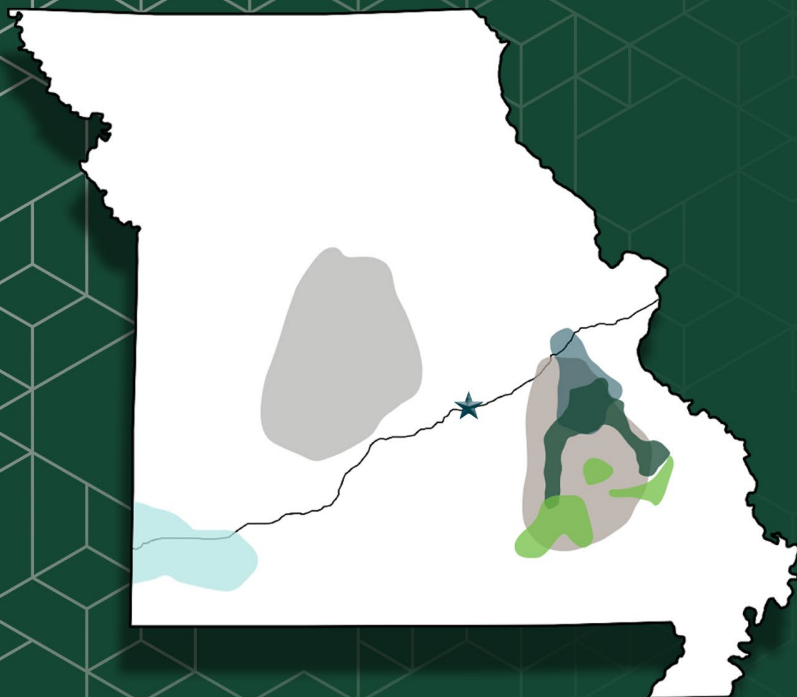




MISSOURI
S&T

Summary Report: 4th Annual National Workshop: Resilient Supply of Critical Minerals

August 7-8, 2024

Rolla, Missouri

Hosted by Missouri University of Science and Technology
criticalminerals.mst.edu

Cover: Known critical mineral distribution in the state of Missouri. Data courtesy of the Missouri Department of Natural Resources, PUB2912. <https://dnr.mo.gov/document-search/other-critical-minerals-missouri-pub2912/pub2912>

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Acknowledgements and Disclaimer

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The findings presented in this report are based on discussions during the workshop, i.e., presentations and breakout sessions. The views and opinions presented here do not necessarily reflect those of the workshop organizers who prepared the report.

Preferred Citations

Summary Report

Locmelis, M., Clark, S., Swain, R. (2024): Summary Report: 4th Annual Workshop on Resilient Supply of Critical Minerals, 7-8 August 2024, Missouri University of Science and Technology, Rolla, Missouri, USA, 20 pages.

Individual Abstracts (example)

Grant, A. (2024): How ‘Just’ are Mineral Supply Chains in the Just Energy Transition? Insights from the Democratic Republic of Congo. In: Locmelis, M., Clark, S., Swain, R. (2024): Summary Report: 4th Annual Workshop on Resilient Supply of Critical Minerals, 7-8 August 2024, Missouri University of Science and Technology, Rolla, Missouri, USA, 20 pages.

Executive Summary

On August 7-8, 2024, the Thomas J. O’Keefe Institute for Sustainable Supply of Strategic Minerals at Missouri University of Science and Technology (Missouri S&T) hosted the fourth annual workshop on ‘Resilient Supply of Critical Minerals’. The workshop was funded by the National Science Foundation (NSF) and was attended by 212 participants. 143 participants attended the workshop in-person in the Havener Center on the Missouri S&T campus in Rolla, Missouri, USA. Another 69 participants attended online via Zoom. Twenty participants (including 12 students and 4 early career researchers) received travel support through the NSF grant to attend the conference in Rolla.

Out of the workshop 212 participants, 199 stated their sectors of employment during registration showing that 88 participants were from academia (34 students), 58 from the private sector and 53 from government agencies. The workshop was followed by a post-workshop field trip to US Strategic Minerals (formerly Missouri Cobalt) in southeast Missouri that was attended by 18 workshop participants from academia (n=11; including 4 students) and the private sector (n=7).

Four topical sessions were covered during the workshop:

- A. The Critical Mineral Potential of the USA: Evaluation of existing, and exploration for new resources.
- B. Critical Minerals Workforce Development: How to grow the US critical minerals workforce.
- C. Critical Mineral Processing and Recycling: Maximizing critical mineral recovery from existing production streams.
- D. Critical Mineral Policy and Supply Chain Economics: Reshoring critical mineral production.

The topical sessions were composed of two keynote lectures and complemented by oral and poster presentations by the workshop participants, as well as a 30-minute open discussion at the end of each topical session. Breakout sessions that concluded each day discussed:

- Can mining lead the new materials future?
- Critical minerals research: where to go from here?
- Should the Bureau of Mines be restored?

Discussions during the workshop highlighted, for example, that:

- (i) Mining companies need to better address downstream needs and develop company cultures inclusive of younger generations;
- (ii) Although funding opportunities over the past year’s started to make a difference for critical minerals supply chain resilience, additional funding that is aimed at strengthening academia – private sector partnerships as well as international collaborations is needed to ensure a long-term impact;
- (iii) The majority of participants would welcome the reestablishment of the Bureau of Mines, although no consensus was reached on its potential responsibilities.

This workshop report provides a detailed summary of the workshop demographics and discussions.

1. Introduction

On June 4, 2019, the U.S. Department of Commerce released the strategic report “A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals”. The report outlines six Calls to Action designed to reduce the vulnerability of the United States to critical mineral supply disruptions. These six Calls to Action are:

1. Advance Transformational Research, Development, and Deployment Across Critical Mineral Supply Chains.
2. Strengthen America’s Critical Mineral Supply Chains and Defense Industrial Base.
3. Enhance International Trade and Cooperation Related to Critical Minerals.
4. Improve Understanding of Domestic Critical Mineral Resources.
5. Improve Access to Domestic Critical Mineral Resources on Federal Lands and Reduce Federal Permitting Timeframes.
6. Grow the American Critical Minerals Workforce.

In 2020, the Thomas J. O’Keefe Institute for Sustainable Supply of Strategic Minerals at Missouri University of Science and Technology (Missouri S&T) received funding from the National Science Foundation (NSF) to host a workshop on the Missouri S&T campus (Rolla, Missouri) to identify research needs associated with these Calls to Action. Initially scheduled for May 2020, the in-person workshop was cancelled because of the global COVID-19 pandemic. Consequently, the format of the workshop was changed to a two-part virtual workshop series. The first virtual workshop was conducted on August 2-3, 2021, via Zoom. The second virtual workshop was conducted on August 4-5, 2022, also via Zoom. A third NSF-funded hybrid in-person and online workshop was held on August 9-10, 2023.

The fourth NSF-funded workshop on Resilient Supply of Critical Minerals was held on August 7-8, 2024. The workshop was held in-person in the Havener Center on the Missouri S&T campus in Rolla, Missouri. Online participation via Zoom was offered to participants who could not travel to Rolla. The workshop was followed by an optional field trip to US Strategic Metals (formerly Missouri Cobalt) an emerging producer of cobalt and nickel from secondary materials (e.g., mine tailings and recycled batteries) in Fredericktown, Missouri.

Previous workshop reports and recordings of presentations are available through the workshop website: <https://sites.mst.edu/criticalmineralsworkshop/>.

2. Workshop Content

The 2024 workshop was divided into four topical sessions that discussed pressing critical mineral research needs as identified by participants during the preceding workshops:

Session A: The Critical Mineral Potential of the USA: Evaluation of existing, and exploration for new resources.

Keynote Lectures:

- **Nedal Nassar (United States Geological Survey):** Quantifying the impact of mineral commodity supply disruptions on the U.S. economy.

- **Cheryl Seeger (Missouri Geological Survey):** The Missouri Geological Survey and Earth MRI: Critical Minerals at the State Level.

Session B: Critical Minerals Workforce Development: How to grow the US critical minerals workforce.

Keynote Lectures:

- **Leigh Freeman (Leigh Freeman Consultancy):** Critical Minerals Workforce Development – Hiring Strategies.
- **Carey Bridges (Missouri Geological Survey):** Critical Minerals Workforce Development at a State Geological Survey – Recruitment and Retention.

Session C: Critical Mineral Processing and Recycling: Maximizing critical mineral recovery from existing production streams.

Keynote Lectures:

- **Sarah Schwarz (Nyrstar):** The Nyrstar Clarksville Critical Minerals Project.
- **Michael Free (University of Utah):** Low-Cost Extraction and Recovery of Critical Minerals from Low Grade Resources.

Session D: Critical Mineral Policy and Supply Chain Economics: Reshoring critical mineral production.

Keynote Lectures:

- **Beia Spiller (Resources for the Future):** Community engagement and social justice in mining.
- **Andrew Grant (Queen’s University):** How ‘Just’ are Mineral Supply Chains in the Just Energy Transition? Insights from the Democratic Republic of Congo.

Keynote lectures were followed by oral presentations of attendees and a 30-minute open discussion session for each topical session. The oral presentations were complemented by a poster session (*cf.* Appendix 1: Workshop Schedule). Each day concluded with a breakout session that asked the participants the following questions: (i) Can mining lead the new materials future? (ii) Critical minerals research: where to go from here? (iii) Should the Bureau of Mines be restored? The findings of the breakout sessions are summarized in sections 4.

3. Workshop Demographics

The 2024 workshop was attended by 212 participants (Fig. 1-A). 143 participants attended in-person in the Havener Center on the Missouri S&T campus in Rolla, Missouri, USA. Another 69 participants attended online via Zoom. Twenty participants (including 12 students and 4 early career researchers) received travel support through the NSF grant to attend the conference in Rolla.

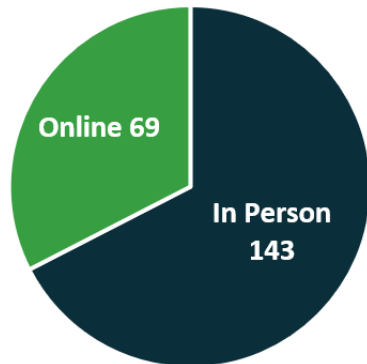
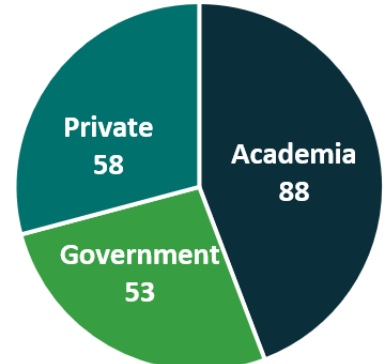
A In-Person vs Online Participation
n=212**B Participants by Sector**
n=199

Figure 1: Breakdown of workshop participants based on (A) In-person vs. online participation, and (B) Sector of employment. It is noted that only 199 out of the 212 workshop participants stated their sector of employment during the registration process.

199 Participants stated their affiliation during the registration process. Among these, 88 participants were from academia (34 students), 58 from the private sector, and 53 from federal- and state-level government agencies (Fig. 1-B). The majority of the 199 registrants who stated their affiliation were from the USA (187, 93.5%; Fig. 2). The remaining participants were from Canada (4), Chile (3), and one each from the following countries: France, India, Mongolia, Nigeria, and Switzerland. Within the United States, participants were from 30 states (Fig. 3). The distribution of participants from US states is shown in Fig. 3.

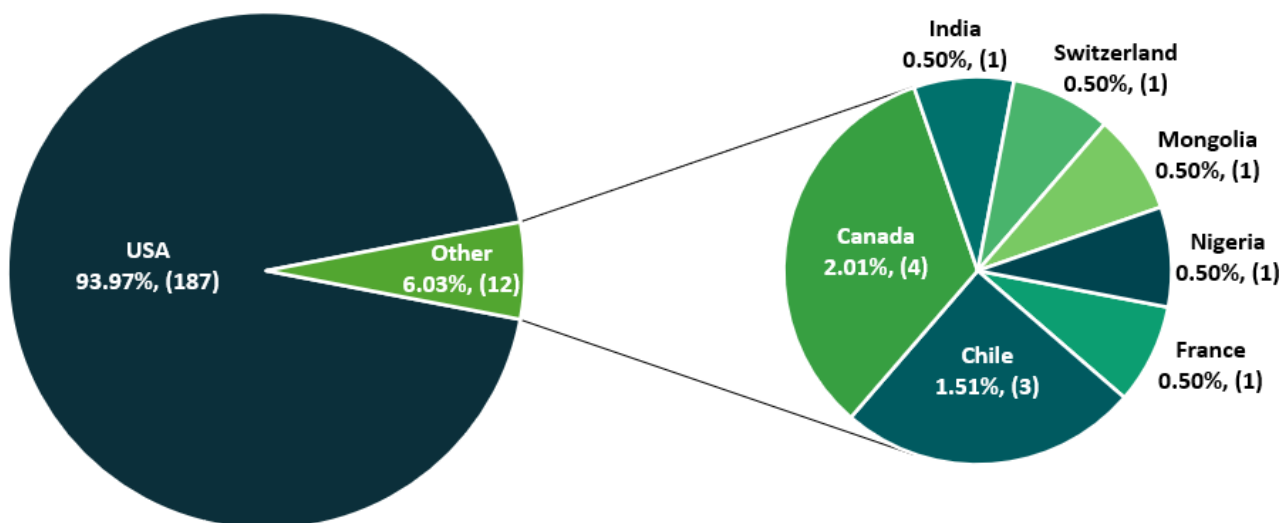
Participants by Work/Study Country
n=199

Figure 2: Workshop participants by country of residence. Note: Only 199 participants (out of 212) stated their work/study country during the registration process.

Participants by Work/Study US State
n=187

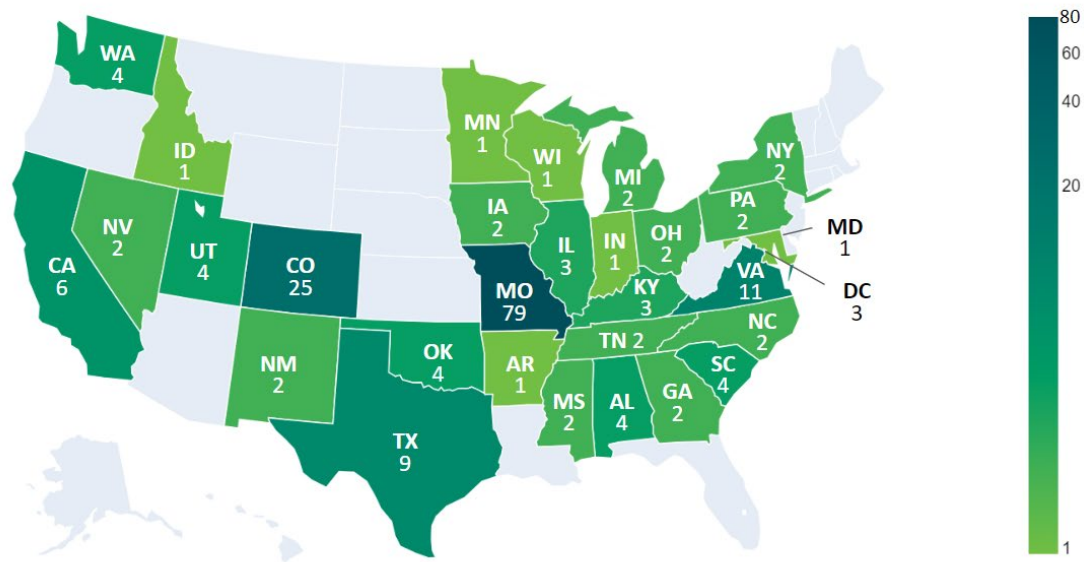


Figure 3: Distribution of workshop participants within the USA. Shown are the states of the 187 participants who stated the USA as the primary place of work/study during registration.

4. Breakout Session Summary

Groups of 10-15 workshop participants (separated into in-person and online groups) were each provided with the following background information:

“Past NSF workshops and breakout sessions have focused primarily on perceived demand growth for minerals and metals in the US and worldwide and the mining industry’s ability to respond, over what time horizons, given large and complex constraints. Over the years, breakout sessions covered a range of topics and related questions including permitting and land management policies and regulations, processing, recovery from waste and recycling, workforce development and retention, sustainability, and R&D, including, to a small extent, for substitutes and alternatives.

Expectations of demand growth for minerals and metals derive from materials intensities of preferred “green” energy technologies for electrification, the main “energy transition” strategy to meet stated goals for GHG reductions. Outlooks (IEA, IRENA, etc.) for minerals and metals consumption reflect very large scale capacity additions of wind, solar, and battery energy storage to replace (higher efficiency, higher capacity factor) grid-based thermal generation in electric power systems, very large scale additions of battery electric power trains to replace (higher volumetric energy density) conventional fuels in combustion engines for transport, all of the associated supply chains and manufacturing (at least theoretically), and all of associated expansions of supporting electric power systems (theoretically).

Realizations are growing that new, advanced materials are needed in order to reduce material (and energy) inputs and improve performance (efficiency, durability, sustainability and more) for “green energy tech” along with much else. Advanced composites including those with advanced carbon fibers

(nanotubes) are widely expected to displace metals, at least to some extent. New alloys, nanomaterials in general, materials such as amorphous metals or bulk metal glass, ceramics, biomaterials and more, including semiconductors/microelectronics, are all in development and/or being commercialized. Altogether, advanced materials have the potential to revolutionize technologies and disrupt conventional outlooks.”

With this background, the participants were asked to answer three questions:

- Can mining lead the new materials future?
- Critical minerals research: where to go from here?
- Should the Bureau of Mines be restored?

The findings of the group discussions are summarized below (sections 4.1 to 4.3). All answers and/or comments are provided in Appendix 2.

4.1 Can mining lead the new materials future?

The workshop participants generally agreed that the mining sector is pivotal to ensuring the commodity supply needed for the new minerals future. Although the participants generally agreed that mining of new materials will still be required for the foreseeable future, efforts should be made to work towards a circular economy through a stronger focus on recycling. Similarly, it was suggested mining operations of the future should strive towards 100% elemental recovery from mined rocks, thereby eliminating (or at least significantly reducing) waste materials. With regards to current mining operations, a stronger focus on increasing critical minerals recovery from existing production streams and/or recovery from mine waste materials was seen as a short- to mid-term solution for increasing critical mineral supply chain resilience in the USA.

Another frequent point of discussion was that workforce development remains a major concern in the mining sector, especially the limited availability of qualified workers which is expected to worsen over the next years. Most groups stated that the mining sector needs to adapt to the needs of younger generations to make the mining sector an attractive career path, starting with outreach at the K12 level. The need to develop greener mining and mineral processing technologies was also frequently highlighted. A ‘greener image’ of the mining sector will likely help to attract younger generations to the mining workforce as they tend to be more environmentally conscious.

4.2 Critical minerals research: where to go from here?

The workshop participants applauded the US government’s funding efforts over the past years and stated that it represents an important step towards increasing domestic critical mineral supply chain resilience. Several participants stated that recent funding opportunities allowed for new collaborations between academia, national labs and the private sector that otherwise likely would not have happened. However, some participants from the private sector cautioned that it is too early to tell if the funding efforts will indeed result in long-term success with regards to improving critical mineral supply chain resilience.

For future funding directions, participants agreed that the government needs to continue to support critical minerals research in order to enable pathways towards decreasing the U.S. dependency on critical minerals sourced from potentially foreign adversaries. It was recommended that future funding should more prominently address social science and policy-oriented research needs, as well as education of elected officials and the general public with regards to critical mineral supply chains (ranging from

exploration to mining and mineral processing, recycling, and reclamation). Considering the global nature of critical mineral supply chains, some participants suggested that future funding opportunities should be targeted at facilitating stronger international research collaborations. Further, it was commented that federal funding is required to lower the entry bar for new companies, especially the ones who intend to produce ‘niche elements’ that do not have a large global market but are of strategic importance to the USA.

4.3 Should the Bureau of Mines be restored?

From 1910 to 1996, the US Bureau of Mines was the primary federal agency conducting scientific research on the extraction, processing, use, and conservation of mineral resources and was responsible for disseminating and communicate relevant findings. Upon closure of the Bureau of Mines, these responsibilities were shifted to federal agencies such as the Department of Energy and the Environmental Protection Agency.

When asked during the workshop if the Bureau of Mines should be restored, more than half of the workshop participants stated that they were not familiar with the Bureau of Mines. Following group discussion where the functions of the Bureau of Mines were outlined, the majority of workshop participants agreed that restoring the Bureau of Mines would be useful to accomplish several critical mineral goals in the USA, such as development of novel mining and mineral extraction techniques, standardized workforce development, and streamlined, and thus faster and more transparent, permitting processes for mining and mineral processing operations. However, workshop participants also cautioned that restoring the Bureau of Mines might be not possible because of the loss of institutional memory since its closure in 1996. Further, participants cautioned that there might be too much overlap between a new Bureau of Mines and federal agencies that have taken over the Bureau’s responsibilities.

5. Workshop feedback

The workshop received overwhelmingly positive feedback from the workshop participants. During a post-survey workshop, 89% of the 32 participants that completed the survey indicated that they are very likely and/or somewhat likely to continue attending the workshop in the future (the categories were: very likely (65%), somewhat likely (24%), not sure (6%), somewhat unlikely = 3%, very unlikely = 3%). When asked to rank the workshop experience on a scale from 1 to 10, workshop participants gave the workshop an average overall score of 8.8/10 (with a range of 3 to 10). The quality of oral presentations received a score of 8.6/10 (range of 3-10) and the poster session received an average score of 8.1/10 (range of 1-10).

As in previous years, participants particularly appreciated the unique networking opportunity the workshop provided, owing to the wide range of science and engineering disciplines that were represented as well as the different sectors (i.e., academia, government, private sector, politicians/staffers). The participants also appreciated the hybrid in-person/online mode of the workshop that gave the workshop a wider reach. Negative aspects were the limited amount of available fieldtrip spots (that filled up quickly), isolated problems with logins to the virtual component, and the remote location of Missouri S&T in Rolla, Missouri, combined with a lack of public transport and Uber/Lyft services in the area which can make attending difficult, particularly for participants without a car.

6. Conclusions

The 2024 workshop on Resilient Supply of Critical Minerals was attended by 212 participants. 143 participants attended in-person in the Havener Center on the Missouri S&T campus in Rolla, Missouri, USA, while 69 participants attended online via Zoom. Twenty participants (including 12 students and 4 early career researchers) received travel support through the NSF grant to attend the conference in Rolla. The feedback the workshop received was generally positive and highlighted the importance of providing a platform that allows participants from a wide range of background to interact.

Appendix 1 -Workshop Schedule

WEDNESDAY, AUGUST 7, 2024

THE CRITICAL MINERAL POTENTIAL OF THE USA

Evaluation of existing, and exploration for new resources

Moderator: Marek Locmelis

8:45-9:00	Welcome and Opening Remarks <i>Marek Locmelis, Workshop Chair</i> <i>David Borrok, Vice Provost and Dean (College of Engineering and Computing) – Missouri S&T</i>
9:00-9:30	Keynote Speaker – <i>Nedal Nassar, USGS</i>
9:30-10:00	Keynote Speaker – <i>Cheryl Seeger, Missouri Geological Survey</i>
10:00-11:00	Oral Presentations
<i>10:00-10:15</i>	<i>Matthew McCaughey – Arcadis/Quapaw Nation</i>
<i>10:15-10:30</i>	<i>Collin Williams – USGS</i>
<i>10:30-10:45</i>	<i>Brandon Sullivan – Doe Run Company</i>
<i>10:45-11:00</i>	<i>Zohreh Kazemi Motlagh – New Mexico Institute of Mining and Technology</i>
11:00-11:15	Break
11:15-11:45	Open Forum Discussion
11:45-13:00	Lunch and Posters (Sessions 1&2)

CRITICAL MINERALS WORKFORCE DEVELOPMENT

How to grow the US critical minerals workforce

Moderator: Alanna Krolikowski

13:00-13:30	Keynote Speaker – <i>Leigh Freeman, Leigh Freeman Consultancy</i>
13:30-14:00	Keynote Speaker – <i>Carey Bridges, Missouri Department of Natural Resources</i>
14:00-15:00	Oral Presentations
<i>14:00-14:15</i>	<i>Daniel LaBrier – Idaho State University</i>
<i>14:15-14:30</i>	<i>Emma Hunt – Furman University</i>
<i>14:30-14:45</i>	<i>James Kubicki – UTEP</i>
<i>14:45-15:00</i>	<i>Gregory Wessel – Geology in the Public Interest</i>
15:00-15:15	Break
15:15-15:45	Open Forum Discussions
15:45-17:00	Presentation by Michelle Michot Foss, Baker Institute for Public Policy, Rice University <i>Introduction to the Discussion for Breakout Sessions</i>
17:00-19:00	Break

THURSDAY, AUGUST 8, 2024**MINERAL PROCESSING AND RECYCLING**

Maximizing critical mineral recovery from existing production streams

Moderator: Lana Alagha

8:55-9:00	Welcome and Opening Remarks <i>Marek Locmelis, Workshop Chair</i>
9:00-9:30	Keynote Speaker – <i>Sarah Schwarz, Nyrstar</i>
9:30-10:00	Keynote Speaker – <i>Michael L. Free, University of Utah</i>
10:00-11:00	Oral Presentations
<i>10:00-10:15</i>	<i>Fardis Nakhaei – Missouri S&T</i>
<i>10:15-10:30</i>	<i>Long Qi – Ames National Laboratory</i>
<i>10:30-10:45</i>	<i>Badri Shyam – Xerion Advanced Battery Corp.</i>
<i>10:45-11:00</i>	<i>Nadine Piatak – USGS</i>
11:00-11:15	Break
11:15-11:45	Open Forum Discussion
11:45-13:00	Lunch and Posters (Sessions 3&4)

POLICY AND SUPPLY CHAIN ECONOMICS

Reshoring critical mineral production

Moderator: Marek Locmelis

13:00-13:30	Keynote Speaker – <i>Beia Spiller, Resources for the Future</i>
13:30-14:00	Keynote Speaker – <i>J. Andrew Grant, Queen's University</i>
14:00-15:00	Oral Presentations
<i>14:00-14:15</i>	<i>Donya Otarod – Missouri S&T</i>
<i>14:15-14:30</i>	<i>Stéphane Goutte – UMI SOURCE, Université Paris-Saclay</i>
<i>14:30-14:45</i>	<i>John Kutsch – Thorium Energy Alliance</i>
<i>14:45-15:00</i>	<i>James Kennedy – Caldera Holding, LLC</i>
15:00-15:15	Break
15:15-15:45	Open Forum Discussion
15:45-17:00	Breakout Sessions (In-person and online). Moderated by Michelle Foss, Baker Institute for Public Policy, Rice University
17:00-17:30	Closing Remarks and Field Trip Introduction <i>U.S. Strategic Metals (Missouri Cobalt) – Greg Sutton</i>

FRIDAY, AUGUST 9, 2024**FIELD TRIP TO U.S. STRATEGIC METALS (MISSOURI COBALT)**

7:00-15:00	Field Trip (reservation only)
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Appendix 2 – Anonymized compilation of answers / comments to the questions asked during the workshop breakout sessions

Question 1: Can Mining Lead the New Materials Future?

- Mining needs to better address downstream critical minerals needs (i.e., product development) / capture higher value of product.
- Changing perception and adapting to younger generations is needed. Mining is not necessarily the bad guy → We need to be better ambassadors for mining.
- What are the actual markets for the end products that will use critical minerals?
- Push for making greener materials and products.
- Government capabilities to push critical mineral production forward:
 - a. Tax credits for local mining companies, manufactures and downstream producers.
 - b. Value on jobs.
 - c. Support mine workforce retention.
 - d. Depletion tax credits.
- Focus is needed on examining organizational culture of industry companies → provide support for culture change and recognize that shift will be slow and people-focused (key problems: sexism and misogyny)
- Go into high schools and possibly fund engineering classes. Good way to get new blood into the industry. Example: GeoBus funded a van with a set of activities for a class period to give Earth Science Lessons.
- Mine of the Future requires advanced technology with advanced engineers (robotics, automation, computer science, etc.).
- Invest more in new graduates, for example through more (and more attractive) internships for high school and college students / graduates.
- Continuing education for teachers and mentors with companies, etc. Example: Missouri Mines Matter Program.
- New materials have to be mined. It is almost impossible to recycle what is needed to meet demand.
- Mining industry exists to make profits.
- New innovative technology will be needed once easy to mine/process resources are exhausted.
- Recycling on a commercial basis has started recently.
- Diversify to make profits.
- Can mining industry respond to downstream changes (recent example: lithium)?
- Resource “are” not – they “become”.
- Collaboration is going a bit better now, but there is still the need for more/better collaboration (‘anti-competitiveness’). The Bureau of Mines would be an ideal platform for this.
- More grant funding is needed for universities (e.g., ARPA-E).
- No real forum exists for new mining ideas, only fragmented conferences by metal or societies (SME/PDAC). Industry groups are optimizing their own processes without sharing ideas or

seeking feedback from other groups ('anti-competitiveness' attitude is needed) → there is the need for the mining industry to be more open / less secretive if mining problems of the future are too be solved

- Not enough corporate R&D. Joint R&D programs between different partners are desirable.
- "Mine of the Future":
 - Clean, green, no emissions.
 - Can we do targeted mining with good grip on reclamation programs?
 - Can tailings be sold to someone else?
 - Recycling should be part of the operation from the beginning.
- The traditional mining industry can play a major part if, and only if, they are willing to give up some of their bottom line.
- Listen to younger generations.
- Harvest all minerals, cradle to grave.
- The mining industry must adopt a long-term perspective to remain sustainable and competitive.
- By embracing changes in material composition and leveraging advancements in new materials, the industry can enhance the formation and functionality of minerals.
- A fundamental rethinking is needed of how minerals are processed and utilized, focusing on innovation and sustainability to improve their performance and applications.
- The implementation of a circular economy is crucial, with the potential to use materials up to 40 times through recycling and a comprehensive life cycle approach.
- Various projects are exploring the extraction of critical minerals from mining and other waste sources, emphasizing the concept of waste as a resource and highlighting the need for further research in this area.
- The mining industry must adopt a long-term perspective to remain sustainable and competitive.
- The energy transition makes things very complicated to the everyday person. We should maybe start with the policy makers and the people who need to be informed. Elected officials are more important to be educated than the average person. We should start there and go into the general public next.

Question 2: Critical minerals research - where to go from here?

- More funding for social science- and policy-oriented research, especially interdisciplinary research.
- More opportunities for research and development.
- More funding to test new materials and batteries before they can be introduced to the market.
- Collaboration: more private sector-funded research at universities.
- Research in academia should be better connected to the need of the industry.
- From an industry perspective, it is too early to tell if previous funding efforts resulted in success.
- Insufficient allocation of funding in some cases over the past years should be addressed.
- More money with emphasis on industry / government / academia / think tank collaborations.

- Help provide forums to enable discussions that will help stakeholders avoid blind spots.
- Involve community in solutions via information dissemination.
- Hold future workshops in less remote regions.
- Companies can also give ‘blind money’ to help negative perceptions of research funded by companies.
- Paywalls on academic papers are an issue. Possibly have a national pot of money to fund paying for papers derived from research paid with government funding.
- Mining research is comparatively underfunded to advanced materials research. A concern is that advanced materials receive funding over mining/geology research.
- Future research should focus more on community engagement, especially with regards to the mining of tailings. For that purpose, research should involve social scientists with people skills.
- Make future funding less restrictive in terms of who can use it, especially in cases where it is difficult to collaborate with desired stakeholders. For example, Departments of Natural Resources cannot receive NSF money.
- Find ways to bring in junior colleges. Could be leveraged to bring in technical people with talents that were previously ignored.
- What has worked: collaborations between academia, industry and national labs. What has not worked: international collaborations!
- What should be more supported:
 - Fundamental research on thermodynamics, geology and mineral processing.
 - Resource/reserve characterization.
 - Large-scale sampling.
- Need more research into the manufacturing of new substitutes.
- More R&D emphasis is needed on pilot-to-mid scale testing.
- What has worked: collaborations between academia, industry and national labs.
- Industry should offer more education opportunities.
- General education on critical mineral topics is not commonly offered which should be changed.
- There need to be more funding opportunities for critical minerals education.
- Need to get general education about mining and critical minerals to non-geologists.
- More programs need to be available on lower educational levels. Everyone needs to be aware of where their stuff comes from – not just hardcore scientists with PhDs.
- Education and outreach –story maps do good outreach but some organizations like state surveys are not able to do a lot of public-facing stuff.
- Better characterization on mine wastes is needed.
- Funding is out there and the work is being done: it is basically an inventory issue.
- Funding for all this stuff will end in a few years. Need to keep up Earth-MRI funding to develop a comprehensive USA-based critical mineral inventory. Other countries should also implement the Earth-MRI funding.
- More Earth MRI surveys are needed, but people need to understand that some of these minerals cannot be recovered at all.
- Earth MRI only gives a guide to companies and the government that these things exist. However, the surveys themselves cannot say if the critical minerals are part of the inventory

- Geophysics is very important thing to consider.
- Big issue with critical minerals is that big companies are not going to jump on opportunities because markets are too small so they. Need to have startups go for it.
- Small startups have a lot of trouble breaking in to the markets and big companies do not want to invest into small startups.
 - Tailings need a lot of money to break into processing and it is difficult to predict demand when you finally get established: hard to convince people to commit when a market is volatile.
- Need to reevaluate the prices and stuff for mine wastes.
- Potential of looking at the waste / more research in waste.
- Getting info out to the public. More outreach to the public is so important. Not even necessarily outreach to students, but adults and the general public.
- Students need to start learning about it. They do not know anything about this really important topic.
- Earth MRI page on the USGS page. Look at geophysics and see the data they are collecting. This program should be reupped and allow for additional projects.
- Talk to people to recycle materials needed for the future. Differing language between the chains. Solving a problem in electronics by also making it easy to recycle.
- Biggest uncertainty from recycling from tailings is the unknown demand of the future. We do not know what the demands will be and cannot fully trust the projections. Very hard to look at commodities and decide the demand for the future
- Funding is needed for more educational opportunities to be offered to people who are not necessarily in geology or mining (i.e., general education for an average person). This can help drum up support in the average person to the potential of mining in the US. Nonscientific people need to be educated in this topic as well, not just limited to Earth science related fields. Make critical minerals knowledge available to the general public to help get more people advocating.
- Recovery from low concentration and or recycling it becomes a combination of solid mechanics, fluid mechanics, and chemistry. Making it work is not easy and universities and industry tend to be stuck. It is hard to get the chemistry and the civil engineering together for example. Universities need to address getting different graduates to get funding together. We need to connect all steps in the process.
- Further down the line from the data collection step: Important not to confuse the policy makers or the public that we are loaded with minerals. Not all that is found can be extracted.
- Need to get the scientists and engineers on the same page. Interdisciplinary studies. Also bring in industry not just academics. We need to link them better.
- Difficulty in getting businesses to produce critical minerals because they are small and undefined markets, need technology still, and need lots of capital to start up.
- Potential to look at the tailings and the waste dumps and get information out to the public. Need to have the public know where to find that information.

Question 3: Should the Bureau of Mines be restored?

Three sub-questions were asked:

- What are the pros and cons?
- What should fall within the scope of a new Bureau of Mines?
- Should advanced materials needs/trends be part of the mission of a new Bureau of Mines?

Stated pros:

- Would allow for centralized funding and local knowledge.
- Can cover all minerals, not just critical minerals.
- Would be good to have the Bureau of Mines back as an advocate for the mining sector.
- The Bureau of Mines excelled at mining, metallurgy and reclamation. It would be good for all areas to be covered by the same agency.
- Bringing the Bureau of Mines back would show that the federal government believes in mining and that its products are important.
- Specialized staff that understands geology and technical mining processes and can communicate their decisions effectively.
- Centralized and streamlined, and thus faster, permitting.
- Could provide valuable insights into tariff structures.
- Could offer guidance, oversight, and significant contributions to policy discussions.
- An agency dedicated to facilitating the supply chain of critical raw materials could significantly enhance the availability and stability of these essential resources.
- Could potentially fill existing gaps in the supply of both primary products and co-products.
- By fostering industry-government partnerships, the Bureau of Mines could ensure that while the mining industry operates independently, it receives the necessary support from government entities to maintain efficient and sustainable operations.

Stated cons:

- Could be a waste of money if it duplicates / takes away responsibilities from DOE, NIOSH, National Labs, etc.
- If the Bureau was reinstated and workers from other agencies would be reassigned to it to address redistributed responsibilities, expertise might be lost if people do not want to change where they work or relocate.
- Possible overlap with other agencies.
- It might be difficult to bring the Bureau back considering that the institutional memory is gone.
- Might be biased.
- Likely resistance from state governments.
- Unclear how interaction with the USGS and other agencies would play out.

What should fall within the scope of a new Bureau of Mines?

- Consulting / advising higher levels of the government.

- Repository of knowledge and point of contact for the industry and government.
- Overseeing waste remediation.
- Licensing.
- Standardization of workforce training.
- Fundamental research not covered DOE, USGS, etc.
- R&D,
- Tech transfer
- Development of standards.
- Permitting.
- Monitoring.
- Research.
- Community engagement.
- International oversight of American companies.
- Tracking and reporting of company performance (nationally and internationally).

Should advanced materials needs/trends be part of the mission of a new Bureau of Mines?

- No, the USGS is already doing this and they can get the info from them.
- Yes, to supply, no to demand.
- Yes, in partnership with the private sector.
- Bureau of Mines could lead the way towards re-use, recycling.