



EXPLORE & DISCOVER

A CORPORATE NEWSLETTER

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Who is Big Rock Exploration?

Big Rock is an international technical consulting company based out of Minneapolis, Minnesota. We specialize in natural resources including metals, minerals and energy.



What does Big Rock do?

Big Rock is focused on identifying, exploring and evaluating mineral and other natural resources. Our vast network of geoscientists, project managers, GIS professionals and field technicians provides clients with reliable expertise for all kinds of natural resource projects.

We focus on tailored project solutions for our clients by offering diverse and professional technical services.

EXPLORE OUR SERVICES

Let's get in touch!

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-  1620 Central Ave NE #104
Minneapolis, MN 55413

Note From The Corner Office

THE NEXT LEAP FORWARD

By **Brian Lentz**, Principal & Vice President of Big Rock Exploration

Welcome to the Big Rock quarterly newsletter where we feature what is happening within our company, examine relevant technical concepts and highlight news about various natural resources industries.

In this issue, we further explore strategic minerals with an in-depth look at cobalt - deemed a *critical* strategic mineral resource for most of the world, especially North America. Cobalt is a strong magnetic metal vital to the fast-growing battery industry and is also a crucial component to the renewable energy, national defense and aerospace industries. Cobalt is largely a conflict mineral produced in central Africa with minimal labor and environmental regulations. Conflict cobalt is a real issue for companies who rely on it for growth and innovation in their products. We also explore structural mapping techniques that aid in highly sophisticated exploration strategies. High-level training of this indispensable field skill at universities has slowly diminished even though innovation in structural mapping is now heavily relied upon by companies exploring for new deposits and resources.

Coming out of a busy first quarter and conference season, there has been a swell of positivity and planning for exploration activities within the mineral industry for both industrial and metal resources. Although there is plenty of cautious optimism, many projects are still working with lean budgets while investment capital slowly trickles in.

Big Rock sees the mineral industry taking a leap forward to explore new ideas and concepts as companies expand their efforts to find the next project portfolio. Our group was electrified by the positive and upbeat vibes from the major conferences including Vancouver Roundup (Jan), SME National (Feb) and PDAC (Mar). We are excited to foster this positivity through our clients as we help them explore and bring them closer to the next big discovery!

Cheers,



Where was Big Rock in 2017-2018?



Strategic Minerals

THE CRITICAL STATE OF COBALT

By **Aubrey Lee**, Project Geologist, Big Rock Exploration

Global demand for cobalt has dramatically jumped in the last 20 years due to the ubiquity of smart phones and electric vehicles. More than half of the world's cobalt supply is mined in central Africa in the Democratic Republic of Congo (DRC) – a geopolitically unstable country with poor infrastructure, social unrest, and rampant corruption. Many companies are wary of using cobalt sourced from DRC and have pushed for more availability of conflict-free cobalt. Most of the world recognizes cobalt as a *critical* strategic mineral because of these supply issues and the lack of resources in more stable regions.



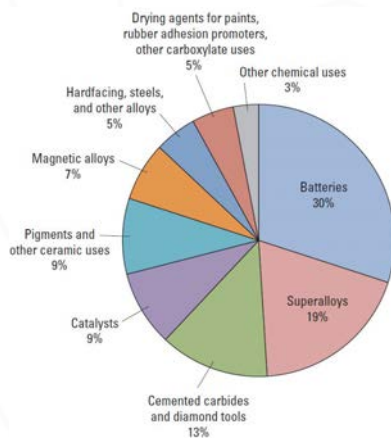
DIG DEEPER:
How we define 'Strategic' and 'Critical' minerals

Strategic minerals are important for our economy and national security.

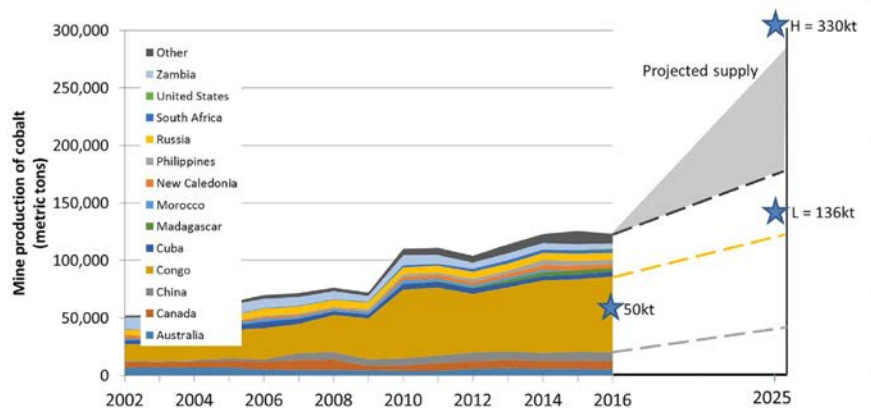
Critical minerals are the most important strategic minerals & subject to supply issues.

READ MORE

The status of cobalt in the United States is particularly *critical*. Historically used in steel alloys and pigments, the utility of cobalt has diversified in recent years to optimize the performance of superalloys, cemented carbides, and rechargeable batteries. The metal is essential to the green energy revolution and United States national security.



Cobalt's diverse uses make it essential to the green energy revolution and United States national security. Chart from USGS (2017).



While most producers remained consistent, the world supply of cobalt has fluctuated due to conditions in the Congo and advances in technology. Stars indicate global demand and show that supply may not meet demand by 2025. Graph from Joule (2016).

Today, the US consumes half of its cobalt in the chemical and ceramics industries and the other half in manufacturing superalloys and cemented carbides. Natural resource production of cobalt within the US is dismally scarce and includes only the Stillwater mine in Montana and the Eagle mine in Michigan where it is a by-product of nickel mining (USGS, 2017). In 2016, the US produced only 4.5% of its consumed cobalt, recycled 17.5%, and imported a whopping 78% from other countries. Most of these imports came from refineries in China which source most of their raw cobalt ore from DRC. North American manufacturers are now trying to work with miners for a direct source of the metal to avoid conflict cobalt.

There is also mounting positivity in the mining sector to explore and produce cobalt in North America. Over 0.6 million tons of cobalt lie within Minnesota's Duluth Complex – a high-tonnage low-grade magmatic nickel-sulfide deposit in the state's northern arrowhead region (USGS, 2017). Miners have been exploring here for decades and the region is forecasted to be producing in the next few years. Additionally, cobalt resources in Idaho and Ontario are strategically poised to supply North America with conflict-free cobalt for years to come. Finally, with the development of deep-sea mining technology, seafloor nodules and crusts may become a viable resource.

To relieve the US of our dependency on China and DRC for our supply of the critical mineral, innovative solutions for domestic metal resources are crucial. North America must expand awareness of the criticality of cobalt, revive exploration for undiscovered cobalt deposits, and improve mining and recycling techniques to protect our infrastructure, security, and lifestyle.

1. Critical Mineral Resources of the United States - Economic and Environmental Geology and Prospects for Future Supply: Cobalt, Slack et. al., United States Geological Survey (USGS), 2017
2. Lithium-Ion Battery Supply Chain Considerations: Analysis of Potential Bottlenecks in Critical Metals, Olivetti et. al., Joule Magazine, 2016

Geologic Mapping

STRUCTURAL GEOLOGY IN MINERAL EXPLORATION

By Eric Nowariak, Project Geologist, Big Rock Exploration

Structural geology is often the key to understanding and unlocking the geological history of a region. Published geological maps are created with a focus on grouping rock types with similar lithologies and age relationships describing **What?** is there. The questions of **Where?** and **When?** can often be addressed by careful observation of structural features and cross-cutting relationships to constrain relative ages of mineralization and rock units as well as predicting offset along faults.

Geologic mapping is the first step in evaluating an area's mineral potential. Mapping attempts to answer three simple questions:

- *What is there?*
- *Where is it?*
- *When did it happen?*

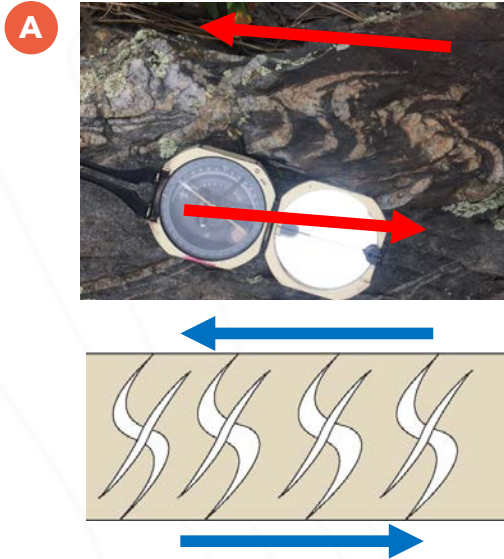


Photo A shows an outcrop and figure of sheared/rotated gash fractures with relative movement directions. Photo B shows a rock with multiple deformational fabrics demonstrated.

Photo credits: Big Rock Exploration, LLC

Many orebodies are hosted in complicated geologic terranes and require high-quality geologic mapping and structural analysis to constrain ore genesis and geometry. This information compiled with additional data such as geochemistry, geophysics, and subsurface analysis is critical for vectoring to mineral resources. Geologic structures including faults, shear zones, and folds act as both pathways and traps utilized in transporting and concentrating mineralizing fluids in mineral deposit systems.

As part of the description of structures and deposits, close and careful analysis of fault kinematics and fold geometry can predict general deposit geometries. In vein deposits hosted in fault zones and shear zones, orebodies are found in local dilations along the fault plane, elongated perpendicular to the direction of fault movement. In the case of stratiform deposits, structural thickening in hinges of folds can concentrate mineralizing fluids and illustrate how an orebody was displaced or modified. Fault kinematics and fold geometry can also give clues to how an orebody was displaced or modified.

Another important consideration in evaluating mineral prospectivity of an area is the extent and scale of geologic structures. The formation of mineral deposits requires a plumbing system of faults or permeable rock capable of large fluxes of mineralizing fluids. In many cases, this means the presence of large crustal scale faults with protracted episodes of deformation or large continental sedimentary basins. Exploration geologists use the structural information gleaned from geologic mapping and kinematic analysis to explore for deposits at scales ranging from district scale prospecting and targeting to property scale resource definition.

An intimate understanding of the structural geology is required to successfully explore for mineral deposits. Big Rock brings sound interpretation and an in-depth knowledge of structural geology to all projects it is involved with.

Big Rock: In The Field

FIELD MAPPING FOR GOLD

By **Robert Bergmann**, President, Big Rock Exploration

With advancing technologies and cyclical markets, the number of geologists that maintain advanced field mapping skills seems to be on the decline. Though this experience is dwindling, the need for this skill remains extremely valuable as deposits become more challenging to discover.

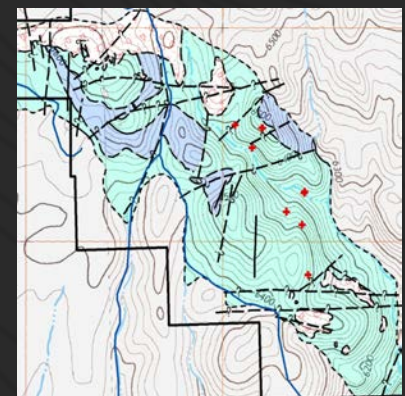
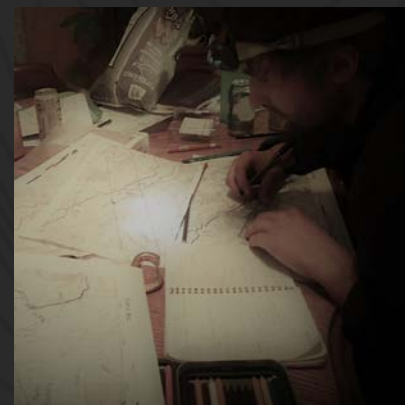
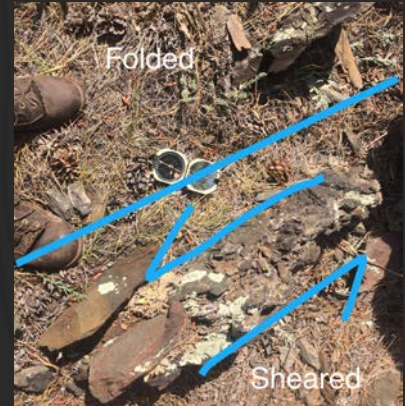
Maps and geospatial data analysis are the foundation of mineral exploration programs worldwide and it is vital to recognize the importance quality field mapping has on the continuum of prospect development. Big Rock is highly experienced in geologic and structural field mapping and we provide turnkey products through robust digital data compilation. These tools have provided a large number of our clients the toolkit needed to hone in on their next big discovery!

A private gold exploration company hired Big Rock to develop a detailed geologic mapping and sampling program for one of their Greenfields (early-stage) gold targets in North America. They requested Big Rock supply turnkey services including; planning, budgeting, logistical management, boots on the ground, database construction, and final digitized products. They required experienced geologic mappers with an acute focus on structure, alteration, mineralization and lithology.

With marching orders in hand, Big Rock developed a robust plan and began executing. We collected over 2,000 rock samples, 4,000+ structural points, and mapped in over 1,000 outcrops. Once the field work was completed, the team constructed a robust ArcGIS database to house all related mapping data and allow for simultaneous interpretation of multiple datasets. Digitization of field maps, and combined with sound database management resulted in a much more detailed geologic model for the region.

Upon completion of the project, Big Rock provided the client with all data, maps, and a detailed report of the work and results. The final map products included a detailed structural, lithologic and alteration maps of the property as well as in-depth geochemical data overlays of all rock samples collected. Furthermore, Big Rock developed mineralization potential maps that utilized fuzzy logic modeling of all available datasets and the impact they may have on mineralization.

The client was able to hone in on new areas of interest within their Greenfields properties and acquire additional claims to advance toward discovery! Big Rock continues to support this program as a turnkey operator supplying all levels of technical development



The images above represent a progression from basic boots on the ground field work to a final map product. In the top photo, data is gathered from rocks in the field, then compiled and processed by BRE geologists as seen in the middle photo, and finally used to produce a robust regional map as shown in the bottom image.

MEET GABRIEL SWEET



Gabriel Sweet

Senior Geologist

PERSONAL HIGHLIGHTS

EDUCATION

MSc Economic Geology

Lakehead University, Thunder Bay, ON - 2011

B.A. Geology

Macalester College, Saint Paul, MN - 2007

EXPERIENCE

Rift-related magmatic Ni-Cu-PGE sulfide systems
Island arc porphyry Cu-Mo-Au systems
Project & data management
Exploration & infrastructure permitting & coordination

CERTIFICATIONS

Explorer Responsible Individual
(MN Dept. Health - No 2992)
40HR HAZWOPER

YEARS OF EXPERIENCE

8 years



gabe@bigrockexploration.com



Gabriel Sweet

Photo courtesy of Critical Minerals Alaska, LLC

"Big Rock embodies the new generation of technical field geologists actively building a name for themselves."

- Gabriel Sweet

Gabe grew up in the greater Boston, MA area and migrated to the Midwest in 2003, eventually calling Duluth, MN home in 2010. He earned a BA in Geology from Macalester College and attended the Precambrian Research Field Camp (2007) in northern MN.



He completed a MSc in Economic Geology from Lakehead University, examining the evolution of arc magmatism with respect to porphyry development in the northern Philippines.

Gabe's academic focus in igneous petrology and magmatic mineralizing systems served him well as a project geologist from 2010-2014 exploring for Ni-Cu-PGE mineralization in the Duluth Complex of northeastern Minnesota.

Since joining the Big Rock team in May 2017, Gabe has worked in a variety of mineral commodities including gold, copper, molybdenum, silver, nickel and PGEs. As a Senior Geologist, he currently provides support for Big Rock's variety of client and internal projects, focusing on management and oversight, permitting and regulatory coordination, and data handling.

In his free time, Gabe enjoys hiking, camping, wood working, music, sharing his passion of geology, and spending time with his family.

"Gabe brings years of diverse experience combined with deep passion for geology and problem solving. These attributes are vital in leading successful projects. His diligence shines through in everything he contributes to our team, clients and projects!"

*-Rob Bergmann,
Big Rock Exploration Co-Founder and President*

Rocks In The News

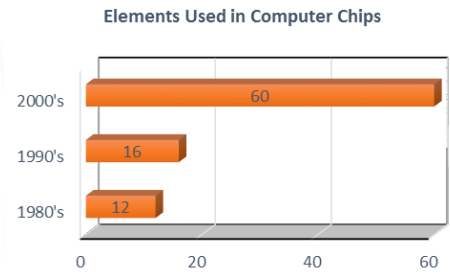
GEOLOGY MAKING HEADLINES

Critical Minerals Of The United States

23 Minerals You Need In Your Life

December 19, 2017, USGS.gov

"In this new volume, entitled Critical Minerals of the United States, USGS geologists provide the latest and greatest on the geology and resources of 23 mineral commodities deemed critical to the economy and security of the United States. This work is meant to provide decision-makers, researchers, and economists with the tools they need to make informed choices about the mineral mix that fuels our society."



Graphic credit: Big Rock Exploration, LLC

[READ FULL STORY](#)

How To Get Diamonds From The Bottom Of A Frozen Lake

March 07, 2018, Rio Tinto

"The best night shifts are when I see the Northern Lights," says Branwen Price as she looks beyond the frozen lake, the icy home of diamonds.

"Branwen is a mine engineering graduate with Rio Tinto and is one of 1,000 shift workers at Diavik Diamond Mine in the Barren Lands of Canada's Northwest Territories, 220 kilometres south of the Arctic Circle. But these lands are not truly barren."



Graphic credit: Diavik Diamond Mines, Lac De Gras, Rio Tinto

Big Rock is proud to be a part of this innovative project

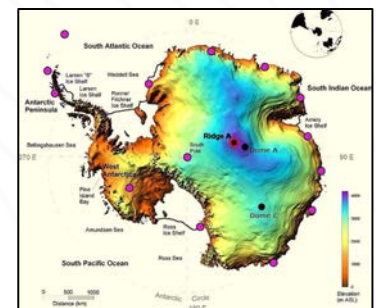
[READ FULL STORY](#)

Astronomers Have Found Their Paradise, And It's The Coldest And Most Remote Point In Antarctica

Jacco van Loon, March 11, 2018, The Conversation

Antarctica. The name evokes images of bitter extremes, an environment unkind to humans. Stories of polar explorers battling with the weather and perishing on their way back to safety. Why would astronomers choose to go there?

To get the best views of space, space itself is the best place to be. Here on Earth, one can escape the grip of our zest for luminescence and seek out a remote corner of the world where nights are still black except for the distant stars. Or one can climb a mountain, to leave below much of the bubbly air that blurs images of space, and especially humid air that blocks our view of space altogether.



Graphic credit: HEAT / University of Arizona, Steward Observatory

[READ FULL STORY](#)

EDUCATION AND OUTREACH



SME 91st ANNUAL MEETING, CONFERENCE & EXPO

February 25 - 28, 2018
Minneapolis, MN USA

The Society for Mining, Metallurgy & Exploration (SME) is dedicated to all disciplines of mining engineering. SME's Annual Meeting, Conference and Exposition was held the last week of February right here in Minneapolis. SME is the preeminent and largest annual mining convention in the U.S., drawing professionals from all over North America to participate in technical sessions, field trips, short courses, networking, and the expansive exhibit hall.

February 25 - 28, 2018 This year, Big Rock project geologist Chris Nicosia spoke during the technical session "North American Exploration Geology." His talk, titled "Mineral Potential Modeling: Knowledge-Driven vs Data-driven Models for Regional Exploration" discussed two common methods used to produce mineral prospectivity maps; a data-driven method called weights of evidence, and a knowledge-driven method known as fuzzy logic modeling.

Big Rock also hosted a reception during the conference to catch up with new and old colleagues, geologists, miners, academics and industry professionals. We organized a raffle to raise money for geology undergraduates who need help paying for geology field camp. These proceeds will be dedicated to training students in field related geology techniques supplying the industry with a future qualified workforce.

Source: www.smenet.org

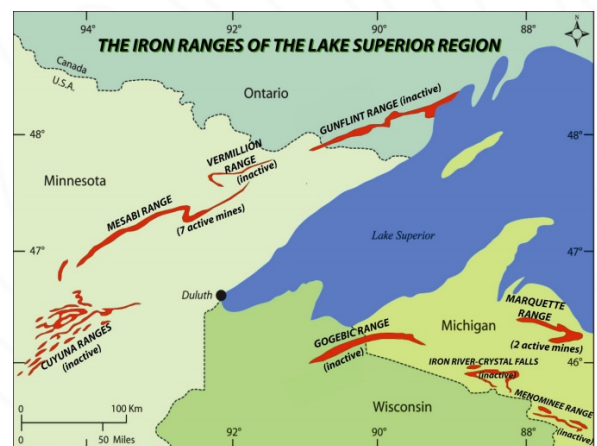
MESABI RANGE GEOLOGICAL SOCIETY MONTHLY MEETING

February 21st, 2018
Duluth, MN USA

The Mesabi Range Geological Society (MRGS) is an organization of geoscience and mining professionals in the arrowhead region of northeastern Minnesota who gather monthly to discuss topics pertaining to the region.

Big Rock senior geologist Leif Johnson spoke at an MRGS meeting in February. His talk, titled "Thar be Fe & Mn in 'dem dar hills! A Mining History, geology, and critical minerals of the Cuyuna Iron Range", addressed the history of the lesser-known Minnesota iron range and its regional geology.

Leif focused on manganese; a mineral on the USGS list of critical mineral resources. The Cuyuna Iron Range is one of the largest known domestic manganese deposits, but under current market conditions is largely uneconomic to develop.



Source: <https://groups.google.com/forum/#!forum/mesabi-geology>