United States Environmental Protection Agency

Radiation Protection Program

Critical Minerals and TENORM: How Do Permitting Reform and Executive Branch Actions Address Radioactivity?

REMPLEX

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US EPA

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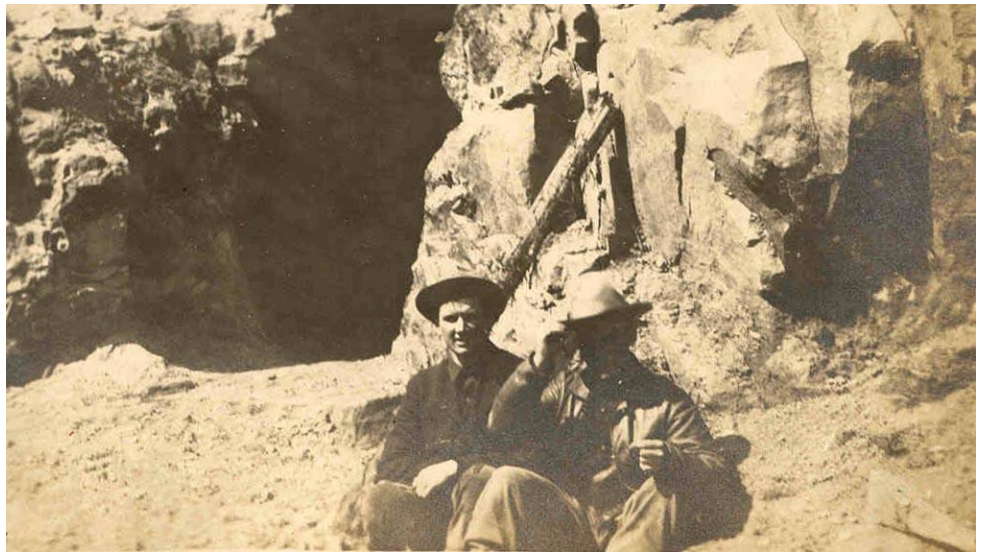
- This presentation is the author's only and does not reflect the policy or position of the U.S. Environmental Protection Agency (EPA) or any other group that has me as a member…
- The purpose is to stimulate discussion and for awareness



Source: Museum of Western Colorado

Gateway CO Vanadium Millsite
Source: the author

Background
Critical Minerals

- After 40 years of a globalized approach to supply chains including:
    - Relying on international sources of raw materials and products,
    - “Just-In-Time” inventory, and
    - Downsizing and offshoring of a trained and knowledgeable workforce,
  - China (and a few others) now control much of the critical minerals supply and presents a vulnerability.
- U.S. policy is now changing back to a supply chain for critical minerals that relies largely on domestic sources (and with trading partners who share our values).
  - This will take time and resources.
  - **Many critical minerals are associated with radioactivity and must be considered in planning and permitting.**
  - The Circular Economy
    - Re-mining, re-processing, re-use, recycling;
    - Incorporation into other materials and products;
    - Goal of zero waste

Change is in the Air… sorta…

- The ongoing and evolving policies of the U.S. with respect to climate change are causing major changes to the needs of certain critical minerals, particularly for electric car batteries and components of wind turbines.
- There are also numerous defense needs that can be impacted from a disruption in supplies.
- To counter these challenges there have been multiple Executive Orders, allocations of funding under the Defense Production Act, and movement in Congress on permitting reform. These actions are all subject to political interference and as such, things can change rapidly.
- One aspect of permitting reform that is not being highlighted is the reality that many critical minerals are associated with natural radioactivity. When the ores are harvested, the radioactivity in the U.S. is called technologically-enhanced naturally occurring radioactive material (TENORM).
- Since TENORM is largely regulated by the States with little federal guidance, consistent licensing and permitting of these projects can be difficult to achieve, particularly if there is a lack of forethought in the environmental review process.

What Are Critical Minerals?

- The Energy Act of 2020 defines a “critical mineral” as a non-fuel mineral or mineral material essential to the economic or national security of the U.S. and which has a supply chain vulnerable to disruption.
- Critical minerals are also characterized as serving an essential function in the manufacturing of a product, the absence of which would have significant consequences for the economy or national security.

- The list includes the rare earth elements (REEs).
- Many REEs are associated with natural radioactivity.
- Other critical minerals with a NORM problem include lithium and cobalt.
- Critical minerals, including rare earths, are crucial to numerous industries and national defense.

Critical minerals

- But it must be done in such a way that is sustainable and does not compromise environmental standards, community engagement, and Tribal consultation.
- Executive Orders have been issued by both the Trump and Biden Administrations to develop and ensure the reliability of domestic supplies of critical minerals (and with trading partners who share our values).
- **TENORM is an issue that must be considered.**

The 2022 List of Critical Minerals -

And major uses…

- Aluminum, used in almost all sectors of the economy
- Antimony, used in lead-acid batteries and flame retardants
- Arsenic, used in semi-conductors
- Barite, used in hydrocarbon production.
- Beryllium, used as an alloying agent in aerospace and defense industries
- Bismuth, used in medical and atomic research
- Cerium, used in catalytic converters, ceramics, glass, metallurgy, and polishing compounds
- Cesium, used in research and development
- Chromium, used primarily in stainless steel and other alloys
- Cobalt, used in rechargeable batteries and superalloys
- Dysprosium, used in permanent magnets, data storage devices, and lasers
- Erbium, used in fiber optics, optical amplifiers, lasers, and glass colorants
- Europium, used in phosphors and nuclear control rods

- Fluorspar, used in the manufacture of aluminum, cement, steel, gasoline, and fluorine chemicals
- Gadolinium, used in medical imaging, permanent magnets, and steelmaking
- Gallium, used for integrated circuits and optical devices like LEDs
- Germanium, used for fiber optics and night vision applications
- Graphite , used for lubricants, batteries, and fuel cells
- Hafnium, used for nuclear control rods, alloys, and high-temperature ceramics

- Holmium, used in permanent magnets, nuclear control rods, and lasers
- Indium, used in liquid crystal display screens
- Iridium, used as coating of anodes for electrochemical processes and as a chemical catalyst
- Lanthanum, used to produce catalysts, ceramics, glass, polishing compounds, metallurgy, and batteries
- Lithium, used for rechargeable batteries
- Lutetium, used in scintillators for medical imaging, electronics, and some cancer therapies

- Magnesium, used as an alloy and for reducing metals
- Manganese, used in steelmaking and batteries
- Neodymium, used in permanent magnets, rubber catalysts, and in medical and industrial lasers
- Nickel, used to make stainless steel, superalloys, and rechargeable batteries
- Niobium, used mostly in steel and superalloys
- Palladium, used in catalytic converters and as a catalyst agent
- Platinum, used in catalytic converters

- Praseodymium, used in permanent magnets, batteries, aerospace alloys, ceramics, and colorants
- Rhodium, used in catalytic converters, electrical components, and as a catalyst
- Rubidium, used for research and development in electronics
- Ruthenium, used as catalysts, as well as electrical contacts and chip resistors in computers
- Samarium, used in permanent magnets, as an absorber in nuclear reactors, and in cancer treatments
- Scandium, used for alloys, ceramics, and fuel cells

- Tantalum, used in electronic components, mostly capacitors and in superalloys
- Tellurium, used in solar cells, thermoelectric devices, and as alloying additive
- Terbium, used in permanent magnets, fiber optics, lasers, and solid-state devices
- Thulium, used in various metal alloys and in lasers
- Tin, used as protective coatings and alloys for steel
- Titanium, used as a white pigment or metal alloys

- Tungsten, primarily used to make wear-resistant metals
- Vanadium, primarily used as alloying agent for iron and steel
- Ytterbium, used for catalysts, scintillometers, lasers, and metallurgy
- Yttrium, used for ceramic, catalysts, lasers, metallurgy, and phosphors
- Zinc, primarily used in metallurgy to produce galvanized steel
- Zirconium, used in the high-temperature ceramics and corrosion-resistant alloys.

Radioactivity Associated with Rare Earths

- Uranium and thorium decay series
- Potassium 40 (K-40)
- Radium, radon, lead and polonium the primary contaminants
- “The natural occurrence of the rare earths with uranium and thorium and their daughter products presents problems in rare earth extraction and processing, results in production of radioactive wastes, and causes radiation exposures to humans and the environment” (IAEA 2011).
- Each rare earth mineral (REM) ore body can be heterogeneous within a deposit.
- Can result in different concentrations and volumes of the radioisotopes present at mines and processing facilities,
- Can result in different radiation exposures (workers, public and environment) and radioactive waste volumes at those stages of the production cycle.

Concentrations vary

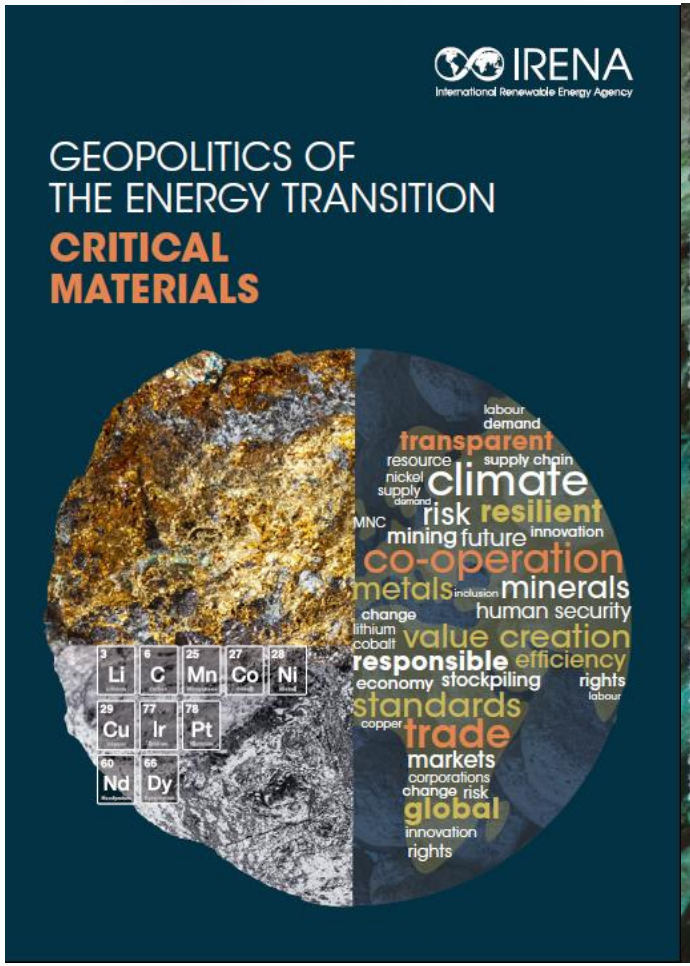
The concentrations of radioactivity will vary:

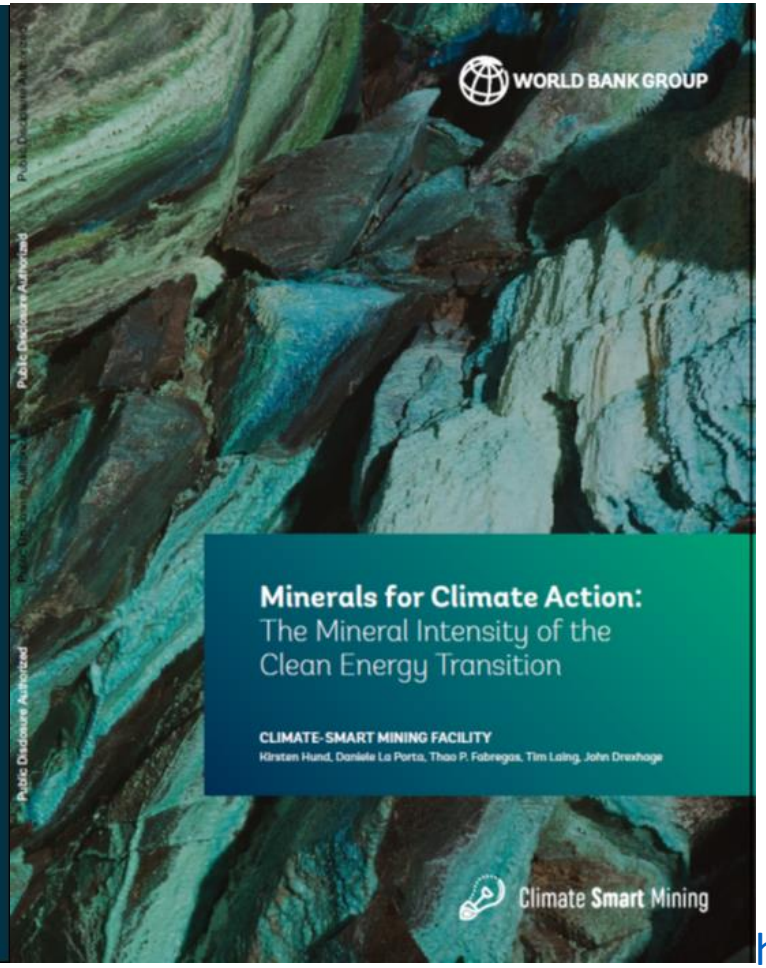
- Ore – 10s to hundreds of pCi/g
- Concentrates – hundreds to thousands pCi/g
- Products – single digits pCi/g
- Wastes – up to hundreds of thousands of pCi/g
- Effluents - undetermined
- Emissions – undetermined – radon and thoron are the biggest concerns
  - Thoron has a short 55-second half life, but decay products up to 10 hour half-lives, so decay products can travel (e.g., Bi-212, Po-212).

Lack of US Processing Capability

- The U.S. currently does not have any facility that can process rare earths in significant quantities.
- The Mountain Pass Mine is the only major mine that is open.
  - They are shipping their concentrate to China for processing.
  - Some monazite mines in the SE U.S.
- The White Mesa Uranium mill in Utah is processing monazite into a concentrate that is shipped to Estonia for processing,
  - Energy Fuels is evaluating the costs and risks of building a circuit for full recovery of rare earth elements.

Geopolitical Implications





Critical Minerals are an international issue…

And a geopolitical issue…

Partnerships with allies will be crucial

It will take too long to develop domestic sources only.

Many countries are prospecting for their own sources (e.g., Sweeden, Finland).

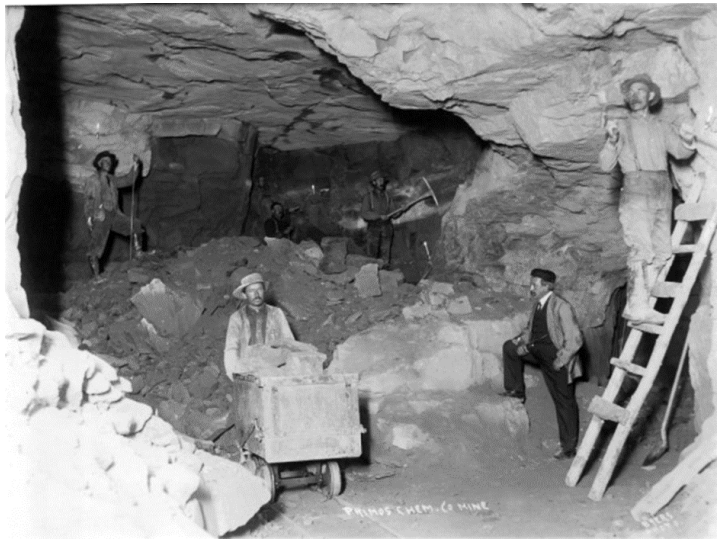
https://openknowledge.worldbank.org/entities/publication/4dd08d0c-ab51-4955-a464-35a95201a5eb

https://mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net/-/media/Files/IRENA/Agency/Publication/2023/Jul/IRENA_Geopolitics_energy_transition_critical_materials_2023.pdf?rev=f289d177cda14b9aaf2d1b4c074798b4

The 1872 Mining Law and the FLMAs

The Federal Land Management Agencies

- There are calls to “streamline” permitting of new mines.
- Discussions underway over the 1872 Mining Law, that is still in effect in most situations.
  - Different approaches to permitting….
  - Mining Law:
    - Locate, stake Claims, Patents (no longer), No Royalties
    - Unpatented Claims have surface rights spilt in many cases
  - FLMAs
    - Leasing and Royalties
    - Promulgated in the 1970s
      - Requirements for bonding
      - Reclamation
      - Environmental Protections
      - Not consistent among agencies



Legacies Persist for Old Mines

Newer mines much better, but there are few of them!

- Tribes and rural communities continue to be impacted by historical mining operations that occurred prior to the enactment of environmental laws and regulations.
- There are more than 160,000 abandoned mines in the Western U.S., a great number of which are on or proximate to Native Lands, https://link.springer.com/article/10.1007/s40572-017-0140-5
- Inspection and enforcement weak in many areas
- The Bureau of Land Management's (BLM) mining regulations under FLPMA were first promulgated in 1980, then comprehensively updated in two steps in 2000 and 2001
- U.S. Forest Service (USFS) regs in 1974.
- Neither require NEPA (e.g., environmental impact statements) unless significant surface disturbance (e.g., >5 acres).
- Discussions ongoing about what reforms to enact.

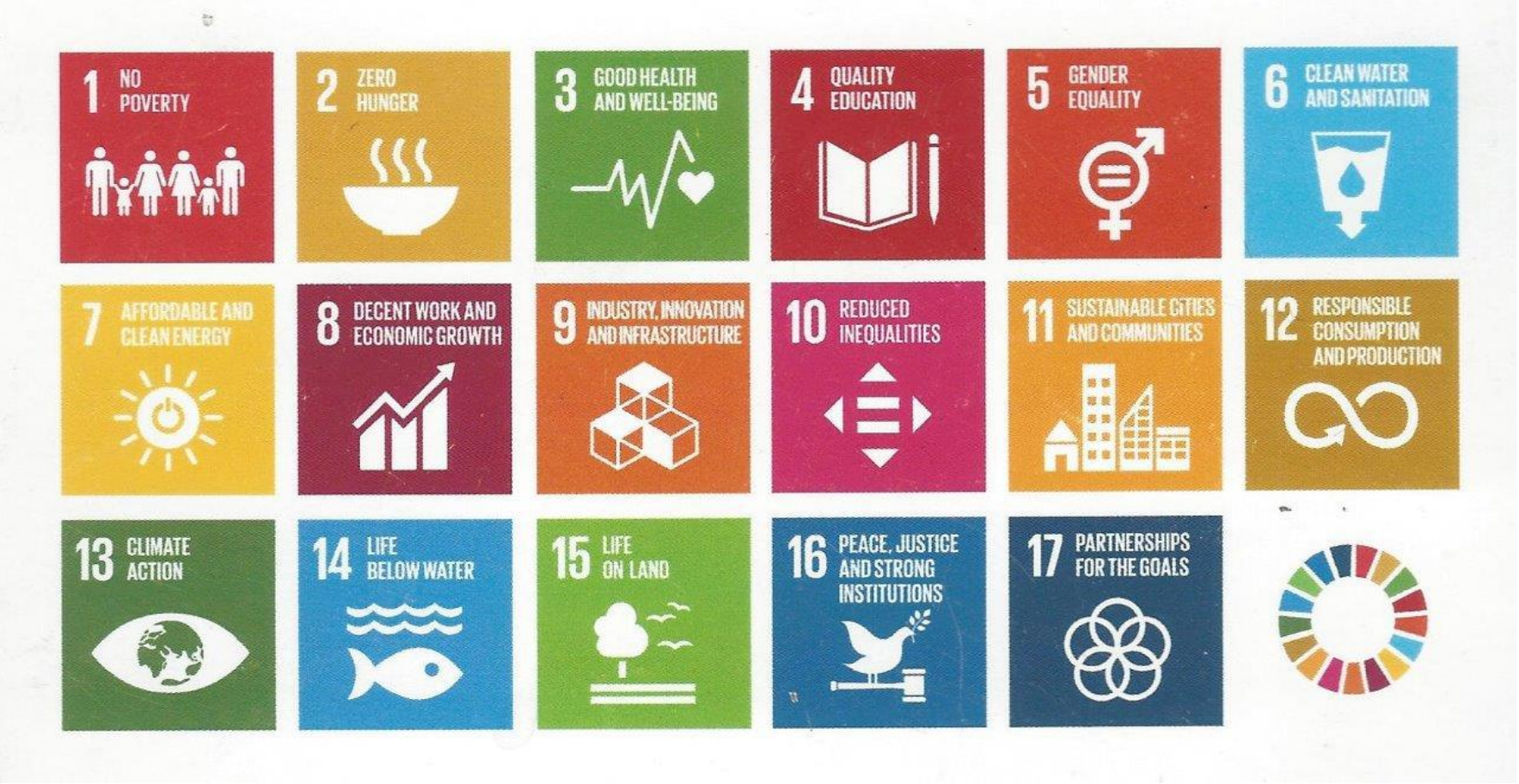
Population increases and dwindling supplies

The Circular Economy

- In 50 years, there will be 10 billion people on earth – and few minerals left
- Reuse, Remining, Substitution are all being considered as future practices under the Circular Economy
  - **Radioactivity should not be introduced into any commodity without an added benefit of adding the radioactivity.**
  - This may change under the Circular Economy:
    - The radioactivity must be considered from a public health and environmental standpoint.
    - When does liability end?
    - Valorization of NORM residuals is already underway.

UN Sustainable Development Goals

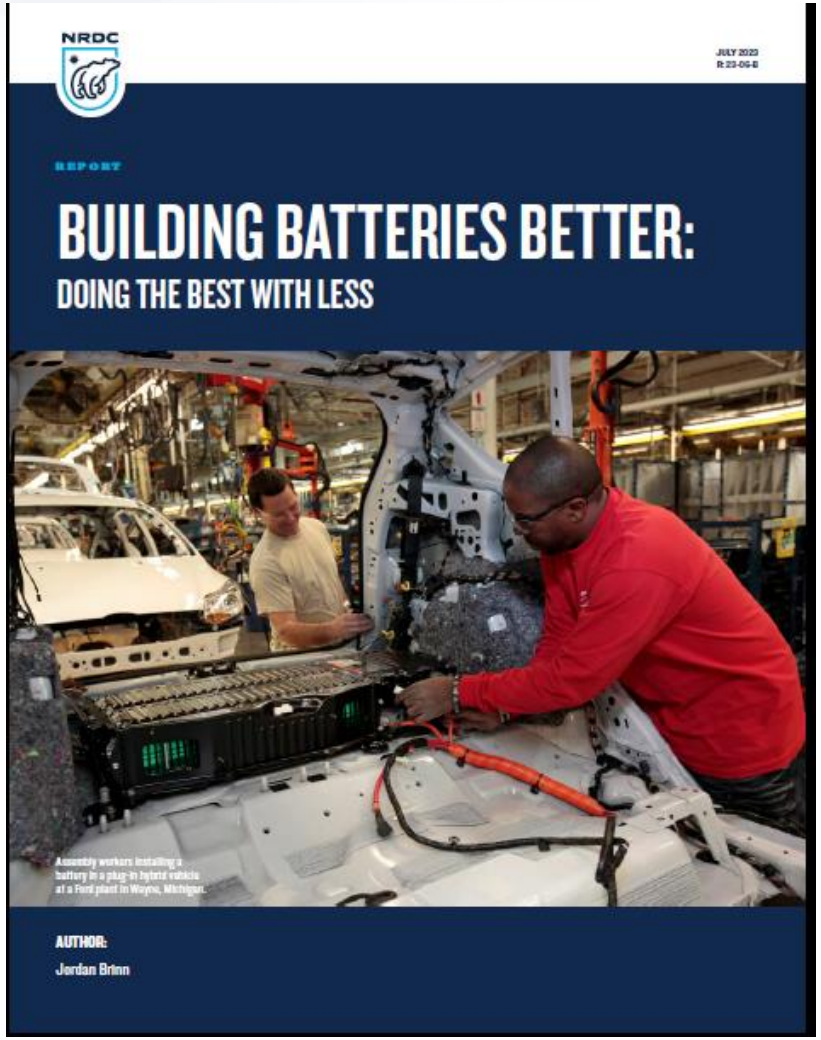
Meanwhile…



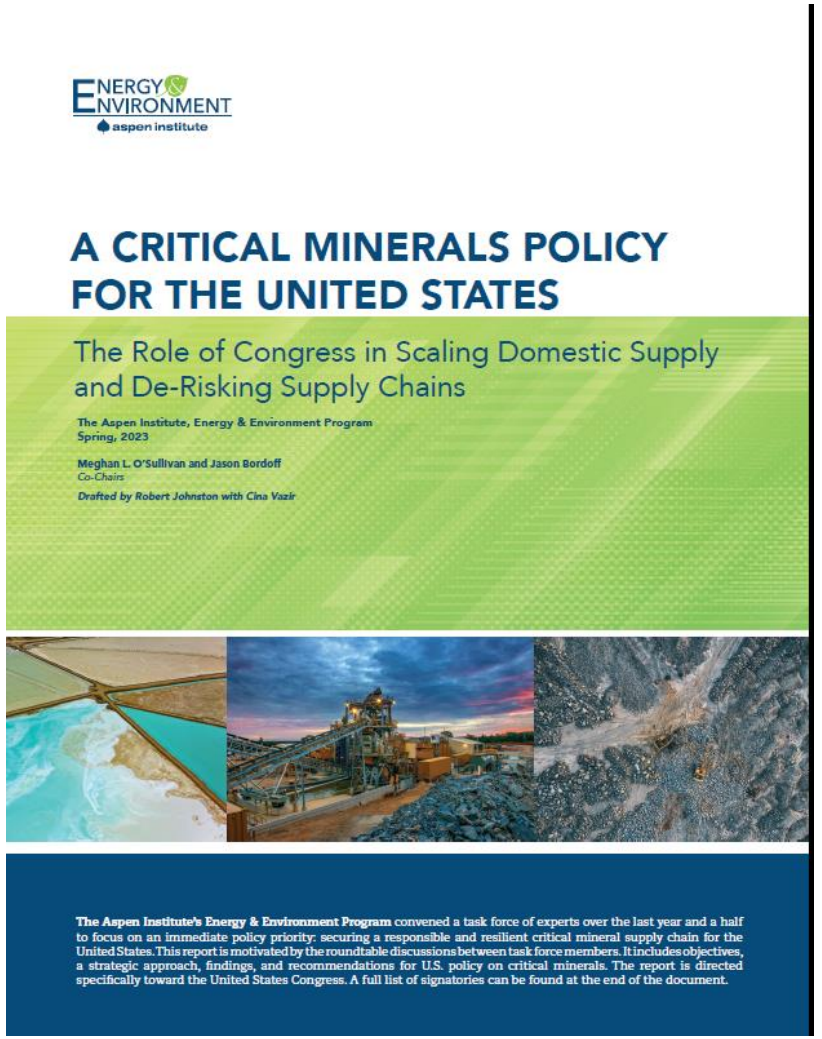
The SDGs provide a framework for working towards a more sustainable future around the world.

Along with Environmental, Social, and Governance (ESG) investment policies, big changes are coming…

…and the reports are flowing

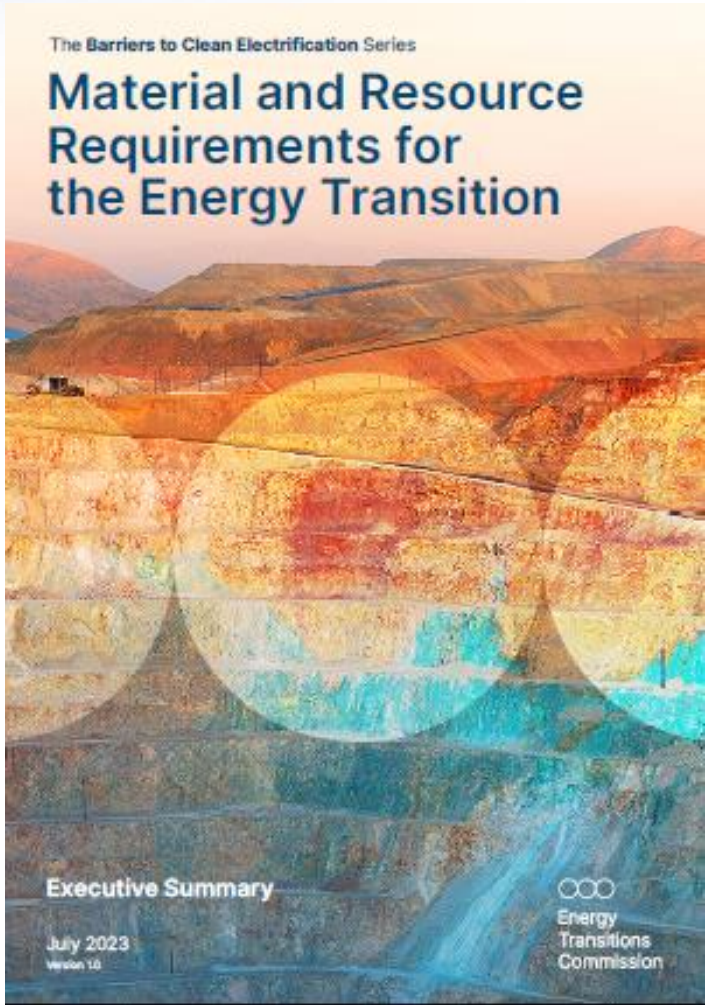


https://www.nrdc.org/sites/default/files/2023-07/ev-battery-supply-chains-report.pdf



https://www.aspeninstitute.org/wp-content/uploads/2023/06/Critical-Minerals-Report.pdf

…and flowing



Critical Minerals Market Review 2023

https://iea.blob.core.windows.net/assets/afc35261-41b2-47d4-86d6-d5d77fc259be/CriticalMineralsMarketReview2023.pdf

…And Now This…

Source: DRI

RESEARCH NOTE

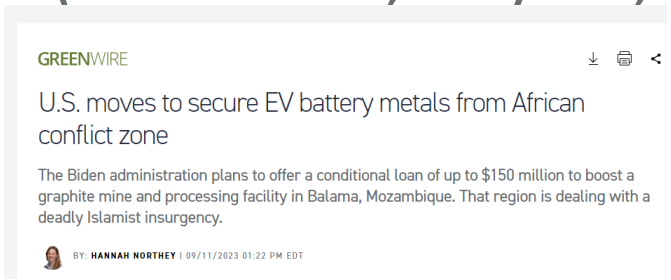
China restricts exports of critical metals used in semiconductors and solar panels

- On July 3, China published a notice restricting the export of certain key metals used in the production of advanced semiconductors and solar panels.
- Issued by the Ministry of Commerce, the directive targeted two types of critical metals: **gallium and germanium**, both on the country's national strategic mineral list.
- China produces over 80 percent of gallium and 68 percent of germanium and their alloys worldwide.

…and in October

Graphite

- China is now limiting exports of graphite
  - China's Commerce Ministry and General Administration of Customs announced that they plan to require special permits for the export of natural and artificial graphite to "safeguard national security and interests."
- DOE announced a $102 million loan to Syrah Resources Ltd.'s graphite plant in Louisiana.
  - However, they will source the minerals from a mine in a region of Mozambique plagued by an Islamist insurgency. (Greenwire, July 27, 2023)



Interagency Work Group

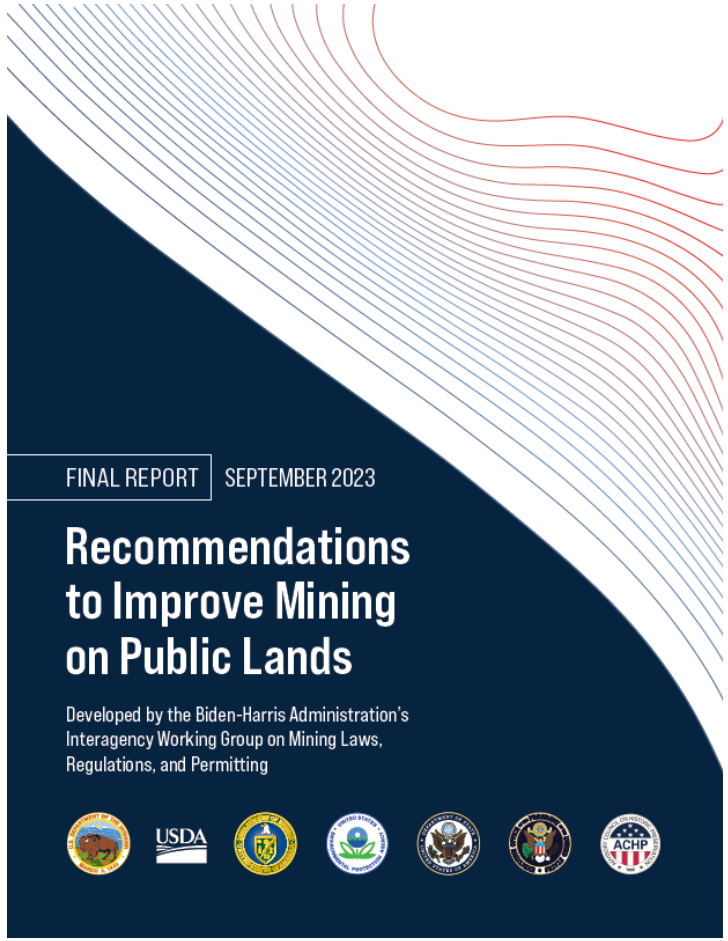
The Interagency Working Group (IWG) on Mining Reform

- Department of the Interior (DOI) and U.S. Department of Agriculture (USDA) primary.
  - Keeping this in the present tense because I am an optimist, and this group can contribute more.
- The IWG chaired by the Deputy Secretary of DOI and consists of representatives from across the government, including the USDA, Department of Energy, Environmental Protection Agency (EPA), Department of State, Council on Environmental Quality, and National Economic Council, among others.
- EPA has a secondary role on the IWG, but it is providing significant input where appropriate, such as in permitting reform.
- IWG tasked with making recommendations related to the 1872 mining law.
- Under the Bipartisan Infrastructure Law, report on IWG's work and recommendations sent to Congress.
- The report was published in September 2023.
- Additional permitting reform may come from Congress. Or not.
- The Permitting Council/FAST-41 is now recommending that critical minerals, including REEs be covered as a sector under the expedited review process.

The IWG Report

The IWG formulated 65 recommendations addressing six broad issue categories:

- (1) improving mineral exploration and development planning and permitting;
- (2) increasing engagement with stakeholders and potentially affected communities;
- (3) expanding consultation and engagement with Tribes;
- (4) obtaining fair compensation for taxpayers for minerals extracted from Federal lands;
- (5) protecting taxpayers from the cost of abandoned mine reclamation; and
- (6) revitalizing domestic mining and other issues.



https://www.doi.gov/sites/doi.gov/files/mriwg-report-final-508.pdf

DOE Investigating Lithium from Geothermal

American-Made Geothermal Lithium Extraction Prize

- Three teams will split a total of $2 million for prototyped innovations to directly extract lithium from the hot water used to produce geothermal energy, known as geothermal brines.
- Winning Team ($1 million): University of Illinois Urbana-Champaign. Team SelectPureLi, A Redox Membrane for Lithium Hydroxide Extraction
- Runner-Up ($500,000): University of Virginia. Team TELEPORT, Targeted Extraction of Lithium with Electroactive Particles for Recovery Technology (TELEPORT)
- Runner-Up ($500,000): George Washington University. Team Ellexco, Chemical-Free Extraction of Lithium from Brines
- https://www.energy.gov/eere/articles/us-department-energy-awards-2-million-innovations-source-domestic-lithium-geothermal?utm_medium=email&utm_source=govdelivery
- There are also numerous hard rock mines for lithium in the planning stages.

So How Has Radioactivity Been Addressed in Permitting Reform?

IT HASN'T

- All of these reports either do not mention radioactivity or just mention it in passing…
- Most permitting reform in the U.S. is aimed at shortening the National Environmental Policy Act (NEPA) review times:
  - Ignoring radioactivity during the planning phase may set projects back.
  - Regulation and control of radioactive materials (source, special nuclear or byproduct materials) are generally regulated under the Atomic Energy Act (AEA) by the Nuclear Regulatory Commission or the Agreement States. But not for mining…
  - Radioactivity in mine waste is generally considered TENORM and regulated by the States.
    - Many mine wastes are considered solid waste instead of hazardous waste due to the Bevill Amendment to the Resource Conservation and Recovery Act (RCRA).

It's Complicated

- The Atomic Energy Act (AEA) is focused on the fission process and its byproducts
- The NRC authority under the AEA starts at the mill, not the mines…
  - "After its removal from its place in nature…"
  - This is a Cold War relic – the government did not want to interfere with the mining companies (e.g., not forcing them to ventilate) because they needed uranium for the weapons program.
  - **Over 1,500 uranium miners died from lung cancer that could have been prevented.**
- Also, uranium recovery has to be "primarily" for its source material content.
  - The unimportant quantity threshold for source material is 0.05% by weight… or 500 ppm
  - This equates to one pound of yellowcake per ton of ore.
  - This was an economic decision and not based on health and safety or environmental concerns.
  - While feedstocks may be below the threshold, it may not account for increased radionuclide concentrations during and after ore processing… triggering licensing.
  - This is why carnotite is processed "primarily" for uranium while producing vanadium in higher volumes.
  - This makes licensing for rare earths/critical minerals that are associated with uranium and thorium awkward and possibly very time consuming.

It's Complicated

- The Mine Safety Health Act has authority over occupational protection from radon in underground uranium mines, but its regulations are outdated and not protective, nor do they address the environment.

- While NRC and Agreement States radiation programs do not have authority over the mines, they do have authority to license mills, concentrators, water treatment facilities or upgraders that may be at the mine site (e.g., Schwardzwalder Mine in CO).
- EPA has authority under the Clean Air Act to limit emissions from operating underground uranium mines.
  - 40CFR Part 61, Subpart B – 10 mrem/y to nearest resident.
- EPA also has surface runoff requirements for radium and uranium mines and mills (40 CFR 440 (c)).
- EPA also has authority under the Safe Drinking Water Act to issue National Pollution Discharge Elimination System permits (often delegated to the States).
  - Many permits do not include rads

…Complicated, awkward and frustrating

- A good example is carnotite ore from the Colorado Plateau
  - Contains vanadium, uranium and heavy metals
  - This ore has been processed for radium, vanadium and uranium at different times (and combinations thereof).
  - Most of the uranium mills have been cleaned up, not so much the vanadium mill sites
    - A few vanadium mills that also ran uranium have been remediated, but many remain orphan sites (e.g., Loma, Gateway)
    - Thousands of abandoned uranium mines dot the west. DOE is characterizing the ones they may be liable for

Photo credit: the author

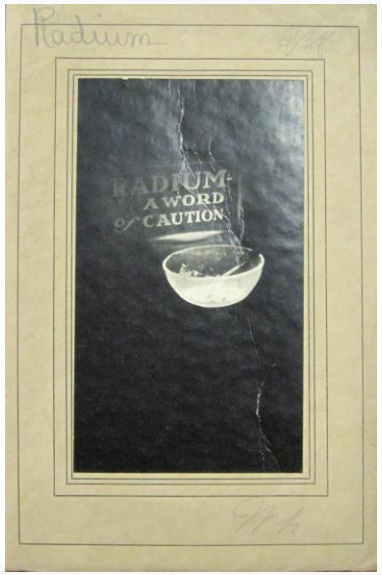
- A new uranium mill was proposed for Colorado about 12 years ago.
  - 15-Volume application
  - Over 400 requests for additional information
  - Applicant spent over $10 million on the application
  - State of the practice technologies required
  - License granted but vacated by the courts
  - Never built

…Complicated, awkward and frustrating

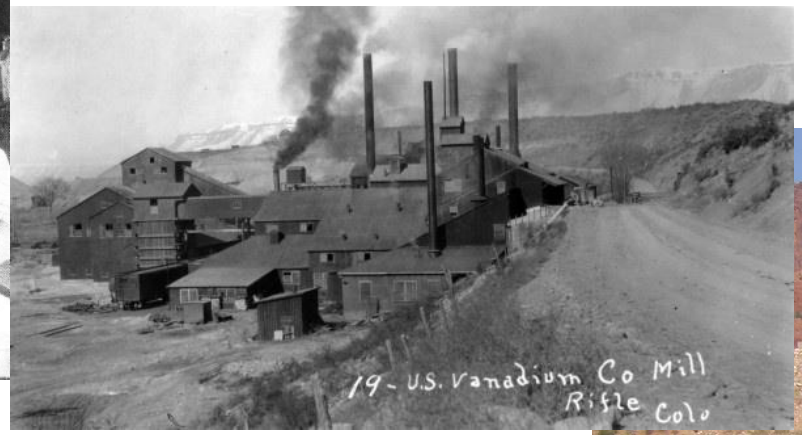
- A new vanadium mine is being permitted in Nevada:
  - Open pit/heap leach operation
  - Ore is below 0.05% by weight (unimportant quantity of source material)
  - Side stream to recover uranium by Ion Exchange.
    - NV is an Agreements State and processed the application
    - Only side stream room and packaging room under license…
    - Eluate from the heap is soluble uranium.
    - Nothing downstream from IX circuit under license (e.g., ponds)

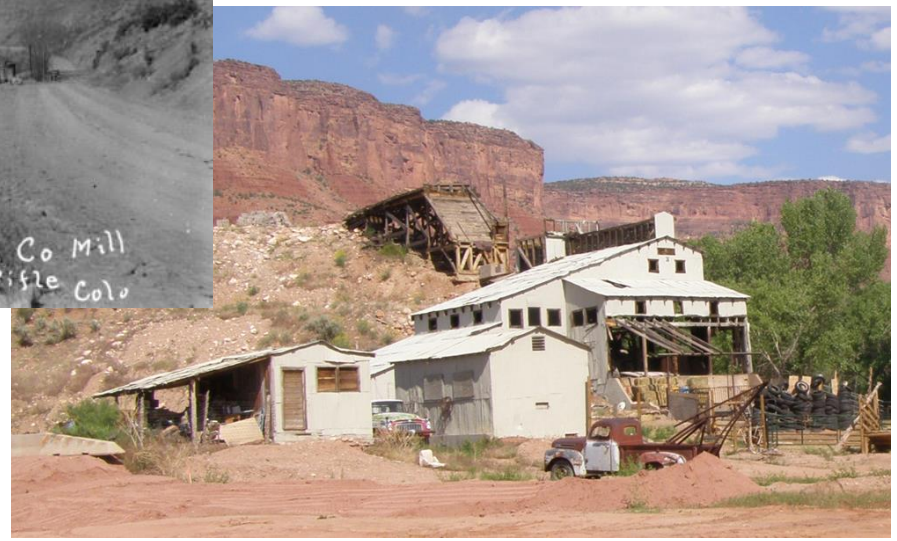
The Three Boom Phases – Radium>Vanadium>Uranium

We Have Been Here Before…

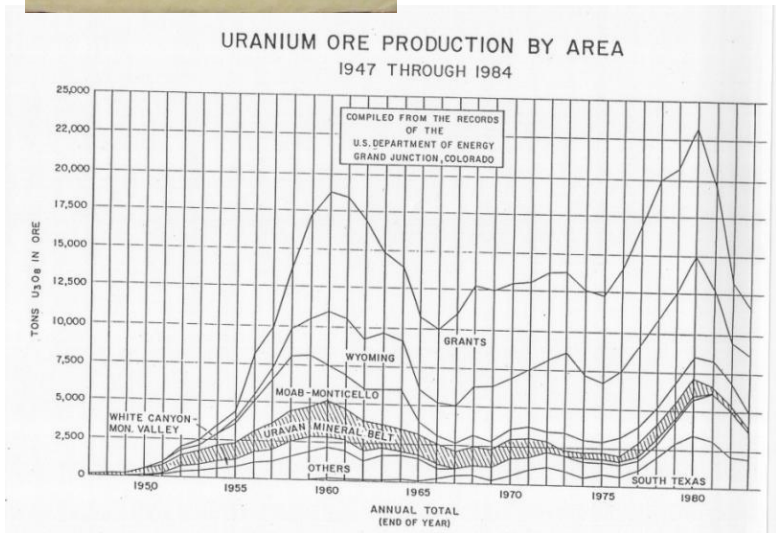


Early 1900s - Radium





1930s - Vanadium



Uranium – 1940s to present

Points to Ponder

- Many of the recommendations of the IWG report are germane to licensing of radioactive materials programs…
- International guidance from the International Atomic Energy Agency is useful (SSG-60, 2021, Ch. 3):
  - Responsibility of the Government to have a national strategy and policy and an adequate regulatory program,
  - Government to conduct inventories of affected industries – volumes and concentrations.
- State radiation programs and environmental programs are often administratively seperated – they need to work together.

Nexus between IWG and Radioactivity

- (1) improving mineral exploration and development planning and permitting;
  - BLM and USFS are not rad experts, yet they have much of the permitting duties,
  - Their regulations are not consistent with each other and other FLMA requirements
  - Most are silent on radioactivity
  - It will fall mostly to the states to coordinate the permitting and licensing processes.
  - Some states have specific TENORM regulations, others do not.
  - NPDES permitting…
  - NESHAPS for rads?
  - USGS is compiling updated geological maps using satellite technology
    - Funded under the BIL.
- (2) increasing engagement with stakeholders and potentially affected communities;
  - Environmental Justice now a focus
  - Many mining communities are evolving
    - Some are now resorts and rely on the tourist industry
  - Radioactivity has been an issue for stakeholders

Nexus between IWG and Radioactivity

- (3) expanding consultation and engagement with Tribes;
  - Sovereign
  - They have been burnt in the past
  - Earlier involvement may alleviate concerns over radioactivity. Or not.
- Recommendations (4) and (5) not germane to today's talk.
- (6) revitalizing domestic mining and other issues.
  - Radioactivity collocated with many critical minerals
  - Holistic but graded approach suggested
    - ICRP Report 142
    - NCRP Report 118

But Don’t Forget the Courts…

The Current Supreme Court is Revisiting Precedent Setting Cases…

- The Major Questions Doctrine:
  - West Virginia v. EPA (https://www.oyez.org/cases/2021/20-1530)
  - Under the “major questions doctrine,” there are “extraordinary cases” in which the “history and the breadth of the authority that [the agency] has asserted,” and the “economic and political significance” of that assertion, provide a “reason to hesitate before concluding that Congress” meant to confer such authority.
  - …Without “clear congressional authorization” for the EPA to regulate in such a manner, the agency lacks authority to implement the Clean Power Plan under the Clean Air Act.
  - Could impact agency's ability to regulate without having to go to Congress to get authority.

But Don’t Forget the Courts…

- The Chevron doctrine.
  - Loper Bright Enterprises v Raimondo (https://en.wikipedia.org/wiki/Loper_Bright_Enterprises_v._Raimondo)
  - A pending United States Supreme Court case regarding *Chevron U.S.A., Inc. v. Natural Resources Defense Council, Inc.*. The Court will decide whether or not to overrule *Chevron*.
  - “… courts must defer to the authority of administrative agency's interpretation of a statute whenever both the intent of Congress was ambiguous and the agency's interpretation is reasonable or permissible.
  - Since being handed down, *Chevron* has become among the most frequently cited cases in American administrative law. The deference afforded to agencies in the interpretation of statues has come to be known as "*Chevron* deference".
- Other pertinent cases are discussed in NCRP Commentary #29 on TENORM in Oil and Gas.
  - https://ncrponline.org/shop/commentaries/commentary-no-29/

Summary

- Numerous efforts by the Trump and Biden Administrations have been put forth to support and stimulate a domestic critical minerals sector that includes rare earths.
  - Hundreds of millions of dollars are allocated.
- In addition to Executive Branch orders, Congress passed a massive infrastructure bill that includes over $200 million in funding for critical minerals.
  - Biden's EO on battery technology did not get funded in the FY 23 Omnibus Bill.
- The private sector is also investing hundreds of millions of dollars in U.S. rare earths capabilities.
- There are many competing interests, and balance must be achieved to expand domestic mining, protect the environment, and engage traditionally marginalized communities, especially Tribes that have been particularly negatively impacted by mining in the past.
- Radioactivity must be considered in planning and permitting – not the focus of any of the reports
- This is an evolving situation!

Thank You!

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It has been an honor to work for EPA and represent them in various forums. I hope to see many of you in the future after my upcoming retirement…

Supplemental information and more links

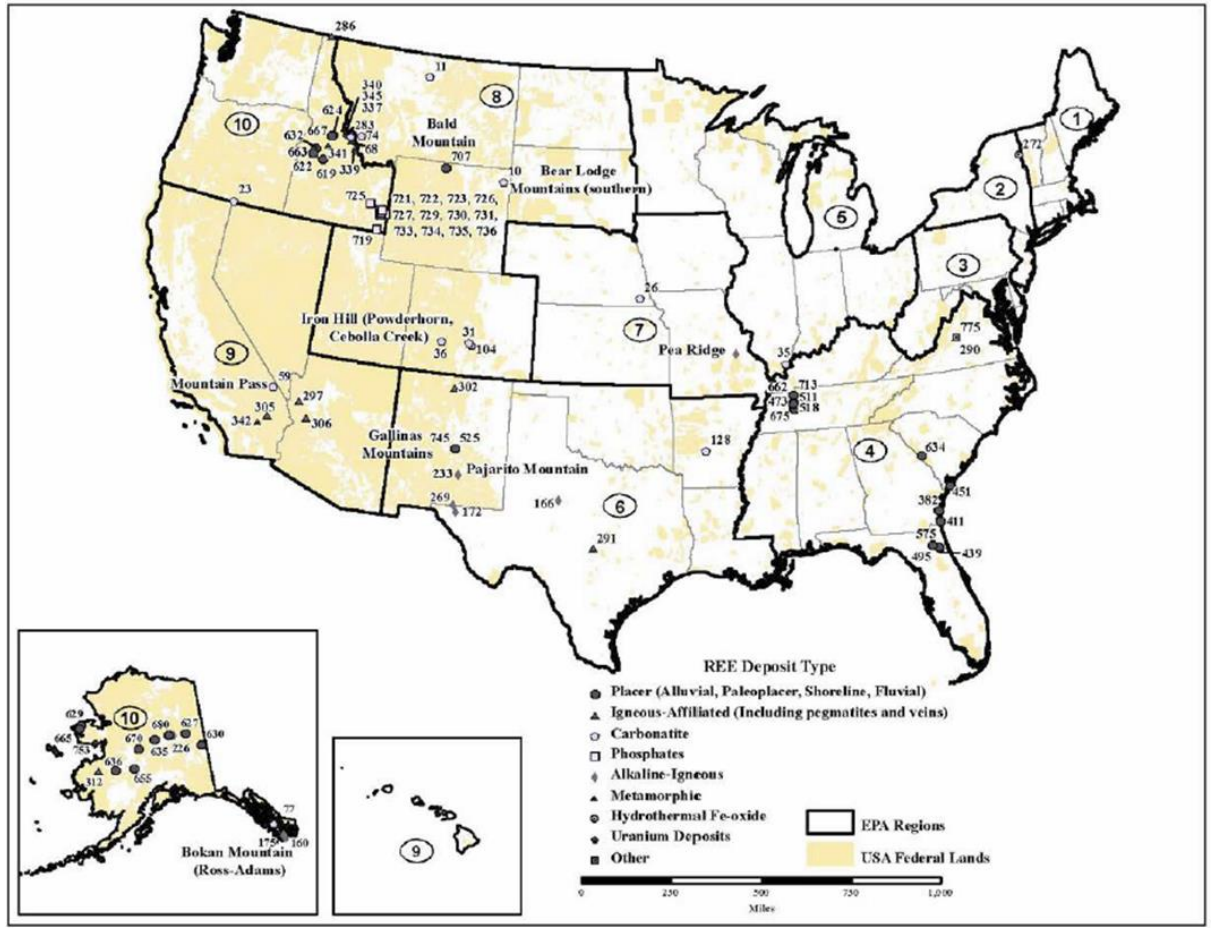
References

- IAEA 2011. Radiation Protection And Norm Residue Management In The Production Of Rare Earths From Thorium Containing Minerals. Safety Report Series 68. International Atomic Energy Agency, Vienna, Austria
- UN SDGs. https://sdgs.un.org/goals
- December 20, 2017, Executive Order (EO) 13817. **Policy to reduce the United States' vulnerability to disruptions in the supply of critical minerals**. https://www.federalregister.gov/documents/2017/12/26/2017-27899/a-federal-strategy-to-ensure-secure-and-reliable-supplies-of-critical-minerals
- June 4, 2019, U.S. Department of Commerce "**A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals**," https://www.commerce.gov/data-and-reports/reports/2019/06/federal-strategy-ensure-secure-and-reliable-supplies-critical-minerals
- September 2020, Executive Order 13953, "**Addressing the Threat to the Domestic Supply Chain from Reliance on Critical Minerals from Foreign Adversaries and Supporting the Domestic Mining and Processing Industries**", https://www.federalregister.gov/documents/2020/10/05/2020-22064/addressing-the-threat-to-the-domestic-supply-chain-from-reliance-on-critical-minerals-from-foreign
- November 2020, DOD "**Rare Earth Element Awards to Strengthen Domestic Industrial Base**". https://www.defense.gov/News/Releases/Release/Article/2418542/dod-announces-rare-earth-element-awards-to-strengthen-domestic-industrial-base/

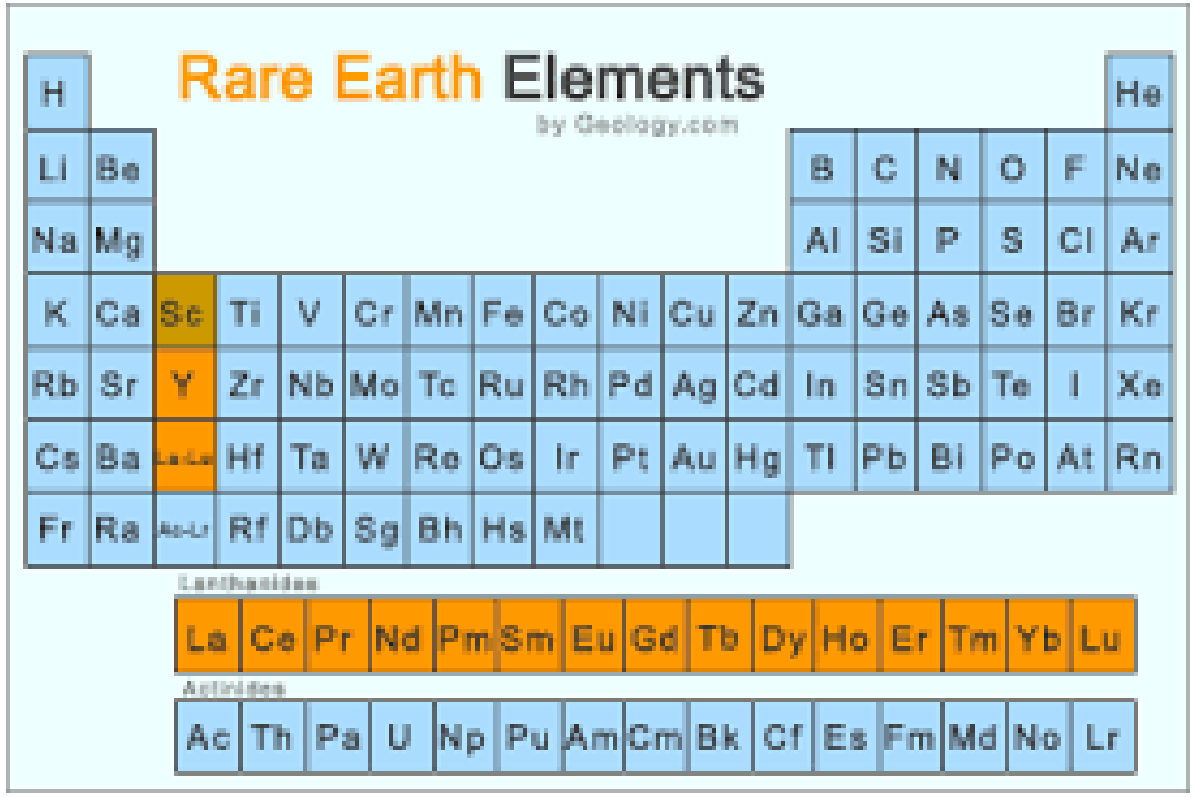
References

- November 15, 2021, **Infrastructure Investment and Jobs Act** (IIJA, P.L. 117-58). https://www.congress.gov/117/plaws/publ58/PLAW-117publ58.pdf
- February 24, 2021, EO 14017, **Executive Order on America's Supply Chains**. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/02/24/executive-order-on-americas-supply-chains/
- DOE issued "**America's Strategy to Secure the Supply Chain for a Robust Clean Energy Transition**." https://www.energy.gov/policy/securing-americas-clean-energy-supply-chain
- February 24, 2022, the critical minerals list. https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals
- March 31, 2022, "**Memorandum on Presidential Determination Pursuant to Section 303 of the Defense Production Act of 1950, as amended"** https://www.whitehouse.gov/briefing-room/presidential-actions/2022/06/06/memorandum-on-presidential-determination-pursuant-to-section-303-of-the-defense-production-act-of-1950-as-amended-on-insulation/
- May 2022, Biden-Harris permitting action plan. https://www.whitehouse.gov/wp-content/uploads/2022/05/Biden-Harris-Permitting-Action-Plan.pdf
- EXTRA: https://www.sciencenews.org/article/rare-earth-mining-renewable-energy-future

The Rare Earth Elements



Source: EPA 2012



Source: Geology.com

Rare Earths

- REEs share a high, trivalent charge ($^{+3}$) and similar large ionic size (radii);
- They do not fit well into most mineral structures (more commonly referred to as incompatible elements), and
- May be found in just a few geological environments.
- Very difficult to chemically separate.

- The principal rare earth bearing minerals found in the U.S. are (Long et al. 2010):
  - Euxenite $[(Y,Er,Ce,U,Pb,Ca)(Nb,Ta,Ti)_2(O,OH)_6]$
  - Bastnäsite $[(Ce,La,Y)CO_3F]$
  - Xenotime (YPO_4)
  - Monazite $[(Ce,La,Y,Th)PO_4]$
  - Allanite $[Ca(Ce,La,Y,Ca)Al_2(Fe^{2+},Fe^{3+})(SiO_4)(Si_2O_7)O($

Executive Actions

Do not require Congressional action

- December 20, 2017, President Trump issued Executive Order (EO) 13817.
  - **Policy to reduce the United States' vulnerability to disruptions in the supply of critical minerals**.
- June 4, 2019, U.S. Department of Commerce "**A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals**," was released as an agreed upon federal coordinated effort to reduce the nation's reliance on foreign supplies of critical minerals.
- July 22, 2019, President Trump signed **Presidential Determinations** (in accordance with Section 303 of the Defense Production Act of 1950 (DPA).
  - Provide production capability for the REMs and REEs as essential to the national defense
  - Two contracts were announced in April 2020:
    - Lynas Corporation (likely with Blue Line Corporation of Hondo, TX), and
    - MP Materials' Mountain Pass Mine in California.
    - There was consternation over funding Mountain Pass due to a Chinese firm holding a stake in the new company. In July 2020 both projects were funded.

More Executive Actions

- September 2020, President Trump signed Executive Order 13953, "**Addressing the Threat to the Domestic Supply Chain from Reliance on Critical Minerals from Foreign Adversaries and Supporting the Domestic Mining and Processing Industries**",
  - Which required progress reports from various agencies on progress to secure a domestic supply of critical minerals.
- November 2020, DOD issued "**Rare Earth Element Awards to Strengthen Domestic Industrial Base**".
  - $2.3 Million to TDA Magnetics of Rancho Dominguez, CA, and $860 thousand to Urban Mining Company of San Marcos, TX.
  - Also to MP Minerals (next slide)

Mountain Pass Redux

- DOD included $9.6 Million to MP Minerals (Mountain Pass) to develop light rare earth processing,
- DOD awarded another $35 million to MP to design and build a facility to process heavy rare earth elements (HREE).
- MP is now funded over $40 Million to develop both light and heavy rare earth elements at Mountain Pass.
- Their radioactive materials license is under timely renewal and is addressing the increase in scope at the site.

Bipartisan Infrastructure Bill…

- November 15, 2021, President Biden signed the **Infrastructure Investment and Jobs Act** (IIJA, P.L. 117-58).
- Huge infrastructure bill with many parts.
- A portion of the bill is directed at energy and minerals issues. It has provisions for:
  - Supporting geological and geophysical data preservation,
  - A USGS energy and minerals research facility, and
  - A rare earth elements demonstration facility.
- These total $140 million.
- Critical minerals mining and recycling research is also funded at $100 million
- Additionally, there are numerous provisions for improvements to battery technology.

More Executive Actions

- February 24, 2021, President Biden issued EO 14017, **Executive Order on America's Supply Chains**.
  - Addressed many supply chain issues (this was in the middle of the pandemic and supply chain issues were front and center).
  - It took an all-of-government-approach
    - Required coordination among federal agencies and required numerous progress reports.
    - Provisions to increase recycling and to invest in sustainable international sources via partnering with our allies.
- DOE issued "**America's Strategy to Secure the Supply Chain for a Robust Clean Energy Transition**."
  - The report lists "…challenges and opportunities facing the energy supply chain along with key strategies to secure America's position as a clean energy superpower in the years and decades to come"

More Recent Activity

- February 24, 2022, USGS updated the critical minerals list
  - Dropped uranium (fuels are not considered critical minerals) and
  - Listed the individual rare earths,
  - Making other changes such that the list now has 50 critical minerals listed.
- March 30, 2022, DOI issued a request for information, to inform the Interagency Working Group on Mining Regulations, Laws and Permitting (IWG).
  - Gathering information and develop recommendations for improving Federal hardrock mining regulations, laws, and permitting processes, and
  - Invited public comments to help inform the efforts of the working group
  - Report is pending…
- May 2022, Biden-Harris permitting action plan which calls for facilitating interagency coordination on siting, permitting, and supply chain issues for 6 sectors – one of which is production and processing of critical minerals

More Recent Activity

- March 31, 2022, the White House issued "**Memorandum on Presidential Determination Pursuant to Section 303 of the Defense Production Act of 1950, as amended**."
- Focused on critical minerals needed for new battery technologies.
- " It is the policy of my [the Biden] Administration that ensuring a robust, resilient, sustainable, and environmentally responsible domestic industrial base to meet the requirements of the clean energy economy, such as the production of large-capacity batteries, is essential to our national security and the development and preservation of domestic critical infrastructure."
- "…sustainable and responsible domestic mining, beneficiation, and value-added processing of strategic and critical materials for the production of large-capacity batteries for the automotive, e-mobility, and stationary storage sectors are essential to the national defense".

FY2023 Omnibus Bill

- Includes: $75 million for a strategic uranium reserve
  - Contracts recently signed…
  - Prices paid range from ~$56 lb - ~$78/lb
  - Uranium spot market has been around $60 lb recently
  - Pretty hard to put uranium in the can for that kind of money
  - There is no lack of uranium out there, even if we exclude countries we are not friendly with…
    - Australia and Canada have vast reserves.

FY2023 Omnibus Bill

- The omnibus snubbed an executive order from President Joe Biden earlier this year designed to boost domestic renewable energy manufacturing.
- DOE did receive some funding for DPA authorities under the Democrats' reconciliation package earlier this year, including $500 million to help address heat pump manufacturing capabilities and another $500 million for critical mineral mining.
- But with clean energy DPA authorities receiving zero funding in the final omnibus, it's unclear how DOE will be able to carry out any of Biden's requested actions.
- The Bill did not contain the text of Sen. Manchin's amendment to overhaul the permitting process
- DOE put out another $700 million in loan guarantees for lithium
- July 17: The Biden administration is offering up $37.5 million under the DPA for graphite mining in Alaska and processing in Washington state.

Private Sector Money

Just a couple of examples

- Energy Fuels Resources also announced in December 2021 that it had entered into a strategic venture with Nanoscale Powders to develop innovative rare earth metal-making technology.
  - They are also considering funding a new plant that could process individual rare earth elements.
- NioCorp in Elk Creek, Nebraska is trying to raise $1Billion for a rare earth mine and processing plant.
- MP Materials will invest up to $700 million at Mountain Pass to develop processing capabilities.
- GM investing $650M into Nev. lithium mining project