power in the 21st Century auto and energy storage industries,” the lithium-ion battery expert added.

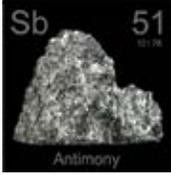
Murkowski said America’s important reliance for the metals and minerals vital to the nation’s economy is a vulnerability that needs to be fixed.

“This is our Achilles’ heel that serves to empower and enrich other nations, while costing us jobs and international competitiveness,” she said.

35 critical minerals, metals and element groups



ALUMINUM (bauxite) – While aluminum is considered the most abundant element in Earth's crust, no appreciable amounts of this lightweight metal are found in Alaska. Utilized in almost all sectors of the economy, aluminum is the second most consumed metal in the world.



ANTIMONY (ALASKA) – Historically mined near Fairbanks and found in many areas of Interior Alaska, antimony is primarily known for its flame-retardant properties. Antimony alloys are also used in batteries and low-friction metals.



ARSENIC (ALASKA) – Commonly occurring as arsenopyrite, a mineral often associated with Alaska's gold mineralization, arsenic is used as an ingredient in wood preservatives, pesticides, copper and lead alloys, glass and semiconductors.



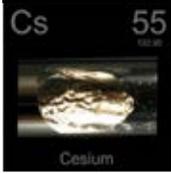
BARITE (ALASKA) – Found in abundance at the Palmer volcanogenic massive sulfide deposit in Southeast Alaska, barite is primarily used as a weighting agent in drilling mud for oil and gas exploration and development drilling.



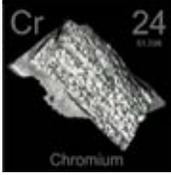
BERYLLIUM (ALASKA) – Associated with tin deposits, such as those in the Lost River area on the Seward Peninsula of western Alaska, beryllium alloys are widely used as a structural material for high-speed aircraft, missiles, spacecraft and satellites.



BISMUTH (ALASKA) – Another element commonly associated with Alaska gold deposits, bismuth is usually mixed with other metals to form low-melting alloys used in sprinkler system's electrical fuses. This element is also used in medical and atomic research.



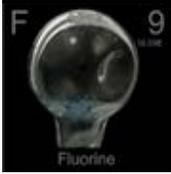
CESIUM – With the second lowest melting point of all metallic elements, cesium is often used in research and development. This element is also used in atomic clocks, photoelectric cells and to remove trace gases from vacuum tubes.



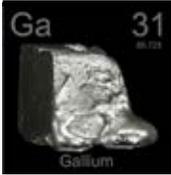
CHROMIUM (ALASKA) – Historically produced at the Queen Chrome Mine on Alaska's Kenai Peninsula, chromium is used primarily in stainless steel and other alloys such as the smooth, reflective and highly corrosion resistant chrome finish on automobiles.



COBALT (ALASKA) – Associated with carbonate-replacement copper, platinum group metal and volcanogenic massive sulfide deposits in many parts of Alaska, cobalt is used in superalloys and as a cathode material in lithium-ion rechargeable batteries.



FLUORSPAR (ALASKA) – Also known as fluorite, fluorspar often occurs in the same granites found around Alaska that also contain beryllium, indium, tantalum, tin, titanium and tungsten. Fluorite is used in the manufacture of aluminum, gasoline, and uranium fuel.



GALLIUM (ALASKA) – Often found in carbonate-hosted copper deposits, such as the Bornite deposit in the Ambler Mining District of Northwest Alaska, gallium is used in medical thermometers, semiconductors, solar panels and integrated circuits.



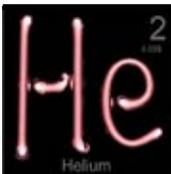
GERMANIUM (ALASKA) – The zinc concentrates from the Red Dog Mine in Northwest Alaska includes some germanium. This metal is also found in carbonate-hosted copper deposits. The largest uses for germanium are fiber optics, night vision devices, semiconductors and transistors.



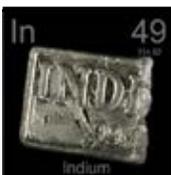
GRAPHITE (NATURAL) (ALASKA) – The Graphite Creek property on the Seward Peninsula of western Alaska hosts a very large deposit of this form of carbon that is widely used for lubricants and as the anode material in the lithium-ion batteries that power electric vehicles.



HAFNIUM (ALASKA) – Found in many of the same regions of Alaska that also host rare earth element and zirconium, hafnium is a good absorber of neutrons and is used in the control rods of nuclear reactors. It is also used in metal alloys and high-temperature ceramics.



HELIUM – Known primarily for its use in lighter-than-air craft, such as weather balloons and airships, helium is also used for magnetic resonance imaging (MRI), as an inert gas for welding, and as a coolant for nuclear reactors and the Large Hadron Collider, the world's most powerful particle accelerator.



INDIUM (ALASKA) – Often found with the tin deposits found across Alaska, indium has an increasingly important role in modern electronics. Transparent and highly conductive, indium-tin oxide is an ideal material for touchscreen phones, tablets and computers.



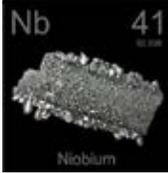
LITHIUM – This lightest of all metals, lithium is experiencing exponential growth in demand due to its importance to the rechargeable batteries that store power for electric vehicles and an increasing number of cordless electronic devices.



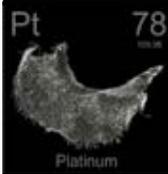
MAGNESIUM (ALASKA) – Not known to be widespread in Alaska, high concentrations of magnesium are found in the Queen Chrome Mine, or Red Mountain mine on the Kenai Peninsula. Magnesium is used in furnace linings for manufacturing steel and ceramics.



MANGANESE (ALASKA) – One manganese-rich occurrence has been identified on the north shore of Chenega Island in the Prince William Sound just west of Alaska's Kenai Peninsula. Manganese is used as a corrosion resistant alloy in aluminum and steel.



NIOBIUM (ALASKA) – Commonly found with Alaska's rare earth element deposits, niobium is primarily used as a steel alloy. These niobium-steel alloys are strong and often used in pipeline construction. Superalloys containing niobium are used for jet engines and rockets.



PLATINUM GROUP METALS (ALASKA) – Alaska is home to two historical platinum group metal (PGM) mines – Goodnews Bay in Southwest Alaska and Salt Chuck Mine in Southeast. Catalysts to remove harmful emissions from autos and refineries is a primary industrial use for PGMs.



POTASH – An alkaline potassium compound, potash is primarily used as a fertilizer, where the potassium helps make plants more drought- and cold-tolerant and protects them from disease and pests. Potash is also used in soaps.



RARE EARTH ELEMENTS GROUP (ALASKA) – This group of 16 related elements are found across wide swaths of Alaska. The unique properties of REEs are important to many modern products such as compact hard-drives, magnets in high-efficiency power generation and military hardware.



RHENIUM (ALASKA) – The Pebble project in Southwest Alaska has rhenium resources that represent more than 40 years of production at current global mine levels. Other Alaska porphyry deposits may also have large amounts of this metal used for lead-free gasoline and superalloys.



RUBIDIUM – A silvery-white metal with properties similar to potassium and cesium, rubidium is primarily used for research and development in electronics. Since it is easily ionized, researchers believe it could be used as a propellant in ion engines on spacecraft.



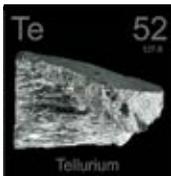
SCANDIUM (ALASKA) – This element has similar unique characteristics as rare earths and is typically found in REE deposits, including the Bokan Mountain project in Southeast Alaska. Aluminum-scandium alloys are used for aerospace components and sports equipment.



STRONTIUM – While strontium is the 15th most abundant element in nature, few viable deposits of its most useful mineral, strontianite, have been identified. Strontium is best known for the brilliant reds its salts give to fireworks and flares. It is also used for ceramic magnets.



TANTALUM (ALASKA) – Most of the areas of Alaska with tin-bearing granites are high-priority targets for tantalum. The chemical inertness of tantalum makes it a valuable substance for laboratory equipment. Its primary uses, however, are in electronic components, mostly capacitors.



TELLURIUM (ALASKA) – Usually associated with intrusive-related gold deposits in Alaska, there is the potential to recover tellurium as a by-product from mining in the state. Tellurium is used as a copper and stainless-steel alloy and for enhancing the electrical conductivity of solar cells.



TIN (ALASKA) – With more than 100 known tin occurrences, Alaska is the best place in the United States to look for a domestic source of tin. In 2018, more than 100 million pounds of tin was consumed in the U.S. Currently, however, no mines in America produce this critical alloy metal.



TITANIUM (ALASKA) – A heavy mineral sands deposit with significant concentrations of titanium and zirconium have been identified on the beaches at Icy Cape on the Gulf of Alaska. Titanium is used in alloys for the aerospace industry, where lightweight strength is important.



TUNGSTEN (ALASKA) – Found in many parts of Alaska, tungsten was historically produced at the Stepovich-Cleary Hill Mine near Fairbanks. Tungsten and its alloys are used in applications where resistance to high-temperatures and extreme wear are important.



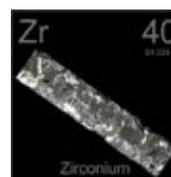
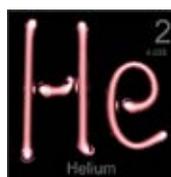
URANIUM (ALASKA) – There are a few places in Alaska known for their uranium potential, including Death Valley on the Seward Peninsula, Revelation Mountains in Southwest Alaska and the Bokan Mountain project on Prince of Wales Island. Uranium is primarily used as a nuclear fuel.



VANADIUM (ALASKA) – This rare metal is found in association with uranium, platinum group metal and magnetite deposits in Alaska. Titanium-vanadium alloys are used in jet engines. Ferrovandium – a strong, shock- and corrosion-resistant alloy of iron – is one of the primary uses for this metal.



ZIRCONIUM (ALASKA) – This corrosive resistant metal is often associated with rare earth deposits in Alaska. Significant amounts have also been found in beach placers at Icy Cape on the Gulf of Alaska. Zirconium is used in high-temperature ceramics and superconducting magnets.





Rare earths consist of 15 lanthanides, yttrium and scandium, elements that are increasingly important to a growing number of high-technology applications. Clockwise from top center: praseodymium, cerium, lanthanum, neodymium, samarium, and gadolinium.

PEGGY GREB, U.S. DEPARTMENT OF AGRICULTURE

Revealing Alaska's critical minerals

USGS, DGGs develop tool to help guide geologists, explorers

By **SHANE LASLEY**

Mining News

GEOLOGISTS FAMILIAR WITH ALASKA ALREADY KNOW the Far North State is a great place to explore for critical minerals and metals such as graphite, rare earths, platinum metals, cobalt and tin. A new report published by the U.S. Geological Survey, however, indicates that Alaska may be richer in these and other minerals and metals vital to the economy and security of the United States than previously realized.

Working alongside the Alaska Division of Geological & Geophysical Surveys, USGS developed a new geospatial tool that integrates and analyzes a massive load of geologic information and applies this data to estimating the resource potential for six deposit types that host a large array of critical minerals.

After crunching all the data, this new tool has turned up new and expanded areas of Alaska with the potential for a wide array of minerals and metals vital to modern living – many of which are not currently mined in the United States.

“Some of the areas that showed high potential were already

known, but many of these areas had not previously been recognized,” explained Sue Karl, an Alaska-based USGS research geologist and lead author of the study. “Areas identified by this method that have high resource potential based on limited data indicate both understudied and underexplored areas that are important targets for future data collection, research investigations and exploration.”

New REE hunting grounds

The new geospatial tool worked particularly well for identifying new areas of Alaska to explore for rare earth elements, or REEs, a group of 17 minerals that possess unique characteristics that make them important ingredients to many high-technology devices used by both civilians and the military.

While high-tech applications make rare earths vital to America's strategic and economic security, the fact that more than 90 percent of these metals used by manufacturers in the U.S. every year come from China elevates their status to critical.

Ucore Rare Metals' Bokan Mountain project at the southern tip of Prince of Wales Island in Southeast Alaska has already been identified as one potential domestic source of rare earths. The USGS

geospatial tool, however, has identified eight large swaths of the Far North State worth checking out.

One such region extends 200 miles northwest from Bokan Mountain and encompasses other known rare earth prospects such as Dora Bay and Salmon Bay, both also on Prince of Wales Island. While this region is worthy of additional exploration, it does not light up USGS's Alaska REE potential map like some other areas of the state.

A 15,000-square-mile region at the west end of the Alaska Range, however, did light up the map with high-potential areas.

The few small REE occurrences previously identified in this area, which covers Mount Estelle and the Revelations Mountains, do not account for the high potential the USGS geospatial tool has given to a large portion of this region – a sign that this area is exceedingly underexplored and a great place to hunt for rare earths.

The other regions were the USGS identified high REE potential are:

- Northern Alaska Range, an area arcing about 220 miles west from Tok;
- Yukon-Tanana, a large swath of Interior Alaska extending from the Yukon-Alaska border to the Roy Creek REE prospect north of Fairbanks;
- Kuskokwim-White Mountains, which stretches about 500 miles southwest from Yukon-Tanana;
- Kokrines-Hodzana, a 200-mile-long area of Interior Alaska just north of the Yukon River that includes known REE hunting grounds like Ray Mountains and Kokrines Hills;
- Darby Hogatza, an area of known uranium and REE occurrences that arcs 200 miles east from the Seward Peninsula; and
- Porcupine, an area centered on Spike Mountain in far northeastern Alaska.

The same areas that show promise for REEs are also great places to look for uranium, according to the data churned out by the new USGS geospatial tool.

Critical mineral-bearing granites

For the most part, specialized granites containing tin, indium, tungsten, titanium, tantalum, and fluor spar can be found in the same regions of Alaska as you would seek REEs. The United States is near 100 percent import-reliant on all of these critical metals except for tin, in which case it imports roughly 80 percent of what it needs.

Tin and indium are important ingredients for architectural glass, flat screens, solar cells, semiconductors, smartphones, lead-free solders and alloys for superconductors.

Tungsten and titanium are primarily used for high-strength metals alloys.

Tantalum is an important ingredient for automotive electronics, mobile phones, personal computers, and light but high-performance glass lenses.

Fluor spar is used to make specialty glass, ceramics, and enamel-ware.

The geospatial tool developed by USGS and DGGs found that the specialized granites that host tin and its associated critical minerals are found in the same areas of Alaska that are good hunting grounds for rare earths.

Beyond the REE prospective areas, the USGS geospatial tool identified the Lost River-Kougarok region on the Seward Peninsula and a stretch of the central Brooks Range as other good places to look for the granites that host this group of critical minerals.



AVALON DEVELOPMENT CORP.

This chromite-bearing outcrop on New Age Metals' Genesis project in Southcentral Alaska is rich in both platinum and palladium.

Elusive PGMs

The geospatial tool also proved to be effective in turning up new areas of Alaska to explore for the elusive platinum group metals – platinum, palladium, rhodium, iridium and ruthenium.

The largest use for this suite of metals, especially palladium and platinum, is as a catalyst to help scrub harmful emissions from internal combustion automobiles and petroleum refineries. These metals also are used in modern electronics, such as increasing storage on computer hard disks, and as an alloy for restorative dentistry. Platinum, palladium, and rhodium are used as investments and are commonly minted into physical bars and coins.

The United States currently relies on foreign sources for about 90 percent of these critical metals.

Though an economic lode-source of PGMs has yet to be discovered in Alaska, about 650,000 ounces of these obscure metals have historically been mined from Salmon River placer deposits in the Goodnews Bay area. This region of Southwest Alaska continues to be an intriguing place to look for PGMs, according to the USGS geospatial tool.

Other areas of the state, however, show higher potential. The best known of these is the Wrangellia terrane, a distinct belt of rocks along much of the southern slopes of the Alaska Range eastward through southern Yukon and into western British Columbia. While intriguing signs of rich deposits of PGMs are found in the Alaska portion of the Wrangellia, such as the Man property about 165 miles southeast of Fairbanks, an economic deposit has yet to be identified here.

The other regions where the USGS identified high PGM potential are:

- Angayucham terrane, a belt of rocks found along the northwestern slopes of the Brooks Range and south of the Brooks Range;
- Peninsular terrane, which stretches along the Chugiak Mountains in Southcentral Alaska; and
- most of the Southeast Alaska panhandle.

Carbonate-hosted critical minerals

As part of its critical minerals and metals investigation, USGS also looked at carbonate-hosted copper deposits, which often also host the critical minerals cobalt, germanium and gallium.

Cobalt is an important ingredient of super-alloys used to make aircraft turbine engines. This application makes up nearly half of the

United States consumption of this critical mineral.

Germanium and gallium have properties that make them important minerals in a number of modern applications including solar cells, infrared optics, LEDs, semiconductors and smartphones.

The best known carbonate-hosted copper deposit in Alaska is Bornite, also known as Ruby Creek, in the Ambler Mining District along the southern slopes of the Brooks Range. While renowned for its high copper grades, Bornite also hosts significant quantities of cobalt and potentially other critical minerals.

To gain a better understanding of the distribution of cobalt at bornite and to study the carbonate-hosted deposit's potential for gallium, germanium and rhenium, USGS has entered into a technical assistance agreement with Trilogy Metals.

Interestingly, the USGS geospatial tool found that almost the entire length of the Brooks, especially the underexplored northern slopes of this range that stretches the entire width of Alaska, is prospective for the style of copper deposits known to host cobalt, germanium and gallium.

In addition, the USGS study identified two areas of the Seward Peninsula and a long stretch of the Wrangellia terrane as prospective for carbonate-hosted copper deposits that may have associated critical minerals.

Gold as critical mineral pathfinder

The USGS also applied the geospatial tool to the rich placer gold deposits Alaska is renowned for.

While gold itself is not a critical mineral, the erosion process that deposited gold into streams across Alaska also happened to concentrate other heavy critical minerals into placer deposits.

USGS points out that in addition to gold, these alluvial deposits in Alaska sometimes hosts valuable concentrations of platinum group elements, tin, tungsten, silver, rare earths and titanium.

Having the material already broken down to sands and gravels and concentrated into stream beds or other placer deposits means nature has completed the first stages of mineral processing, making the recovery of the precious and critical metals easier and less expensive.

The best known critical minerals bearing placer deposits in Alaska may be found along the Tofty tin belt, a 12-mile-long area of tin- and gold-bearing gravels in Interior Alaska's Manley Hot Springs district. Other gold mining districts in Alaska also have interesting quantities of tin, as well as tungsten.

When it comes to a wide array of critical minerals, the Ray Mountains area about 50 miles north of the Tofty belt may be the richest.

Ucore Rare Metals holds mining claims covering placer deposits in this area with potentially economic concentrations of REEs, tin, tungsten, tantalum and niobium.

Using gravity methods, Ucore concentrated placer samples from the property.

Assays of these concentrates returned up to 50 percent tin; as much as 10 percent rare earths; and 0.01 to 1 percent tungsten, tantalum and niobium.

USGS and DGGs identified 17 major areas of Alaska to seek the placer deposits that host gold, many of which could also carry critical minerals.

Broadened potential

Overall, the geospatial tool seems to have broadened Alaska's critical mineral potential, while narrowing the search to the hottest areas across the 663,000-square-mile minerals-rich state.

"Using this process, we have identified the potential for critical minerals in new areas such as the northern Brooks Range, and have expanded the area with potential for resources around known mineralized areas like the Seward Peninsula and east-central Alaska," the authors of the study wrote in a summary of their findings.

For explorers, the new and under-explored areas turned up by the geospatial tool may provide enough data to make critical mineral discoveries in areas where no one has thought to look.

The authors of the report offer a tidbit of advice for such intrepid explorers: "Future geologic investigations should focus on areas that have relatively high potential scores but for which available data are limited."

Given the results of the critical minerals investigation, USGS believes the geospatial tool shows promise for identifying other deposits across the expansive Far North State.

"This study will help guide our minerals-focused geologic investigations for many years to come. We have so much left to learn about the basic geologic framework of Alaska, and now we have a great new geospatial tool to help make our research efforts more efficient and effective," said Jamey Jones, research geologist, USGS, and co-author of the study.

The full report – complete with source information, datasets and maps – can be found under the title "GIS-based identification of areas that have resource potential for critical minerals in six selected groups of deposit types in Alaska" in the publications section of the USGS website.

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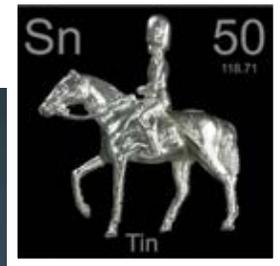
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Tin – Alaska’s gateway critical mineral

Getting hooked on tin deposits leads to other critical minerals

By **SHANE LASLEY**

Mining News

WITH MORE THAN 100 KNOWN TIN OCCURRENCES, Alaska is considered the best place in America to establish a domestic source of this critical alloy metal that has defined human progress since the dawn of the Bronze Age.

“Today, Alaskan tin deposits are known to be widespread, occurring from the central Alaska Range north to the Brooks Range and across Interior Alaska ... Southwest Alaska and the Seward Peninsula,” according to the 1997 publication, Mineral Deposits of Alaska.

And where an explorer finds tin in Alaska, he is likely to find himself dabbling in at least a few of the other minerals critical to the

strategic and economic wellbeing of the United States.

In fact, more than a dozen metals considered critical by the U.S. Geological Survey – beryllium, bismuth, chromium, fluor spar, gallium, indium, manganese, niobium, platinum group metals, rare earth elements, scandium, strontium, tantalum, tungsten and vanadium – have been found associated with the placer and lode tin occurrences across the state.

Eons of criticality

Primarily associated with cans, cups and roofs, tin does not spark the imagination with images of a strategic metal. The Pentagon, however, sees the United States’ heavy reliance on foreign countries for this fundamental metal as a detriment to national security.

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This dredge is a reminder of the early 20th Century placer tin mining carried out in the Lost River area on the Seward Peninsula.

JAMES BARKER

“In a congressionally mandated U.S. Department of Defense study of strategic minerals published in 2013, tin was shown to have the greatest shortfall amount (insufficient supply to meet demand measured in monetary terms – US\$416 million) in a list of strategic minerals, and more than twice the shortfall amount of the next strategic mineral, antimony (US\$182 million),” USGS penned in Critical Mineral Resources of the United States, a report published late in 2017.

Tin’s provenance as a critical mineral, however, dates back eons before the formation of the United States.

In fact, this metal’s strategic importance can be traced at least 5,500 years, when early human civilizations discovered that mixing a little tin with copper created bronze, an alloy that produced much more durable weapons and tools than those cast from copper alone.

The first civilizations to discover this cutting-edge metallurgical technology had a strategic and economic advantage over their counterparts. This edge was so powerful that we now consider the Bronze Age one of the most important epochs of human history, an era that spans more than 2,000 years.

Not unlike our Bronze Age forebearers, we continue to almost exclusively use tin in alloys, mixtures that keep tin on the list of critical minerals.

In 2018, the United States consumed roughly 101.3 million pounds of tin for bronze, brass and other alloys; cans and containers; solder; bearing surfaces and other applications.

None of this tin was mined in the U.S. Instead, roughly 78 percent America’s tin supply was imported from foreign countries –Indonesia (23 percent), Malaysia (23 percent), Peru (22 percent) and Bolivia (17 percent) are top tin suppliers – and the balance was the product of recycling.

“Tin has not been mined or smelted in the United States since 1993 and 1989, respectively,” USGS penned in its Mineral Commodity Summaries 2019 publication.

This complete dependence on foreign sources for new supply, coupled with the alloying metal’s importance to both manufacturing and defense, is the reason both the Pentagon and USGS consider tin critical to the United States.

The average paid for this tin during 2018 was around US\$9.30/lb but the price of the alloying metal dropped sharply to US\$6.00/lb in March.

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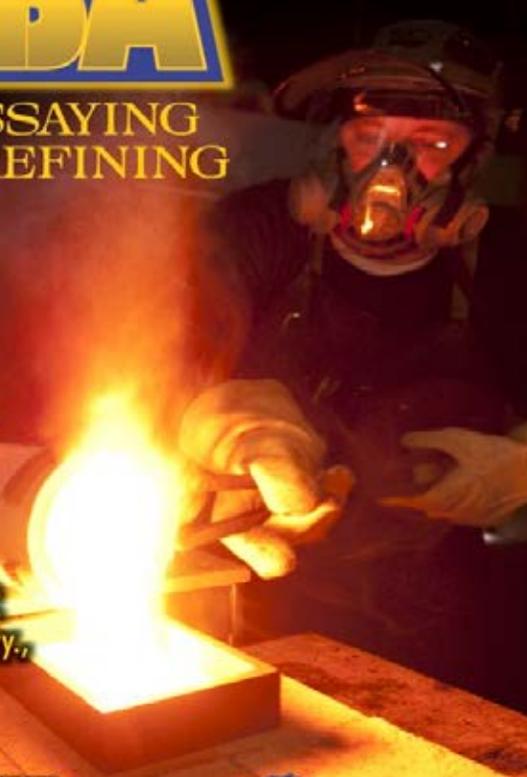
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New York dealer price for tin, the estimated value of imported refined tin was \$703 million, and the estimated value of tin recovered from old scrap domestically was \$213 million,” USGS wrote on the 2018 tin sector in the United States.

Around Tin City

Unlike most metals and minerals, where hardrock mining dominates large scale production, the majority of global tin supplies come from placer mining of cassiterite, a tin mineral, from alluvial deposits that have eroded from the lode source.

“Placer deposits have traditionally been an important source of tin; in 2012, they accounted for about 70 percent of the world output of cassiterite concentrates,” USGS inked in its critical minerals report.

While there have not been any notable placer tin deposits identified in the Lower 48 states, they are widespread across Alaska.

In fact, the western tip of the Seward Peninsula has alluvial deposits so rich in cassiterite that early prospectors who flocked to the area during the gold rush days established Tin City, a small mining town near Cape Mountain and about 90 miles northwest of Nome, in 1904.

Placer mining of Cape Creek, which drains the mountain rising to the northwest of Tin City, produced an estimated 3.3 million pounds of tin, according to the USGS. The largest known chunk of cassiterite recovered during placer mining of Cape Creek weighed 142 lbs.

While Tin City and the mines it hoped to support were short-lived, this minerals-rich area of western Alaska still hosts rich placer and lode tin deposits.

Other tin prospects found near Cape Mountain include Lost River and Potato Mountain.

Kougarok, located about 90 miles east of Tin City, is another promising lode tin deposit on the Seward Peninsula.

Work in the 1980s estimated a portion of the tin-bearing granites there hosts some 6 million lb of tin in 240,000 tons of historical resource averaging 1.3 percent tin. Some of the tin deposits at Kougarok have an appreciable amount of beryllium, tungsten, fluorspar, niobium and tantalum, all on the USGS list of critical minerals.

Interior gold miners’ nuisance

Tin has also been produced from placer deposits in Interior Alaska, primarily as a product of gold mining.



JAMES BARKER

Tin, rare earth elements, tungsten, tantalum and niobium were recovered from placer samples collected in the Ray Mountain area of Interior Alaska.

The tin in at least one Interior Alaska stream – Boulder Creek in the Circle Mining District – is so prolific that it plugs the placer recovery plant, making it a nuisance for miners attempting to mine the gold from this stream about 125 road miles northeast of Fairbanks.

While there has been no systematic testing of the placer tin content, a miner attempting to recover the gold in a particularly tin-enriched portion of the creek estimated the gravel contained more than 2 lb of cassiterite, a primary tin mineral, per yard.

An investigation carried out by James Barker for the U.S. Bureau of Mines indicates that the lode source of this tin mineralization is very close.

“Cassiterite occurs as fresh unweathered crystals up to 3/8 of an inch long, some of which are attached to gangue rock,” he wrote in a 1979 report. “Tin is particularly concentrated in the coarser size fractions. The gold is also quite fresh, occurring primarily as thin irregular flakes. The balance of the concentrate consists of rounded nuggets of hematite, magnetite, and scheelite.”

Scheelite is a mineral of tungsten, which the USGS also considers critical.

One sample of fresh granite collected by Barker near Boulder Creek returned 20 parts per million tin and 22 ppm tungsten. The sample also contained gold and molybdenum.

Tin and tungsten have been found in many of the other creeks in the region – Bedrock, Deadwood, Independence and Half Dollar, to name a few.

The Lime Peak and Mount Prindle areas to the west of the Circle Hot Springs granitic intrusive feeding these creeks also has tin and tungsten mineralization.

Cassiterite a Tofty by-product

The most widely known placer tin deposits in Interior Alaska, however, are found along the Tofty tin belt, a 12-mile-long area of tin- and gold-bearing gravels in the Manley Hot Springs district, another gold-rich area of Interior Alaska.

While it is unclear how much tin has been recovered from the streams of this mining district about 90 miles northwest of Fairbanks, much like the area around Tin City, gold miners were recovering placer cassiterite at the dawn of the 20th Century.

“Gold mining in the district developed rapidly, and as the productive area in the vicinity of Tofty increased it was found that tin and gold were generally associated and that the richer concentrations of the two minerals were generally coincident,” Henry Eakin wrote in a 1914 report, Tin Mining in Alaska.

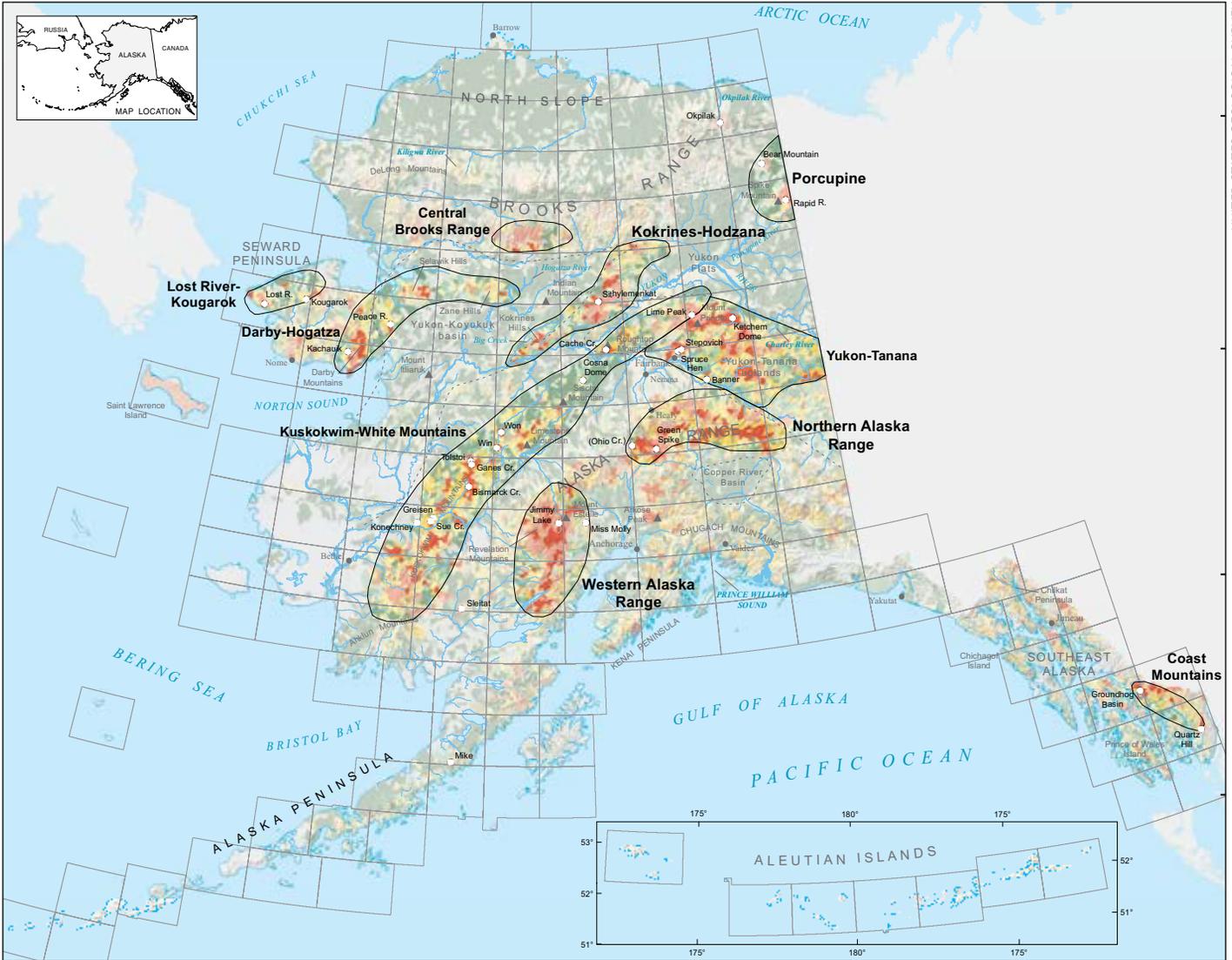
Like Boulder Creek, the high tin concentrations plugging the riffles of their sluice boxes was a nuisance to the early miners attempting to recover placer gold in the Hot Springs District. These miners, however, soon decided to try to cash in on the cassiterite piling up on their claims.

In 1911, about 1,200 pounds of tin concentrates accumulated from cleaning out the sluice boxes were shipped to Singapore for processing.

“The ore was found to be of high quality, and the returns from the small shipment directed attention for the first time to the possible value of tin as a by-product,” Eakin penned.

And in 1914, roughly 48 tons of tin was shipped from the gold mines in the Hot Springs district.

Over the years since, various miners have recovered cassiterite as a by-product of gold mining.



A search for the lode source of the tin found in the stream did not turn up appreciable amounts of cassiterite but samples collected by the Alaska Division of Geological and Geophysical Surveys did find intriguing quantities of other minerals now considered critical by the USGS. The host of critical minerals – bismuth, chromium, gallium, manganese, niobium, rare earth elements, scandium, strontium, tantalum and vanadium – have been identified in samples collected from the Manley Hot Springs district.

About 60 miles north of the cassiterite-bearing streams at Tofty, Ucore Rare Metals has found that the rare earths-rich placer deposits on its Ray Mountains property contain appreciable amounts of tin and other critical minerals.

Concentrates from gravity separation of placer samples collected at Ray Mountains returned up to 50 percent tin; 10 percent rare earths; and 0.01 to 1 percent tungsten, tantalum and niobium.

“The Ray Mountains project has select areas rivaling HREE (heavy rare earth element) content at our Bokan property, and the remarkable advantage of collateral tin, niobium and tantalum mineralization which enhances prospective values per ton.” Ucore President and CEO Jim McKenzie said, referring to the company’s Bokan Mountain rare earth property on Prince of Wales Island in Southeast Alaska.

A definitive lode source of the 100-meter-deep critical mineral-bearing gravels at Ray Mountains has yet to be identified.

Hawley’s Alaska Range discoveries

One place where the lode source of tin has been identified is in the Alaska Range south of Fairbanks.

Coal Creek, a 2,400-acre property just west of the Parks Highway roughly halfway between Anchorage and Fairbanks, is one such property that has garnered some interest in recent years.

Discovered by Charles Hawley in 1972, Coal Creek was staked for its tin-silver potential by Houston Oil and Minerals in 1980. Over the ensuing five years, this exploration company carried out exploration programs that included 5,240 meters of drilling in 42 holes.

A preliminary resource calculated for Houston Oil and Minerals in 1982, estimated the drilled portion of the Coal Creek deposit contained roughly 4.8 million metric tons averaging 0.27 percent tin, according to data published by the U.S. Geological Survey.

While the resource does not meet the rigor of current reporting standards, sampling of core stored at the Alaska Geologic Materials Center in Anchorage and four holes drilled by Brett Resources in 2006 confirms the tin-silver potential of this easily accessible property.

Highlights from the drilling include: 9.4 meters averaging 0.41 percent tin, 18.21 grams per metric ton silver and 0.81 percent zinc; and 9.3 meters averaging 0.45 percent tin, 11.95 g/t silver and 0.29 percent zinc.

Tungsten and gold also have been identified at Coal Creek. Choice

grab samples collected from the property in 1990 turned up 720 g/t tungsten, 65 g/t silver, 0.5 g/t gold and 4.86 percent zinc.

Like the other tin deposits in Alaska, Coal Creek has tin-bearing neighbors enriched with a suite of other critical minerals.

Ohio Creek, another Hawley discovery to the northwest, has yielded a wide variety of minerals and metals.

A study completed by the U.S. Bureau of Mines in the 1980s identified wadginite, a manganese-tin-niobium oxide; tungsten; gold; silver; palladium, a platinum group metal; and a suite of rare earths in the area.

As part of Alaska's Strategic and Critical Minerals Assessment project, the Alaska Division of Geological & Geophysical Surveys re-analyzed rock samples from the earlier study. A report published by DGGS in 2014 confirmed the earlier findings.

Strongbow Exploration Inc. acquired Coal Creek and commissioned a technical report on the property in 2015 but has not followed up with any significant exploration there.

Tin-rich Kuskokwim Mountains

The Kuskokwim Mountains of Southwest Alaska is another place known for its tin potential and Strongbow also holds a cassiterite-bearing property there.

This property, Sleitat, was explored by Cominco (now Teck Resources) in the 1980s, which discovered two zones of tin mineralization.

One hole drilled by Cominco cut 3.1 meters of 12.55 percent tin and 197.5 g/t silver. The overall deposit evaluated by the nine holes drilled by the company was much lower grade.

Using the information from Cominco drilling and surface sampling, the Bureau of Mines estimated the area of known mineralization at Sleitat encompassed roughly 25.9 million metric tons averaging between 0.22 and 0.37 percent tin, 17 g/t silver and 0.04 percent tungsten.

In a 2015 technical report for Strongbow, Alaska Earth Sciences recommended airborne geophysical surveys that could help target future drilling at Sleitat.

Three other prospects in the Kuskokwim region of Southwest Alaska – Bismarck Creek, Win and Won – are also prospective for tin.

Chip-channel samples collected at Bismarck Creek, about 40 miles southwest of McGrath, returned up to 2.8 percent tin, 63 g/t silver, 590 g/t copper, more than 1 percent zinc and 0.03 percent antimony.



JAMES BARKER

A tin-rich specimen collected by geologist James Barker during a 1990 U.S. Bureau of Mines investigation of the Sleitat tin-tungsten deposit in Southwest Alaska.

Selected samples are also reported to run up to 0.01 percent indium, another USGS critical mineral.

Based on extensive surface sampling, it is estimated that the Bismarck Creek deposit contains 500,000 metric tons averaging 0.14 percent tin and 47.8 g/t silver.

Sampling at Win, located about 20 miles north of McGrath, yielded several high-grade samples of polymetallic mineralization. One 7.75-foot channel sample collected by the Bureau of Mines in 1992 returned 18.82 oz/t silver and 6.97 percent tin.

Other samples from Win ran as high as 94.63 oz/ton silver, 46.4 percent tin, 926 ppm bismuth, 0.36 percent copper, 0.17 percent niobium and 5 percent antimony.

Despite the high-grade metals found at Win, no drilling is reported for this prospect.

The tin-bearing veins at the Won prospect, however, have been drilled.

Two holes drilled by Anaconda Minerals Company cut up to 6.9 percent tin and 3.3 oz/ton silver, along with antimony, lead, arsenic, copper, and tungsten over unknown widths.

The authors of a 2004 USGS report, Metallogenesis and Tectonics of the Russian Far East, Alaska, and the Canadian Cordillera, the Win and Won prospects "contain some of the most important tin-polymetallic resources in the Kuskokwim Mineral Belt and perhaps in all of Alaska."

Like the other tin-enriched regions of the state, a winning search for tin in Southwest Alaska will likely lead to the discovery of a suite of the minerals the USGS considers critical to America's security and economic well-being.

This makes tin an ideal gateway metal for anyone exploring the Last Frontier's rich critical minerals potential.



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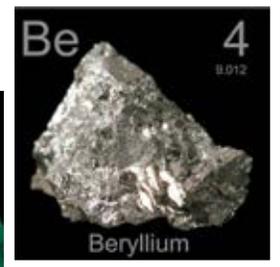
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In addition to being a critical aerospace metal, beryllium is a vital element in numerous gemstones such as this emerald.

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Strategic beryllium makes critical list

Western Alaska hosts lodes of this lightweight aerospace metal

By **SHANE LASLEY**

Mining News

ROUGHLY 78 PERCENT OF THE UNITED STATES' beryllium needs are met by domestic mine production, making it unique among the 35 minerals and metals that have been listed as critical to America. While the U.S. Geological Survey's definition does not state that America must be net import-reliant on a mineral or metal for it to be considered critical, this is a common thread among most of the other 34 on the list.

Among the lightest and stiffest of the metals, beryllium has unique and oftentimes irreplaceable characteristics needed by the aerospace, defense, and nuclear sectors – properties that weigh in on the metal's criticality.

"High-purity beryllium metal is classified as a strategic and critical

material by the Strategic Materials Protection Board of the U.S. Department of Defense because it is used in products that are vital to national security," the USGS penned in a 2017 report on critical minerals. "The DOD is required by the board to continue to take special actions to maintain a long-term domestic supply because domestic beryllium production capabilities have diminished over time."

The beryllium-rich tin deposits found on Alaska's Seward Peninsula could provide a future domestic source of this and a host of other critical minerals for decades.

Crucial properties

Pound-for-pound, beryllium is six times stiffer than steel. Coupled with the ability to maintain its shape across a wide range of temperatures, this critical metal has a number of aerospace and military

applications, especially where lightweight and precision are a must.

“Because the cost of beryllium is high compared with that of other materials, it is used in applications in which its properties are crucial,” the USGS wrote.

One such use is in the construction of the mirrors on the James Webb Space Telescope, the successor to the Hubble Telescope, which is scheduled to be put into orbit about 1 million miles above Earth in 2021.

The primary mirror of the Webb Telescope contains 18 hexagonal segments, each 4.3 feet across, that must maintain their exact shape even at temperatures of -400 degrees Fahrenheit. The gold-plated mirrors built for this next generation telescope take advantage of beryllium traits to accomplish this task, which will allow scientists to see further into time and space than ever before.

Another important attribute of beryllium is this metal is almost transparent to x-rays. This property makes beryllium foil an ideal material to use for windows in x-ray and other radiation machines; and beryllium metal and beryllium oxide are used to control fission reactions.

The largest use for this temperature resistant metal, however, is in beryllium-copper alloys, which accounts for roughly 80 percent of U.S. consumption.

Strong, hard, and nonmagnetic; good conductors of electricity and heat; and resistant to corrosion and fatigue, beryllium alloys are used in connectors, springs, switches, and other electronic components.

Beryllium averaged roughly US\$227/lb in 2018.

The USGS estimates that roughly 220 metric tons of beryllium, at an apparent market value of US\$110 million, was consumed in the United States during 2018.

Roughly 22 percent of this beryllium was used in industrial components, 21 percent in consumer electronics, 16 percent in automotive electronics, 9 percent in defense applications, 8 percent in telecommunications infrastructure, 7 percent in energy products, 1 percent in medical devices and 16 percent in other applications.

“Sales of beryllium products to the consumer electronics, defense, energy, and industrial components markets increased owing to stronger demand,” USGS wrote in the Mineral Commodity Summaries 2019.

Finding Lost River beryllium

While the Lost River area on Alaska’s Seward Peninsula is widely renowned for its rich tin potential, the same deposits rich in this alloy metal also host beryllium and more than a dozen other metals considered critical to the United States.

According to the 2017 USGS report on critical minerals, the Lost River area hosts 10,000 to 57,500 short tons of beryllium in 3 million metric tons of historical resource averaging 0.3 to 1.75 percent beryllium.

A USGS study completed in 1997, the Lost River lode deposit, itself, hosts roughly 4,500 tons of beryllium, along with tin, fluorite and tungsten.

“Tin and fluorspar could possibly be produced as coproducts, along with tungsten and possibly beryllium as byproducts, if a mine can operate profitably in that remote location and extreme climate,” USGS wrote about Lost River in its 2017 critical minerals report.

Interesting quantities of beryllium, fluorspar, niobium, tantalum and tungsten have also been identified at Kougarok, a promising lode tin deposit about 90 miles east of Lost River.

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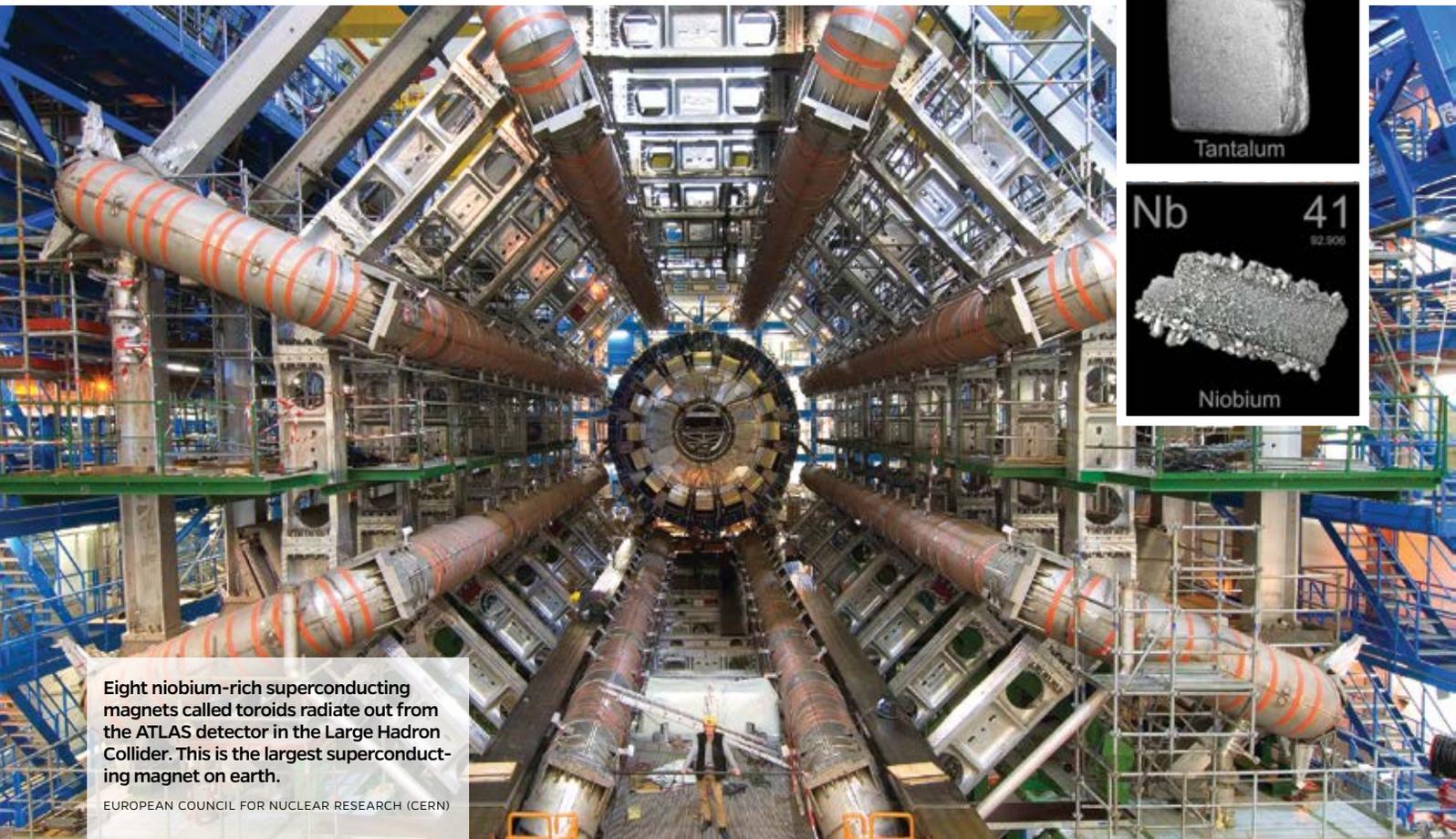
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Indispensable twin metals critical to US

Niobium-tantalum; closely related metals with vital properties

By SHANE LASLEY

Mining News

WITH NEARLY INDISTINGUISHABLE CHARACTERISTICS, niobium and tantalum are considered the “indispensable twins” among the 35 minerals and metals considered critical to the United States.

“Niobium and tantalum are transition metals that are almost always found together in nature because they have very similar physical and chemical properties,” the U.S. Geological Survey wrote in a 2018 paper on the twin metals.

While nearly identical twins, they each have their own set of unique characteristics that make them vital to a wide array of products used in the defense, energy, high-tech and medical sectors.

“The leading use of niobium is in the production of high-strength steel alloys used in pipelines, transportation infrastructure, and structural applications,” USGS penned in its report. “Electronic

capacitors are the leading use of tantalum for high-end applications, including cell phones, computer hard drives, and such implantable medical devices as pacemakers.”

Niobium and tantalum share one more quality that places these indispensable twins firmly on the list of minerals and metals the USGS has deemed critical to the security and economic wellbeing of the United States – you cannot find a good substitute for either without sacrificing performance and increasing costs.

Like the majority of the 35 critical minerals and metals, Alaska has the potential to be a domestic source of both niobium and tantalum.

Tough niobium

Niobium’s toughness, resistance to corrosion and high melting point makes it an important alloy to steel that is used in situations where durability is vital. That is why around 75 percent of this metal is used as an alloy in high-strength steel used in pipelines, transportation, and structural applications.

Niobium's extreme resistance to heat makes this metal an important ingredient for iron-, nickel- and cobalt-based superalloys that need to stand up to high temperatures.

Roughly 20 percent of the niobium consumed in the U.S. is used to make high-temperature superalloys used in parts that go into jet engines, rockets, gas turbines and turbochargers.

Adding to its résumé of "super" properties, niobium is among the most powerful superconducting metals.

Superconducting magnets made from niobium-germanium, niobium-tin and niobium-titanium alloys are used in a range of important devices, from imaging equipment to particle accelerators.

The magnetic resonance imaging (MRI) scanners, which use niobium superconducting magnets, along with radio waves and a computer to create a detailed image of the inside of a human body – is among the applications of this critical metal's special characteristics.

Niobium superalloy magnets also play a crucial role in the Large Hadron Collider, a 27-kilometre (17 miles) circular tunnel deep under the border between Switzerland and France that physicists use to collide particles together at near the speed of light. These high-energy collisions of protons help scientists investigate dark matter, antimatter and other secrets of the universe.

Magnetic fields guide and squeeze the particle beams, creating a more powerful collision. Niobium-titanium magnets currently being used to provide these powerful magnetic fields are being replaced with even more powerful niobium-tin magnets.

International scientists are now floating the idea for the Future Circular Collider, a 100-kilometers (62 miles) successor that would be 10 times more powerful than the Large Hadron Collider. This massive US\$27.5 billion project, including initial and upgrade costs, would need a whole lot more niobium and a slew of other metals considered critical to the United States.

Beyond its "super" characteristics, niobium is also hypoallergenic and inert, making it a good candidate for uses inside the human body, such as pacemakers and prosthetics.

Niobium is also one of the few metals that can be heated to produce a wide array of iridescent colors. The heat creates anodized oxide layers on the surface of niobium that creates this color changing effect by diffracting the light that bounces off it.

This ability, coupled with being hypoallergenic, makes it a popular for creating colorful jewelry, especially for body-piercing.

Exceptional tantalum

While tantalum shares many of niobium's characteristics, its exceptional capacity to store and release energy is this twin's superpower. Due to this unique ability, more than 50 percent of the tantalum consumed in the United States was used in capacitors and high-power resistors for the electronics sector.

"Major end uses for tantalum capacitors include automotive electronics, mobile phones, and personal computers," the USGS penned in its 2018 minerals report.

Because it is so good at storing and releasing energy, tantalum capacitors and resistors can be exceptionally small. This is crucial in the shrinking of modern electronics, such as cell phones and hard drives, and medical devices, such as hearing aids.

Tantalum oxides are also used to make lighter weight glass camera lenses that produce a brighter image.

In addition to traits that set it apart from its twin, tantalum shares many of niobium's characteristics and is often used for similar



The poinsettia on this coin is made from niobium that has been oxidized to provide the distinctive color. This coin is part of Royal Canadian Mint's "Flowers of Canada" series, with oxidized niobium providing a different color for each flower of the series.

ROYAL CANADIAN MINT

applications. Being substantially more expensive, however, tantalum typically imbues its properties as a coating on other metals.

One such parallel is devices going inside the human body, where tantalum-coated blood vessel stents, plates, bone replacements, suture clips and wire are often used.

In the chemical industry, tantalum's corrosion resistance makes it useful as a lining for pipes, tanks, and vessels

Wholly dependent on others

While deposits of both niobium and tantalum are found in the United States, it has been roughly six decades since either of these critical minerals have been produced domestically.

"Primary production of niobium or tantalum in the United States has not been reported since the late 1950s; therefore, the United States has to meet its current and expected future needs by importing primary mineral concentrates and alloys, and by recovering them from foreign and domestic alloy scrap," USGS inked in an information sheet on the indispensable twins.

As a result, the U.S. imported an estimated 11 million kilograms (24.3 million pounds) of niobium, valued at US\$310 million, to meet the needs of U.S. manufacturers in 2018.

Accounting for roughly 72 percent, Brazil was by far the United States' largest source for niobium. Canada (18 percent), Russia (3 percent) and Germany (2 percent) accounted for most of the balance.

While tantalum consumption in the U.S. is a little more than 10 percent that of niobium, the high price this energy storing metal fetches makes up the differential.

According to the USGS, about 1.17 million kg (2.6 million lb) of tantalum, valued at US\$310 million, was used in the U.S. last year.

Brazil, at 35 percent, shipped the most tantalum ore and concentrates to the U.S. in 2017. Rwanda (31 percent), Australia (15 percent) and Congo (8 percent) were other sources of tantalum minerals.

When it comes to tantalum metal, China, at 40 percent, was the



While best known for its rare earth elements, the Dotson Ridge deposit at Ucore Rare Metals' Bokan Mountain project in Southeast Alaska hosts other critical metals, including niobium.

UCORE RARE METALS INC.

United States' largest supplier last year. Germany (18 percent), Kazakhstan (17 percent) and Thailand (11 percent) were other countries that supplied America's growing tantalum metal requirements.

Because the U.S. is wholly dependent on foreign sources for both niobium and tantalum, it is vulnerable to potential supply disruptions from swings in the metal markets, such as the recent downturn that interrupted operations at several mines, and global economic instability that could create supply problems.

"Other possible disruptions include war, civil unrest, political changes, natural disasters, environmental issues and market manipulation," the USGS penned in its niobium-tantalum paper. "For example, rebel sales of 'conflict coltan' (coltan is a niobium-tantalum mineral) in the Democratic Republic of Congo, amidst a civil war, have led to discussions about supply-line transparency and traceability as tools for excluding illegal columbite-tantalite while keeping the market open for legitimate, small-scale artisanal mining in central Africa."

An improved global economy – coupled with continued economic development of BRIC (Brazil, Russia, India and China) countries – is expected to drive up the competition for niobium and tantalum.

"Niobium and tantalum are considered critical and strategic metals based on the potential risks to their supply (because current production is restricted to only a few countries) and the significant effects that a restriction in supply would have on the defense, energy, high-tech industrial, and medical sectors," according to the USGS.

Alaska is home to potential domestic supplies of both indispensable metals.

Twins found at Kougarok

The Kougarok prospect about 90 miles north of Nome on the Seward Peninsula is one Alaska locale where both niobium and tantalum are known to exist.

Situated on the north side of Kougarok Mountain, this prospect is best known for its tin, another of the 35 metals considered critical to the United States.

While an official resource estimate is not available for Kougarok, work carried out by Anaconda Mining Company in the 1980s has outlined potentially large and critical mineral-rich deposits at Chuck's dike, Main plug and Roof greisen, the main targets identified so far.

The richest tantalum and niobium concentrations were identified in Main plug. According to preliminary calculations, this portion of the larger Kougarok prospect hosts 1.4 million metric tons averaging 0.45 percent (12.6 million lb) tin and 0.1 to 0.3 percent (2.8 million to 8.4 million lb) combined niobium and tantalum.

Navigator Exploration Corp. and Chapleau Resources, Ltd., which optioned Kougarok in 2001, took a closer look at the prospect's tantalum potential. These explorers found elevated tantalum values across the wider prospect area.

One hole drilled outside of Main plug cut 31.5 meters averaging .033 percent tantalum. The niobium values of this hole were not reported.

Numerous other tin deposits are found on the Seward Peninsula, making this region of western Alaska highly prospective for the niobium and tantalum that is associated with the specialized granites that host this critical metal.

Placer niobium at Tofty

The Tofty tin belt, a 12-mile-long stretch of the Manley Hot Springs district in Interior Alaska, is an area rich in placer tin deposits and intriguing clues of at least a third of the 35 minerals and metals critical to the United States have been found.

The tin potential of the Tofty area became readily apparent to the early placer miners that discovered gold in this area about 90 miles northwest of Fairbanks.

Niobium is also present in the gold- and tin-rich placers mined in this area. Pan concentrates from the tailings at Idaho Gulch and Miller Gulch, gold producing creeks in the area, turned up 0.2 to 7 percent niobium bearing minerals.

It has been estimated that the placer tailings in the upper portion of Idaho Creek contain roughly 100,000 pounds of niobium.

While investigating the lode source of the prolific tin found in the streams of the Hot Springs District, the Alaska Division of Geological and Geophysical Surveys found interesting quantities of many of the minerals and metals considered critical to the United States, including bismuth, chromium, gallium, manganese, niobium, rare earth elements, scandium, strontium, tantalum and vanadium.

About 60 miles north of the cassiterite-bearing streams at Tofty, Ucore Rare Metals has found that the rare earths-rich placer deposits on its Ray Mountains property contain appreciable amounts of tin and other critical minerals.

Concentrates from gravity separation of placer samples collected at Ray Mountains returned up to 50 percent tin; 10 percent rare earths; and 0.01 to 1 percent tungsten, tantalum and niobium.

“The Ray Mountains project has select areas rivaling HREE (heavy rare earth element) content at our Bokan property, and the remarkable advantage of collateral tin, niobium and tantalum mineralization which enhances prospective values per ton.” Ucore President and CEO Jim McKenzie said, referring to the company’s Bokan Mountain property in Southeast Alaska.

A definitive lode source of the 100-meter-deep bed of critical mineral-bearing gravels at Ray Mountains has yet to be found.

Niobium with rare earths

It is also common for niobium to be found alongside the suite of lanthanide minerals known as rare earth elements and Alaska holds a lot of potential as a domestic source of this suite of critical minerals.

Ucore’s Bokan Mountain project on Prince of Wales Island in Southeast Alaska hosts the most advanced rare earth deposit in the state. “REE prospects at Bokan Mountain may have the greatest immediate potential for development of an REE resource in the state,” USGS penned in its 2017 report on Alaska’s critical mineral potential.

A rare earth mine here has the potential to provide a by-product supply of niobium, along with zirconium and tantalum.

The Dobson Ridge deposit at Bokan Mountain hosts 4.79 million metric tons of indicated resource averaging 0.6 percent (63.54 million lb) total rare earth oxides.

Dobson Ridge, however, is only one of numerous REE occurrences

radiating from Bokan Mountain. Back in the 1980s, the U.S. Bureau of Mines estimated that these occurrences contain some 374 million lb of rare earths plus yttrium; another 638 million lb of zirconium, another critical metal; 96 million lb of niobium; and an unquantified amount of tantalum.

While this resource estimate does not comply with modern reporting standards, it does provide a sense of the critical minerals at Bokan Mountain and similar rare earth targets found across Alaska.

A stretch of Southeast Alaska, extending 200 miles northwest from Bokan Mountain, is known to host additional rare earth prospects such as Salmon Bay at the northern end of Prince of Wales Island.

Other places to look

The good news for explorers seeking niobium and tantalum in Alaska is the two deposit types – tin-bearing granites and REE-bearing intrusive rocks – are typically found close to each other across the state.

Working with the Alaska Division of Geological & Geophysical Surveys, USGS has identified 10 areas of Alaska that are highly prospective for tin-rich granites that typically also host tantalum, niobium and a suite of other critical minerals.

Besides the Kougarak area on the Seward Peninsula and the swath of Alaska’s Interior that hosts Tofty and Ray Mountains, the other regions that are good hunting grounds for tin, niobium and tantalum are:

- Northern Alaska Range, an area arcing about 220 miles west from Tok;
- Western Alaska Range, a 15,000-square-mile region centered on the Revelation Mountains that shows very high potential;
- Yukon-Tanana, a large swath of Interior Alaska extending from the Yukon-Alaska border to the Roy Creek REE prospect north of Fairbanks;
- Kuskokwim-White Mountains, which stretches about 500 miles southwest from Yukon-Tanana;
- Darby Hogatza, an area of known uranium and REE occurrences that arcs 200 miles east from the Seward Peninsula; and
- Porcupine, an area centered on Spike Mountain in far northeastern Alaska.

The areas that show promise for tin-bearing granites are also great places to look for rare earth deposits, all of which could provide domestic sources for the indispensable twins – niobium and tantalum.

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Wind and other forms of renewable energy require roughly five metric tons of copper for every megawatt-hour of generation capacity.

PEXELS



Copper turns green with critical minerals

While not critical, copper is vital to world's electric future

By **SHANE LASLEY**

Mining News

WHILE COPPER IS NOT ON THE LIST of 35 minerals and metals critical to the United States there is no doubt of this metal's importance to both the everyday and avant-garde technologies vital to America's economy and security.

"None of the other critical minerals work without copper," Trilogy Metals President and CEO Rick Van Nieuwenhuysse told Mining News.

Automobiles are a prime example of how emerging technologies and green energy will drive the demand for copper into the future.

It is estimated that fully electric cars, such as Tesla's S, 3, X and Y models, contain around 180 pounds of copper, which is roughly 4 to 10 times more than the 18-49 lb in a conventional internal combustion vehicle.

There are currently nearly 4 million electric cars on global highways,

a figure that is expected to swell to 125 million by 2030, according to the International Energy Agency (IEA). This equates to roughly 22.9 billion lb (10.4 million metric tons) of copper needed just to build EVs over the next 11 years. This does not account for the increased electrical infrastructure or demand these vehicles will drive, all of which will also need copper.

And IEA thinks its electric car projections could be conservative.

"Should policy ambitions rise even further to meet climate goals and other sustainability targets, ... the number of electric cars on the road could be as high as 220 million in 2030," the international energy policy organization wrote.

While Alaska does not currently have a copper producing mine in operation, it is a past supplier of this critical electric conductor and has billions of pounds in deposits ready to deliver this green metal to world markets in the coming years.

And many of these copper deposits have the potential to produce significant quantities of other minerals and metals that are on the



Electric vehicles, green energy and urbanization are all expected to contribute to the growing demand for copper.

DANIELA MACKOVA

USGS critical list. Barite, cobalt, germanium, gallium and rhenium are among the critical commodities found in some of Alaska's advanced copper exploration projects.

People, green energy & EVs

While more than 2 billion lb of copper per year going into electric cars is going to play a role in driving up demand for this metal, the EV sector is only a part of the story. The growing amount of electricity needed to power these vehicles, the push for greener sources of that electricity and a growing populace that requires more electricity per capita contributes much of the rest of this tale.

More than 25,000 terawatt hours, or 25 billion megawatt hours, of electricity was generated worldwide during 2017, roughly double the electrical generation in 1990. This trend is not expected to abate anytime soon and the transition to greener sources of this electricity will call for much more copper.

It is estimated that renewable energy power generation, such as solar and wind, require approximately five metric tons of copper for every megawatt-hour of electric generation, which is around five times more copper than traditional power sources, such as coal and natural gas.

This does not take into account the additional copper wire to connect the power generation source to the grid.

“So, if we want less CO₂ going into the atmosphere, we need to produce more copper under it!” Van Nieuwenhuyse wrote in a 2018 column on copper and its role in green energy.

While green energy and other modern applications are exciting drivers of copper demand in the coming years, more basic economic and social developments add to and underly the growing global need for this metal.

By 2030, roughly 59.7 percent of the global populace will live in urban regions, a roughly 4.8 percent increase from current levels.

The promise of economic prosperity is the major factor in this migration to metropolitan areas. Better income and the conveniences inherent to urban living equates to new homes, more

consumer goods, expanded electrical grids and a lot more copper.

This urbanization is especially pronounced in China, already the largest copper consumer, and India, where copper demand is growing by around 8 percent per year.

Carbonate-hosted Bornite

Van Nieuwenhuyse's interest in the future demand of copper is rooted in the roughly 9 billion pounds of copper Trilogy Metals has identified so far at Arctic and Bornite – two deposits at the Upper Kobuk Mineral Projects (UKMP) in the Ambler Mining District of Northwest Alaska.

Arctic, the most advanced UKMP project, hosts roughly 2.5 billion lb of this copper, along with zinc, lead, gold and silver.

A prefeasibility study completed in 2019 details plans for an open-pit mine to extract the volcanogenic massive sulfide mineralization at Arctic and a 10,000-metric-ton-per-day mill to produce metals-rich concentrates to deliver to markets.

The largest copper prize identified so far at UKMP, however, is Bornite.

According to the most recent resource calculation, the Bornite project hosts roughly 5.45 billion lb of copper and 77 million lb of cobalt.

Bornite also carries at least two other critical minerals – germanium and gallium – though the concentrations and recoverability of these metals has yet to be determined.

To gain a better understanding of the distribution of these potential byproduct metals at Bornite, as well as to investigate the deposit's rhenium potential, Trilogy Metals entered into a technical assistance agreement with the USGS. In addition to providing Trilogy with data on these potential byproduct metals, this work will enable the USGS to assess the potential for critical mineral resources in carbonate-hosted deposits in Alaska and elsewhere.

More information on cobalt and the Bornite deposit can be found in “Batteries create critical cobalt situation” in this magazine.



A rainbow touches down at Bornite, a carbonate-hosted deposit on Trilogy Metals' Upper Kobuk Mineral Projects in Northwest Alaska that hosts roughly 5.5 billion lb of copper and 77 million lb of cobalt.

SHANE LASLEY

The Pebble giant

Bornite is not the only advanced stage copper project in Alaska known to carry critical minerals – the giant Pebble deposit hosts a globally significant amount of rhenium.

Most of the world's rhenium is produced as a byproduct from porphyry copper-molybdenum deposits like Pebble.

Considered the largest undeveloped copper deposit on Earth, Pebble hosts 6.46 billion metric tons of measured and indicated resource averaging 0.4 percent (56.9 billion lb) copper, 0.34 g/t (70.6 million oz) gold, 240 parts per million (3.4 billion lb) molybdenum and 1.7 g/t (344.6 million oz) silver.

Pebble Partnership, the company hoping to build a mine at this world-class porphyry deposit, submitted permit applications for an operation that would mine roughly 10 percent of this resource over two decades.

The reason for this modest mine in relation to the deposit size is to address concerns over potential impacts to the salmon fisheries in the region of Southwest Alaska where Pebble is located.

Federal permitting is being spearheaded by the United States Army Corps of Engineers, which released a draft environmental impact statement for Pebble in February.

The Pebble Mine under consideration in this draft EIS is expected to produce 5.74 billion lb of copper, 6.4 million oz of gold, 260 million lb of molybdenum and 32 million oz of silver over this 20-year mine life.

Pebble Partnership said this plan demonstrates the thoroughness and thoughtfulness that its engineers put into designing an environmentally optimized mine for Pebble.

"We have stated that the project must co-exist with the important salmon fishery in the region and we believe we will not harm the fish and water resources in Bristol Bay," said Pebble Partnership CEO Tom Collier. "Now we have a science-based, objective assessment of the project that affirms our work."

In addition to providing global markets with roughly 287 million lb of copper, 320,000 oz of gold, 13 million lb of molybdenum and 1.6



SHANE LASLEY

A mine being permitted for the Pebble project in Southwest Alaska would produce copper, gold, molybdenum, silver and potentially rhenium.

million oz of silver per year, Pebble hosts significant quantities of rhenium, palladium and tellurium.

Calculations completed in 2011 estimates that the Pebble deposit contains roughly 0.45 g/t rhenium, which equates to around 2.9 million kilograms, or roughly US\$6.4 billion of the critical superalloy metal.

This is enough rhenium to supply America's total needs for nearly six decades at 2018 consumption levels and does not account for the rhenium contained in the 4.45 billion metric tons of inferred resource outlined at Pebble.

More information on rhenium and the Pebble deposit can be found in "Rhenium – the hot superalloy element".

Barite at Palmer

Palmer, a copper-rich volcanogenic massive sulfide deposit in Southeast Alaska, hosts a massive quantity of another mineral critical to the U.S. – barite.

While best known for its copper, zinc, silver and gold, the deposits outlined so far at Palmer contain around 3.8 million metric tons of barite. This is more than 25 percent of the weight of the entire deposits, which also happens to carry 1.6 billion lb zinc, 278 million

lb of copper and 25 million oz of silver.

Palmer project partners Constantine Metal Resources Ltd. (51 percent) and Dowa Metals & Mining Co. Ltd. (49 percent) are investigating the potential of selling the barite as a co-product to the base and precious metals that would be extracted if a mine is developed there.

Considering that Palmer is only about 45 miles from a Pacific Rim port and the barite would be handled as part of the mining process, this critical industrial mineral has the potential to add an important revenue stream to any future operation developed at the VMS project.

“This may have very positive implications with the potential to both enrich gross metal value per tonne (metric ton) and provide significant environmental and operational benefits by reducing waste,” said Constantine Metal President Garfield MacVeigh.

More information on barite, its uses and market can be found in “Barite weighs in on critical minerals list” in this magazine.

Alaska’s abundant copper

Whether it be carbonate-hosted, porphyry or VMS, deposits that could provide future supplies of copper are abundant in Alaska.

USGS and Alaska Division of Geological & Geophysical Surveys have identified several areas of the state prospective for carbonate-hosted copper deposits.

A geospatial tool developed by the federal and state agencies found that almost the entire length of the Brooks Range, mountains that separate the oil-rich North Slope from the rest of the state, to be a good place to look for this style of copper deposit that sometimes carry cobalt, germanium and gallium.

In addition, the USGS study identified two areas of the Seward Peninsula in western Alaska and the Wrangellia terrane, a distinct belt of rocks along much of the southern slopes of the Alaska Range, as prospective for carbonate-hosted copper deposits similar to Trilogy Metals’ Bornite project.

In recent years, several porphyry deposits in Alaska have drawn the interests of mining companies looking for stores of copper similar to Pebble.

Two of the world’s largest mining companies – Freeport-McMoRan and Rio Tinto – have quietly nabbed interests in porphyry copper-gold projects in eastern Alaska.

Freeport-McMoRan has entered an agreement to option Tanacross – a porphyry copper-gold project that lies right against the Yukon border about 50 miles northeast of Tok, Alaska – from Kenorland Minerals, a privately held project generating explorer.

Kennecott Exploration, the exploration arm of Rio Tinto, has optioned the Oreo Mountain project about 10 miles southwest of the Tanacross property from another privately held explorer, Tubutulik Mining Company.

Given the early stage of exploration at Tanacross and Oreo, Freeport and Rio Tinto have not released details from their exploration or future plans from the eastern Alaska projects.

South32 Ltd. is the most recent major to invest in Alaska’s porphyry copper potential.

Early in 2018, South32 entered into an option agreement to acquire up to 70 percent in Freegold Ventures Ltd.’s Shorty Creek porphyry deposit about 75 miles northwest of Fairbanks.

While also early stage, Shorty Creek shows the potential to host the size majors are interested in.

For example, one hole drilled in 2017 cut 408 meters averaging 0.27



FREGOLD VENTURES LTD.

Core from Freegold Ventures’ 2018 drill program at Shorty Creek, a porphyry copper-gold-silver-tungsten project in Alaska’s Interior.

percent copper, 0.05 g/t gold, 4.97 g/t silver and 0.05 percent tungsten trioxide.

Another hole drilled in 2018 cut 442.2 meters of 0.24 percent copper, 0.09 g/t gold, 4.74 g/t silver and 0.02 percent tungsten trioxide.

While not as valuable as the copper and the gold in the emerging deposit, the tungsten grades at Hill 1835 could provide a source of this critical metal as a by-product.

South32 has agreed to invest up to US\$10 million to explore the porphyry potential at Shorty Creek over a four-year span, including US\$2 million during 2019.

The Australia-based major is also funding exploration at Trilogy Metals’ Upper Kobuk Mineral Projects as part of an option to earn a 50 percent interest in this world-class copper district.

PolarX Ltd., an Australia-based junior, is also on the hunt for large porphyry deposits in Alaska.

This company has already outlined a high-grade skarn deposit, often found on the periphery of porphyries, with 90.4 million lb of copper, 213,000 oz gold and 1.5 million oz of silver.

This skarn, known as Zackly, lies in the middle of a 7.5-mile- (12 kilometers) long structural corridor bookended by the Mars and Saturn porphyry gold-copper prospects.

Mars and Saturn have the classic geochemical and geophysical signatures associated with porphyry deposits. Neither, however, have ever been drilled – a dearth that PolarX plans to remedy in 2019.

And, who knows, this drilling could turn up critical metals such as rhenium or tungsten that often come along with the copper needed to power the world’s electrical future.



The turbines in newer generation U.S. fighters, such as these F35s, are made from nickel-based alloy containing 6 percent rhenium.

PIXABAY

Rhenium – the hot superalloy element

Alaska copper deposit hosts 40-year supply of vital jet metal

By **SHANE LASLEY**

Mining News

WITH A MELTING POINT OF 5,756 DEGREES FAHRENHEIT and a heat-stable crystalline structure, rhenium is extremely resistant to both heat and wear. This durability makes it a vital element in superalloys used in jet and industrial gas turbine engines.

“The high-temperature properties of rhenium allow turbine engines to be designed with finer tolerances and operate at temperatures higher than those of engines constructed with other materials,” the United States Geological Survey penned in an informational sheet on rhenium. “These properties allow prolonged engine life, increased engine performance, and enhanced operating efficiency.”

While these performance enhancing characteristics make rhenium a vital ingredient to modern transportation, its extreme scarcity helps boost it onto the list of 35 elements critical to the United States.

According to the USGS, the average rhenium abundance in the earth's crust is less than one part per billion, making it one of the rarest elements on the periodic table.

Though extremely scarce, economically viable concentrations of rhenium are often found associated with porphyry copper-molybdenum deposits and one such deposit in Alaska encompasses more rhenium than has been used globally for the past four decades.

Turbines drive demand

Roughly 49,000 kilograms, or 49 metric tons, of rhenium was

produced from mines around the world during 2018.

Roughly 51,000 kilograms, or 51 metric tons, of this high-temp critical metal was used in the United States during 2018. While U.S. consumption alone outstripped mine output, the supply-demand ratio is tipped to slight oversupply. This is because secondary production, primarily recycling, added more than enough to meet global demand last year.

Nearly 80 percent of the rhenium consumed in the United States is used in superalloys vital to highly efficient jet turbine engines.

“The high-temperature properties of rhenium allow turbine engines to be designed with closer tolerances, thus enabling increased thrust and higher operating efficiency,” the USGS explains.

The turbine engines in older generation U.S. military aircrafts, such as the F-15 and F-16 fighters, were made from a nickel-based superalloy containing 3 percent rhenium. The turbines in newer generation fighters, such as the F-22 and F-35, contain 6 percent rhenium.

The higher rhenium content alloys and limited supply pushed the price of rhenium to a high of US\$10,600 per kilogram before the markets crashed in 2009.

The same restrictions on supply that drove prices skyward also prompted manufacturers to develop newer alloys that use less rhenium.

“The major aerospace companies ... were expected to continue testing superalloys that contain one-half the quantity of rhenium used in engine blades as currently designed, as well as testing

rhenium-free alloys for other engine components,” the USGS penned in its annual report, Mineral Commodity Summaries 2018.

The second most popular application for rhenium, accounting for about 10 percent usage, is in the production of high-octane, lead-free gasoline.

Catalysts made from platinum and rhenium improve the efficiency of refineries that make gasoline with higher octane.

Rhenium’s high melting point and stability outside of a vacuum also makes it a great ingredient for filaments used in open air. Camera flashes and mass spectrometers are among the common uses of rhenium filaments.

This high melting point – coupled with good wear resistance and ability to withstand corrosion – also makes rhenium a good metal for electric contacts and heating elements.

New lower rhenium content alloys have pushed the price of this critical metal down to around US\$1,750/kg during the first half of 2019.

USGS, however, sees growing demand for rhenium in the United States.

“Consumption of catalyst-grade APR (ammonium perrhenate) by the petroleum industry was expected to remain at high levels. Demand for rhenium in the aerospace industry, although more unpredictable, was expected to continue to increase,” USGS inked in its 2019 minerals report.

To sate its appetite for rhenium, the U.S. produced around 8,300 metric tons of this critical mineral domestically during 2017. Most of the balance was imported from Chile, Kazakhstan, Germany, Canada, Republic of Korea and Belgium.

Four decades of rhenium

Most of the world’s rhenium is produced from porphyry copper-molybdenum deposits. Molybdenite, which commonly contains between 100 and 3,000 parts per million rhenium, is the principal source of rhenium in these types of deposits.

While the overall rhenium concentrations in porphyry deposits tends to be low, usually less than 0.5 grams per metric ton, the large tonnage mined from this type of deposit makes it possible to recover economically viable quantities of the critical mineral.

The Pebble deposit in Alaska holds a particularly large store of rhenium on U.S. soil.

The Pebble deposit hosts 6.46 billion metric tons of measured and indicated resource averaging 0.4 percent (56.9 billion pounds) copper, 0.34 grams per metric ton (70.6 million ounces) gold, 240 parts per million (3.4 billion lb) molybdenum and 1.7 g/t (344.6 million oz) silver.

Calculations completed in 2011 estimates the measured and indicated resource contains roughly 0.45 g/t rhenium, which equates to around 2.9 million kilograms, or roughly US\$6.4 billion, of the critical superalloy metal.

This is enough rhenium to supply the world’s needs for more than four decades at 2017 consumption levels and does not account for the rhenium contained in the 4.45 billion metric tons of inferred resource outlined at Pebble.

Carbonate-hosted rhenium

USGS believes rich stores of rhenium at Pebble could be indicative of Alaska’s larger potential for this superalloy metal.

“(R)ecent delineation of the giant Pebble porphyry copper-molybdenum-gold deposit in Alaska, which has estimated rhenium

PEBBLE LIMITED PARTNERSHIP



The rhenium estimated to be contained in the Pebble copper deposit in Southwest Alaska is equivalent to 40 years of current global mine production of this critical superalloy metal.

resources that represent more than 40 years of production at the current level of worldwide mine production, suggests that there is the potential for significant rhenium resources in undiscovered porphyry copper deposits in Alaska,” the USGS penned in a 2018 rhenium report.

The federal geologists also believe Bornite, a carbonate-hosted copper project in Northwest Alaska, could hosts appreciable amounts of rhenium and other critical minerals.

Situated on lands owned by NANA Regional Corp. and being explored by Trilogy Metals Inc., Bornite already hosts roughly 6.4 billion lb of copper and 77 million lb of cobalt, both important metals in electric vehicles.

USGS has entered into a technical agreement with Trilogy to better understand the cobalt, germanium, gallium and rhenium potential Bornite.

This agreement will contribute to an assessment of domestic sources of critical minerals and metals being carried out by USGS. The finding could also widen the potential of critical by-product in other Alaska copper deposits.

Rhenium refineries

It takes a special process at the refinery, however, to recover a usable form of rhenium from the molybdenite.

“Rhenium is recovered from gases released during the roasting of molybdenite concentrates from porphyry copper deposits and of copper sulfide ores from sediment-hosted stratabound copper deposits,” the USGS explains. “During the roasting process, rhenium is oxidized and passed up a flue stack with sulfur gases. Scrubbing of the flue dusts and gases produces sulfuric acid and other fluids that contain dissolved rhenium.”

Most of the rhenium sold is in the form of ammonium perrhenate, a white powder that is precipitated from the solution scrubbed from the refinery flues.

Currently, there is only one refinery in the United States set up to recover rhenium. This roaster, which is located at Freeport-McMurray Copper & Gold’s Sierrita facility in Arizona, processes byproduct molybdenite concentrates from the company’s own mines as well as third party concentrates.

A second refinery capable of recovering rhenium is being developed. Combined, however, these facilities would only produce around 30 percent of domestic demand.

For the United States to take advantage of the rich deposits of rhenium found at Pebble and other domestic deposits, additional refineries capable of recovering this critical metal will need to be developed.

“The future supply of rhenium is likely to depend largely on the capacity of the specialized processing facilities needed to recover rhenium from molybdenite concentrates,” according to the USGS.



An aerial view of Bornite, a large copper deposit in Northwest Alaska that also hosts 77 million lb of cobalt.

TRILOGY METALS INC.

Batteries create critical cobalt situation

Less cobalt per battery does not overcome sheer volume forecast

By SHANE LASLEY

Mining News

COBALT IS A CRITICAL SAFETY INGREDIENT in the lithium-ion batteries powering the ever-increasing number of electric vehicles traveling global highways and a plethora of cordless electrical devices.

“Globally, the leading use is in the manufacture of cathode materials for rechargeable batteries – primarily lithium-ion, nickel-cadmium, and nickel-metal-hydrate batteries – which are used in consumer electronics, electric and hybrid-electric vehicles, energy storage units, and power tools,” the United States Geological Survey wrote in a 2018 report on critical minerals

As a result, the rechargeable battery sector will drive the demand of cobalt higher, faster than the mining sector will bring new supplies of the battery metal to market.

According to Benchmark Mineral Intelligence, an analytical firm that specializes in the lithium-ion battery supply chain, 54,354 metric tons of cobalt went into lithium-ion batteries alone during 2017. The analyst forecasts that the amount of cobalt going into batteries will

climb to 276,401 metric tons by 2028, skyrocketing the demand side of the equation over the next decade.

The USGS calculates that roughly 140,000 metric tons of cobalt was mined globally during 2018. Even with substantial supply from recycling, the current mine output falls well short of the cobalt needed for batteries.

This limited supply could affect more than the battery sector.

“Cobalt’s diverse uses—particularly in parts for aircraft turbine engines; in numerous magnet applications, including marine propulsion systems, missile guidance systems, sensors, and radar; and in machine tools—make it important to the U.S. military and civilian industries,” USGS wrote.

The United States currently gets roughly 61 percent of its cobalt from overseas suppliers, with most of the balance coming from recycling.

“This high reliance on imports increases the potential for supply disruption and high prices during supply shortfalls,” according to the USGS.

This import-reliance is further complicated by the fact that the Democratic Republic of Congo (DRC), a country considered politi-

cally and socially unstable, supplied 69 percent of the world's new cobalt supply in 2018.

Combined, these factors have prompted the USGS to place cobalt on the final list of 35 minerals deemed critical to the United States.

There are a number of deposits and prospects in Alaska that could provide the United States domestic sources of cobalt, the most advanced of which is the large and high-grade Bornite copper-cobalt deposit at Trilogy Metal Inc.'s Upper Kobuk Mineral Project in the Ambler Mining District.

"It has become imperative that the United States secure its own sources of critical minerals," said Trilogy Metals President and CEO Rick Van Nieuwenhuysse.

Supply-side complications

Having around 70 percent of the world's cobalt supply coming from DRC has created a dilemma for electric automobile manufacturers and their customers.

"This country has a high-risk index for doing business owing to poor infrastructure, resource nationalism, a high perception of corruption, and a lack of transparency as well as wars," USGS wrote in its cobalt report.

While Amnesty International believes EVs have an important role to play in curbing climate change, they are urging carmakers to consider the human costs associated with the cobalt that goes into these vehicles.

"Without radical changes, the batteries which power green vehicles will continue to be tainted by human rights abuses," said Amnesty International Secretary General Kumi Naidoo.

In March, the global organization pressed its vision for a battery that does not harm human rights or the environment at the Nordic Electric Vehicle Summit in Oslo.

Coupled with pressure from socially conscious EV consumers, this call for ethical batteries has automobile and lithium-ion battery manufacturers looking for solutions, including less cobalt-intensive recipes for cathodes.

Tesla Inc., which produced roughly 350,000 cars and dominated the U.S. luxury vehicle market in 2018, is among the EV manufacturers developing cathode chemistries that require less cobalt.

"Cells used in Model 3 are the highest energy density cells used in any electric vehicle," Tesla CEO Elon Musk penned in a 2018 letter to shareholders. "We have achieved this by significantly reducing cobalt content per battery pack while increasing nickel content and still maintaining superior thermal stability."

While Tesla and other rechargeable battery manufacturers are looking at ways to further reduce the amount of cobalt, researchers and analysts do not see a scenario where the reduction of cobalt per battery can come close to offsetting the growing number of batteries that will be needed in the coming three decades.

"Cobalt is a critical safety component of the lithium-ion battery, and while auto makers are seeking to reduce their consumption of this mineral, it is our opinion that cobalt will not be engineered out of a lithium-ion battery in the foreseeable future," Benchmark Mineral Intelligence Managing Director Simon Moores penned in a 2019 written testimony to the U.S. Senate Energy and Natural Resources Committee.

McKinsey Basic Materials Institute agrees, predicting that cathodes with nickel-manganese-cobalt chemistries with ratios of 8-1-1 or 6-2-2 will be the norm in the coming decade.

That means that cobalt is expected to make up somewhere



Due to supply complications, Tesla and other electric vehicle manufacturers are looking for ways to reduce the amount of cobalt required in the lithium-ion rechargeable batteries that power their EVs.

between 10 (8-1-1) and 20 percent (6-2-2) of the cathodes in the coming generation of EVs.

Tesla said the cobalt content of the nickel-cobalt-aluminum cathode being put into its Model 3 cars is already lower than next generation 8-1-1 ratios.

Even so, roughly 4.5 kilograms (about 10 pounds) of cobalt goes into the average Tesla produced today, according to Benchmark.

Limited supply flexibility

The projected need to quadruple cobalt production over the coming decade is further complicated by the fact that cobalt is seldom mined as a standalone metal. Instead, this increasingly needed battery metal is typically produced as a byproduct at copper and nickel mines. This means that any future cobalt mines would

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likely need to consider the economics of the moneymaking metal in the deposit.

“This situation limits producers’ flexibility in adjusting the amount of cobalt mined in response to changes in demand and can result in periods of oversupply or shortage,” according to the USGS.

While at lower prices, the cost to recover cobalt from copper or nickel mines may not have been economically viable, the demand electric vehicles are putting on this metal has mining companies taking a closer look at the feasibility of recovering cobalt exploring and developing copper deposits in the United States.

“With the market interest in finding significant cobalt sources outside of the Congo – where child labor and worker exploitation have been highlighted by Amnesty International and others as problematic for the auto and electric battery Industries – defining a large, North American cobalt resource has become a priority for the company,” said Trilogy Metals CEO Van Nieuwenhuysse.

Investigating Bornite cobalt

Trilogy Metals’ endeavor to establish a North American cobalt resource is currently focused on Bornite, an enormous copper project located on NANA Regional Corp. land in Northwest Alaska’s Ambler Mining District.

According to the most recent resource calculation, the world-class Bornite deposit hosts roughly 6.4 billion pounds of copper and 77 million lb of cobalt.

Knowing that the carbonate-hosted mineralization at Bornite carries cobalt,



SHANE LASLEY

A sample of the copper- and cobalt-rich mineralization extracted from an exploration shaft Kenecott Exploration sunk into the Bornite deposit in Northwest Alaska during the 1960s.

Trilogy Metals began looking into the viability of recovering this battery metal as a by-product of the copper there.

“We have known that cobalt occurs with copper mineralization at Bornite for some time,” said Van Nieuwenhuysse. “With the completion of our metallurgical work related to copper, we decided to put forth further effort to understand how the cobalt was distributed.”

The initial metallurgical work shows promise that a separate cobalt concentrate could be produced at Bornite and Trilogy is now having a resource calculated for the battery metal.

Using traditional grinding and flotation processes, this testing recovered an average of 89.7 percent of the copper in the nine samples into a copper concentrate that contained an average of 27.6 percent copper.

Most of the cobalt in the Bornite deposit is attached to the pyrite found there. This cobalt-rich pyrite is largely discharged as tailings after the copper is recovered.

In order to produce a cobalt-rich concentrate, an additional flotation stage to recover pyrite from the copper flotation tailings was added to the recovery circuit plan for Bornite.

This added step to the recovery process demonstrates that roughly 60 percent of the contained cobalt can be recovered into pyrite concentrate containing 700 to 4,500 grams per metric ton cobalt.

“(W)e are very pleased with the first pass cobalt results which show that the Bornite project could recover between 50 and 70 percent of the contained cobalt to a high-quality pyrite concentrate,” said Van

Nieuwenhuysse.

“The next steps include finding out if the cobalt concentrate can be further processed into a saleable product,” he added.

Bornite-like prospects

Bornite is not the only carbonate-hosted copper target in The Last Frontier with cobalt potential.

According to a recent study by USGS and the Alaska Division of Geological & Geophysical Surveys, most of the Brooks Range where Bornite is found has the potential to turn up similar cobalt-enriched copper deposits.

A couple of carbonate-hosted copper targets on the southern slopes of the Brooks Range about 100 miles northwest of Bornite – Omar Peak – have interesting cobalt credits.

Novagold Resources Inc. collected samples at Omar in 2007 that contained as much as 34.3 percent copper, 0.85 percent zinc, and 0.4 percent cobalt.

Less is known about the cobalt content at Peak but the mineralogy shows similarities to Omar.

In all, the USGS and DGGs has identified a belt extending more than 300 miles along the south slope of the Brooks, and the entire north slope of this range that extends across the breadth of Alaska, is prospective for carbonate-hosted copper deposits that could contain cobalt.

The federal and state geological agencies also ranked the Nome Complex on the Seward Peninsula as highly prospective for these types of deposits.

The Nome Complex consists of a roughly

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Coastal Southeast Alaska

2,500-square mile area immediately northeast of Nome and a separate, slightly smaller area about 30 miles to the north.

The geology of the copper enriched deposit found in the Nome Complex is not well understood but USGS geologists have drawn some comparisons to the carbonate-hosted copper deposits and prospects in the Brooks Range, about 200 miles to the northeast.

A span of the Wrangellia Terrane that blankets PolarX Ltd's Alaska Range property is another area USGS and DGGS see as a good place to look for cobalt-bearing copper deposits.

Wrangellia cobalt

The Wrangellia Terrane also happens to be prime hunting grounds for platinum group metal-nickel deposits with decent amounts of cobalt.

The most advanced PGM deposit along the Wrangellia Terrane – which runs the length of the Southeast Alaska Panhandle before arcing through southwestern Yukon and into Southcentral Alaska – is Nickel Creek Platinum Corp.'s Nickel Shāw (formerly known as Wellgreen) in the Yukon.

Situated about 60 miles east of the Alaska-Yukon border, Nickel Shāw hosts 6 million oz of platinum group metals, 2 billion lb of nickel, 1 billion lb of copper and 120 million pounds of cobalt in the measured and indicated resource categories.

There are intriguing signs that similar PGM-nickel-copper-cobalt deposits could be lurking in the Alaska portion of the Wrangellia, such as the Man property about 165 miles southeast of Fairbanks.

Most holes that drilled through the Eureka zone mineralization at Man cut thick zones averaging 0.015 percent to 0.018 percent cobalt.

Pure Nickel, the former owner of Man, said that a review of drilling shows that all holes that cut the Eureka zone encountered disseminated sulfide mineralization with strikingly similar grades along seven kilometers (4.5 miles) in the central part of a longer trend of mineralization known as the Alpha Complex.

One hole drilled in 2010 cut 319.7 meters averaging 1.21 grams per metric ton palladium, 0.54 g/t platinum, 0.018 percent cobalt, 0.25 percent nickel and 0.09 percent copper. Another hole drilled in 2013 cut 205.2 meters averaging 1.22 g/t palladium, 0.61 g/t platinum, 0.017 percent cobalt, 0.24 percent nickel and 0.09 percent copper.

Despite the properties promise, Pure Nickel relinquished the state mining claims covering Man to save money during the recent downturn in mineral exploration markets.

Besides Man, numerous PGM-nickel and potentially cobalt prospects are found along a roughly 200-mile section of the Wrangellia Terrane in Southcentral Alaska.

Amphitheater, which borders the Man property to the south and west; Butte Creek, located about 40 miles southwest of Amphitheater; and Talkeetna, a block of claims roughly 30 miles further along this cobalt prospective arc on the south side of the Alaska Range.

Southeast Alaska cobalt

The Southeast Alaska Panhandle may be the most prospective area for cobalt in the state. The USGS has even asked whether the silver-rich veins at Hecla Mining Company's Greens Creek Mine on Admiralty Island could also contain cobalt.

This query of the potential of cobalt at Greens Creek is not unfounded, considering that a historical mine produced cobalt, nickel and copper from a rich deposit a few miles to the northeast.

While there is little information on the amount of cobalt produced at this mine that went into operation in 1895, referred to as Funter

Bay Nickel and Perkovich Cobalt, there is evidence that rich deposits of the battery metal remain.

According to a historical resource calculated in 1984, the Funter Bay deposit hosts roughly 508,000 tons of prospective ore averaging 0.15 percent cobalt, 0.34 percent nickel and 0.35 percent copper. And like the nearby Greens Creek Mine, the Funter Bay deposit is reported to host silver, gold, zinc and lead.

Volcanogenic massive sulfide deposits similar to Greens Creek are known to contain appreciable amounts of cobalt – Windy Craggy in British Columbia, which contains roughly 0.66 percent cobalt, and the Besshi VMS deposit in Japan, which has 0.05 percent cobalt.

The VMS deposits and prospects on Constantine Metal Resources' Palmer property at the northern end of the Southeast Alaska Panhandle also hosts intriguing hints of cobalt.

Historical samples collected from the Cap prospect at Palmer returned 0.013 percent cobalt, along with silver, zinc, gold and barite. Samples from the Jarvis Glacier prospect at Palmer returned 0.016 percent cobalt, along with copper, zinc, silver and gold.

Some of the highest grade cobalt samples in the area were collected from the Claire Bear occurrence, which is on the Haines Block lands Constantine leased from the Alaska Mental Health Trust in 2014.

Samples collected from Claire Bear contained up to 0.107 percent cobalt, 0.229 percent copper, 0.07 percent tin, 0.1 percent bismuth and 0.7 percent antimony.

The potential for existing and future VMS mines in Southeast Alaska to produce cobalt, coupled with the cobalt prospectivity of this battery metal being associated with the many PGM-nickel prospects along this stretch of the Wrangellia Terrane, makes the panhandle another potential Alaska source of critical cobalt.



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Rising above Kendrick Bay on Prince of Wales Island, Bokan Mountain hosts Alaska's most advanced deposit of rare earth elements.

UCORE RARE METALS INC.

Alaska is rich in critical rare earths

Geological endowment alone may not elevate state's REE status

By **SHANE LASLEY**

Mining News

ALASKA IS RICH IN RARE EARTH, A UNIQUE GROUP of elements that are so distinctive that most are placed in their own separate section at the bottom of the periodic table.

While scientist have long realized that rare earths possessed distinctive characteristics that set them apart from their fellow elements, it wasn't until the advent of the color television in the 1960s that these unique properties had any sort of widespread practical application.

Over the ensuing five decades, however, the unique properties of this group of outcasts have found their way into nearly every high-tech device you can think of – from speakers that deliver rich sound but so small you can fit in your ear, to enormous wind turbines delivering high-efficiency green-power generation to electrical grids around the world.

“Because of their unusual physical and chemical properties, the

REEs have diverse defense, energy, industrial, and military technology applications,” USGS wrote in a 2018 report on minerals critical to the United States.

These growing uses, coupled with news coverage of China's near total monopoly on worldwide supply, has elevated the renown of rare earth elements.

“China has been the leading producer of REEs for decades and since the late 1990s it has accounted for more than 90 percent of global production, on average,” USGS inked in its critical minerals report.

This supply and demand dynamic has also elevated the resolve of the U.S. and other nations to establish a supply of these specialty metals outside of China.

Recent work by the USGS and Alaska Division of Geological & Geophysical Surveys have unveiled wide swaths of Alaska that either host known deposits of rare earth elements or are highly prospective for these increasingly important ingredients to modern devises.

“Some of the areas that showed high potential were already known,



UCORE RARE METALS INC.

Ucore Rare Metals and IBC Advanced Technologies worked together to apply the use of molecular recognition technology to create nearly pure rare earth elements from a solution derived from Bokan Mountain.

found in REE deposits and have similar characteristics.

The lanthanides are divided into two categories, heavy and light rare earth elements.

Light REEs make up the first seven elements of the lanthanide series and include lanthanum, for which the series gets its name; cerium, used for polishing high quality optical surfaces; praseodymium, valued for its magnetic and optical properties; and neodymium, used to create the strongest permanent magnets available.

The remaining eight lanthanides are considered heavy REEs, which are less abundant in most deposits and tend to be more valuable. Some of the rare earths in highest demand are europium, used primarily in red and blue phosphors in televisions and computer monitors; terbium, used in high-temperature magnets and to create a green phosphor; and dysprosium, which improves the durability of magnets in electric vehicle motors and wind turbine generators.

While all rare earths possess unique characteristics that make them valuable to certain modern applications, the heavy ones tend to be less abundant and more valuable.

Roughly 40 percent of the rare earths in the Dotson Ridge deposit at Bokan Mountain are in the heavy REE category.

Ucore completed a preliminary economic assessment in 2012 that outlines an underground mine at Bokan Mountain that was envisioned to produce 2,500 tons of rare earth oxides per year during the first five years of full production; including an annual output of 105 tons of dysprosium oxide, 15 tons of terbium oxide, and 568 tons of yttrium oxide.

In a quest to find a more efficient and environmentally sound means of separating the rare earths at Bokan, Ucore came across a unique way of separating the notoriously tightly interlocked rare earths that could have more potential for providing a domestic source of REEs than developing a rare earth mine on U.S. soil.

Separating rare earths

This search for a cutting edge REE separation technology led Ucore to IBC Advanced Technologies and that company's proprietary molecular recognition technology, commonly known as MRT.

The basic idea behind the MRT process is that "SuperLig resins" are engineered to grab ions based on various traits such as size, chemistry and geometry. Loaded into a series of columns, these resins latch onto the targeted material suspended in a solution that is pumped through the columns. Simply rinsing the resin with a mildly acidic solution releases a nearly pure version of the material the resin is engineered to bind to.

This technology, which has been around for roughly three decades,

but many of these areas had not previously been recognized," explained Sue Karl, an Alaska-based USGS research geologist and lead author of the Alaska critical minerals study.

It may not be Alaska's geological endowment, however, that elevates the state to an important domestic REE supplier – at least not directly.

From China

Rare earths are not as uncommon as their name may suggest and America's endowment of this group of elements goes beyond Alaska.

In fact, the U.S. began producing rare earths again in 2018.

After three years of being under care-and-maintenance, Mountain Pass in California, currently the only mine on American soil that produces this group of high-tech metals, resumed operations early last year.

The rare earth concentrates produce at this mine in the Mojave Desert, however, were shipped overseas for further processing – leaving the U.S. 100 percent dependent on imports for its supply of rare earth metals and compounds.

"The estimated value of rare earth compounds and metals imported by the United States in 2018 was \$160 million, an increase from \$137 million in 2017," the USGS penned in its Mineral Commodities Summaries 2019 report.

Roughly 80 percent of these rare earths were imported from China. Estonia (6 percent), France (3 percent) and Japan (3 percent) were other REE suppliers to the U.S.

When you trace the source, however, it is apparent that even more of the rare earths used in America originated in China.

"Imports of compounds and metals from Estonia, France, and Japan were derived from mineral concentrates and chemical intermediates produced in China and elsewhere." USGS wrote in its annual minerals report.

The growing demand driven by the increased use of REEs in today's high-tech devices, coupled with China currently dominating the supply side of the equation, has resulted in the U.S. Geological Survey listing the group of technological elements among 35 minerals and metals considered critical to the economic wellbeing and security of the United States.

Bokan Mountain

For roughly a decade now, Ucore Rare Metals Inc. has been endeavoring to establish a domestic source of rare earths in Alaska.

This work started with advancing Bokan Mountain, the best known and most advanced deposit of rare earths in Alaska, toward production.

"REE prospects at Bokan Mountain may have the greatest immediate potential for development of an REE resource in the state," USGS penned in its 2017 report on Alaska's critical mineral potential.

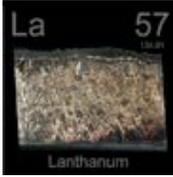
Located on Prince of Wales Island in Southeast Alaska, Bokan Mountain hosts a deposit with 4.79 million metric tons of indicated resource averaging 0.6 percent (63.54 million pounds) total rare earth oxides.

While not particularly high-grade, the mix of rare earths found at Bokan is what makes this Southeast Alaska deposit attractive.

Most rare earths deposits contain some mixture of all the elements considered rare earths, which includes 15 lanthanides – the group of elements in their own row at the bottom of the periodic table – along with scandium and yttrium – a pair of elements that are commonly

Continued on page 42

15 rare earth elements, scandium and yttrium



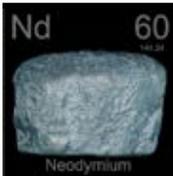
Lanthanum - High quality camera and telescope lenses; and as a cathode in nickel metal hydride rechargeable batteries. The nickel metal hydride batteries in each Toyota Prius hybrid car contains around 4.5 kilograms of lanthanum.



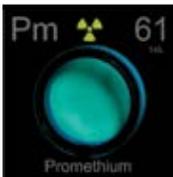
Cerium - Cerium oxide powders are used for polishing high quality optical surfaces; and as a catalytic converter to reduce carbon monoxide emissions. Cerium is also used in phosphors for color televisions and fluorescent lighting.



Praseodymium - As an ingredient in high-power magnets; an alloy in high-strength metals used in aircraft engines; carbon-arc lighting use by the motion picture industry; and to yellow coloring for glass, enamels and ceramics.



Neodymium - High-power permanent magnets in computers, cell phones, medical imaging equipment, electric car and other motors, wind turbines and audio systems; crystal in lasers used to treat skin cancer and for hair removal.



Promethium - Extremely rare and instable in nature. Atomic promethium batteries are used in pacemakers, guided missiles and radios. Due to this element's radioactive decay, electricity can be produced from the light given off by a promethium phosphor.



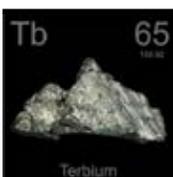
Samarium - Highly resistant to demagnetization, even at high temperatures, samarium-cobalt magnets are used in precision-guided weapons. These magnets are also used in headphones, quartz watches, camera shutters and electric guitar pickups.



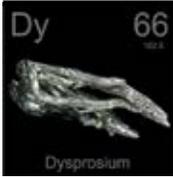
Europium - Widely used to create blue and red phosphors in televisions and computer monitors; white light in fluorescent bulbs; and anti-forgery marks on Euros. Quantum memory chips made with europium can store data for days.



Gadolinium - Small amounts of gadolinium are used to improve heat and oxidation resistance in iron and chromium alloys. This REE is also used as green phosphor in color televisions. Gadolinium yttrium garnets are used in microwaves and lasers.



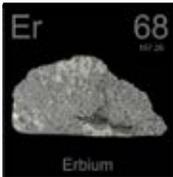
Terbium - Magnets for high-temperature applications such as electric vehicles and wind turbines; and a green phosphor used in televisions and other devices. Terbium green is among three colors used for trichromatic lighting technology.



Dysprosium - Improves durability and reduces weight of magnets in electric vehicle motors and wind turbine generators. It is estimated that each EV has roughly 100 grams of dysprosium, or about one metric ton per 10,000 cars.



Holmium - Has the highest magnetic strength of any element, which is used to create the strongest artificial magnetic fields; holmium-doped garnets are used in lasers used for medical, dental, and fiber-optic applications.



Erbium - Used with vanadium to increase the pliability of metals; medical lasers for tattoo removal and other skin resurfacing; nuclear reactor control rods; and pink coloring agent in glazes and glasses.



Thulium - High precision lasers used for surgery. Thulium that has been bombarded in a nuclear reactor is used as a radiation source for portable X-ray diagnostics. Euro banknotes also take advantage of thulium's blue fluorescence under ultraviolet light as counterfeit prevention.



Ytterbium - Being studied as an alloy to improve the strength and other mechanical properties of stainless steel. Used in stress gauges to monitor ground deformations caused by earthquakes or underground explosions; and as a radiation source for a portable X-ray machine where electricity is unavailable.



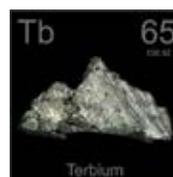
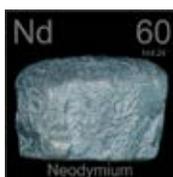
Lutetium - Has few commercial applications, due to being expensive and rarer than most REEs. It is, however, used as catalysts in petroleum cracking in refineries. Research indicates that lutetium-ion atomic clocks could provide greater accuracy than any existing atomic clock.



Scandium - Certain aluminum-scandium alloys are strong as titanium, light as aluminum, and hard as ceramic. These alloys are used in aerospace components and high-end sports equipment such as bicycle frames and baseball bats. Metal-halide lamps and lasers are other uses.



Yttrium - Yttria, an oxide used to create the red component of color in television picture tubes, is the largest use of yttrium. This element is also the ingredient of a large variety of synthetic garnets used as microwave filters, lasers, jewelry and white LEDs. An isotope of yttrium is used to treat cancer.



has already been proven in mining. Notable applications include platinum group metals refining and removing bismuth impurities from copper.

Before Ucore and IBC, however, no one had ever tried to utilize MRT to separate the hard to break apart rare earth elements.

With a pilot plant dubbed SuperLig-One, IBC and Ucore extracted individual REEs from a solution derived from Bokan Mountain, proving that MRT could be used to separate rare earths.

“We’ve demonstrated the capability to separate the 16 individual REEs, at greater than 99 percent purity and 99 percent recovery, from PLS (pregnant leach solution) derived from Bokan-Dotson Ridge REE ore,” said IBC President and CEO Steven Izatt.

“Dysprosium, for example, has been separated from Bokan PLS in a pilot plant operation at the 99.99 percent level with 99 percent recovery.”

This means that essentially all of dysprosium fed into SuperLig One came out the other end as a virtually pure product.

After proving the concept at the pilot plant scale, Ucore has been looking for an ideal U.S. locale for the first Strategic Metals Complex, a commercial scale REE separation facility.

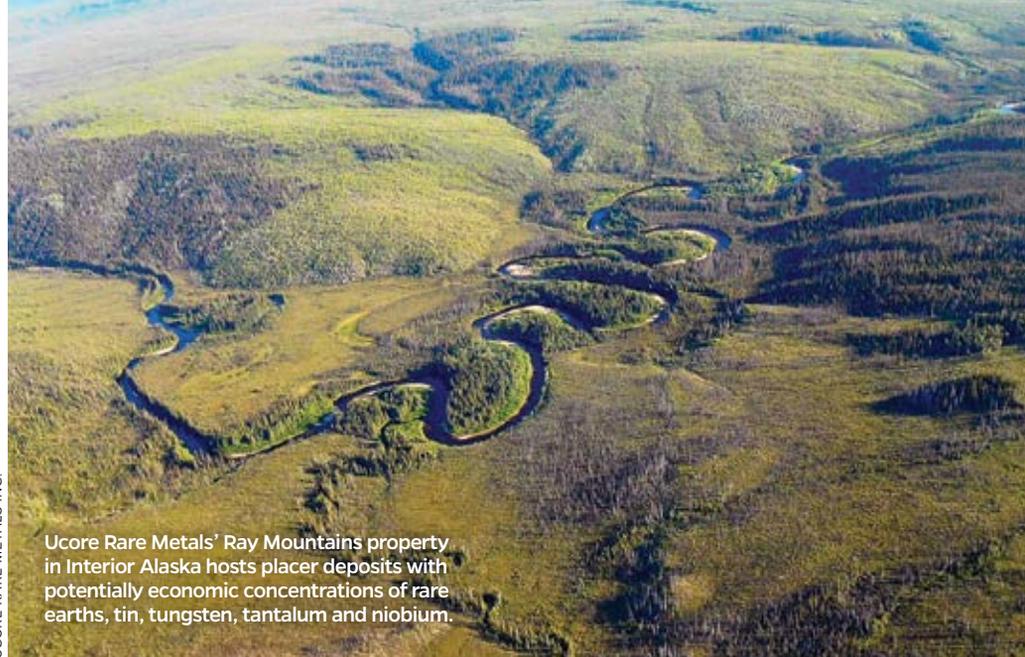
Ease of access to international shipping corridors, industrial infrastructure, permitting, and potential for local incentives and state funding programs were among the considerations weighed when looking for the best place to build the first SMC.

This search led Ucore to Ketchikan, a Southeast Alaska coastal town that is about 35 miles northeast of its Bokan Mountain project.

Hosting a deep-sea port on the Pacific Rim and situated roughly 60 miles from a Canadian rail-head that connects the project to all of North America, Ketchikan has a number of advantages for a metals separation facility that is looking to produce high purity rare earths from REE-bearing feedstock sourced from around the globe.

“Engineering and economic studies have confirmed that Ketchikan is our preferred location to construct our first strategic and critical metals separation facility,” said Ucore COO Mike Schrider.

For the initial feedstock for this facility, Ucore is seeking concentrates that contain the rare earths needed to feed the increasing demand for electric vehicles, as well as individual REE oxides required for other U.S. commercial and military technologies.



Ucore Rare Metals' Ray Mountains property in Interior Alaska hosts placer deposits with potentially economic concentrations of rare earths, tin, tungsten, tantalum and niobium.

UCORE RARE METALS INC.

So, the first rare earths produced in Alaska seem likely to come from sources outside the state. Feedstock from locations in the Lower 48, South America, Africa, Asia, and Australia are under consideration.

The Ketchikan SMC, however, could also eventually serve as a rare earth separation facility for a mine at Bokan.

“The intent is also to maintain the processing flexibility and capacity to accommodate ore concentrate from the Bokan-Dotson Ridge project, once that project has been developed,” Schrider said.

Beyond Bokan

While Bokan Mountain is the most advanced rare earth deposit in Alaska, it is far from the only potential geological source of these technological elements found in the state.

To compile and rate Alaska’s REE potential, USGS and Alaska’s DGGS developed a geospatial tool that can integrate and analyze a massive load of geologic information and use this data to estimate the state’s potential for a large array of critical minerals, including rare earths.

After crunching the data, this new tool confirmed and expanded upon areas of Alaska already known for their rare earth potential and turned up at least one surprisingly hot REE hunting ground in the state.

In fact, the federal and state geological agencies identified a stretch of Southeast Alaska, extending 200 miles northwest from Bokan Mountain, as a great place to look for REEs.

Numerous rare earth prospects – including Doris Bay, Salmon Bay and Stone Rock – have been identified on this stretch of

Southeast Alaska that is dominated by Prince of Wales Island.

The critical minerals study done by USGS and DGGS also found that most of Alaska’s gold-rich Interior region is prospective for rare earths.

This includes Yukon-Tanana, a roughly 100-mile-wide swath of Eastern Interior Alaska that extends from the Yukon-Alaska border to the Roy Creek REE prospect north of Fairbanks.

Interior Alaska’s most exciting REE hunting ground, however, is Kokrines-Hodzana, a 200-mile-long area of Interior Alaska just north of the Yukon River that includes the Ray Mountains and Kokrines Hills.

“The Ray Mountains and the Kokrines Hills area of the state is one of the places that stand out of rare earths,” Avalon Development President Curt Freeman told Mining News in 2012.

One of the interesting characteristics of the Ray Mountains area is this area hosts significant placer REE occurrences. Having the material already broken down to sands and gravels deposited in stream beds could make the first stages of REE recovery easier and less expensive.

Ucore holds mining claims that blanket an 11,400-acre area of the Ray Mountains that hosts placer deposits with potentially economic concentrations of REEs tin, tungsten, tantalum and niobium.

To better understand the placer potential of its Ray Mountain property, Ucore collected alluvial samples from upper Kilolitna River, Ray River, and No Name Creek during a field investigation carried out in 2011.

Using a shaking table – a standard gravity separation tool common to placer gold

mining – Ucore concentrated these samples collected from the Ray Mountain drainages.

That assays of these concentrates returned up to 50 percent tin; as much as 10 percent rare earths; and 0.01 to 1 percent tungsten, tantalum and niobium. Heavy rare earths – including terbium, dysprosium, erbium and yttrium – make up 15 to 25 percent of the total rare earth content in the majority of samples.

As much as 60 percent of the rare earths recovered from samples collected at No Name Creek are the prized heavy REEs.

The company said most of the initial samples were collected directly from surface exposures, and the heavy mineral content can be expected to increase at greater depths within the alluvium. In some areas the gravels are reported to be as much as 100 meters deep.

“The Ray Mountains project has select areas rivaling HREE content at our Bokan property, and the remarkable advantage of collateral tin, niobium and tantalum mineralization which enhances prospective values per ton.” Ucore President and CEO Jim McKenzie said at the time.

Possibly the most intriguing find made by USGS and DGGs’ assessment of Alaska’s rare earth potential is a 15,000-square-mile region at the west end of the Alaska Range, an area that includes Mount Estelle and the Revelation Mountains.

While this area contains a few small known REE occurrences, these do not account for the high potential the USGS geospatial tool has given to a large portion of this region – a sign that this area is

exceedingly underexplored and a great place to hunt for rare earths.

The area does host Windy Fork, a placer REE deposit reminiscent of the Ray Mountain placers in Interior Alaska.

Bulk sampling at Windy Fork in the 1990s indicates that the Windy Fork placer deposit contains roughly 17 million cubic meters of placer material containing rare earths, primarily cerium; niobium; titanium; and zirconium; all of which have been deemed critical minerals by the USGS.

With the geospatial tool, USGS and DGGs identified four other regions of Alaska to hunt for rare earths:

- Northern Alaska Range, which covers a stretch of this iconic mountain range that extends roughly 220 miles west from the community of Tok;
- Kuskokwim-White Mountains, a 500-mile-long province that lies south and roughly parallel southwest from Yukon-Tanana;
- Darby Hogatza, an approximately 200-mile-long area of western Alaska that includes parts of the Seward Peninsula known for its uranium and REE occurrences; and
- Porcupine, an area centered on Spike Mountain in far northeastern Alaska.

Given Alaska’s vast and underexplored rare earth potential, along with a new REE separation facility being proposed there, the United States has the option of looking to its Far North State for a domestic supply of these increasingly critical ingredients for modern technology.

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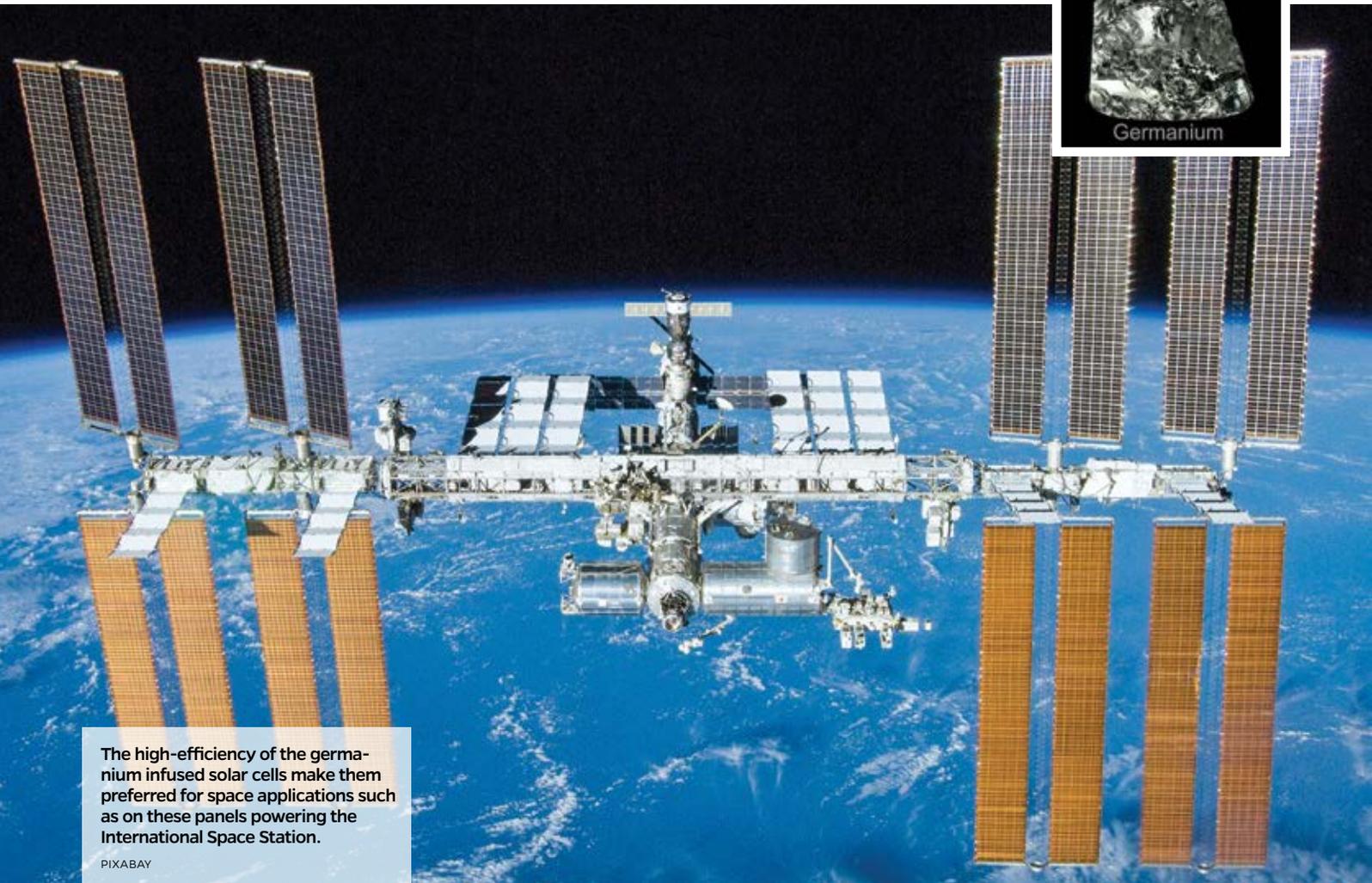


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The high-efficiency of the germanium-infused solar cells make them preferred for space applications such as on these panels powering the International Space Station.

PIXABAY

Solar, fiber optics drive germanium demand

Vital optics metal already a byproduct of mining Red Dog zinc

By **SHANE LASLEY**

Mining News

In addition to being a past producer and future source of most of the 35 minerals and metals considered critical to the United States, Alaska currently contributes a globally significant amount of one of these vital metals – germanium.

While not a widely known metal, germanium has optical qualities that make it an important ingredient in fiber-optics, infrared optics, electronics and solar energy systems.

“The extensive use of germanium for military and commercial applications has made it a critical material in the United States and the rest of the world,” the United States Geological Survey wrote in a

report on critical minerals published at the beginning of 2018.

Due to this criticality, the United States and China have included germanium in their stockpile programs and the European Union included germanium in a list of raw materials of critical concern for its member countries in 2010.

Like many other critical metals, germanium is not mined as a primary metal.

“As a byproduct metal, the supply of germanium is heavily reliant on zinc production,” the USGS penned in its report.

Alaska happens to be home to the world’s largest producing zinc mine, Red Dog, and the concentrates shipped from there contain noteworthy quantities of germanium.

“Worldwide, primary germanium was recovered in Canada from



Highly efficient solar powerplants, such as this Amonix 7700 solar generator, focus high concentrations of sunlight onto germanium-based solar cells.

MBUDZI; CREATIVE COMMONS 3.0

zinc residues (concentrates) shipped from the United States (specifically, the Red Dog zinc-lead mine in Alaska and a previously idled zinc mine complex in Tennessee); in China, from zinc residues and coal from multiple sources; in Finland, from zinc residues (concentrates) originating in Congo (Kinshasa); and in Russia, from coal from domestic sources on Sakhalin Island in Sakhalinskaya Oblast,” the USGS penned in its critical minerals report.

Optical qualities

While germanium is an intrinsic semiconductor, the metal has several optical qualities – transparent to the infrared electromagnetic spectrum, can be formed into glass, has an exceptionally high refractive index and low chromatic dispersion – that drives most of its demand.

Roughly half of the 27,000 kilograms (59,525 pounds) of germanium consumed in the United States during 2018 was used in the infrared imaging devices widely used by the military and law-enforcement agencies.

“Infrared optical devices improve a soldier’s ability to operate weapon systems in harsh conditions effectively, and they are increasingly used in remotely operated unmanned weapons and aircraft,” the USGS inked in its germanium report. “Infrared optical devices are also used for border patrol and by emergency response teams for conducting search-and-rescue operations.”

An extraordinarily high refractive index – the ability to bend light – is an important characteristic germanium lends to fiber-optic cables.

“Germanium is added to the pure silica glass core of the fiber-optic cable to increase its refractive index and minimize signal loss over long distances,” the USGS explains.

This property is strengthened by germanium’s low chromatic dispersion – the scattering of light passing through a medium.

“Chromatic dispersion is a serious consideration in long-haul optical fibers. Its effect is essentially to stretch or flatten the initially sharply-defined binary pulses of information. This degradation

makes the signals (1s and 0s) more difficult to distinguish from each other at the far end of the fiber,” M2 Optics Inc. CEO Kevin Miller explains.

The growing need to send and receive data continues to drive the demand for more fiber-optic cable and the germanium that goes in it.

Solar power generation and electronics are the other big drivers for growing germanium demand.

“Germanium substrates are used to form the base layer in multijunction solar cells, which are the highest efficiency solar cells currently available,” according to the USGS.

These solar arrays, which have three layers of cells that use germanium and other critical metals, are much more expensive to build than the typical photovoltaic cell that primarily uses silicon to convert light into electricity.

The high-efficiency of the germanium infused solar cells make them preferred for space applications such as the Mars rovers.

“The solar cells are stacked in three layers on the rover’s solar arrays and, because they absorb more sunlight, can supply more power to the rover’s re-chargeable lithium batteries,” NASA Jet Propulsion Laboratory explains on technologies to power space missions.

USGS said recent research could make similar high-efficiency solar arrays commercially viable on Earth, a potential driver for future germanium demand.

“Solar powerplants that use concentrator technology composed of lenses or mirrors that focus high concentrations of direct sunlight onto germanium-based multijunction solar cells have emerged as viable sources for large-scale renewable energy generation,” the geological survey wrote.

Red Dog germanium

Due to being a byproduct metal that is credited to the refinery extracting the germanium from the zinc and lead concentrates, it is hard to pinpoint exactly how much germanium is produced at Red Dog each year.



The Red Dog Mine in Northwest Alaska produces a globally significant quantity of germanium as a byproduct to the zinc and lead produced there.

SHANE LASHLEY

Indicators are, however, that Red Dog's germanium production are significant in relation to the global market of this critical mineral.

Teck Resources Ltd. – which operates Red Dog and owns Trail Operations in southern British Columbia where zinc and lead concentrates from the Northwest Alaska mine are refined – is one of the world's largest integrated germanium producers.

The Trail refinery offers a wide variety of high-quality germanium products, including germanium dioxide and fiber optic grade germanium tetrachloride.

While Red Dog is not Trail's only supplier, USGS said the majority of the germanium the refinery produces likely comes from there.

“Most of the germanium produced at metallurgical facilities at Trail, British Columbia, Canada, likely comes from sphalerite concentrates from the Red Dog district,” the geological survey wrote.

While the quantity of germanium produced at Trail is guarded, it is considered globally significant.

A partial force majeure – unforeseeable circumstances that prevent someone from fulfilling a contract – on germanium output from Trail early in 2018 pushed germanium prices up 31 percent,

from US\$1,757/kg in January to US\$2,300/kg in March.

Repairs to the damaged facilities at Trail were expected by the end of 2018, which allows the refinery to resume germanium production.

The critical mineral has maintained a price of around US\$2,200/kg into 2019.

Teck announced plans in 2018 to extend the life of the Red Dog Mine out to at least 2031, based on the 57.6 million metric tons of reserves averaging 13.6 percent (13.9 billion pounds) zinc, 3.9 percent (2.5 billion lb) lead and an undisclosed amount of germanium in the deposits currently being mined.

Aktigirug, a large and high-grade zinc target roughly five miles northwest of the current operations, could extend the life of Red Dog 25 to 50 years deeper into the 21st Century.

Part of the same group of sphalerite-rich sedimentary exhalative (SEDEX) deposits that is currently being mined at Red Dog, Aktigirug likely means Alaska will be a global germanium source for decades to come.

Germanium at Bornite

While zinc deposits are the primary source for germanium and Red Dog is among the richest such stores on Earth, carbonate hosted copper deposits also sometimes have a germanium component to them and there is one such deposit in Alaska that could be a source of this critical metal in the not too distant future.

Although germanium is known to be found in carbonate hosted zinc-lead deposits, not a lot is understood about potential associations with this style of deposit carrying mostly copper. The critical metal, however, has a known affinity for chalcopyrite, a copper mineral, which raises the possibility that a large carbonate hosted copper deposit, such as the Bornite deposit at Trilogy Metals Inc's Upper Kobuk Mineral Projects in Northwest Alaska, could be a future germanium source.

With 6.4 billion lb of high-grade copper, Bornite has long been as a world-class deposit of this energy metal. Now this carbonate-hosted deposit is being investigated for its critical metals potential.

Roughly 77 million lb of cobalt has already been identified at Bornite and the deposit is known to also carry germanium and gallium.

To find out more about the distribution of these critical minerals and to investigate the deposit's potential for rhenium, Trilogy Metals has entered into a technical assistance agreement with USGS.

The work carried out under this study is providing Trilogy a better understanding of the potential of recovery critical minerals as a by product of mining the billion of pounds of copper at Bornite and is providing USGS information it can apply to other deposits in Alaska as it continues to seek potential domestic sources of the metals considered critical to the United States.



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With a natural ability to adhere to glass and silvery appearance, indium is used in energy saving coatings on architectural glass commonly seen on high-rise buildings.

JOHANNES PLENIÖ

Indium – the everyday metal you never see

Virtually all flat-panel displays, touchscreens have indium coating

By **SHANE LASLEY**

Mining News

IF YOU ARE READING THIS ARTICLE ON YOUR COMPUTER, tablet or phone, you are almost certainly looking through indium as we speak; and, if that device happens to be a touchscreen you have the unique properties of this critical mineral to thank as you scroll down to read more about indium and where it can be found in Alaska.

This is because indium-tin oxide is used as a transparent conducting film applied to virtually every flat-panel display and touchscreen on the market. This thin coating transforms incoming electrical data into an optical form.

When it comes to the combination of characteristics required for this widely used application – transparency; electrical conductivity; strong adherence to glass; corrosion resistance; and chemical and mechanical stability – indium-tin oxide has no equal.

This irreplaceability to devices used by virtually all Americans and every major sector of the economy is why indium is on the U.S. Geological Survey's list of 35 critical minerals.

"Indium can be considered a critical material for display technology because there are few substitutes," the USGS penned in a 2017 report on critical minerals.

This criticality is compounded by the fact that the U.S imports all of its indium from other countries. There are, however, a few places in Alaska that could provide a domestic source of this touchscreen metal.

More than a glassy metal

Flat-panel displays and touchscreens account for roughly 65 percent of indium consumed globally. While each of these devices only need a small amount of indium-tin oxide, the massive quantity of televisions, computer screens, tablets, smartphones and numerous other devices with liquid crystal displays adds up to a lot of this metal.

In addition to the strong adherence to glass that contributes to indium's use on electronic displays, this silvery metal is highly reflective, making it an ideal ingredient for an energy saving coating on architectural glass most commonly seen on high-rise buildings.

Another attribute that makes indium useful is the metal's low melting point, which makes it a good candidate for several other alloying applications.

"Alloys and solders are the second-ranked end use of indium globally (9 percent). Indium-containing solders have lower crack propagation and improved resistance to thermal fatigue compared with tin-lead solders," according to the USGS.

Interestingly, indium solders can be used to bond certain non-metallic materials such as glass glazed ceramics, and quartz.

A gallium-indium-tin alloy called galinstan is a liquid at room temperature, which can be substituted for mercury in certain applications. Other indium alloys with slightly higher melting temperatures are used to turn on fire sprinkler systems when heated by the blaze.

Semiconductors make up roughly another 9 percent of indium's global use, primarily in laser and light-emitting diodes (LEDs).

While sometimes used in LED displays, indium containing LEDs are primarily used for optical data transmission. Likewise, indium-based laser diodes are used for fiber-optic communications.

The United States consumed roughly 170 metric tons (170,000 kilograms) of indium in 2018. All of this metal is supplied from other countries. China (27 percent); Canada (22 percent); Republic of Korea (11 percent) and Taiwan (10 percent) were the major sources for these indium imports. Indium averaged US\$310 per kilogram during 2018 and was selling for around US\$385/kg in March.

Red Dog byproduct?

Like its sister metal germanium, indium is primarily produced as a byproduct from zinc mining. As a result, indium production is often credited to the refinery that extracts the metal from concentrates, which makes the mine source sometimes difficult to track down.

There are good indicators, however, that Teck Resources Ltd.'s Red Dog Mine in Northwest Alaska is the source of at least some of the indium the U.S. imports from Canada.

While most zinc smelters are not equipped to recover indium, Teck's Trail Operations in southern British Columbia is.

"Indium is produced as a co-product of the zinc smelting process at our integrated refinery in Trail," according to the Teck website. "We have expanded our production capability to meet the growing demands of indium-tin-oxide manufacturers."

Teck Resource CEO Don Lindsay has previously noted that Trail could easily deliver 75 metric tons of indium annually.

Much of the refinery's zinc concentrates come from Red Dog, though it is unclear if this contributes to Trail indium output.

Scattered across Alaska

In addition to the zinc-rich sedimentary exhalative deposits (SEDEX) deposits in the Red Dog region, a number of places around Alaska that could provide future supplies of indium.

One place critical mineral explorers should look for indium is in tin-bearing "specialized granites" and these rocks are found all across Alaska.

The Lost River and Kougarok tin regions on the Seward Peninsula in far western Alaska is an area particularly rich in these granites.

Using a geospatial tool developed in cooperation with Alaska Division of Geological & Geophysical Surveys, USGS identified at least nine other areas to search for tin deposits that may have indium associated with them.

"In addition to the known tin province in the Lost River-Kougarok belt of intrusive rocks on the Seward Peninsula, areas that have high potential for tin-tungsten-molybdenum-tantalum-indium-fluorspar deposits associated with 'specialized' granites also are widely scattered across Alaska," USGS and DGGs penned in a 2016 Alaska critical minerals report.

For more information on these deposits, see "Tin - Alaska's gateway critical mineral" in this magazine.

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Constantine Metal Vice President of Exploration Darwin Green examines an outcrop of barite-sulfide boulders rich in zinc and copper at Mount Henry Clay, one of numerous volcanogenic massive sulfide prospects on the company's Palmer property near Haines, Alaska.

CONSTANTINE METAL RESOURCES LTD.

Barite weighs in on critical minerals list

SE Alaska deposit contains some 3.8M tons of weighty mineral

By SHANE LASLEY

Mining News

WHILE NOT THE FLASHIEST OF THE 35 MINERALS on the United States Geological Survey's critical list, barite plays an essential role in America's energy sector.

Barite derives its name from *barús*, the Ancient Greek word for heavy, owing to an exceptionally high specific gravity for a non-metallic mineral. It is this weight that makes barite a key element to the oil and gas sector and lands the mineral on USGS' critical list.

"More than 90 percent of the barite sold in the United States was used as a weighting agent in fluids used in the drilling of oil and natural gas wells," USGS penned in its annual report, Mineral Commodity Summaries 2018.

Added to drill mud, barite lubricates the bit and drill stem, removes rock chips, helps maintain the integrity of the drill hole and prevents

oil and natural gas wells from blowing out when over-pressured reservoirs are tapped. Examples of what happens when these pressured basins are drilled into without barite can be seen in historical photographs showing geysers of oil spewing from new wells drilled in the early 20th Century.

"Barite has an unusual combination of properties – high density, softness, and chemical inertness – that make it exceptionally well suited for this purpose," USGS penned in a 2018 report on the minerals it deems critical to the United States.

Barite also lends its weight to heavy cement used as a jacket around underwater pipelines that transport oil and gas from offshore production, adding an extra layer of protection and prevents the pipes from floating.

While the U.S. Geological Survey withheld information on domestic barite production in 2018, it is estimated that about 86 percent of the roughly 3 million metric tons of barite used in the United States last



Core from a 4.8-meter section of a hole drilled in the AG zone at Constantine Metal's Palmer project that averaged 76.7 percent barite, 3.59 percent zinc, 1.61 percent lead, 435.9 g/t silver and 1.25 g/t gold.

year was imported.

Constantine Metal Resources Ltd. would like to shift this balance by producing a high-quality barite at Palmer, an advanced staged exploration project in Southeast Alaska that is better known for the zinc, copper, silver and gold also found there.

China weighs heavy

China, which currently produces more than a third of the world's supply of barite, supplied roughly 63 percent of this critical mineral shipped to the United States during 2018. The balance was supplied from India, Mexico and Morocco.

"Global dependence on a limited number of countries for specific mineral commodities could lead to sudden supply disruptions for the United States, and barite is one such commodity," USGS penned in a 2014 report on this mineral.

While America's petroleum industry would be hit hardest by such a supply disruption, barite also is used in products such as paints, plastics, rubber and even playing cards.

Taking advantage of the high specific gravity that makes barite ideal for drilling mud, some card makers mix this mineral in the paper they use. This makes the cards heavier and therefore easier to deal around the table.

The mineral also lends its weight to mudflaps, which helps to keep them from "sailing" when the trucks and other vehicles they are mounted to are traveling down the highway.

Other uses of barite by the auto industry is in brake and clutch pads, and as a metal protectant in paint primer.

While most of barite's industrial uses take advantage of its weight, its ability to significantly blocks x-ray and gamma-ray emissions adds another layer of uses for this critical mineral.

Taking advantage of this radiation blocking characteristic, it is used as aggregate in high-density concrete for shielding around x-ray units

in hospitals, nuclear powerplants, and university nuclear research facilities.

This ability to block x-ray emissions is also used as a medical diagnostic tool.

When a patient drinks a thick liquid containing ultrapure barite, barium, the barite coated digestive tract shows up on x-ray. This provides physicians with the ability to "see" soft tissues that otherwise would not show up on this type of imaging.

Quality barite in SE Alaska

Like many of the other minerals critical to the United States, barite was previously mined in Alaska. This production came from Castle Island near the town of Petersburg on the Southeast Panhandle.

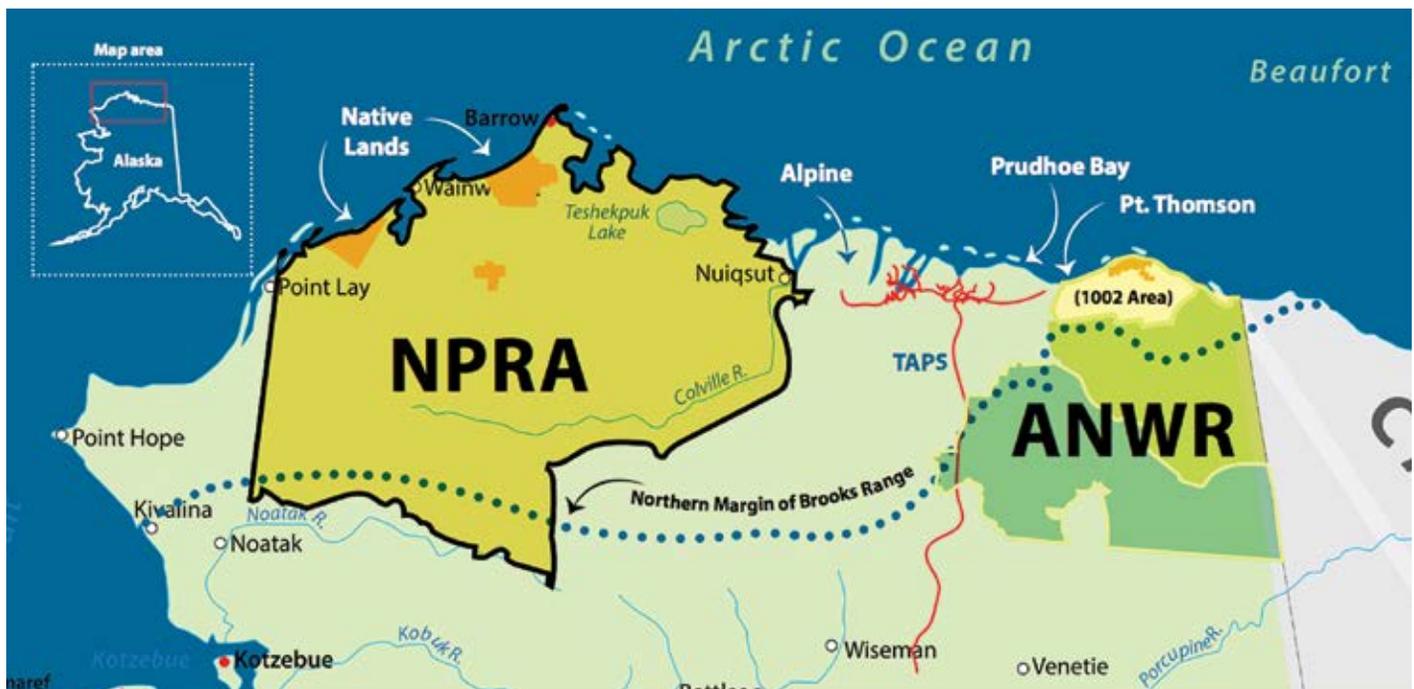
Three companies – Alaska Barite Co., Inlet Oil and Chromalloy America – produced roughly 750,000 metric tons of barite from Castle Island from 1966 to 1980.

While very little reserves of barite are known to remain on Castle Island, some 3.8 million metric tons of this critical mineral has been outlined so far at the Palmer project further north on the panhandle.

Being advanced by a joint venture between Constantine Metal Resources (51 percent) and Dowa Metals & Mining Co. Ltd. (49 percent), the Palmer project is better known for the base and precious metals also found there.

According to a resource calculated in 2018, the South Wall-RW deposit at Palmer hosts 4.68 million metric tons of indicated resource averaging 5.23 percent (539 million lb) zinc, 1.49 percent (154 million lb) copper, 30.8 g/t (4.2 million oz) silver, 0.3 g/t (40,900 oz) gold and 23.9 percent (1.12 million metric tons) barite; plus 5.34 million metric tons of inferred resources averaging 5.2 percent (612 million lb) zinc, 0.96 percent (113 million lb) copper, 29.2 g/t (4.5 million oz) silver, 0.28 g/t (43,600 oz) gold and 22 percent (1.17 million metric tons) barite.

AG Zone, located about 3,000 meters southwest of South Wall-RW,



About 35 miles north of Noatak, the barite-rich mineralization in the Red Dog District is near the southwest corner of the National Petroleum Reserve – Alaska.

hosts another 4.26 million metric tons of inferred resource averaging 4.64 percent (435 million pounds) zinc, 0.12 percent (11 million lb) copper, 0.96 percent (90 million lb) lead, 119.5 grams per metric ton (16.4 million ounces) silver, 0.53 g/t (72,500 oz) gold, and 34.8 percent (1.48 million metric tons) barite.

“Barite constitutes about a quarter of the rock mass of the defined mineralized zones and ... has the potential to materially enhance the value of the already high-value mineralization,” said Constantine President and CEO Garfield MacVeigh.

Wanting to find out whether the barite could be economically recovered in a product that would be useful to the oil and gas sector, Constantine initiated a metallurgical program focused on Palmer’s barite earlier this year.

This work demonstrates that 91.1 percent of the barite at Palmer can be recovered in a clean high-grade concentrate with a specific gravity of 4.44.

The specific gravity is important for barite that would be used as a weighting agent in drill mud.

American Petroleum Institute, a trade association that establishes and maintains standards for the global oil and gas sector, prefers a 4.2 specific gravity for barite used in oil and gas drilling. Due to few deposits in the United States able to produce this heavy barite, API lowered this minimum specific gravity requirement for barite to 4.1 in 2010.

Contaminants in barite can cause problems while drilling, especially abrasive particles that can ruin bits.

In addition to a specific gravity well above requirements, Constantine reports that the testing shows that a barite concentrate from Palmer meets all API and U.S. Environmental Protection Agency specifications for oilfield drilling grade barite, including particle size and purity, and appears to be a market-ready product.

“These results confirm that a premium-quality barite concentrate can be produced from the copper-zinc ores at Palmer, and that it can be achieved by the addition of simple steps to mineral processing,” said MacVeigh.

Barite market analysis

With the metallurgical results showing quality barite can be recovered from Palmer, Constantine has commissioned experts in the market to assess wholesale barite prices for different North American oil basin markets.

Preliminary estimates completed in 2018 identified a range from US\$170 per short ton to US\$225 per short ton.

According to the USGS, barite averaged US\$180 per ton during 2018.

The market analysis being done for Constantine will also include an analysis of transportation options and cost to access the most likely of these markets.

Palmer’s proximity to the Pacific Rim deep-water port at Haines, is expected to have a significant competitive advantage to delivering barite in North America.

“The project’s excellent location, 60 kilometers (37 miles) by road from deep tidewater facilities enables low-cost shipping to markets,” MacVeigh said.

Alaska, with its oil and gas fields on the North Slope and in Cook Inlet, would be a good market for Palmer barite.

On top of its locational advantage, the barite at Palmer would also benefit from being produced as a co-product of the copper, zinc, lead and precious metals also found there.

Much of the barite found in the deposit would be extracted with the ore at a future Palmer Mine and then need to be stored as either waste rock or tailings. By adding the extra step of producing a saleable barite product, Constantine and Dowda could get paid for this critical mineral that is already being handled.

“This may have very positive implications with the potential to both enrich gross metal value per tonne (metric ton) and provide significant environmental and operational benefits by reducing waste,” said MacVeigh.

Barite-rich Red Dog district

While Palmer is the most advanced, and likely most economically viable source of barite in Alaska, there are other metal-rich deposits in

the state that host intriguing quantities of this critical drill mud mineral.

In fact, the Red Dog district in Northwest Alaska, best known for its fantastically high-grade deposits of zinc, is believed to host well above 1 billion metric tons of barite.

Teck Resources Ltd. produced roughly 1.19 billion pounds zinc and 254.4 million lb of lead at Red Dog last year from high-grade deposits on lands owned by NANA Region Corporation Inc.

While the deposits currently being mined contain some barite, the mass quantities of this critical mineral are associated with the next generation of Red Dog deposits about five miles to the north.

Anarraaq consists of a barite body, estimated to be as much as 1 billion metric tons, and an 18 metric ton zone of massive sulfide with 19.4 million metric tons of inferred resource averaging 14.42 percent zinc and 4.2 percent lead.

The much bigger deposit in this barite-rich area, however, is Aktigiruaq.

While an NI 43-101-compliant resource estimate has yet to be reported for this deposit, the widely spaced holes drilled prior to 2017 suggest this exploration target has somewhere between 80 million and 150 million metric tons of material averaging around 13 percent zinc and 4 percent lead.

Though the seasonality of the Arctic port that currently delivers zinc and lead concentrates from Red Dog would currently restrict shipments of barite from the district, this regions proximity to the west end of Alaska's oil-rich North Slope provides interesting market potential for the massive deposits of barite found in this minerals-rich corner of Northwest Alaska.

In fact, the southwest corner of the National Petroleum Reserve-Alaska, a 23.6-million-acre oil-rich region of the North Slope is only



Constantine Metal Resources President and CEO Garfield MacVeigh beside a large barite-rich boulder at the Mount Henry Clay prospect at Palmer.

about 30 miles northeast of Red Dog.

Late in 2017, the USGS estimated that NPRA, along with adjacent state and tribal lands and waters, hosts roughly 8.7 billion barrels of oil and 25 trillion cubic feet of natural gas.

Exploration and development of this massive domestic energy resource would require a lot of barite, a critical mineral that could be supplied by Palmer, Red Dog or imported from overseas sources.

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Benchmark Minerals Intelligence estimates that the amount of graphite needed for the anode material in lithium-ion batteries, such as those in Tesla's vehicles and Powerwall, will increase by nine-fold over the next decade.

TESLA INC.

EV batteries to drive 9x graphite growth

Will Alaska be future US source of vital battery ingredient?

By SHANE LASLEY

Mining News

AT LEAST 125 MILLION ELECTRIC VEHICLES are expected to be traveling global highways by 2030, which means the world is going to need a lot more graphite in the coming decade and beyond.

This is because graphite serves as the anode in the lithium-ion batteries that power these EVs, not to mention the growing number of portable tools and electronics that use the same type of battery.

According to Mineral Commodity Summaries 2019, an annual report published by the United States Geological Survey, there are currently no graphite mines in the United States, a dearth that required domestic manufacturers to import mined graphite for roughly 40,000 metric tons of the carboniferous material used in the U.S. during 2018.

China was the largest supplier of this graphite, followed by Mexico, Canada and Brazil.

This dependence on foreign suppliers and rocketing demand are the key reasons USGS includes graphite on its list of 35 minerals and metals considered critical to the United States.

USGS sees a major spike in U.S. demand for graphite when Tesla Motor's Gigafactory, an enormous lithium-ion battery facility being constructed in Nevada, is fully operational.

The Gigafactory, partially complete, is producing the batteries going into the cars coming off Tesla's assembly-line.

Once complete, this 10-million-square-foot plant in Nevada is expected to be able to manufacture enough batteries for roughly half a million Tesla's per year.

This plant alone will need around 35,200 tons of spherical graphite per year, a special form of graphite that is manufactured for batteries.

The spherical shape allows the graphite to be more efficiently packed into battery cells, while the coating extends the graphite's lifetime capacity.

It is expected to take about 2.9 tons of average flake graphite to make 1 ton of spherical graphite.

Graphite One Inc. has plans to provide an American source of spherical graphite from Graphite Creek, an enormous deposit in western Alaska with unique characteristics that makes it well suited for lithium-ion batteries.

"Our goal for Graphite One is to become a reliable producer of high-quality graphite for the rapidly evolving energy and high-tech sectors," said Graphite One CEO Anthony Huston.

Holding the power

With the growing number of EVs expected to drive lithium-ion battery demand, Benchmark Mineral Intelligence Managing Director Simon Moores told U.S. legislators that America is not doing enough to secure reliable sources of graphite and other materials that go into these cells.

"We are in the midst of a global battery arms race in which the U.S. is presently a bystander," the global battery materials authority inked in a testimony to the U.S. Senate Energy and Natural Resources Committee.

Benchmark estimates that the amount of graphite needed for the anode material in lithium-ion batteries will rocket to 1.75 million metric tons by 2028, a nine-fold increase over 2017 levels.

The battery analysts said China supplied 56 percent of the world's flake graphite supply – the mined feedstock that is used to manufacture lithium-ion battery anodes – and 100 percent of the world's uncoated spherical graphite supply during 2017.

Moores' primary message to Washington D.C. lawmakers is the U.S. cannot afford to stand on the sidelines when it comes to lithium-ion batteries, and the graphite, lithium, cobalt and nickel that goes into them.

"Those who control these critical raw materials and those who possess the manufacturing and processing know-how, will hold the balance of industrial power in the 21st Century auto and energy storage industries," he wrote.

STAX advantage

Graphite One hopes to leverage its



GRAPHITE ONE INC.

Graphite Creek hosts an enormous deposit of graphite well suited for lithium-ion battery applications.

enormous deposits of graphite in western Alaska to provide the U.S. a domestic source of the lithium-ion battery anode material.

While the Vancouver B.C.-based graphite exploration and development company has only systematically drilled a small section of the near-surface mineralization at this vast western Alaska graphite project, it has outlined a deposit that could provide a healthy domestic supply of this critical battery ingredient for decades.

Located about 35 miles north of Nome, the Graphite Creek deposit hosts roughly 5.7 million metric tons of graphite in resources, mostly inferred.

While globally significant, this deposit only considers a small fraction of the thick lenses of graphite surfacing along a 11-mile-long stretch of the Kigluaik Mountains on Graphite One's property.

In addition to size, the graphitic carbon at Graphite Creek has unique characteristics that make it ideally suited for being refined into the coated spherical graphite that lithium-ion battery manufacturers are looking for.

TRU Group Inc. – a technology metals consultant with expertise along the entire graphite-graphene supply chain – identified characteristics of the Graphite Creek deposit that may make the material a good fit for many of the high-tech and green energy sectors that are driving a large part of the growing market for graphite.

The graphite specializing consultant

postulated that these distinctive characteristics could lend to different specialized applications with minimal processing.

Graphite One has coined the acronym STAX to describe these unique and naturally occurring properties.

Tests carried out by TRU found that more than 74 percent of the STAX flake graphite could be turned into spherical graphite without milling.

This is a monumental achievement considering that only about 40 percent of the best-performing flake graphite found in any other known deposit can be converted to spherical graphite, even using high-end equipment.

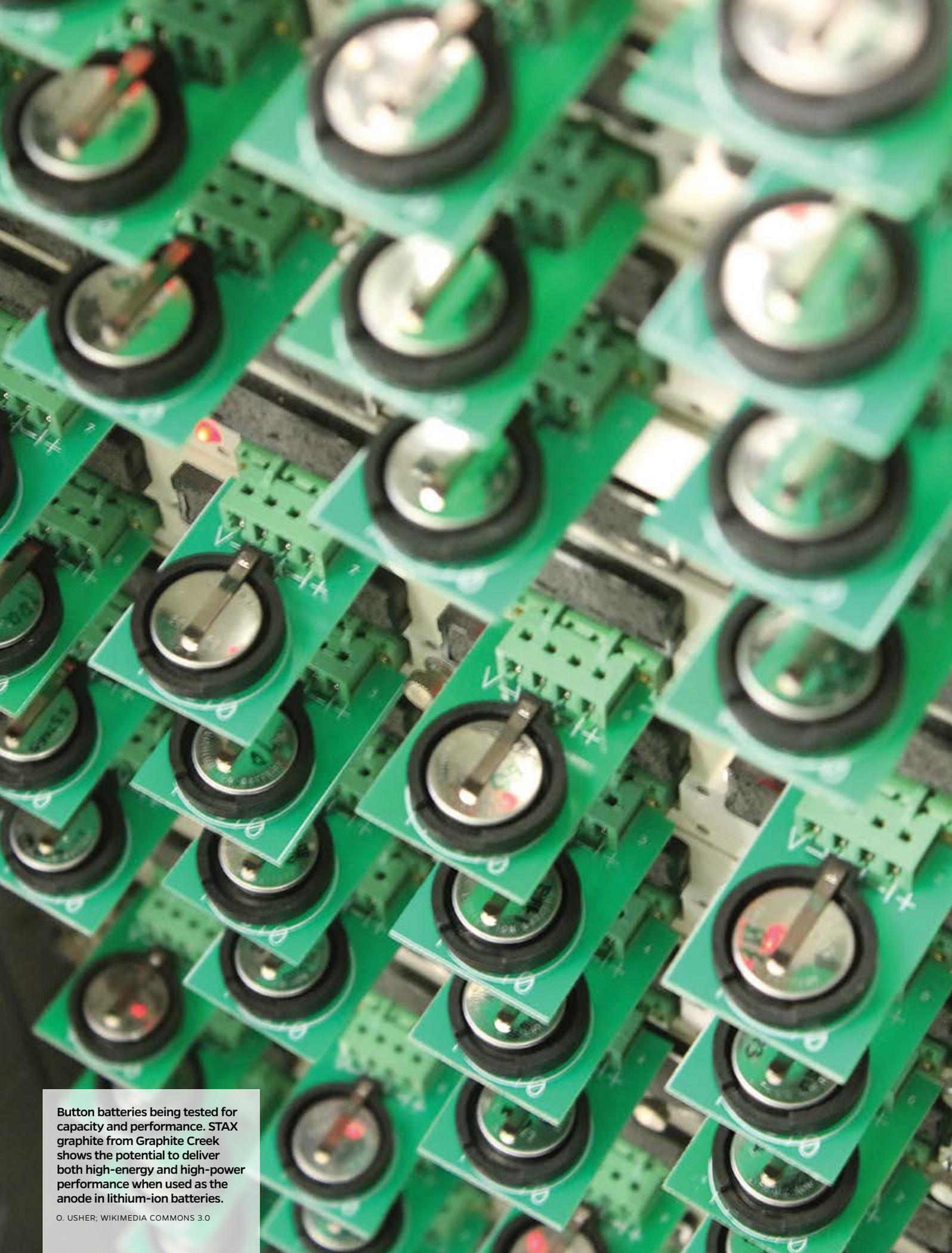
"From the time we identified the unique mineralization of our STAX graphite, we've observed a number of potential performance advantages," said Huston.

Domestic graphite producer

Establishing that the Graphite Creek deposit has both the size and graphite characteristics to be a domestic source of graphite for lithium-ion battery anodes, Graphite One completed a preliminary economic assessment for the project early in 2017.

This PEA outlines plans for a roughly 2,800-metric-ton processing facility at Graphite Creek that would produce 60,000 metric tons of graphite per year.

At the time, the deposit hosted 10.32 million metric tons of indicated resource



Button batteries being tested for capacity and performance. STAX graphite from Graphite Creek shows the potential to deliver both high-energy and high-power performance when used as the anode in lithium-ion batteries.

O. USHER; WIKIMEDIA COMMONS 3.0

containing 744,000 metric tons of graphite; plus 71.24 million metric tons of inferred resource with another 4.97 million metric tons of the graphitic carbon.

A six-hole infill drill program carried out in 2018 has upgraded and expanded these resources.

The best hole of the program cut two layers of graphite – 5.8 meters of 8.06 percent graphite from 27.8 meters and 16.3 meters of 11.93 percent graphite from 44 meters.

Other intercepts from the 2018 drilling include:

- 25.3 meters of 7.76 percent graphite;
- 8.5 meters of 10.81 percent graphite;
- 8.7 meters of 8.05 percent graphite;
- 4.6 meters of 12.27 percent graphite;
- 5.3 meters of 9.32 percent graphite;
- 20.5 meters of 7.71 percent graphite; and
- 1.7 meters of 25.14 percent graphite.

“Graphite Creek continues to show potential to be a significant domestic source of critical materials for electric vehicle batteries, power storage and various other critical and strategic end uses,” said Huston.

With this drilling, Graphite Creek now hosts 10.95 million metric tons of measured and indicated resources averaging 7.8 percent (850,534 metric tons) graphite; plus 91.89 million metric tons of inferred resource averaging 8 percent (7.34 million metric tons) graphite.

This marks the first graphite reporting to the measured category; an 8 percent increase in grade and 14 percent increase in total graphite in the combined measured and indicated resource categories; and a 14 percent increase in grade and 48 percent increase in inferred resources, when compared to the resource calculation used to complete a preliminary economic assessment for the project in 2017.

“This increase in resources demonstrates the potential for a robust, high-grade U.S. graphite project,” said Huston.

Graphite One will use the upgraded resource to advance the Graphite One project towards prefeasibility.

This higher level economic and engineering study will further investigate plans to ship concentrates from Graphite Creek to an advanced material processing facility that would refine them into an expected 41,850 metric tons of coated spherical graphite and 13,500 metric tons of purified graphite powders annually.

Graphite One would prefer to build this processing facility in Alaska but is also looking at locations in Washington, due to the lower cost power in the Pacific Northwest state.

Together, the mine and refinery are known as the Graphite One project.

“This PEA shows the strong potential of our project as America’s emerging producer of lithium-ion battery-grade coated spherical graphite,” said Huston.

“With the prospect of a low-cost, 40-year mine life using half of the identified graphite mineral resources and, given our projected production costs and conservative pricing assumptions, we are confident that Graphite One has the potential to become a reliable provider of graphite materials critical to clean-tech, high-tech and national security applications,” the Graphite One CEO added.

Tapping AIDEA’s expertise

To help with search for a viable Alaska locale to build the advanced graphite processing facility, Graphite One entered into a memoran-



Drilling completed at Graphite Creek during 2018 both upgraded and expanded the Graphite Creek deposit in western Alaska.

dum of understanding with the Alaska Industrial Development and Export Authority.

Alaska candidates for the facility would need to have reasonably priced electricity and adequate supply; industrial zoned land; be close to tidewater and port facilities; and infrastructure that allows easy access for the workers needed to operate the facility.

In a 2018 report, AIDEA identified four Southcentral Alaska locations – Homer, Kenai, Port Mackenzie and Seward – that meet the criteria and “are very interested in discussing this project with Graphite One management.”

The development authority said Alaska has advantages that could outweigh the higher power costs at these sites, compared to sending the concentrates to the Lower 48 for further refinement.

“While Outside locations may provide cheaper power costs, Alaska is a mining and industrial friendly state that supports the development of value-added activities, and has a regulatory regime that supports responsible development while being less costly than other potential Northwest locations,” AIDEA penned in the preliminary report.

Producing a significant portion of the coated spherical graphite needed for America’s growing lithium-ion battery sector from Alaska mined ore would make the Far North state a domestic hub for this increasingly important critical mineral.

“Tapping AIDEA’s expertise in helping us assess potential refinery sites is the first step towards making Alaska a key player in the clean-tech energy sector,” said Huston. “The AIDEA report confirms the considerable interest Alaska localities have in serving as a base for our advanced-material spherical graphite refinery.”



Titanium's superior strength-to-weight ratio, corrosion resistance and ability to withstand extreme heat makes this metal an important ingredient in a wide variety of parts for both military and civilian aircraft.

PIXABAY

Titanium – the lighter, whiter metal

From F-35 fighters to milk; a critical mineral we use every day

By **SHANE LASLEY**

Mining News

TITANIUM CONJURES IMAGES OF THE DURABLE and lightweight metal used to build aircraft, replacement hips, high-end bicycle frames and even quality golf clubs. While its outstanding weight-to-strength ratio and corrosion resistance makes this critical metal ideal for these applications, roughly 93 percent of the world's titanium is used to impart a stark whiteness to many of the consumer goods we use every day.

"Titanium is different than most other metallic elements in that it is mined primarily to satisfy demands for a chemical product – titanium dioxide for pigment – rather than for the metal itself," the United States Geological Survey penned in a 2017 report on titanium.

Unlike many of the other 35 minerals and metals considered critical to the United States, no appreciable amounts of titanium have been mined in Alaska. There are, however, several places across the Far

North state to look for this essential household and aerospace metal.

Whiter whites

Titanium dioxide has three qualities that make it an ideal material for creating whiter whites in a surprisingly wide variety of products we use today – it is white, it is safe for human consumption and it has a very high refractive index, which means it scatters light extremely well.

"Titanium dioxide has properties of whiteness, opacity, and chemical inertness that make it especially suitable for use as pigment to impart a durable white color to paints, paper, plastic, sunscreen, toothpaste, and wallboard," the USGS inked in its titanium report.

Around 69 percent of the roughly 920,000 tons of titanium dioxide used in the United States in 2018 was added to paint. In fact, most high-quality white paints you buy in the hardware store today contain "titanium white" a pigment made from this highly reflective, white material.



Skim milk is among the surprisingly wide array of products we use every day that take advantage of titanium dioxide's opacity and whitening properties.

In addition to imparting a reflectiveness and whiteness that makes rooms appear brighter, titanium dioxide increases paint's opacity, which assists in the "one-coat cover" touted by many paint manufacturers.

There are very few replacements for titanium dioxide when it comes to pigments. Lead, which was the ingredient of choice for white paint for nearly 2,000 years, has similar whitening qualities but is seldom used in paints today because of its toxicity.

Beyond being safe enough to whiten paint, titanium dioxide is used in many of the products we put on our skin and consume – even dairy products.

Taking advantage of some of the qualities this material lends to paint, titanium dioxide is used to increase the opacity and whiteness of skim milk and cottage cheese.

Cosmetics, sunscreens, toothpaste and many other food products take advantage of the inert whitening, reflecting and opaque qualities titanium dioxide has to offer.

Because it is used in such a wide variety of products, the vast majority of us consume or use a product containing titanium dioxide every day.

Lighter, stronger metal

While we typically don't think about titanium dioxide in our toothpaste or milk, many of us are much more familiar with the bicycle frames, golf clubs, tennis rackets and goalie masks that take advantage of the lightweight strength titanium metal lends to

high-performance sporting gear.

Medical implants, such as hip and knee replacements, also take advantage of titanium metal's superior strength-to-weight ratio, corrosion resistance and inertness that allows the element to be added to milk.

The aerospace industry, however, is by far the largest consumer of titanium metal.

"As the number one customer for titanium, the aerospace industry and the titanium industry are directly linked to each other economically," according to TMS Titanium, a leading supplier and distributor of titanium mill products in the United States.

When it comes to aircraft performance, the lighter the better.

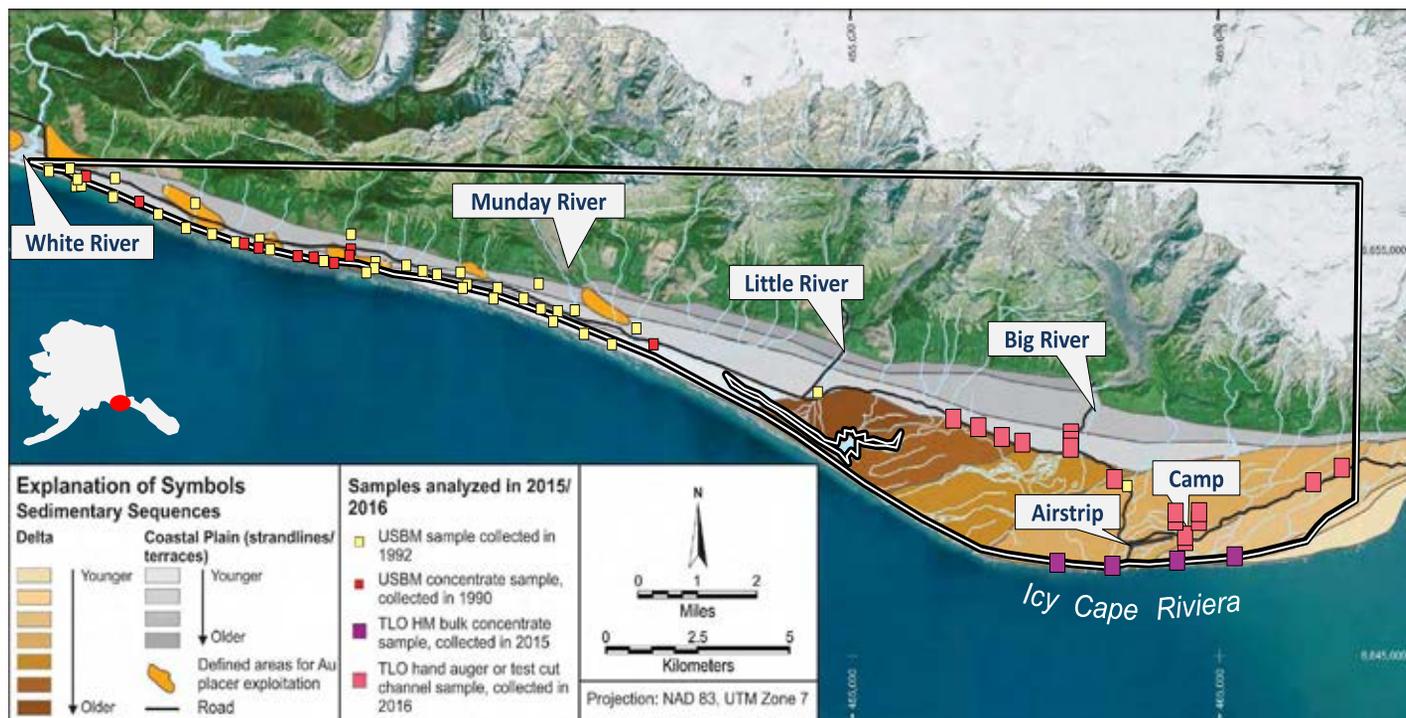
While aluminum is about 60 percent lighter than titanium, it is only about half as strong, corrodes much easier and does not hold up to heat as well. Since it is important not to break- or melt-down at 20,000 feet, titanium is the metal of choice for many aircraft parts.

"Titanium metal's combination of corrosion resistance, excellent weight-to-strength ratio, and very high melting point is not found with other metals," the USGS penned in its titanium report.

For these reasons, the geological survey said there are no completely satisfactory substitutes for titanium.

In addition to being lightweight and strong on its own, titanium alloys with aluminum, iron, nickel, molybdenum, vanadium and other metals – which makes it ideal for a wide array of aircraft parts and military equipment.

The airframes, landing gear and fasteners used in many commer-



Icy Cape Gold and Industrial Heavy Minerals project

cial and military aircraft today are made from titanium or a titanium alloy.

The ability to withstand temperatures from subzero to above 1,100 degrees Fahrenheit, also makes titanium an increasingly useful metal for jet engine parts.

According to the USGS, an estimated 80 percent of titanium metal consumed in the U.S. during 2018 was used in aerospace applications; the balance was used in armor, chemical processing, marine hardware, medical implants, power generation, and consumer and other applications.

“Countries that have considerably large military budgets, like the United States, have a high demand for titanium and consider the availability of titanium a matter of national security,” said TMS Titanium.

Widely dispersed

While titanium is the ninth most abundant element in the Earth’s crust, for the most part it is too widely dispersed to be economically mined. There are a few titanium minerals, however, that contain higher concentrations of this element. About 90 percent of the world’s titanium is found in one such mineral, ilmenite, made up of iron and titanium oxide.

About 100,000 tons of titanium mineral concentrates were produced in the United States during 2018. This production came from mining and tailings in Florida and Georgia.

The remaining 1.1 million tons of titanium mineral concentrates used to make titanium dioxide pigment, welding rod coatings and titanium metal in the U.S. came from overseas sources.

South Africa (35 percent), Australia (27 percent), Canada (12 percent) and Mozambique (11 percent) were America’s principle suppliers of titanium concentrates.

This heavy reliance on imports, coupled with the broad applications – from toothpaste to stealth fighters – are the reasons titanium ranks among the 35 minerals the USGS currently considers critical to the economy and security of the United States.

The sparse quantities of titanium mined in the United States, however, belies the amount of resource found here.

Rich deposits of this critical mineral are found along the East Coast of the United States, a region known as the eastern North America titanium province. The deposits in this province extend from New York to the Gulf of Mexico, with the bulk of the resource in this highly populated region found in heavy-mineral concentrations in beach, bar, dune, and stream sands along the Atlantic and Gulf.

In total, about 111.9 million metric tons of titanium dioxide has been identified in 20 U.S. states.

Gulf of Alaska beach sands

Alaska is not among the 20 states that report a titanium resource but that could soon change. This is because Alaska Metal Health Trust, which was granted 1 million acres of land to earn money to provide mental health care in the state, is exploring titanium enriched beach sands along the Gulf of Alaska coast.

Located about 75 miles northwest of Yakutat, this expansive potential source of titanium and other minerals and metals is known as the Icy Cape Gold and Industrial Heavy Minerals project.

The mineral-rich beach sands found at Icy Cape were first discovered in 1899. At the time, though, the main interest was gold. Up until World War II, small hand operations along this stretch of beach, previously known as the Yakataga district, produced around 15,000 ounces of gold.

The iron and titanium oxide potential of these beach sands were first sampled by the U.S. Bureau of Mines in 1962.

The best of these samples contained 7.3 pounds of titanium per ton. Most, however, were less than two lb/t titanium.

In 1995, the Bureau of Mines revisited the beach sands. This work found the Yakataga beach sands contained ilmenite and rutile, both titanium minerals; and zircon, a mineral made up of two other elements considered critical to the United States.

“Samples from Cape Yakataga contain an average of 0.57 percent valuable heavy minerals (0.49 percent ilmenite; 0.05 percent rutile;

0.03 percent zircon), with a range of less than 0.1 to 2.9 percent in 68-120 million metric tons of sand,” Jeff Foley, the geologist that led the Bureau of Mines study, inked in a 1995 report.

The Bureau of Mines team estimated that less thoroughly sampled stretches of beach in the Cape Yakataga area contain roughly another 128 million metric tons of titanium enriched beach sands.

Since 2015, the Alaska Mental Health Trust has been systematically exploring this roughly 30-mile-long stretch of mineral sands that parallels the beach at Icy Cape. These programs have included high-resolution aeromagnetic geophysical surveys and drilling.

While a report detailing the results from this work has yet to be published, the Mental Health Trust Lands Office has reported the mineral sands being investigated include garnets and platinum, in addition to the titanium, zircon and gold previously reported. This could provide an economically interesting mix of metals and minerals, three of which are on the current list of 35 minerals the USGS deemed critical to the United States.

The Trust Lands Office said a high-resolution magnetic geophysical survey flown over Icy Cape in 2016 shows magnetic patterns consistent with its geologic and deposit models for the property. They followed this geophysical survey up with roughly 4,000 meters of drilling. While the results from the drilling have yet to be published, Trust Lands Office geologists have told Mining News that they are encouraged by the results.

In addition to investigating the heavy mineral sands on the now Icy Bay property, the Bureau of Mines also sampled the beaches in the immediate area of the town of Yakutat, which is 75 miles to the southeast.

After extensive sampling in 1962 and 1995, the Bureau of Mines calculated that a 14-mile stretch of beach at Yakutat hosts 57 million metric tons of sand averaging 3.4 percent ilmenite, zircon and rutile. This investigation also recognized the gold and platinum metals found in these beach sands but did not do enough analysis on these metals to estimate the concentration.

The federal mining bureau also investigated the Mount Fairweather area, another stretch of beach just southeast of Yakutat. Samples collected from here averaged 2.43 percent ilmenite, 0.01 percent rutile and 0.05 percent zircon.

In total, the Bureau of Mines calculated that Icy Bay, Yakutat and Mount Fairweather host 450 million to 500 million metric tons of sand in modern shoreline deposits containing 0.5 to 3 percent valuable heavy minerals. This estimate does not include the garnets, which are used for abrasives and water filtration, platinum group metals or gold.

Humble titanium discovery

Beaches are not the only place you can find titanium in Alaska. Kemuk, a prospect in Southwest Alaska hosts what could be an enormous lode of this critical metal.

Humble Oil Company originally investigated this property for its iron potential, after identifying an extremely strong magnetic signature over a four-square-mile area there. This anomaly identified a large mafic and ultramafic – igneous rocks rich in magnesium and iron – body buried about 25 to 40 meters below the surface.

Humble drilled 16 holes into this iron- and titanium-rich body, some going as deep as 600 meters.

Based on this initial work, it was estimated that the Kemuk prospect hosted 2.4 billion tons of material averaging 15 to 17 percent iron, along with titanium and silicon.

A beneficiation test in the 1960s indicates the feasibility of producing a concentrate containing 65 percent iron, 2 to 3 percent titanium dioxide, and 2 to 3 percent silicon dioxide.

This project was revisited by Millrock Resources Inc. in 2010. The company, however, was less interested in the titanium and iron than the potentially even larger porphyry copper-deposit might represent.

Core from Humble’s 1950s drilling – now stored at the Alaska Geological Materials Center in Anchorage – provided Millrock geologists with a peek at what lies below the surface at Kemuk.

The Millrock team postulated that Kemuk could be analogous to a similar igneous body lying next to the enormous Pebble porphyry copper-gold-molybdenum project about 100 miles to the east.

Millrock Chief Exploration Officer Phil St. George was the first to recognize the porphyry potential at Pebble and is very familiar with the mineralization found there.

Staking a block of state mining claims covering Kemuk and the surrounding lands, Millrock began investigating the potential of this property it called Humble.

Kinross Gold Corp. funded a 2011 drill program carried out by Millrock to investigate a theory that a Pebble-like deposit lies next to Kemuk. Due to tough drilling conditions, however, this theory was not fully tested.

While it is unclear whether a porphyry copper-gold deposit on the scale of Pebble is hidden near Kemuk, the large body of iron-titanium mineralization already identified there is an indication of Alaska’s latent potential to be a domestic source of titanium and other metals and minerals critical to the United States.

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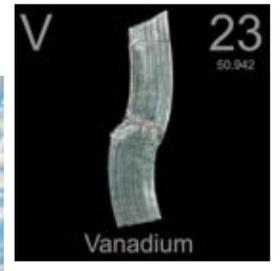
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Vanadium redox-flow batteries show the potential to store large amounts of wind and solar electricity for delivery into power grids, a key to wider implementation of green energy.

PIXABAY

New battery tech revives vanadium interest

Prices double over past year; potential deposit in SE Alaska

By **SHANE LASLEY**

Mining News

THE STRENGTH AND DURABILITY OF STEEL and other alloys is greatly enhanced by adding a small amount of vanadium, currently the primary use of this critical mineral. While this toughness is legendary, the future of vanadium could rest in another set of more subtle traits that could make it the element of choice for large-scale storage of renewable energy generated by wind and solar.

“Vanadium is becoming more widely used in green technology applications, especially in battery technology,” the U.S. Geological Survey penned in a 2018 report on critical minerals and metals.

Due to its importance to both the economic and strategic security of the United States, coupled with the fact that none of this high-strength metal is mined domestically, the alloying properties of vanadium alone would likely be enough to elevate vanadium to critical status.

The USGS estimates that roughly 9,800 metric tons of vanadium was consumed in the United States during 2018, a 13 percent increase over 2017. Approximately 93 percent of this vanadium was used in steel and other alloys.

Vanadium’s potential as a battery metal, however, could be a market disruptor.

This emerging technology, coupled with an expected major increase in Chinese demand of vanadium for alloys, has resulted in soaring prices for this metal.

“Average 2018 vanadium pentoxide prices almost doubled compared with 2017 prices, and ferrovanadium prices more than doubled to \$33 per pound in 2018 compared with 2017,” USGS penned in its annual Mineral Commodities Summaries 2019.

Rising prices, coupled with growing demand from traditional and emerging applications, has prompted mineral exploration companies to identify new sources of this alloy-battery metal.

One such explorer, Northern Cobalt Ltd., has nabbed a large



Adding strength and durability to tool steels is an application vanadium is more widely renowned for.

vanadium-bearing magnetite prospect in Southeast Alaska.

Model T to jet engines

Vanadium first gained its notoriety as steel strengthener in 1908, when Ford Motor Company decided to use vanadium steel to make its Model T more durable.

Inspired by racing cars being developed with it in Europe at the time, Henry Ford had many of the most stressed parts of the Model T – axles, crankshaft, springs and wheel spindles – forged from lighter, more durable and flexible vanadium steel.

These characteristics were used to tout “Ford superiority” in car building at the time.

“Vanadium is used throughout the Model T wherever strength is required,” the iconic carmaker penned in a 1908 promotional flyer, “Watch the Fords go by”.

Today, vanadium continues to be used in commercial and military applications where strength is required.

“The high-strength, low-alloy (HSLA) steels containing vanadium are widely used for the construction of auto parts, buildings, bridges, cranes, pipelines, rail cars, ships, and truck bodies, including armor plating for military vehicles,” the USGS wrote.

In combination with chromium, niobium, manganese, molybdenum, titanium, and tungsten, vanadium also imparts its strength and durability to tool steels.

Many tools found in hardware stores are proudly stamped “chrome vanadium” to signify the quality of the tool.

While other metals could replace ferrovanadium steel alloys, it is

typically not worth the costs and energy required to create steel with the same characteristics.

And, vanadium serves an irreplaceable alloying role in the aerospace industry, according to the USGS. This is because vanadium-titanium alloys have the best strength-to-weight ratio of any engineered material yet discovered.

“Vanadium, when combined with titanium, produces a stronger and more stable alloy, and when combined with aluminum produces a material suitable for jet engines and high-speed airframes,” USGS inked in its critical minerals report. “No acceptable substitutes exist for vanadium in aerospace titanium alloys.”

Batteries could be the future

While alloys currently drive the market for vanadium, emerging battery technologies will likely add to the demand for this critical metal.

One such technology, is vanadium redox-flow batteries (VRBs). These batteries, which use vanadium in solution as both the anode and cathode, could be the answer for storing large amounts of electricity that could be fed into power-grids when the need arises.

“Because of their large-scale storage capacity, development of VRBs could prompt increases in the use of wind, solar, and other renewable, intermittent power sources,” USGS wrote.

Taking advantage of vanadium’s ability to exist in solution in four different oxidation states, the vanadium redox battery uses vanadium in two of these states as electroactive elements, instead of separate elements for the cathode and anode.

The amount of energy a VRB can store is really only limited by the size of the storage tank built to hold the vanadium solutions, which are separated by a proton-exchange membrane.

These batteries can also remain completely uncharged over an extended period without major effects, another advantage that makes them particularly well suited for backup electrical storage.

The disadvantages are that these VRBs store relatively small amount of energy for their size and weight, making them less useful for mobile applications such as electric vehicles.

This does not mean vanadium will not be used to power future cars.

“Lithium-vanadium-phosphate batteries produce high voltages and high energy-to-weight ratios, which make them ideal for use in electric cars,” USGS penned.

In these batteries, the lithium-vanadium phosphate serves as the cathode, and lithium metal serves as the anode.

While still early stage, this adds to the reason mining companies are looking for new supplies of vanadium.

Vanadium on Alaska’s coast

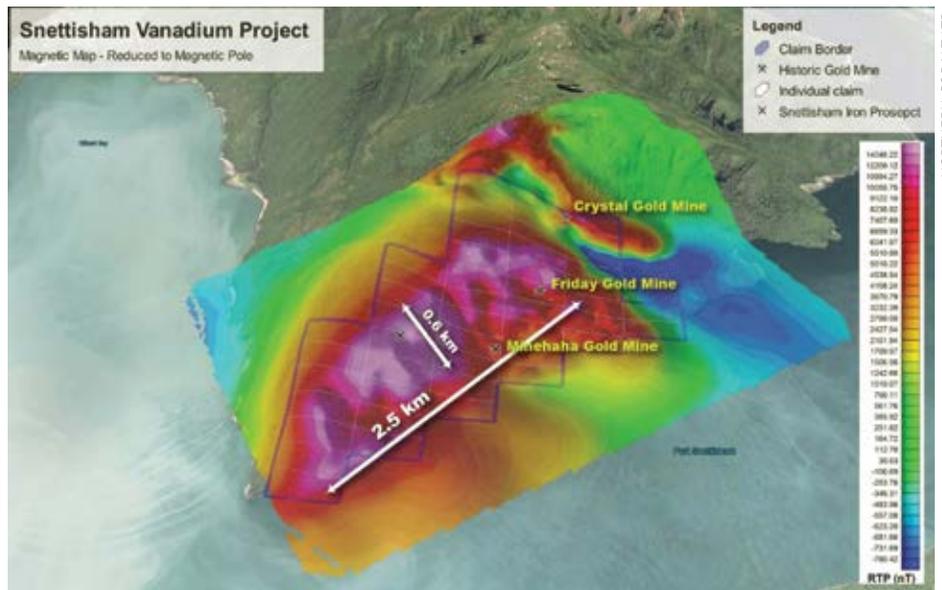
Australia-based Northern Cobalt has identified a potential coastal source of vanadium about 30 miles of Juneau, Alaska’s capital city.

Seeking potential deposits of metals essential to renewable energy led this mineral exploration company to Snettisham, a large outcropping body of magnetite with iron, titanium, vanadium, and possibly platinum-group elements.

This intrusion extends for at least 3,800 meters along the coast of the Snettisham Peninsula and up to 1,500 meters inland.

Historical magnetite-rich rock chip samples from this prospect have returned values as high as 0.34 percent vanadium pentoxide and 5 percent titanium dioxide; and 0.56 percent vanadium pentoxide and 6.5 percent titanium dioxide.

Northern Cobalt said Snettisham enjoys the advantage of being



A recently flown geophysical survey indicates a large body iron-, titanium- and vanadium-rich magnetite at Northern Cobalt’s Snettisham project in Southeast Alaska.

located on the Pacific Rim coast, adjacent to a deep-water channel capable of hosting Panamax and Cape class vessels that could ship iron-, titanium- and vanadium-rich magnetite concentrates to market.

Given that such a large, easily accessible prospect with these grades is open to staking, Northern Cobalt could not pass it up.

The Aussie company staked claims covering the Snettisham occurrence late in 2018 and flew a magnetic survey over the property early in 2019.

“The sheer magnitude of the magnetic anomaly at Snettisham gives Northern Cobalt a good indication of significant concentrations and volume of vanadium bearing magnetite in the intrusion,” Northern Cobalt Managing Director Michael Schwarz said of the initial results from the geophysical survey.

Northern Cobalt plans to use the results to target a drill program this summer.

Hints of vanadium elsewhere

In addition to magnetite deposits like Snettisham and other similar occurrences in Southeast Alaska, vanadium is sometimes found in platinum group metal-bearing mafic intrusive rocks and sandstone-hosted uranium deposits.

A 1990s investigation by the now idled U.S. Bureau of Mines found Wiseman, a road accessible gold mining district about 180 miles northwest of Fairbanks, and Eagle, a region near the state’s eastern border with Yukon, as particularly good areas to look for vanadium.

Data collected during the National Uranium Resource Evaluation, a 1970s federal initiative to identify domestic uranium resources, indicated widespread vanadium anomalies in stream sediments in the Wiseman area and rock samples collected there contained as much as 1 percent vanadium.

In the Eagle area, vanadium associated with uranium and copper was identified at the Road River formation. Samples containing as much as 0.2 percent vanadium, 188 parts per million uranium and 0.14 percent copper were collected during the 1990s investigation by USBM.

Hints of vanadium have also been found at the Death Valley uranium deposit on the Seward Peninsula in western Alaska.

SPOTLIGHT: ZIRCONIUM & HAFNIUM



Zirconium and hafnium are both used for fuel rods in nuclear reactors, though for opposite purposes.

WOLFGANG STEMME, PIXABAY

Zirconium-hafnium – bound beyond nature

Freed from zircon, critical minerals work in same sectors

By **SHANE LASLEY**

Mining News

ZIRCONIUM AND HAFNIUM ARE CLOSELY RELATED

elements that share bonds that tie them together in nature, an affinity that carries over into their industrial applications.

“Zirconium and hafnium are metals that are used in the chemical and nuclear-reactor industries in applications for which corrosion resistance, structural stability at high temperatures, and specific alloying properties and (or) specific neutron-absorption characteristics are required,” the United States Geological Survey wrote in a 2017 publication on critical minerals.

The main ore mineral for both of these corrosion- and heat-resistant metals is zircon, which typically contains about 50 times more zirconium than hafnium.

Most zircon is recovered from heavy mineral sands, which are

marine placer deposits that often contain zircon, titanium, rare earth elements, gold, garnets, gemstones and chromite.

“The main ore deposits worldwide are heavy-mineral sands produced by the weathering and erosion of preexisting rocks and the concentration of zircon and other economically important heavy minerals, such as ilmenite and rutile (for titanium), chromite (for chromium), and monazite (for rare earth elements) in sedimentary systems, particularly in coastal environments,” the USGS wrote.

A long stretch along the northeast coast of the Gulf of Alaska has an abundance of these heavy mineral sands rich in zircon and other critical, precious and industrial minerals and metals.

Hot zircon

With a melting point of 2,550 degrees Celsius (4,622 degrees Fahrenheit), heat resistance is one of the most important applications for zircon, a mineral that contains both zirconium and hafnium.

“Thus, zircon is used for facings on foundry molds, and milled or ground zircon is used in refractory paints for coating the surfaces of molds,” the USGS inked in its critical minerals report. “Zircon bricks and blocks are used in furnaces and hearths for containing molten metals, and glass tank furnaces use fused-cast and bonded alumina-zirconia-silica-based refractory metal.”

This heat resistance, coupled with excellent wear qualities, makes zircon an abrasive of choice for heavy grinding and sanding in metal working shops.

A small amount of zircon is also used to make cubic zirconia, a cubic crystalline form of zirconium dioxide that resembles diamonds.

Beyond glimmering jewelry, zirconia is used in fiber-optic connector components, high-temperature coatings, engineering and structural ceramics, and oxygen sensors that control combustion in automobile engines.

The process to separate zircon into zirconium and hafnium is complicated but each metal has attributes that make the process worth it.

Because of zirconium’s excellent resistance to corrosion, it is often used as an alloy in metals used in harsh environments.

One such environment is nuclear fuel rods, which also takes advantage of zirconium’s resistance to absorbing neutrons. Alloys that are typically more than 95 percent zirconium, with enough other metals mixed in to provide the necessary mechanical properties, are used to encase these radioactive rods in nuclear reactors.

Hafnium is also used in nuclear reactors but for the completely opposite reason – this critical metal is an excellent absorber of neutrons. For this reason, hafnium is put in the fuel rods themselves to absorb excess neutrons and prevent a chain reaction that would cause an explosion.

While on opposite ends of the spectrum when it comes to neutron absorption, hafnium shares zirconium’s high resistance to heat. At 3,900 degrees Celsius (7,052 degrees Fahrenheit) hafnium carbide, a hafnium-carbon compound, has the highest melting point of any two combined elements.

This high resistance to heat is why hafnium alloys are used in rocket engines. One such example is a niobium-hafnium-titanium alloy used on the main thrusters of the Apollo Lunar Modules that first put a man on the moon.

The nozzles of plasma-arc metal cutting tools also benefit from hafnium’s extreme heat resistance.

Intel, IBM and others use hafnium-based compounds as insulators in the computer circuit boards they manufacture.

Though America is a net exporter of zircon ores and concentrates, USGS considers both hafnium and zirconium critical metals.

This is because the geological survey foresees a scenario where limited supply coupled with increased demand could cause an imbalance that would put zircon in short supply.

“Although new zircon mines were brought online in recent years, the global financial situation led to decreased production and delayed the development of several mining projects. Thus, constricted supply together with the projected increase in demand could create a scarcity of zircon in the future,” USGS wrote in a 2017 critical minerals report.

Icy Cape

Alaska Metal Health Trust, which was granted 1 million acres of land to earn money to provide mental health care in the state, is exploring beach sands along the Gulf of Alaska coast that could



HYPERTHERM

The nozzles of plasma-arc metal cutting tools benefit from hafnium’s extreme heat resistance.

relieve future zircon scarcity.

Located about 75 miles northwest of Yakutat, this potential source of critical metals, industrial minerals and gold is known as the Icy Cape Gold and Industrial Heavy Minerals project.

In 1995, the U.S. Bureau of Mines found the Yakataga beach sands contained ilmenite and rutile, both titanium minerals; and zircon, another mineral considered critical to the United States.

In a report on this investigation, the Bureau of Mines estimated that Yakataga hosted some 68 to 120 million metric tons of sand averaging around 0.03 percent (about 20,000 to 36,000 metric tons) of zircon, along with titanium and other industrial mineral.

This team, led by geologist Jeff Foley, estimated that less thoroughly sampled stretches of beach in the Cape Yakataga area contain roughly another 128 million metric tons of zircon enriched sands.

In recent years, Alaska Mental Health Trust’s land office have also been working to quantify the appreciable amounts of garnets, platinum and gold that also enrich this roughly 30-mile-long stretch of marine placer deposits that are mostly inland from the beach.

This could provide an economically interesting mix of metals and minerals, three of which are on the current list of 35 minerals the USGS deemed critical to the United States.

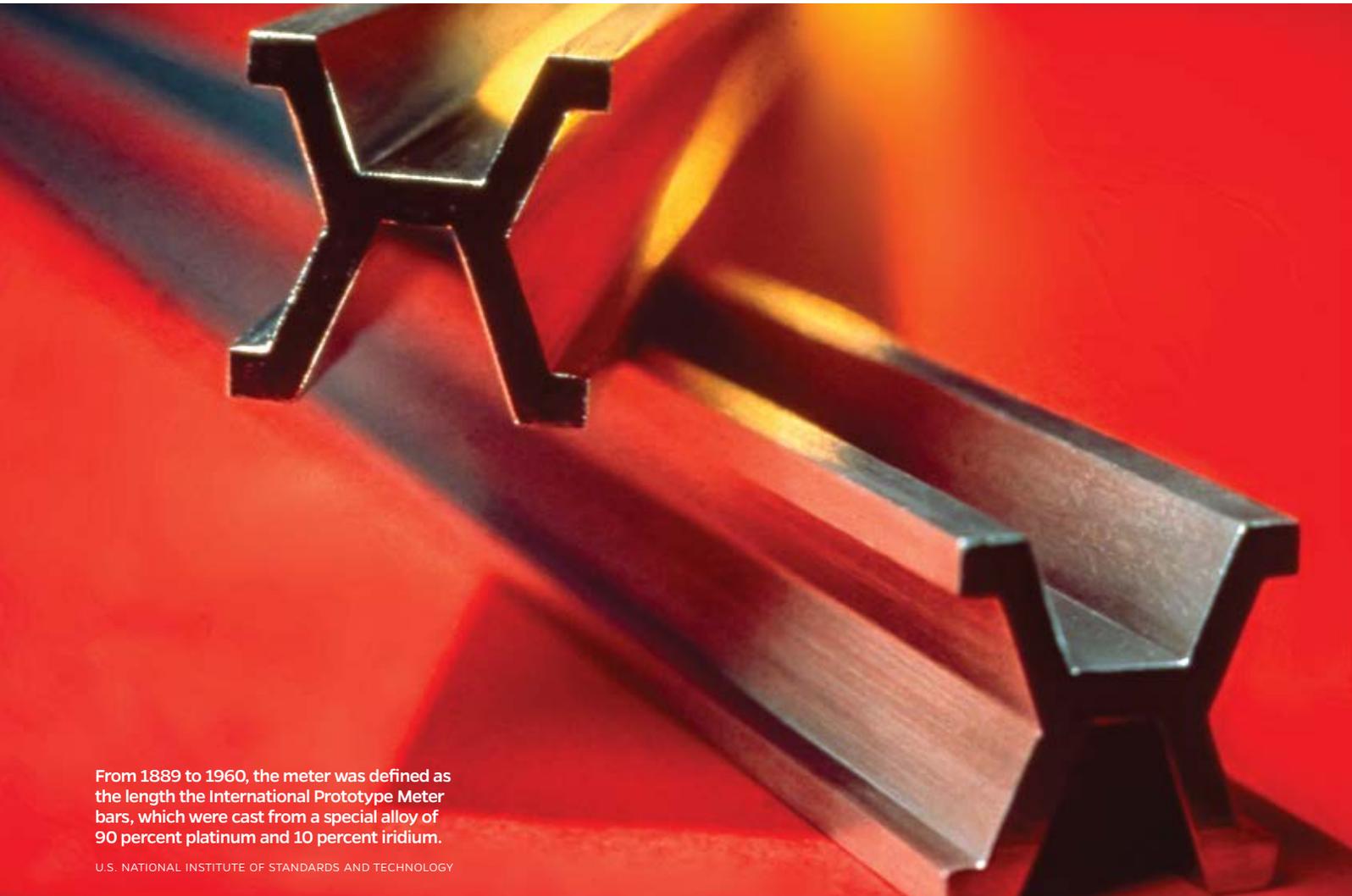
In addition to investigating the heavy mineral sands on the now Icy Bay property, the Bureau of Mines also found interesting quantities of zircon and titanium minerals in the immediate area of Yakutat and at Mount Fairweather, another stretch of beach just southeast of town.

In total, the Bureau of Mines calculated that Icy Bay, Yakutat and Mount Fairweather host 450 million to 500 million metric tons of sand containing 0.5 to 3 percent valuable heavy minerals. This estimate does not include the garnets, platinum or gold also found there.

In addition to marine placers such as Icy Cape, zirconium-hafnium minerals are also commonly associated with rare earths deposits.

Ucore Rare Metals Inc.’s Bokan Mountain at the southern end of the Southeast Alaska Panhandle is one REE project known to host zirconium and hafnium.

Considering Alaska’s widespread rare earth potential, other deposits containing zirconium and hafnium will likely turn up as explorers continue to reveal the state’s critical mineral potential.



From 1889 to 1960, the meter was defined as the length the International Prototype Meter bars, which were cast from a special alloy of 90 percent platinum and 10 percent iridium.

U.S. NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

PGEs – the hard-working precious metals

Alaska is historical source of this critical group of elements

By **SHANE LASLEY**

Mining News

THE SIX PLATINUM GROUP ELEMENTS – platinum, palladium, rhodium, ruthenium, iridium, and osmium – are amongst the rarest metals on Earth. This scarcity, coupled with PGEs’ uses in the automotive, petrochemical and electronics industries, has this group of industrious precious metals firmly planted on the United States Geological Survey’s critical minerals list.

“PGEs are indispensable to many industrial applications but are mined in only a few places,” USGS inked in a 2017 report on platinum group elements. “The availability and accessibility of PGE supply

could be (and have been) disrupted by social, environmental, political, and economic events.”

Alaska is home to two historically significant PGE mines and is prime hunting grounds for future domestic sources of these industrious precious metals.

Alaska is so prospective for PGEs that a category of deposits hosting these intriguing metals – Ural-Alaska-type ultramafic complexes – have been named after the state where they are found.

These PGE prospective deposits can be found along Wrangellia Composite Terrane — a series of associated assemblages that span a 1,250-mile-long arc sweeping from the Southeast Alaska Panhandle to Goodnews Bay along the southwest coast of the state.

Catalyst for demand

Platinum group elements – also referred to as platinum group metals – are highly corrosion resistant, durable, have excellent high-temperature characteristics and stable electrical properties. These traits make PGEs a hardworking group of precious metals used by wide sectors of manufacturing.

The largest use for this suite of metals – especially palladium, platinum and rhodium – is as a catalyst to help scrub carbon monoxide, hydrocarbon, and nitrous oxide emissions from automobiles and petroleum refineries.

USGS sees these irreplaceable catalytic properties driving PGM demand in the coming years.

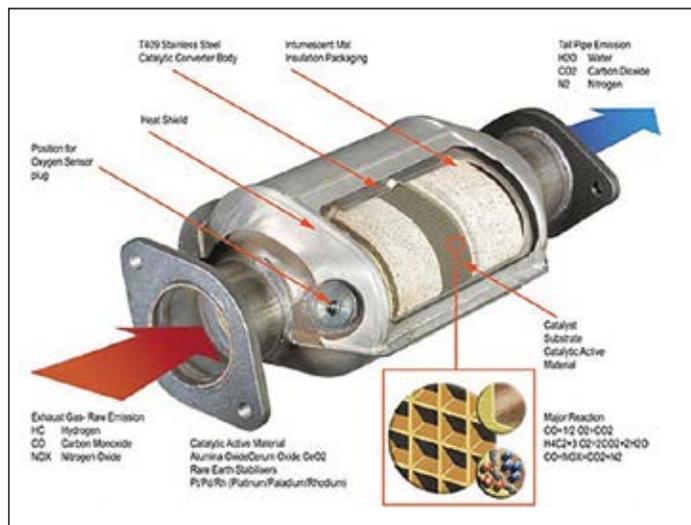
“The leading domestic use for PGMs was in catalytic converters to decrease harmful emissions from automobiles,” USGS wrote in its Mineral Commodity Summaries 2019. “Platinum-group metals are also used in catalysts for bulk-chemical production and petroleum refining; dental and medical devices; electronic applications, such as in computer hard disks, hybridized integrated circuits, and multilayer ceramic capacitors; glass manufacturing; investment; jewelry; and laboratory equipment.”

Their white color, strength, and resistance to tarnish of platinum alloys make PGMs prized jewelry metals.

Furthering their role as precious metals, platinum, palladium, and rhodium are minted into coins and bars for investment purposes.

While the value of platinum coins and bars has gone down, the price of the other PGEs have soared over the past year.

In late-March platinum was fetching for around US\$840 per ounce, down about 12 percent over a 12-month span.



Palladium on the other hand has risen sharply from a low of US\$842/oz in mid-2018 to more than US\$1,600/oz in March of this year. This catalyst metal had dropped to around US\$1,450/oz at the time this article was written.

“Since October 2017, the average price of palladium has been higher than that of platinum, which had not been the case previously since 2001,” USGS penned in its annual minerals report.

Rhodium’s rise over the past year has been even more pronounced, soaring from just below US\$2,000/oz from early 2018 to above US\$3,300/oz in March of this year.

Over the past year, the price of ruthenium has risen roughly 33



percent, to US\$266/oz; iridium jumped more than 40 percent to above US\$1,400/oz; and osmium has fallen roughly 10 percent to US\$400/oz.

With only one platinum mining operation in Montana, the United States relies on other countries – primarily South Africa – for roughly 73 percent of its new supply of this precious industrial metal.

Goodnews for platinum

For an explorer seeking the extremely rare economically minable deposit of PGEs, a town by the name of Platinum seems to be a good place to start.

About 120 miles south of Bethel, Platinum is in the Goodnews Bay region of Southwest Alaska, an area that was the primary domestic source of platinum in the United States for about five decades.

Yup'ik residents of the area, Walter Smith and Henry Wuya, first discovered platinum in the streams draining Red Mountain in 1926.

This discovery led to a claim-staking rush followed by several small-scale mining operations. Eventually, Goodnews Bay Mining Co. consolidated the platinum producing claims in the area and operated a bucket-line dredge in the area from 1937 to 1978, accounting for most of the roughly 650,000 oz of platinum that has been mined from the streams in this area.

High PGM prices have sparked renewed interest in the Goodnews Bay placer deposits over the past decade. This interest has included using modern equipment and techniques to recover platinum left behind by the dredge.

In addition to additional PGMs remaining in the streams of this platinum-producing area of Southwest Alaska, USGS geologists believe there could be significant marine placer platinum deposits just offshore.

In addition to what might be found in the ocean downstream from this historical placer deposits in Goodnews Bay, there has been interest in finding the lode source upland from Salmon River and its platinum-bearing tributaries.

An Ural-Alaska-type ultramafic body is believed to be the lode source of this historical placer production.

Red Mountain is considered the likely source of the placer platinum deposits in the Goodnews Bay area.

Exploration at Last Chance, a prospect at the head of a platinum bearing creek draining Red Mountain, has turned up some promising results. Rock samples taken from an outcrop at Last Chance returned assay results up to 2.27 grams per metric ton platinum. Geologists have also discovered platinum- and palladium-enriched veins there.

As intriguing as the Goodnews Bay PGM potential is, other areas of Alaska are even more prospective, according to recent work completed by USGS and the Alaska Division of Geological & Geophysical Surveys.

Historic palladium in Southeast

While Goodnews Bay is known for its historic platinum production, the past producing Salt Chuck Mine on Prince of Wales Island in Southeast Alaska was a top palladium producer in the United States until being shuttered during World War II.

From 1915 to 1941, Salt Chuck produced some 300,000 metric tons of ore averaging 0.95 percent copper, 1.96 g/t palladium, 1.12 g/t gold and 5.29 g/t silver, according to U.S. government summaries (1948).

Though Salt Chuck was never put back into production after its wartime shutdown, a 7,000-meter-by-1,600-meter mafic-ultramafic igneous complex is prospective for the metals recovered at the bygone operation.



AVALON DEVELOPMENT CORP.

This chromite-bearing outcrop on New Age Metals' Genesis project in Southcentral Alaska is rich in both platinum and palladium.

This site, however, has been on the U.S. Environmental Protection Agency Superfund list for the past several years.

Superfund – the informal name for the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) – is a federal program designed to fund the cleanup of contaminated sites.

In March of this year, EPA completed Superfund activities at Salt Chuck and is now seeking ideas to return the site to productive use through its Superfund Redevelopment Initiative.

The entire Southeast Alaska Panhandle is prospective for PGM deposits similar to Salt Chuck.

One such prospect is Duke Island, located about 70 miles southeast of the historic palladium mine.

Group Ten Metals, the company that owns the Duke Island project, said the abundance of copper-nickel-PGE sulfide mineralization found there is unlike any known Ural-Alaska complex.

Outcrop grab samples have returned values up to 2.8 percent copper, 0.25 percent nickel and more than 1 g/t PGE.

Of the four large zones of copper-nickel-PGE mineralization identified at Duke Island, only one, Marquis, has been drilled.

None of the 16 holes are thought to have been drilled deep enough to tap the contact with a feeder zone where the highest grades of mineralization at Duke Island is believed to occur.

Brady Glacier, a significant nickel-copper deposit at the north end of the Southeast Alaska Panhandle, also carries a significant amount of platinum group metals.

Historical drilling at Brady Glacier outlined 100 million tons of rock averaging 0.5 percent nickel and 0.3 percent copper. Roughly 250,000 oz of PGEs are estimated to be included in this drilled resource area.

Though Newmont officials deemed Brady Glacier the largest copper-nickel deposit in the United States during the company's investigation of the deposit in the 1970s, this PGM-enriched deposit is within the Glacier Bay National Park and Monument.

While this locale likely precludes any development in the foreseeable future, the rich deposit speaks to the PGE potential along the entire Southeast Alaska Panhandle.

Exploring Wrangellia

From the Southeast Alaska Panhandle, the Wrangellia Terrane arcs through southwest Yukon and back into Southcentral Alaska, a stretch of this distinct geological body considered to be prime hunting

ground for the suite of platinum metals.

The most advanced PGM deposit along the Wrangellia Terrane is Nickel Shāw (formerly known as Wellgreen) in the Yukon.

Situated about 60 miles east of the Alaska-Yukon border, Nickel Shāw hosts 6 million oz of platinum group metals, 2 billion pounds of nickel, 1 billion lb of copper and 120 million lb of cobalt in the measured and indicated resource categories.

Nickel Creek Platinum Corp. (formerly Wellgreen Platinum) is currently working on the optimization of metallurgical recoveries ahead of an updated preliminary economic assessment for developing a mine at Nickel Shāw.

There are intriguing signs that similar PGM-nickel-copper-cobalt deposits could be lurking in the Alaska portion of the Wrangellia, such as the Man property about 165 miles southeast of Fairbanks.

With holes cutting 81 meters averaging 0.315 g/t platinum-palladium-gold, 0.17 percent copper and 0.25 percent nickel in the Eureka zone at Man indicate the great PGE potential of this property.

Pure Nickel, the former owner of Man, said that a review of drilling shows that all holes that cut the Eureka zone encountered disseminated sulfide mineralization with strikingly similar grades along seven kilometers (4.5 miles) in the central part of Alpha.

Despite the properties promise, Pure Nickel relinquished the state mining claims covering Man to save money during the recent downturn in mineral exploration markets.

A recent proposal to establish the Tangle Lakes Game Refuge on state land just south of the PGE-enriched areas at Man has discouraged further investigations of Man.

The PGE and nickel potential of this section of the Wrangellia Terrane stretching across Southcentral Alaska has attracted the attention of global miners such as Australia-based MMG Ltd.

In 2013 and 2014, MMG investigated three large blocks of state of Alaska mining claims that follow an arc south of the Alaska Range.

These claim groups include Amphitheater, which borders the Man property to the south and west; Butte Creek, located about 40 miles southwest of Amphitheater; and Talkeetna, a block of claims roughly 30 miles further along this PGE prospective arc.

New Age exploration

The Peninsular Terrane, which stretches along the Chugiak Mountains in Southcentral Alaska, is a subsection of the Wrangellia Composite Terrane also known for its PGE potential.

New Age Metals Inc. recently signed an agreement with Anglo Alaska Gold Corp. to acquire full ownership of Genesis, a 10,240-acre, drill-ready platinum group metal project in the Peninsular Terrane.

Situated along the Richardson Highway about 75 highway miles north of the deep-water port city of Valdez, Genesis is an under-explored palladium-platinum-nickel-copper property with great infrastructure.

Sampling of one drill-ready reef style target at Sheep Hill on the Genesis property returned up to 2.4 g/t palladium, 2.4 g/t platinum, 0.96 percent nickel and 0.58 percent copper.

The property also hosts a separate style of chromite mineralization containing up to 2.5 g/t palladium and 2.8 g/t platinum.

Despite this surface PGE-copper-nickel mineralization, no drilling has ever been carried out on this project that is less than two miles from a paved highway and an electric transmission line.

New Age Metals Chairman and CEO Harry Barr told Mining News that this ease of access, superb infrastructure – along with the

PGE-nickel-copper mineralization right at surface – makes Genesis the type of property that major mining companies are looking for.

New Age and its geological partner in Alaska, Avalon Development Corp., plan to compile the historical data on Genesis this year and based on the findings of this work complete the field work needed to get this intriguing PGE project ready for drilling.

“(A)fter the preliminary field work and additional ground proofing, our objective is to find an option-joint venture partner to further the development of this promising new drill ready project, with excellent base metal credits,” said Barr.

In the meantime, New Age Metals is looking for other PGE properties in Alaska.

Beyond Wrangellia

While the Wrangellia Composite Terrane is considered the best place in Alaska to hunt for platinum group metals, a number of prospects exist beyond this belt.

The Angayucham Terrane, a belt of rocks found along the north-western slopes and south of the Brooks Range in Northwest Alaska is another area state and federal geologists consider to be highly prospective for PGMs.

Misheguk Mountain, a chromium occurrence about 45 miles east of the Red Dog Mine, is an Angayucham Terrane prospect with significant PGEs.

Assay values of 4.3 percent chromium and 0.22 percent nickel were obtained by the U.S. Bureau of Mines over a 50-foot sample reported in 1978. Individual samples collected from Misheguk Mountain returned up to 4.2 g/t platinum, 4.7 g/t palladium, as well as small amounts of rhodium, ruthenium, iridium, and osmium.

From the Seward Peninsula in western Alaska to the Fortymile district adjacent to the Yukon border, small amounts of placer platinum have been recovered as a by-product of gold mining. These anomalous occurrences underscore the potential of discovering PGMs across Alaska’s vast gold-producing districts.

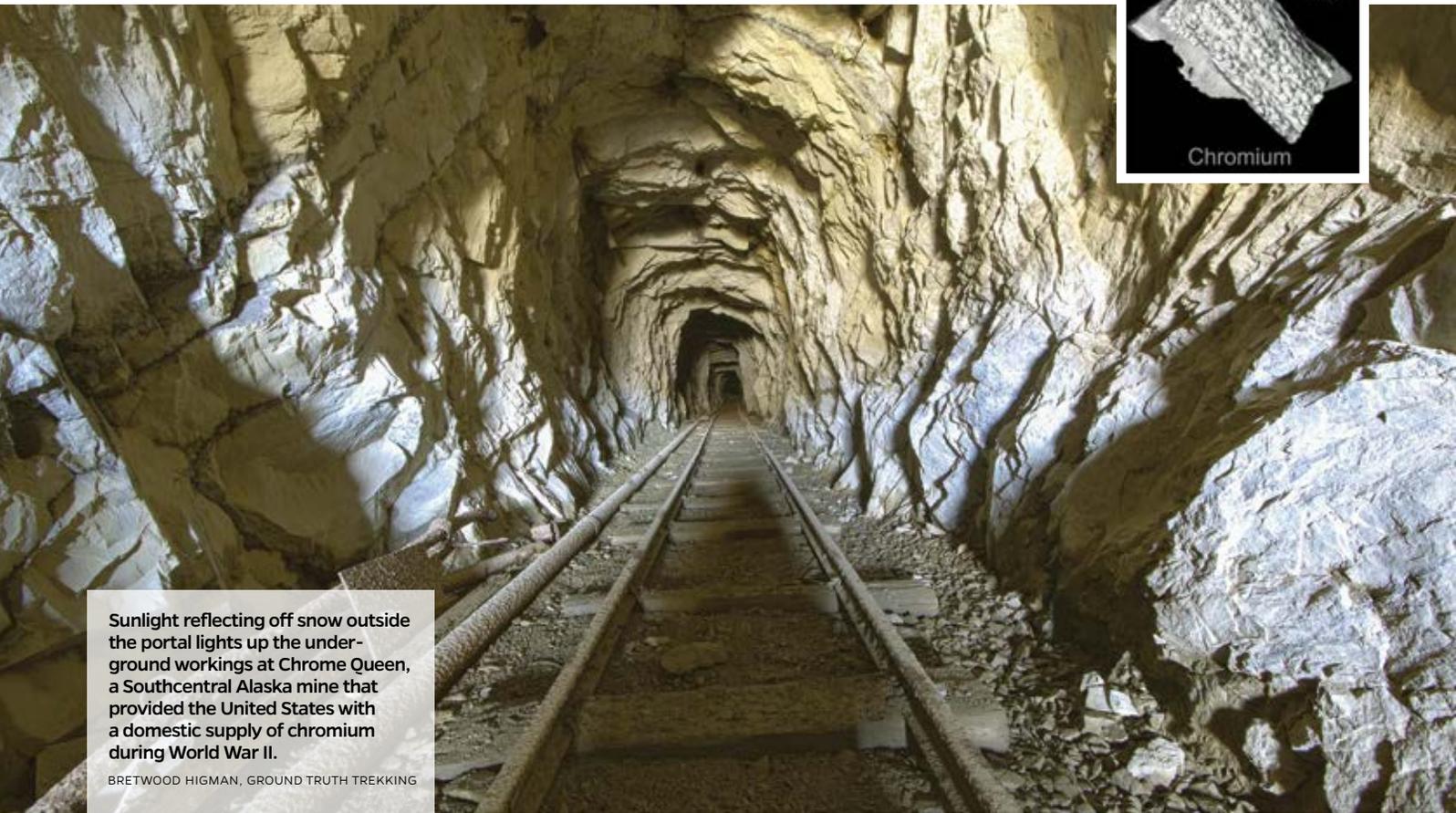
The Valdez Creek Mining District, about 65 miles southeast of Fairbanks, is one such region. According to a 1988 U.S. Bureau of Mines report, concentrates from 52 alluvial samples collected from placer gold streams in the district contained measurable quantities of PGMs.

One sample from Gold Creek contained 3.1 g/t platinum; another sample from Tyone Creek measured 4.1 g/t platinum and 0.28 g/t ppb palladium, while a sample from Fourth of July Creek returned 2.5 g/t platinum.

No mafic or ultramafic rocks – the igneous rocks typical to Ural-Alaska-type ultramafic complexes – are known to exist in many of these areas where PGMs are found, opening up much of Alaska to new ideas of where to hunt for these rare and critical metals.

“What’s intriguing is there are sniffs in a number of places. All it takes is for someone to come up with a model that makes sense, which could lead to a lot of exploration and/or discoveries,” Dave Szumigala, a renowned Alaska geologist, told Mining News in 2012. “But, with the conventional models, these little hits here and there have not evoked an exploration target looking totally at platinum.”

Already rich in Ural-Alaska-type ultramafic platinum group element targets, the potential of a new Alaska-type PGM complex could open wider areas of the state for the search of this group of precious, industrial and critical metals.



Sunlight reflecting off snow outside the portal lights up the underground workings at Chrome Queen, a Southcentral Alaska mine that provided the United States with a domestic supply of chromium during World War II.

BRETWOOD HIGMAN, GROUND TRUTH TREKKING

No viable substitute for critical chromium

Stainless-steel ingredient mined in Alaska during both World Wars

By SHANE LASLEY

Mining News

A VITAL INGREDIENT IN STAINLESS STEEL and superalloys, chromium is considered by the United States Geological Survey as “one of the nation’s most important strategic and critical materials.”

“Because there is no viable substitute for chromium in the production of stainless steel and because the United States has small chromium resources, there has been concern about domestic supply during every national military emergency since World War I,” the USGS explains.

Rich chromite deposits on Alaska’s Kenai Peninsula were able to ease some of these concerns by providing a domestic supply of chromite, the only mineral of chromium metal, to help fill America’s increased demand for chromium during both World Wars.

Alaska is second only to Montana when it comes to the best states to explore for future domestic needs of this important strategic and critical mineral.

No stainless substitute

Best known for being the primary ingredient of the smooth, mirrorlike plating on automobiles, chromium is a highly prized alloy due to the hardness and corrosion resistance it lends to other metals.

By far the largest use of chromium is in stainless steels, which typically contain 10.5 to 32 percent of this critical alloying metal.

This strategic metal also lends its hardness and corrosion-resistant properties to superalloys, specialty metals that can maintain their integrity in extreme conditions.

“Chromium in superalloys (high-performance alloys) permits jet engines to operate in a high-temperature, high-stress, chemically oxidizing environment,” USGS inked in an informational page on the metal.

The properties chromium imbues into alloys, coupled with limited domestic supply, is why the geological survey considers it a critical and strategic metal.

While shiny bumpers, hubcaps and tailpipes are obvious applications of chromium’s properties, yellow school buses and stripes down

the center of American highways are lesser known yet highly recognizable uses of this element's pigment properties.

"School bus yellow, originally called chrome yellow for the chromium pigment, was adopted for use on school buses in North America in 1939 because black lettering on the yellow buses is easy to see in the semidarkness of early morning," the USGS explained.

In fact, chromium derives its name from the Greek word for color, *chroma*, due to the intense coloration of many chromium compounds.

Interestingly, chromium impurities give some of our most prized gems their brilliant colors. The colorless corundum crystal is a ruby with the addition of chromium, and a bit of chromium changes the geometry of the atoms of beryl slightly, resulting in emeralds.

While chromium derived its name from its pigmentation qualities, it is the durability this metal lends to alloys that drives its demand.

Roughly 85 percent of the world's chromium is used for stainless steel and chrome plating, and the metal has no equal when it comes to the anti-corrosive and hardness qualities.

"World stainless steel producers depend directly or indirectly on chromium supply," USGS wrote in its annual report, *Mineral Commodity Summaries 2019*.

Global chromium sources

While the U.S. consumes roughly 6 percent of the world's chromite ore production, none of this chromium mineral is mined domestically. Instead, America relies on foreign sources for approximately 71 percent of its supply of chromium, the balance comes from the domestic recycling of stainless steel.



FRANK PIZZACALLA

Shiny bumpers, hubcaps and tailpipes are the most recognizable applications of chromium's properties.

Roughly 36 million tons of chromite was mined globally in 2018. Rich South Africa deposits accounted for around 44 percent of this production. The remaining 56 percent came from mines in Turkey (6.5 million tons); Kazakhstan (4.6 million tons); India (3.5 million tons); and other countries (4.5 million tons).

The U.S., which is not among the "other countries" that produced chromite, consumed roughly 550,000 tons of chromium, worth an estimated US\$1.1 billion during 2018.

Domestic recycling supplied about 160,000 tons of this chromium. The balance was imported as chromite, refined chromium and chromium-containing scrap.

South Africa accounted for roughly 38 percent of the chromite and refined chromium metal imported into the United States last year. Kazakhstan (8 percent) and Russia

(6 percent) were other suppliers of chromium.

The price of ferrochromium, the iron-chromium alloy used by the steel industry that is traded on global markets, is highly influenced by the health of the economy. As a result, the price of ferrochromium rocketed from around US\$60 cents per pound in 2006 to around US\$2.80/lb in 2008 before plummeting again in 2009.

"The price of ferrochromium reached historically high levels in 2008 and then declined in 2009 with a weakening world economy. During the same time period, China's role as a chromium consumer has grown with its expanding stainless-steel industry," USGS penned in its chromium report.

Ferrochromium was down around US\$1.15/lb early in 2019.

Alaska's Chrome Queen

Looking around the United States for domestic sources of chromium, the USGS investigated both known types of chromite deposits – stratiform (layered) deposits such as the rich deposits mined in South Africa and podiform (pod shaped) deposits that developed in oceanic crust below the sea floor and have been pushed up by tectonic forces.

It is the podiform variety found around Red Mountain – situated near the southern end of the Kenai Peninsula in Southcentral Alaska – which provided the U.S. with a domestic supply of chromium during World Wars I and II.

Chromium-rich mineralization was

ERNESTO ESLAVA



Chrome is as a pigment for school buses in North America because black lettering on the "chrome yellow" buses is easy to see in the semidarkness of early morning.

discovered in the Red Mountain area around 1910 and some limited mining occurred there during World War I.

Knowing Red Mountain could provide a domestic source of chromium during World War II, the U.S. Bureau of Mines drilled more than thirty holes to evaluate this chromite-rich area near the Southcentral Alaska town of Seldovia. This exploration resulted in development and mining at Chrome Queen and other orebodies discovered over a four-mile-long area at Red Mountain.

From 1942 through 1944, production from the Chrome Queen Mine totaled 6,650 tons of 40 to 42 percent chromium oxide.

Past investigations have identified 31 deposits at Red Mountain that contain at least 30 percent chromite and 20 of these are estimated to contain roughly 97,000 tons of chromium oxide. Three other lower grade deposits in the area are estimated to host another 1.5 million tons of chromium oxide.

No resource was calculated for the 11 other high-grade deposits due to small size or lack of exposure.

In total, about 26,000 tons of ore containing 38 to 43 percent chromium oxide was produced from Red Mountain from 1942 to 1958, and about 1.6 million tons of ore is estimated to remain in deposits historically investigated there.

Additional chromium was identified at Claim Point, an area about 15 miles southwest of Red Mountain that underlies Chrome Bay and extends for about 1,000 feet onshore.

Roughly 2,000 tons of ore was mined from the tidewater deposits at Claim Point and results of drilling and surface sampling indicate 295,000 tons of 17.8 percent chromium oxide ore remain at this area on the southern tip of the Kenai Peninsula.

Together, roughly 27,800 tons of ore averaging 42 percent chromium oxide, having a chromium-to-iron ratio of 2.75-to-1 was mined from the chromite deposits at Red Mountain and Claim Point.

Investigating the Border Ranges

While Red Mountain and Claim Point are the best-known chromite deposit areas in Alaska, they are far from the only ones found here. In fact, an investigation carried out by the U.S. Bureau of Mines in the early 1980s identified 94 podiform chromite deposits along a 600-mile stretch of the Border Ranges Fault that arcs 600 miles southwest from McCarthy to the southwestern tip of Kodiak Island.

While most of these were considered



AVALON DEVELOPMENT CORP.

In addition to being rich in platinum, the two main mineralized areas on New Age Metals' Genesis project host appreciable quantities of chromite.

sub-economic at the time, the number of prospects indicate Alaska's potential as a future source of this critical and irreplaceable mineral.

Excluding all deposits more than 10 miles from tidewater or existing roads and ones containing low-quality chromite, 41 hardrock deposits identified along Alaska's Border Ranges Fault during the Bureau of Mines study are estimated to host 2.2 million tons of chromium oxide.

In addition to hardrock deposits, the Bureau of Mines identified a rich chromium placer deposit in the Windy River valley, which drains Red Mountain. Sampling of this deposit by Anaconda Minerals and BOM outlined 20.92 million cubic yards of placer material averaging 1.33 percent (556,000 tons chromium oxide).

Three of the hardrock chromite prospects along the Border Ranges Fault are found at Tonsina, an area east of the Richardson Highway at about milepost 80.

Two of these – Bernard Mountain and Sheep Hill – are found on the Genesis property recently picked up by New Age Metals Inc. The third – Dust Mountain – is on lands owned by Ahtna Corp., an Alaska Native corporation.

While New Age Metals is primarily interested in the platinum group metals also found on Genesis, the two main complexes there are known to host chromite.

Historical investigations have located 15 chromite deposits and occurrences at Bernard Mountain. Bureau of Mines estimates that three of the surfacing deposits there contain 343,000 tons of chromium oxide. Sampling indicates that the Bernard Mountain chromite can be concentrated to meet the metallurgical-grade specifications for the alloying metal.

Another 12 chromite deposits and occurrences were identified on Sheep Hill

and Dust Mountain.

One deposit at Sheep Hill is estimated to contain 26,000 tons of chromium oxide. Not all the chromite found in this deposit, or the other occurrences on Sheep Hill and Dust Mountain, however, is considered able to be concentrated to the specifications needed for alloying.

Numerous other occurrences have also been identified in the Chugach Mountains from near the Sheep Mount Lodge on the Glenn Highway to the Eklutna area near the town of Palmer.

From Eklutna, the Border Ranges Fault runs south on the Kenai Peninsula, through the Red Mountain and Claim Point area and onward to the adjacent Afognak and Kodiak Islands, where five other chromite-bearing mafic or ultra-mafic complexes have been identified.

Hints of chromite

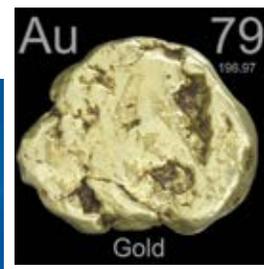
In addition to the chromite deposits found along the Border Ranges Fault, numerous occurrences of the critical alloying metal have been identified across Alaska. Small and scattered, however, these prospects have not resulted in a find considered to be an important source of chromite.

These hints of chromite, however, might add up to something in the future.

“Mineral resource assessments are dynamic. Because they provide a snapshot that reflects our best understanding of how and where resources are located, the assessments must be updated periodically as better data and concepts are developed,” USGS penned in its chromium facts sheet. “Current research by the USGS involves updating mineral deposit models and mineral environmental models for chromium and other important nonfuel commodities and improving the techniques used to assess for concealed mineral resource potential.”

Fort Knox is a prime example of the suite of critical elements – arsenic, antimony, bismuth, tellurium and tungsten – associated with intrusive-related gold deposits in Alaska.

KINROSS GOLD CORP.



Gold – a pathfinder to critical minerals

Six critical metals oft found with placer, lode aurum in Alaska

By **SHANE LASLEY**

Mining News

SINCE THE STAMPEDES OF PROSPECTORS TREKKED NORTH in the latter half of the 19th Century, the lure of Alaska's rich gold lodes has drawn dreamers and miners North. Today, four hardrock mines and hundreds of family-run placer operations across the Last Frontier churn out roughly 1 million ounces of this alluring precious metal each year – and the largest stores of aurum discovered here have yet to be realized.

Despite being a relatively rare metal that has served as a currency for more than 5,000 years and possessing many unique attributes that make it invaluable to modern technology, gold is not on the list of minerals considered critical to the United States.

This precious metal, however, could serve as a pathfinder element for several of the other minerals and metals the United States Geological Survey has listed as critical to America.

This is because where you find gold in Alaska you typically find some mix of six of the metals that did make it onto the USGS list – antimony, arsenic, bismuth, tellurium, tin and tungsten.

Most geologists throughout Alaska's relatively short mining history think about this suite of critical minerals as a signature for finding the world-class deposits of gold for which Alaska is renowned.

Even enormous stores of gold, such as the 40-million-oz Donlin Gold deposit in Southwest Alaska, can be tough to find by just relying on looking for gold on the surface.

For this reason, geologists seeking similarly large lodes of gold look for traces of antimony, arsenic, bismuth, molybdenum, tellurium, tin and tungsten, elements that travel with gold but are easier to find in the soils lying over multi-million-oz gold deposits.

Reversing this typical line of thinking, geologists seeking an economic deposit of any one of these critical minerals can take a look at the rich deposits of hardrock and placer gold turned up by the explorers that came before them.

Tintina gold pathfinders

While gold is found across Alaska's entire vast landscape, with the exception of the oil-rich plains of the North Slope, the Tintina Gold Belt – a 125- by 750-mile gold-rich province that arcs across the middle of the state – is particularly well endowed with large intrusion-related gold systems and critical minerals associated with them.

Kinross Gold Corp's Fort Knox Mine a few miles north of Fairbanks is a textbook example of the intrusion-related gold systems typical of the Tintina Belt and the potential to find deposits of critical minerals nearby.

While Fort Knox is a low-grade gold deposit, it is large and has been a profitable mine in Kinross' portfolio since production began there in 1996. So far, this operation has churned out 8 million oz of gold and has enough ore to keep the mine operating until at least 2030.

When explorers are searching for gold deposits across the Tintina Belt, Fort Knox and the suite of critical pathfinder elements associated with it is often the model.

Bismuth, tellurium and tungsten are typically found right over the deposit, while arsenic and antimony become more predominant as you get further away.

This is the case for Fort Knox.

"The quartz contains gold, scheelite (a tungsten mineral), bismuthinite (a bismuth mineral), and according to assay some mineral containing tellurium," L.M. Prindle wrote in 1916 of samples taken from what would 80 years later be the Fort Knox Mine.

"It's a shame Kinross never installed a heavy mineral circuit in their Fort Knox mill to catch the bismuthinite and scheelite and wolframite that was known in the area since at least Prindle's 1916 USGS report," James Barker, who investigated much of Alaska's critical minerals potential while working as a geologist for the U.S. Bureau of Mines, told Mining News.

Distal deposits of antimony and tungsten, often containing bismuth, however, have been mined when demand for these critical metals pushed the price high enough.

In 1915, Balkan immigrant Mike Stepovich discovered a high-grade tungsten lode on the flanks of what is now the Fort Knox Mine. His discoveries contributed to America's need for the tough metal during both World Wars and led to further tungsten finds nearby.

Mines around Fort Knox also provided the United States with a domestic supply of antimony during both World Wars.

While these mines have the potential to be a future supply of this semi-metal critical to the economic welfare and security of the United States, the underlying gold is typically more valuable.

Scrafford, a mine that provided a domestic source of antimony during World War I, is one such example.

"The Scrafford antimony deposit is affiliated with an east-west, south-dipping shear zone of the same name that can be followed for at least six miles (10 kilometers)," Barker said.

Today, Barker is the project manager for Treasure Creek Partnership, a company that is exploring the gold potential of a land package that blankets this antimony-gold trend a few miles west of the Fort Knox Mine.

Drilling on this property in the 1990s encountered a large gold zone with grades similar to what is being stacked on the heap-leach pad at the neighboring Fort Knox Mine.

There are indications that some bismuth was mined in the Salcha River area a few miles east of Fairbanks. In fact, reports of placer bismuth nuggets in Caribou Creek in this area has attracted the interest of gold explorers, considering the critical minerals association

ALASKA DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES



Completed in 2016, this road to the community of Tanana on the Yukon River cuts through the gold- and tin-rich Tofty region of Interior Alaska.

to Fort Knox to the west and Pogo to the east.

The same pathfinders that led to the discovery of these Interior Alaska gold mines apply to find other aurum deposits across the Tintina Gold Belt and beyond.

Cassiterite a coincidence

Many of Alaska's most prolific placer gold producing regions, such as the Circle and Manley Hot Springs districts in Interior, also happen to be rich in tin. This relationship, however, has more to do with meteorology than geology.

The most widely known placer tin deposits in Interior Alaska are found along the Tofty tin belt, a 12-mile-long area of tin- and gold-bearing gravels in the Manley Hot Springs district.

"Gold mining in the district developed rapidly, and as the productive area in the vicinity of Tofty increased it was found that tin and gold were generally associated and that the richer concentrations of the two minerals were generally coincident," Henry Eakin wrote in a 1914 report, *Tin Mining in Alaska*.

At least one stream in the Circle Mining District – Boulder Creek – is also so rich in tin mineral cassiterite that it plugs the recovery plants of placer miners also attempting to recover the gold there.

This gold and tin winding up in the same streams, however, is a coincidence more associated with lack of glaciers erasing the alluvial history than a close relationship in mineralization.

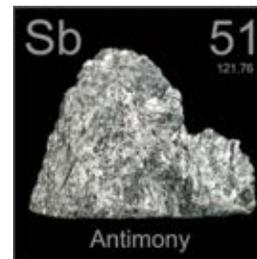
Barker, who investigated the placer tin occurrences at Boulder Creek while with the U.S. Bureau of Mines, said the tin and gold found together there "is more a function of the common erosional and alluvial weathering processes in the absence of major ice sheets."

This lack of major glaciation has contributed to gold, tin, tungsten, niobium, rare earth elements and other critical minerals being found together in placer deposits across Alaska.

"What is unique is the vast extent of old alluvial terrane in the Interior and in eastern Siberia, that have weathered underlying mineralized terranes and sometimes co-mingled the heavy minerals of interest," Barker told Mining News.

This weathering has also completed the initial stages of milling and concentration, giving a would-be placer gold-critical metals miner a head-start over those digging into the hardrock source of these alluvial deposits.

Antimony – resists heat, draws criticality



Flame resistant battery metal found in Alaska gold districts

By SHANE LASLEY
Mining News

ANTIMONY IS A POOR CONDUCTOR OF HEAT, an attribute that lends itself to this semi-metal's most common use, as an ingredient to make clothing, mattresses and other products flame resistant.

While making work clothes and household items safer and less likely to catch fire is a relatively new use for antimony, humans have been using antimony for other purposes for more than 5,000 years.

“For example, the ancient Egyptians and early Hindus used stibnite, which is the major ore mineral for antimony, to produce black eye makeup as early as about 3100 B.C.,” the United States Geological Survey wrote in an 852-page report on critical minerals.

“Today, antimony is used in lead-acid storage batteries for backup power and transportation; in chemicals, ceramics, and glass; in flame-retardant materials; and in heat stabilizers and plastics,” the federal agency continued.

These uses are vital across a wide array of American industries, including the defense and energy sectors.

While recycling and imported concentrates supplies roughly 15 percent of this demand, the United States is completely import-reliant for its new antimony metal supply.

Approximately 58 percent of this antimony metal the U.S. imports comes from China. Most of the balance comes from India, Vietnam and United Kingdom.

Alaska provided America with a domestic supply of stibnite during both World Wars and has the potential to be a future supply of this semi-metal critical to the economic welfare and security of the United States.

Fireproofing to liquid metal batteries

It is estimated that more than a third of the antimony consumed globally is for some form of flame-retardant.

When combined with a halogen – such as fluorine, chlorine, bromine or iodine – antimony trioxide suppresses the spread of flames. In addition to safety clothing, tents, toys, aircraft, and automobile seat covers are among the products imbued with antimony trioxide's life-saving flame resistance.

“During World War II, the fireproofing compound antimony trichloride saved the lives of many American troops when it was applied to tents and vehicle covers,” the USGS penned in its 2017 critical minerals report.

When added to lead, antimony imparts increased hardness and mechanical strength into an alloy known as antimonial lead.

Bullets and shot, bearings, electrical cable sheathing, type metal for



The antimony mineral stibnite was used to create the distinctive black eye makeup common in ancient Egypt.

printing machines, solders and pewter are among the products that often contain some amount of antimony.

The most common application for antimonial lead is in the lead-acid batteries used in most internal-combustion-engine automobiles, where the alloy improves plate strength and charging characteristics.

While lead-acid battery usage is expecting to decline as more electric vehicles populate global highways, antimony may find new applications in future generation batteries.

A liquid-metal rechargeable battery developed at the Massachusetts Institute of Technology in Cambridge contains healthy amounts of antimony.

This battery, also known as a molten-metal battery, uses an alloy of lead and antimony as the anode (positive electrode); liquid lithium the cathode (negative electrode); with a lithium salt electrolyte in between. All of these liquids are stored in a single tank without the need for dividers because, like oil and water, they have different densities and do not mix.

The passing of ions through the electrolyte as the battery charges and discharges keeps the metals molten.

While such batteries won't likely be used in vehicles, they could solve the problem of creating durable batteries for storing power from renewable sources such as solar and wind power – electricity that can

be delivered to the grid as needed.

Such large batteries need to be inexpensive and durable. MIT believes the molten-metal battery may be the answer.

Given the fairly straightforward design – basically a large container holding three liquids that do not need membranes or other separators – that is expected to be able to supply years without degradation, this new battery concept is expected to deliver dependable power with very little maintenance.

Adding in the size, this could be the answer to delivering renewable electricity when the sun is not shining or the wind is not blowing, a key to making green energy practical on a grander scale.

Stibnite near Nome

That Alaska's gold districts also have potentially economically viable deposits of antimony has been recognized for well over a century.

"It has long been known that stibnite, the sulphide of antimony and the principal source of that metal, is widely distributed in Alaska," Alfred Brooks penned in a 1917 report, *Antimony deposits of Alaska*.

Brooks' early 20th Century investigation identified 67 stibnite occurrences in Alaska, most of which are found in areas also rich in gold – Nome, Fairbanks and Iditarod.

The first record of primary antimony mining in Alaska was the Sliscovich Mine about 30 miles northeast of the famed gold mining town of Nome.

First opened in 1906, Sliscovich was positioned to provide a domestic source of antimony at the onset of World War I, which sparked stibnite mining across much of Alaska.

"WWI created considerable demand for antimony," James Barker, who investigated much of Alaska's critical minerals potential while working as a geologist for the U.S. Bureau of Mines, told *Mining News*.

While roughly 100 tons of ore from mining shipped from Sliscovich in 1914 and 1915 contained about 35 percent antimony, the value of the gold and silver in this ore outweighed the critical mineral.

"Antimony is often a high-level indicator of deeper gold deposits," said Barker.

Later investigations by Bear Creek Mining included samples topping 1 oz./t gold, as well as antimony-rich samples with gold, silver and arsenic.

Hed and Strand, a mine in the Lost River area about 85 miles northwest of Nome, also produced antimony during World War I.

Situated in a region famous for tin and a bounty of other minerals now considered critical to the United States, Hed and Strand produced about 106 tons of antimony from a roughly two-foot-thick vein during 1915 and 1916.

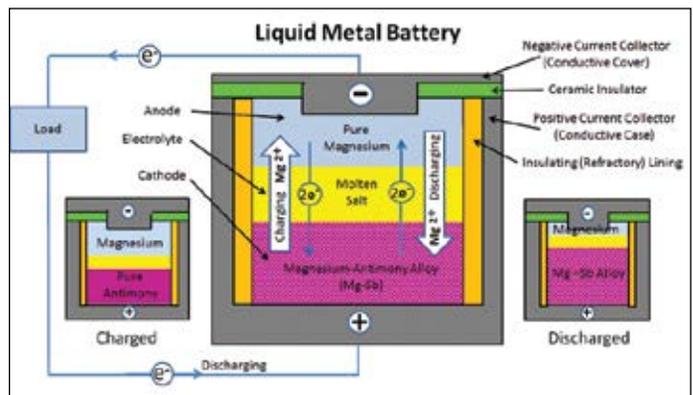
Brooks said a second type of antimony deposit was also identified in the Lost River area early in the 20th Century.

"Mention should also be made of the occurrence of stibnite in association with fluorite in an altered rock, now largely composed of scapolite, in the Lost River basin of the York district," he penned in his 1917 report. This adds to the mounting evidence that the Lost River area near the western tip of the Seward Peninsula could be a significant source of a broad range of minerals and metals considered critical to the United States.

From Fairbanks to Tok Antimony

As intriguing as the Seward Peninsula is, the area around Fairbanks and east towards the Yukon border could be the best place in Alaska to look for economic lodes of antimony.

In fact, while the World War I-era mines near Nome were shipping



MASSACHUSETTS INSTITUTE OF TECHNOLOGY

out antimony, larger loads of higher grade concentrates were sent from mines around the Interior Alaska city.

"In 1915 antimony ore was mined on four properties in the Fairbanks district at the Scrafford, in Treasure Creek basin; the Stibnite, in Eva Creek basin; the Gilmer, in Vault Creek basin; and at Chatham Creek mine," Brooks wrote. "All the operations were on a small scale and consisted chiefly of open cuts. The total shipments of stibnite from the district during 1915 were 685 tons, which probably averaged 58 percent antimony."

Former U.S. Bureau of Mines geologist Barker said the lump antimony mined from Scrafford "was sacked and transported by cable tram up to the ridge top and then by horse drawn wagons into Fairbanks to be shipped south by river steamer."

Scrafford, the most prolific of these Fairbanks area stibnite mines, has been estimated to produce 2,700 tons of ore containing greater than 50 percent stibnite over the years.

Today, this property near the Fort Knox Mine is being explored primarily for its gold potential.

Treasure Creek Partnership consolidated claims covering Scrafford, as well as other gold and antimony occurrences in the area.

"The Scrafford antimony deposit is affiliated with an east-west, south-dipping shear zone of the same name that can be followed for at least six miles (10 kilometers)," Barker, who is now the project manager for Treasure Creek Partnership, told *Mining News*.

"We are now exploring the underlying gold potential and hope to find a partner to continue drill exploration," he added.

Drilling on this property in the 1990s encountered a large gold zone with grades similar to what is being stacked on the heap-leach pad at the neighboring Fort Knox Mine.

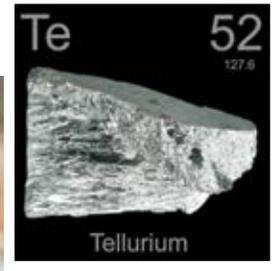
When exploring for antimony, a creek named Stibnite is a good place to start. Such a creek in Alaska is found about 180 miles south-east of Fairbanks in yet another area where historical antimony mining led to later gold exploration.

The Tok Antimony, also known as Stibnite Creek, deposit was first mined in 1914 and was set to ship ore during World War II. The stockpiles mined from an open-pit there, however, were washed away by the river and never made it to market.

Like its contemporaries near Nome and Fairbanks, this antimony property about 20 miles west of Tok turned into a gold exploration project.

In 2009 and 2010, two Australia-based exploration companies carried out gold exploration at the Tushtena project, a large land package that covered Stibnite Creek.

While this exploration work did not turn up the world-class gold deposits the Aussie companies were seeking, this area still hosts the antimony deposits that drew miners here in the first place.



Cadmium telluride thin-film solar cells are providing a lower-cost alternative to conventional silicon-based solar panels.
FIRST SOLAR INC.

Tellurium – solar lights metalloïd future

Alaska copper deposit may be rich source of solar cell element

By SHANE LASLEY

Mining News

EXCEEDINGLY RARE, YET A VITAL INGREDIENT to emerging solar panel technologies, tellurium is the epitome of what it means to be a critical metalloïd, an element that possesses the properties of both a metal and non-metal.

“Most rocks contain an average of about 3 parts per billion tellurium, making it rarer than the rare earth elements and eight times less abundant than gold,” the United States Geological Survey wrote in a 2015 report on this critical metalloïd. “Grains of native tellurium appear in rocks as a brittle, silvery-white material, but tellurium more commonly occurs in telluride minerals that include varied quantities of gold, silver, or platinum.”

Though this scarce element is seldom found in economic concentrations, one deposit in Alaska that also has abundant copper and rhenium hosts “an enormous tellurium endowment” and could provide a future source of this solar panel ingredient.

Solar drives growing demand

Traditionally, the small amounts of tellurium produced were used as an additive to improve the strength and pliability of steel, copper and lead alloys. This has changed with the advent of the cadmium telluride (CdTe) thin-film solar panels, which are much less expensive to produce than traditional silicon panels.

According to the USGS, roughly 40 percent of the tellurium used last year was made into cadmium telluride, a stable crystalline compound for these thin-film solar cells.

“CdTe solar cells are the second most common photovoltaic technology in the world marketplace after crystalline silicon, currently representing 5 percent of the world market,” according to the U.S. Department of Energy. “CdTe thin-film solar cells can be manufactured quickly and inexpensively, providing a lower-cost alternative to conventional silicon-based technologies.”

Due to the low cost of cadmium telluride solar cells, coupled with being less affected by dust, shading and high temperatures, this emerging technology is nabbing larger shares of the solar market.

Driven by the solar market, U.S. imports of tellurium increased 41 percent to 230 metric tons during 2018, accounting for more than half of all known world production.

As a result of the increased demand, tellurium prices nearly doubled during the first half of 2018, from about US\$52 per kilogram at the onset to around US\$100/kg by mid-year. The price has since settled, and tellurium was selling for around US\$65/kg in early April of this year.

U.S. tellurium imports during 2018 came from Canada (66 percent), China (27 percent) and Germany (3 percent).

While U.S. tellurium production data is proprietary, it is estimated another roughly 60 metric tons was produced as a byproduct at one copper refinery in Texas.

In fact, almost all of the tellurium currently produced comes from copper refining and the USGS said this helps to reduce the geopolitical risks of sourcing this solar metalloid.

“Regardless, demands for tellurium, particularly as the global carbon footprint is reduced and solar energy technology becomes more widespread, are predicted to increase steadily over the next 15 to 20 years,” USGS penned in its tellurium brochure. “The main concern surrounding tellurium supply is the question of whether or not global copper production can meet the growth in tellurium demand.”

Enormous quantities at Pebble

If developed into a mine, the Pebble deposit in Southwest Alaska has the potential to provide an enormous domestic supply of tellurium.

While there has never been an official calculation of how much tellurium is contained within the Pebble deposit, there are indications that it is sizable. Work completed in 2013 estimates that 2.5 to 3 percent of the more than 100 million ounces of gold identified at Pebble is hosted in telluride minerals. This gold carrying telluride, in turn is hooked to chalcopyrite, which is the main copper ore mineral at

the Pebble deposit.

“The majority of what is conjectured to be an enormous tellurium endowment at the Pebble deposit is potentially hosted in the structure of chalcopyrite and pyrite,” USGS wrote in a 2017 report on minerals critical to the United States.

If these sulfide minerals contain telluride concentrations similar to other porphyry deposits, which provide much of the byproduct tellurium produced in the United States and the world, USGS said this could add up to a very large amount of this increasingly important metalloid within the Pebble deposit.

As such, whatever facility refines the copper concentrates from a future mine at Pebble could likely also produce tellurium.

Besides porphyry copper deposits such as Pebble, tellurium is found almost anywhere you find gold in Alaska.

In fact, tellurides are among the suite of minerals geologists look for when exploring for the large intrusion-related gold deposits Alaska’s famed Tintina Gold Belt has become renowned for.

For the most part, these large deposits, such as Fort Knox near Fairbanks and Donlin Gold in Southwest Alaska, do not have economically viable concentrations of this critical metalloid.

High-grade orogenic gold deposits in Southcentral and Southeast Alaska, such as those found in the Willow Creek District north of Anchorage and Kensington Mine north of Juneau contain abundant telluride minerals.

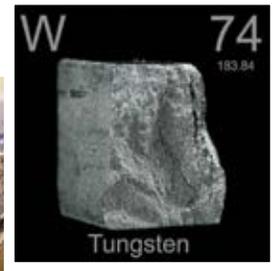
Tellurium, though, is seldom considered an economic byproduct from this type of mine globally and only two mines on the planet produce this critical metalloid as primary commodity.

So, the world will likely lean on porphyry copper mines such as the one Northern Dynasty Minerals Ltd. hopes to develop at its Pebble deposit in Southwest Alaska for futures supplies of the tellurium that is expected to be needed to produce solar electricity in the coming years.

Cadmium telluride panels being produced by First Solar are driving up the demand for tellurium.

FIRST SOLAR INC.





Tungsten carbide is used to make core drilling bits used by the mining industry, such as the Atlas Copco bit on the left. Diamond impregnated bits, such as the two on the right, however, are the most common choice for hard rock drilling.

MIKE WAI, CREATIVE COMMONS

China domination makes tungsten critical

Evidence of past production, promising prospects found across Alaska

By SHANE LASLEY

Mining News

EXTREMELY HARD AND WITH THE HIGHEST melting point of all the elements on the periodic table, tungsten is vital to a broad spectrum of commercial and military applications, yet there are no mines in the United States producing this durable metal.

Nearly 60 percent of the tungsten consumed in the U.S. during 2018 was used to make the cemented tungsten-carbide, a compound of approximately equal parts tungsten and carbon.

Roughly twice as strong as steel, tungsten carbide is often found on the working end of drill bits, saw blades, wear plates and other items that require this compounds toughness to meet some of the most demanding conditions in the mining, oil and gas, construction and metal-working industries.

Tungsten carbide's hardness, coupled with a very high density, also makes this metallic compound ideal for making armor-piercing ammunitions for the military.

Because it retains its strength at high temperatures, elemental tungsten is used in many high-temperature applications. Heating elements, rocket engine nozzles and TIG (tungsten inert gas) welding are among the many applications that take advantage of tungsten's ability to hold up to heat.

A past producer of the tungsten minerals, wolframite and scheelite, Alaska could once again provide America a domestic source of these and other critical minerals.

China dominates tungsten

Like many of the 35 minerals and metals deemed critical to the United States, China controls the new tungsten coming into global markets.

"World tungsten supply was dominated by production in China and exports from China," USGS penned in its annual report, Mineral Commodity Summaries 2019.

At around 67 million metric tons of tungsten, the Middle Kingdom accounted for roughly 82 percent of the global titanium supply during 2018. The world's second largest tungsten supplier, Vietnam, produced 6 million metric tons last year. Russia, Austria and the United Kingdom round out the world's top tungsten sources.

In recent years, China has put limitations on tungsten mining and exports of this durable metal, causing concerns about global supply of this metal.

"China's government regulated its tungsten industry by limiting the number of mining and export licenses, imposing quotas on concentrate production, and placing constraints on mining and processing," the USGS wrote.

This effort has put constraints on the availability of tungsten concentrates in China.

While China touts stronger environmental safeguards as one of the primary reasons for restricting the mining of tungsten, as well as a host of other critical metals, many analysts believe the government's motives have more to do with consolidating mining to the country's largest producers and bolstering prices.

Whatever the impetus, China's production and export restrictions resulted in sharp increases in the price. During 2018, tungsten averaged US\$330 per metric ton, a 35 percent increase over the US\$245 per metric ton average the year before.

China also happens to be the largest consumer of tungsten, making it a major influencer on the demand side of the price equation.

"Beginning in 2017, economic conditions improved in China and elsewhere, resulting in increased tungsten consumption," USGS penned in its 2019 commodity summaries. "In early to mid-2018, prices of tungsten concentrate and downstream tungsten materials trended upward and then stabilized or decreased during the remainder of the year."

The United States consumed roughly US\$900 million worth of tungsten during 2018, more than half of which came from foreign sources.

China, America's largest source of tungsten products, accounted for 32 percent of imports. Bolivia (9 percent), Germany (9 percent) and Canada (8 percent) were also contributors to U.S. needs for this durable metal.

Tungsten mining around Fairbanks

While there is not any tungsten produced in the United States today, this hard, industrial metal has been historically mined in several locations across Alaska.

The gold-rich hills around Fairbanks, in the heart of Alaska's Interior, is one of the past producing tungsten regions.

In 1915, Balkan immigrant Mike Stepovich discovered hardrock tungsten mineralization on the eastern flank of Gilmore Dome about 15 miles northeast of Fairbanks, which is near Kinross Gold Corp's currently producing Fort Knox gold mine.

Over the ensuing three years, Stepovich and his crew dug more than 2,000 feet of underground workings and produced 300 tons (600,000 pounds) of high-grade tungsten ore averaging 8 percent tungsten and 10 tons of concentrates that averaged about 65 percent



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TIG (tungsten inert gas) welding is among the many applications that take advantage of tungsten's extremely high melting point.

tungsten trioxide.

With a substantial drop in tungsten prices at the end of World War I, however, Stepovich put a halt to his hardrock tungsten operations to resume mining the rich deposits of placer gold near Fairbanks, which is what drew him to Interior Alaska in the first place.

Stepovich's discovery, however, sparked interest in the regions tungsten potential.

"The scheelite deposits of the Fairbanks district are believed to be much more extensive than the surface outcrops show and to give promise of a large future production of tungsten," the USGS wrote in its 1917 report, "Mining in the Fairbanks District."

While this promise has yet to be fully realized, World War II rekindled interest in the tungsten around Fairbanks. In 1942,



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Cleary Hill Mines Co. leased the properties covering the tungsten lode from Stepovich and produced another 43,920 pounds, or nearly 22 tons, of tungsten trioxide.

All of Cleary Hill Mines' World War II production was sold to the U.S. Government-owned Metals Reserve Company.

Several other tungsten deposits and prospects were identified near Stepovich's discovery, including the Colbert lode, and Yellow Pup and Schubert prospects.

In the late 1970s and early 1980s, several tons of high-grade tungsten concentrates were shipped from Yellow Pup and un-milled ore was stockpiled there.

Exploring Circle, Fortymile districts

While the Fairbanks Mining District is a past producer of tungsten, it is not the only Interior Alaska mining district to host this critical metal.

"The Circle Mining District, including the Birch Creek area, has been known for years for its tin (cassiterite) and tungsten (wolframite and scheelite) minerals occurring in gold placer concentrates," James Barker penned in a 1979 U.S. Bureau of Mines report, "A trace element study of the Circle Mining District."

Barker's investigation found tungsten in most streams draining the Circle Hot Springs granitic intrusive, which is also the source of much of the gold in the heart of the Circle Mining District.

Sampling in the Lime Peak and Mount

Incandescent light bulb filaments are another use that takes advantage of tungsten's ability to hold up to heat.



FREEGOLD VENTURES LTD.

Tungsten adds to Shorty Creek mix

Freegold Ventures Ltd. has found lode tungsten at its Shorty Creek property in the Livengood Mining District, about 70 miles north of Fairbanks.

Freegold discovered tungsten at Shorty Creek during its 2016 drill program to expand upon the porphyry copper-gold mineralization associated with a large magnetic high geophysical anomaly at the Hill 1835 target on the property.

SC 16-01 cut 207 meters averaging 0.045 percent tungsten trioxide; and SC 16-02 cut 409.6 meters averaging 0.03 percent tungsten trioxide.

Follow-up drilling last year continued to cut long sections of tungsten mineralization at Hill 1835, as well as the copper, gold, silver and cobalt also found at Shorty Creek.

Drilled about 200 meters southwest of the 2016 intercepts, hole SC 17-01 cut 360 meters averaging 0.24 percent copper 0.07 g/t gold, 4.04 g/t silver, 100 parts per million cobalt and 0.03 percent tungsten trioxide.

SC 17-02, drilled in the same area, cut 408 meters averaging 0.27 percent copper 0.05 g/t gold, 4.97 g/t silver, 85 ppm cobalt and 0.05 percent tungsten trioxide.

Hole SC 17-03, which was lost at a depth of 362.2 meters in strong mineralization due to mechanical difficulties, cut 105.2 meters averaging 0.27 percent copper, 0.05 g/t gold, 6.75 g/t silver, 114 ppm cobalt and 0.06 percent tungsten trioxide on the eastern edge of the magnetic high at Hill 1835.

One hole drilled at Steel Creek, another large magnetic anomaly about 1,500 meters northeast of Hill 1835, also encountered copper, gold, silver, cobalt and tungsten. While the mineralization was only anomalous, this first hole drilled into the target provides evidence of the larger prospectivity across the road accessible property.

The mix of base, precious and critical minerals at Shorty Creek has drawn the interest of Australian major South32 Ltd., which has agreed to invest up to US\$10 million to this property over the next four years.

Friendliest tungsten ghost town

Interior is not the only region of Alaska to produce tungsten. During World War II this critical industrial metal was also extracted from the zinc-lead-copper concentrates produced from the Riverside Mine in the Hyder District of Southeast Alaska.

Located just across the border from Stewart, a British Columbia mining town at the southern tip of the Canadian province's famed Golden Triangle, the Hyder District experienced a boom of mining activity in the 1920s. While most mining in this region at the southern end of the Southeast Alaska panhandle faded in the 1930s, the Riverside Mine was revived in 1940.

Records show that 70,000 lb (35 tons) of tungsten, 3,000 oz of gold, 100,000 oz of silver, 100,000 lb of copper, 250,000 lb of lead and 20,000 lb of zinc was recovered from 30,000 tons of ore mined at Riverside.

At least six prospects – Last Shot, Mountain View, Fish Creek, Blue Bird, Monarch and Last Chance – have been identified across a 1.5- by three-mile area near the Riverside Mine, about 5.5 miles north of the town of Hyder.

While mining and mineral exploration is prolific around Stewart, there has been virtually no mining in the Hyder District just across the Alaska-B.C. border since the closing of the Riverside Mine.

The roughly 87 residents of Hyder embrace this disparity with the motto “the friendliest ghost town in Alaska.”

Large, inaccessible Bear Mountain

The largest deposit of tungsten in Alaska, however, may lie in the

In addition to copper and gold, Freegold Ventures' Shorty Creek property in Interior Alaska also hosts intriguing quantities of tungsten and cobalt.

Prindle areas west of the intrusive also turned up tungsten and tin mineralization.

While the load source of tungsten in the Circle Mining District has not been identified, a sample of fresh granite collected by Barker at the upper end of Bedrock Creek, a stream known for its heavy tin mineralization, returned 22 parts per million tungsten, 20 ppm tin, as well as gold and molybdenum.

“Minable deposits of placer tin-tungsten minerals may exist in the Circle Mining District,” Barker concluded.

The Fortymile Mining District, situated just across the border from Yukon's famed Klondike District, also has some interesting tungsten occurrences.

Doyon Ltd., an Alaska Native corporation representing 19,000 shareholders that have called Alaska's Interior home for millennia, owns tungsten prospective lands in the Fortymile.

These prospects, Duval Creek and Happy, were identified during investigations of the area in the 1970s.

Anomalous tungsten was discovered in stream-sediment and heavy-mineral concentrates in Duval Creek on what is now Doyon land during reconnaissance sampling in 1978.

Scheelite and molybdenite were discovered at Happy, located near Duval Creek, around the same time. Float boulders of quartz veins collected at Happy contained as much as 0.82 percent tungsten and 0.3 percent molybdenum.

These hints of tungsten add to the future potential of the Circle and Fortymile mining districts, regions of Interior Alaska that have produced some 2 million oz of placer gold.

Bear Mountain occurrence along the southern slopes of the Brooks Range.

During visits to Bear Mountain in the 1980s, Barker and fellow U.S. Bureau of Mines geologist R.C. Swainbank identified a 100-acre area of surface mineralization indicative of a large porphyritic molybdenum-tungsten deposit.

Analysis of 20 soil and 36 rock samples collected during 1985 returned abundant tungsten and molybdenum along with lesser amounts of niobium.

Soil samples collected over roughly 75-acres returned tungsten values of more than 500 parts per million wolframite, with the best samples containing 5,000 ppm of this tungsten mineral.

“I believe Bear Mountain to be likely the most important tungsten deposit in the U.S.,” Barker told Mining News.

The potential of this intriguing tungsten-molybdenum discovery, however, may never be realized due to its location.

In addition to being located in a remote region of northeast Alaska, this potentially world-class tungsten-molybdenum deposit is situated within the Arctic National Wildlife Refuge, or ANWR, a 19.3-million-acre region set aside for wilderness and wildlife conservation.

“It’s a shame that mineral evaluations aren’t done before we place an area off limits,” Barker reflected.

Rediscovering the Lost River Mine

While Bear Mountain may host the largest deposit of tungsten in Alaska, the Lost River skarn on the Seward Peninsula about 80 miles northwest of Nome likely holds the most promise for developing a tungsten mine in the state.

The significant amount of tin found in the aptly named Cassiterite Creek led early miners and prospectors to the Lost Creek deposit around 1902 and small-scale underground mining began there shortly after the discovery.

At the time, the tin found in this deposit was the target of mining. The tungsten, fluorite (or fluorspar) and beryllium also found there – all currently considered minerals critical to the United States – were largely ignored.

This mix of metals drew the interest of Lost River Mining Company, which planned to develop a mine there in the 1970s.

In preparation for developing a mine, roughly 16,100 meters of drilling in around 110 holes were drilled there at the time.

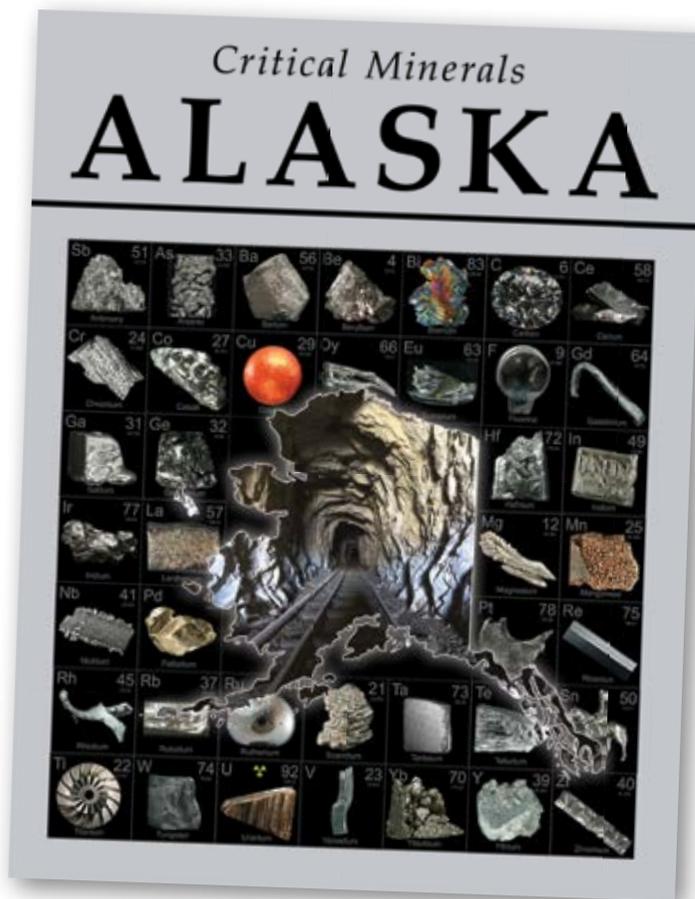
Based on this drilling, it was estimated that the Lost River skarn deposit hosts some 23.53 million short tons of resource averaging 16.43 percent fluorite, 0.26 percent tin, and 0.04 percent tungsten trioxide that could be mined by open pit methods; and 1.28 million tons of 11.66 percent fluorite, 0.15 percent tin, and 0.01 percent tungsten trioxide considered more suitable for underground mining.

According to this historical estimate, the surface minable portion of the Lost River deposit hosts 18.84 million lb of tungsten, 7.7 billion lb of fluorite and 122 million lb of tin.

Beryllium is also reported to be associated with this deposit but is not reported as a resource due to the difficulties recovering it.

Geologists familiar with Lost River, however, caution that further work needs to be done to shore up the historical estimate due to the spatial and mineralogical complexities of the deposit.

Considering the tungsten, fluorite, tin and beryllium found there – all considered critical to America’s economic and strategic security – finding out just how much of these metals the Lost River deposit contains may well be worth the effort.



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