“If you can’t grow it, you mine it”

Library Research for Critical Minerals, Conflict Minerals, and Rare Earths

GPO FDLP Webinar: June 17, 2021

Emily C. Wild, Chemistry, Geosciences and Environmental Studies Librarian
ewild@princeton.edu

https://www.usgs.gov/media/images/cobalt-ore

lithium-bearing clays and lithium brines

https://www.usgs.gov/media/images/manganese-ore

https://www.mindat.org/element/Magnesium

https://manitousprings.org/mineral-spring-water/

Library User: “I spent two weeks searching for what you found in five minutes”
Past GPO Presentations

Upcoming and Past Webinars:
https://libguides.princeton.edu/geo/librarianwebinars

USGS Library Materials for Earth’s Age
https://www.fdlp.gov/usgs-library-materials-for-earth-s-age

USGS Library: Indexes, catalogs, and other bibliographic tools, a day in the life of a reference librarian

USGS Library: Oil, Gas, Coal, Uranium, and Minerals Maps and Data

USGS Library: Using USGS Image, Map, and Data Products for Information Inquiries

Thank You – Research Chemists & Geologists!!!!!!!

USGS Mineral Resources Program:
https://www.usgs.gov/energy-and-minerals/mineral-resources-program

USGS Geology, Geophysics, and Geochemistry Science Center:
https://www.usgs.gov/centers/gggsc

USGS Energy Resources Program:
https://www.usgs.gov/energy-and-minerals/energy-resources-program

USGS Central Energy Resources Science Center (CERSC)
https://www.usgs.gov/centers/cersc

USGS International Programs:
https://www.usgs.gov/about/organization/science-support/international-programs

International Geological Surveys:
Algeria, Afghanistan, United Arab Emirates, Saudi Arabia, Iraq, Australia, United Kingdom, Canada, Quebec, and France
Session Outline

- Critical Minerals: Varied lists of critical minerals by country, can change
- Conflict Minerals: Can change through time
- Rare Earths: Actually, not really that rare, after all
- Environmental Research for Mining Activities: Before, During, After

https://pubs.er.usgs.gov/publication/mcs2021

Chemistry: Periodic Table of Elements
Geology: Minerals – Geologic processes forming

Working with Mineral Research Chemists & Geologists in:
- Worldwide Geological Surveys
- Mining Companies
- Mining Societies & Organizations
- Regulatory Agencies
- Universities/Colleges
- Indigenous Communities

In addition to Chemistry, Geosciences and Environmental Studies, Students I help looking for Minerals Research are also from: Politics, Policy, Engineering, Economics, Finance, Ecology & Evolutionary Biology, History, Chinese Studies, Art & Archeology, Anthropology

https://library.princeton.edu/staff/specialists

Where are the elements/minerals on Earth?
Who mines the elements/minerals on Earth?
Emily C. Wild  
Princeton University Library  
ewild@princeton.edu

Schedule a Research Consultation: Mon – Fri  
Meet Our Specialists – Emily Wild

From hurricanes to astrogeology: Princeton’s geosciences librarian and collections serve national, international communities

My personal investments are still within the USGS & Interior Ethics Guidelines: https://on.doi.gov/3hOdIpi

I follow ALA Code of Ethics, Privacy & Confidentiality: http://www.ala.org/tools/ethics

Princeton University Library, 2018-Present  
Chemistry, Geosciences and Environmental Studies Librarian

2008-2018 - Librarian (Physical Scientist): Denver, Colorado  

I am from Northern New York along Québec border = English & French daily  
During my childhood, my family spoke: French, Italian, German, Polish  
Mining history from family: Québec, France, Poland, Germany, Italy

https://gisservices.dec.ny.gov/gis/maw/  
https://mern.gouv.qc.ca/ mines/  
https://sigeom.mines.gouv.qc.ca/signet/classes/l108_afchCartelntr
### Periodic Table of Elements

A Resource for Elementary, Middle School, and High School Students

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Period 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H (1.008)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period 2</th>
</tr>
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<tbody>
<tr>
<td>2</td>
</tr>
<tr>
<td>Li (8.94)</td>
</tr>
<tr>
<td>Be (9.11)</td>
</tr>
<tr>
<td>Mg (12.01)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Period 3</th>
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<tbody>
<tr>
<td>Na (22.99)</td>
</tr>
<tr>
<td>K (39.10)</td>
</tr>
<tr>
<td>Ca (40.08)</td>
</tr>
<tr>
<td>Sc (44.96)</td>
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<tr>
<th>Period 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ti (47.88)</td>
</tr>
<tr>
<td>V (50.54)</td>
</tr>
<tr>
<td>Cr (52.00)</td>
</tr>
<tr>
<td>Mn (54.94)</td>
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<tr>
<td>Fe (55.85)</td>
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</tbody>
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<tr>
<th>Period 5</th>
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</thead>
<tbody>
<tr>
<td>Co (58.93)</td>
</tr>
<tr>
<td>Ni (58.69)</td>
</tr>
<tr>
<td>Cu (63.55)</td>
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<tr>
<td>Zn (65.38)</td>
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<tr>
<td>Ga (69.72)</td>
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<tr>
<th>Period 6</th>
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</thead>
<tbody>
<tr>
<td>Ge (72.63)</td>
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<tr>
<td>As (74.92)</td>
</tr>
<tr>
<td>Se (80.86)</td>
</tr>
<tr>
<td>Br (79.90)</td>
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<tr>
<th>Period 7</th>
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<tbody>
<tr>
<td>Kr (83.80)</td>
</tr>
<tr>
<td>Sr (87.62)</td>
</tr>
<tr>
<td>Y (88.91)</td>
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<tr>
<td>Zr (91.22)</td>
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<tr>
<th>Period 8</th>
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</thead>
<tbody>
<tr>
<td>Nb (92.91)</td>
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<tr>
<td>Mo (95.94)</td>
</tr>
<tr>
<td>Tc (98.77)</td>
</tr>
<tr>
<td>Ru (101.07)</td>
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<tr>
<td>Rh (102.91)</td>
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<tr>
<td>Pd (106.42)</td>
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<tr>
<td>Ag (107.87)</td>
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<tr>
<td>Cd (112.41)</td>
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<tr>
<td>In (114.82)</td>
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<tr>
<td>Sn (118.71)</td>
</tr>
<tr>
<td>Sb (121.76)</td>
</tr>
<tr>
<td>Te (127.60)</td>
</tr>
<tr>
<td>I (126.90)</td>
</tr>
<tr>
<td>Xe (131.30)</td>
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<tr>
<td>Cs (132.91)</td>
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</table>

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<tr>
<th>Period 10</th>
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</thead>
<tbody>
<tr>
<td>Ba (137.33)</td>
</tr>
<tr>
<td>La (138.91)</td>
</tr>
<tr>
<td>Ce (140.11)</td>
</tr>
<tr>
<td>Pr (140.91)</td>
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<tr>
<td>Nd (144.24)</td>
</tr>
<tr>
<td>Sm (150.36)</td>
</tr>
<tr>
<td>Eu (152.00)</td>
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<tr>
<td>Gd (157.25)</td>
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<tr>
<td>Tb (158.92)</td>
</tr>
<tr>
<td>Dy (162.50)</td>
</tr>
<tr>
<td>Ho (164.93)</td>
</tr>
<tr>
<td>Er (167.25)</td>
</tr>
<tr>
<td>Tm (168.93)</td>
</tr>
<tr>
<td>Yb (173.04)</td>
</tr>
<tr>
<td>Lu (174.97)</td>
</tr>
</tbody>
</table>

### Other Resources

- **Los Alamos National Laboratory**

- **USGS Laboratories**
  - [https://www.usgs.gov/usgs-laboratories](https://www.usgs.gov/usgs-laboratories)

- **International Union of Pure and Applied Chemistry**

- **IUPAC Technical Report**

Ex. Chemistry from my childhood

Periodic Table of Elements = Le tableau périodique des éléments = Periodensystem der Elemente

United States: ACS  
https://www.acs.org/content/acs/en.html

France: Société Chimique de France  
https://new.societechimiquedefrance.fr

Germany: Gesellschaft Deutscher Chemiker (GDCh)  
https://www.gdch.de/

European Chemical Society:  
https://www.euchems.eu/euchems-periodic-table/
European Chemical Society: https://www.euchems.eu/euchems-periodic-table/
Why do I help researchers with Critical Minerals? In the News:

EU-Canada summit, Brussels, 14 June 2021

To diversify sources of important green and digital economy inputs away from less like-minded producers, and to foster competitive EU-Canada supply chains, the leaders established an EU-Canada Strategic Partnership on Raw Materials.

https://www.consilium.europa.eu/en/meetings/international-summit/2021/06/14/

The leaders announced a new strategic partnership on raw materials to help ensure the security of supply chains for the critical minerals and metals that are essential to the transition to a cleaner and digitized economy, including for use in electric vehicles and advanced battery storage.


**Murkowski Raises Domestic Critical Mineral Supply Chain to Secretary of Energy**

MISSOURI DEPARTMENT OF NATURAL RESOURCES AWARDED GRANT FOR INITIATIVE TO ASSESS RARE EARTH ELEMENTS AND CRITICAL MINERALS

French mining company Eramet and local utility Électricité de Strasbourg (ÉS) successfully extract lithium from geothermal brine in Alsace, France.

Missouri Department of Natural Resources awarded grant for initiative to assess rare earth elements and critical minerals

"Invest in sustainable domestic and international production and processing of critical minerals"

Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)

First test of a manganese nodule collector in around four kilometers of water: research consortium successfully completes monitoring of environmental impacts in the Pacific

Page 12:
Comparison to the Initial Critical Minerals List

The list of mineral commodities that are recommended for inclusion on the CML in this analysis (and the basis for that recommendation) is provided and compared to those on the initial CML in table 2.

Interior Releases 2018’s Final List of 35 Minerals Deemed Critical to U.S. National Security and the Economy

Figure 1. Supply risk indicators for selected mineral commodities from 2007 through 2018. The 54 mineral commodities assessed (shaded areas) for the period 2007 through 2018, time-series evaluations of the following supply risk indicators are displayed on a periodic table of the elements: A, disruption potential; B, trade exposure; C, economic vulnerability; and D, overall supply risk for 2007 through 2018. Normalized indicator scores range from 0 to 1, with higher scores indicating a greater degree of disruption potential, trade exposure, economic vulnerability, or supply risk. For some commodities, indicator scores are rounded to avoid disclosing company proprietary data. The scores for graphite and fluorspar are provided under carbon ("C") and fluorine ("F"), respectively, and because no one element is associated with mica or feldspar, these mineral commodities are shown separately. Element symbols are defined in the periodic table provided in the front of the report.
Interior Releases 2018’s Final List of 35 Minerals Deemed Critical to U.S. National Security and the Economy


• Aluminum (bauxite), used in almost all sectors of the economy
• Antimony, used in batteries and flame retardants
• Arsenic, used in lumber preservatives, pesticides, and semi-conductors
• Barite, used in cement and petroleum industries
• Beryllium, used as an alloying agent in aerospace and defense industries
• Bismuth, used in medical and atomic research
• Cesium, used in research and development
• Chromium, used primarily in stainless steel and other alloys
• Cobalt, used in rechargeable batteries and superalloys
• Gallium, used for integrated circuits and optical devices like LEDs
• Germanium, used for fiber optics and night vision applications
• Graphite (natural), used for lubricants, batteries, and fuel cells
• Hafnium, used for nuclear control rods, alloys, and high-temperature ceramics
• Helium, used for MRIs, lifting agent, and research
• Indium, mostly used in LCD screens
• Lithium, used primarily for batteries
• Magnesium, used in furnace linings for manufacturing steel and ceramics
• Manganese, used in steelmaking
• Niobium, used mostly in steel alloys
• Platinum group metals, used for catalytic agents
• Potash, primarily used as a fertilizer
• Rare earth elements group, primarily used in batteries and electronics
• Rhenium, used for lead-free gasoline and superalloys
• Rubidium, used for research and development in electronics
• Scandium, used for alloys and fuel cells
• Strontium, used for pyrotechnics and ceramic magnets
• Tantalum, used in electronic components, mostly capacitors
• Tellurium, used in steelmaking and solar cells
• Tin, used as protective coatings and alloys for steel
• Titanium, overwhelmingly used as a white pigment or metal alloys
• Tungsten, primarily used to make wear-resistant metals
• Uranium, mostly used for nuclear fuel
• Vanadium, primarily used for titanium alloys
• Zirconium, used in the high-temperature ceramics industries
Why do I help researchers with Critical Minerals?
https://www.usgs.gov/media/images/critical-mineral-commodities-renewable-energy
Why do I help researchers with Critical Minerals?
https://www.usgs.gov/media/images/critical-mineral-commodities-renewable-energy

Batteries
Batteries play an important supporting role for renewable energy sources like wind and solar, allowing excess power to be stored for usage when direct solar or wind power are unavailable. Just like the energy sources they complement, modern batteries rely on critical mineral commodities, particularly cobalt, graphite, lithium, and manganese.

Cobalt
On a global basis, the leading use of cobalt is in rechargeable battery electrodes. In 2018, the United States relied on foreign sources for 61% of the cobalt it consumed.

Graphite
Graphite serves as an electrode in many lithium batteries. In 2018, the United States was 100% reliant on foreign sources for graphite.

Lithium
Lithium has a long history in batteries and is a common material used in batteries today. In 2018, the United States was more than 50% reliant on foreign sources for lithium.

Manganese
Manganese serves as an electrode in many lithium batteries. The United States was 100% reliant on foreign sources for manganese in 2018.
Australia, Chile, and Argentina often produce the lithium used in battery cathodes, while the hard-to-come-by tantalum – used in smartphone circuitry – mostly comes from Congo, Rwanda, and Brazil.

Lithium: https://pubs.er.usgs.gov/publication/pp1802K
“Lithium, the lightest of all metals, is used in air treatment, batteries, ceramics, glass, metallurgy, pharmaceuticals, and polymers.”

Manganese: https://pubs.er.usgs.gov/publication/pp1802L
“Manganese is an essential element for modern industrial societies. Its principal use is in steelmaking, where it serves as a purifying agent in iron-ore refining and as an alloy that converts iron into steel.”

https://pubs.er.usgs.gov/search?q=critical+minerals
https://library.princeton.edu/find/all/USGS%202020%20CRITICAL%20MINERALS%20REVIEW

“Emily’s helping mineral researchers cycle”
I help Chemists & Geologists prior to publication
I help geologists find data and new research published since this publication
I help researchers find the publication & data when published through outreach & instruction events
I help mining companies and investors find the references & data within the publication (NYC, Princeton, Alumni, ...)

https://pubs.er.usgs.gov/publication/pp1802
https://pubs.er.usgs.gov/publication/ofr20211045
https://pubs.er.usgs.gov/publication/ofr20181021
Geological Surveys Worldwide


Geoscience Organizations of the World

Directory of Geoscience Organizations of the World

by
Research Planning Office for Geological Survey of Japan, AIST
Geological Survey of Canada, Ottawa (Headquarters)

Ontario Geological Survey (OGS) http://www.geologyontario.mndm.gov.on.ca
Ministère de l’Énergie et des Ressources naturelles (MERN) https://mern.gouv.qc.ca/

Alberta Geological Survey (AGS) http://ags.aer.ca
British Columbia Geological Survey (BCGS) http://www.em.gov.bc.ca/geology/
Manitoba Geological Survey (MGS) http://www.manitoba.ca/iem/geo/
New Brunswick Minerals and Petroleum http://www.gnb.ca/0078/minerals

Geological Survey Division of Newfoundland and Labrador http://www.nr.gov.nl.ca/nr
Northwest Territories Geological Survey http://www.nwtgeoscience.ca/
Saskatchewan Geological Survey http://www.economy.gov.sk.ca/
Yukon Geological Survey (YGS) http://geology.gov.yk.ca/
Geological Surveys Worldwide


France

Bureau de Recherches Géologiques et Minières (BRGM)
3, Avenue Claude Gullemin, B.P. 6009, F-45060, Orléans Cedex 2
Phone: +33-2 38 64 34 34
Fax: +33-2 38 64 35 18
WWW Page: http://www.brgm.fr/

French Research Institute for Exploitation of the Sea (IFREMER) (Institut Français de Recherche pour l'Exploitation de la Mer)
Technopole de Brest-Iroise, BP 70 29280 PLOUZANE
Phone: +33-2-98224040
Fax: +33-2-98224545
WWW Page: http://www.ifremer.fr/

http://www.brgm.fr/
http://www.ifremer.fr/
Geological Surveys Worldwide

Germany

Federal Institute of Geoscience and Natural Resources (BGR) (Bundesanstalt für Geowissenschaften und Rohstoffe)
Geozentrum Hannover, Stillweg 2, D-30655 Hannover
Phone: +49-511-543-0
Fax: +49-511-643-2304
Email: poststelle@bgr.de

Alfred Wegener Institute Helmholtz Center for Polar and Marine Research (AWI) (Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung)
Am Handelshafen 12, 27570 Bremerhaven
Phone: +49-471-4331-0
Fax: +49-471-4831-1149
WWW Page: [https://www.awi.de/en.html](https://www.awi.de/en.html)

Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences (GFZ) (Helmholtz Zentrum Potsdam - Deutsches GeoForschungsZentrum GFZ)
Telegrafenberg, D-14473 Potsdam
Phone: +49-331-288-0
Fax: +49-331-288-1044

GEOMAR Helmholtz Centre for Ocean Research Kiel
Wischnihowstrasse 1-3, D-24148 Kiel
Phone: +49-431-600-0
Fax: +49-431-600-2805
Email: info@geomar.de
Mineral commodity summaries 2021, Mineral Commodity Summaries
Minerals Yearbook, volume III, Area Reports—International—Latin America and Canada, 2018, Minerals Yearbook (III) -
Minerals Yearbook, volume III, Area Reports—International—Europe and Central Eurasia, 2018, Minerals Yearbook (III) -
Minerals Yearbook, volume III, Area Reports—International—Asia and the Pacific, 2018, Minerals Yearbook (III) -
Minerals Yearbook, volume III, Area Reports—International—Africa and the Middle East, 2018, Minerals Yearbook (III) -
Minerals Yearbook, volume I, Metals and Minerals, 2018, Minerals Yearbook (I) -
Minerals Yearbook, volume II, Area Reports—Domestic, 2018, Minerals Yearbook (II) -
Minerals Yearbook, volume III, Area Reports—International, 2018, Minerals Yearbook (III) -

By Country: https://www.usgs.gov/centers/nmic/international-minerals-statistics-and-information

Algeria - Map (GIF) (Key)
The Mineral Industry of Algeria PDF Format:

https://www.usgs.gov/centers/nmic/mineral-commodity-summaries

Helium PDF Format:
Cobalt Statistics and Information
https://www.usgs.gov/centers/nmic/cobalt-statistics-and-information
Mineral Industry Surveys
Cobalt
PDF Format:
2021: | Jan | Feb | Mar |
2020: | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
Mineral Commodity Summaries
Cobalt
PDF Format:
Minerals Yearbook
Cobalt
PDF Format:
1994 | 1994
Lithium: [https://www.usgs.gov/centers/nmic/lithium-statistics-and-information](https://www.usgs.gov/centers/nmic/lithium-statistics-and-information)

Mineral Commodity Summaries

- Lithium
- PDF Format:
- Appendixes

Minerals Yearbook

Lithium
- PDF Format:

Australia: [https://www.ga.gov.au/](https://www.ga.gov.au/)

Lithium--For Harnessing Renewable Energy
- Fact Sheet 2014-3035
- Lithium use in batteries
- Circular 1371

Niobium (Columbium) and Tantalum Statistics and Information

Mineral Commodity Summaries
Tantalum PDF Format:


Minerals Yearbook Tantalum PDF Format:

| 2015 | 2016 | 2017 |

Conflict Minerals from the Democratic Republic of the Congo--Global Tantalum Processing Plants, a Critical Part of the Tantalum Supply Chain
Fact Sheet 2014-3122

Tantalum is extensively used in products that require high reliability in extreme environments. The metal is commonly found in capacitors and super alloys that are applied in many electronics, automotive and aerospace products. More than half of the world’s tantalum is mined in Africa, including artisanal mining operations in the Democratic Republic of the Congo (DRC) and its neighboring countries. Tantalum is covered by regulations related to “conflict minerals” in the United States and the European Union.
A challenge for the global economy is to meet the growing demand for commodities used in today’s advanced technologies. Critical minerals are commodities (for example, elements, compounds, minerals) deemed vital to the economic and national security of individual countries that are vulnerable to supply disruption. The national geological agencies of Australia, Canada, and the United States recently joined forces to advance understanding and foster development of critical mineral resources in their respective countries through the Critical Minerals Mapping Initiative (CMMI). An initial goal of the CMMI is to fill the knowledge gap on the abundance of critical minerals in ores. To do this, the CMMI compiled modern multielement geochemical data generated by each agency on ore samples collected from historical and active mines and prospects from around the world. To identify relationships between critical minerals, deposit types, deposit environments, and mineral systems, a unified deposit classification scheme was needed. This report describes the scheme developed by the CMMI to classify the initial release of geochemical data. In 2021, the resulting database—along with basic query, statistical analysis, and display tools—will be served to the public through a web-based portal managed by Geoscience Australia. The database will enable users to trace critical minerals through mineral systems and identify individual deposits or deposit types that are potential sources of critical minerals.
U.S. Geological Survey

*Vic worked down the hall from the USGS Denver Library & he introduced me to visiting researchers & referred researchers from international geological surveys & societies: Australia, Canada, France, Iraq, Japan, Venezuela, and many others...

2016 - Underpinning Innovation: The Science and Supply of America's Critical Minerals and Materials

Advances in critical mineral research: A forum in memory of Victor Labson


Sponsored by the World Community of Geological Surveys and hosted by the American Geosciences Institute

https://www.americangeosciences.org/webinars/critical-minerals-forum-2021

https://www.youtube.com/playlist?list=PLTBBygdCOWWc3qmnd31sktv8UxD_oTG6

27 videos:


Europe and Africa: Laboratório Nacional de Energia e Geologia and Instituto Geológico y Minero de España (Portugal and Spain), Geologian Tutkimuskeskus (Finland), British Geological Survey (United Kingdom), Bureau de Recherches Géologiques et Minières (France), Botswana Geoscience Institute (Botswana), Council for Geoscience (South Africa)

Asia and Oceania Session: Geoscience Australia, Coordinating Committee for Geoscience Programmes in East and Southeast Asia (Thailand), Korea Institute of Geoscience and Mineral Resources, GNS (New Zealand) Geological Survey of Queensland (Australia), Geological Survey of India

Society of Exploration Geophysicists

https://library.seg.org/doi/10.1190/tle40020155.1

Geological Surveys Unite to Improve Critical Mineral Security

The USGS has over 500 laboratories nationwide. Those with active sites are listed here, with many more coming online over the coming year.

Reston Stable Isotope Laboratory: https://isotopes.usgs.gov/
Isotopic Reference Materials
https://isotopes.usgs.gov/research/topics/isotopereferencematerials.html
Isotope-Ratio Reporting Guidelines
https://isotopes.usgs.gov/research/topics/reportingguidlines.html
https://www.usgs.gov/staff-profiles/tyler-b-coplen

Reference Materials and Calibration Services
https://isotopes.usgs.gov/lab/referencematerials.html

Instructions for Collecting Samples
https://isotopes.usgs.gov/lab/instructions.html

Methods & SOPs
https://isotopes.usgs.gov/lab/methods.html
Colorado Laboratories:

Spectroscopy Lab [https://www.usgs.gov/labs/spec-lab]
Software: [https://www.usgs.gov/labs/spec-lab/software]

Mineralogy and Microscopy Laboratory
The Mineralogy and Microscopy Laboratory in the Geosciences and Environmental Change Science Center, Denver Colorado, supports the investigation of mineralogical components of sediments and whole rock materials. [https://www.usgs.gov/centers/gecsc/labs/mineralogy-and-microscopy-laboratory]

USGS TRIGA Reactor
[https://www.usgs.gov/core-science-systems/crc/gstr]
The USGS TRIGA® Reactor (GSTR) is a low–enriched uranium–fueled, pool–type reactor. The mission of the TRIGA® is to support USGS science by providing information on geologic, plant, and animal specimens to advance methods and techniques unique to nuclear reactors.
Methods used for the collection and analysis of chemical and biological data for the Tapwater Exposure Study, United States, 2016–17

https://pubs.er.usgs.gov/publication/ofr20181098

Prepared in cooperation with the Colorado School of Mines, Center for Environmental Risk Assessment; National Institutes of Health/National Institute of Environmental Health Sciences (NIH/NIEHS), National Toxicology Program Laboratory; University of Illinois at Chicago, School of Public Health; U.S. Environmental Protection Agency, National Exposure Research Laboratory; U.S. Environmental Protection Agency, National Health and Environmental Effects Laboratory
Recent Lewis Science Library & East Asian Library acquisitions: Geochemical Atlas series (China)
https://library.princeton.edu/find/all/Geochemical%20Atlas%20China

Acta geologica Polonica
Languages= Polish, English, French, Russian
The Association of American State Geologists (AASG) represents the State Geologists of the 50 United States and Puerto Rico. Founded in 1908, AASG seeks to advance the science and practical application of geology and related earth sciences in the United States and its territories, commonwealths, and possessions.

In the context of the present national and international outcry over continuing unjust treatment toward people of color in this country, the Association of American State Geologists, during our annual meeting held the week of June 8th, 2020, took steps to ensure that we will more actively face injustices and commit to challenging and changing the biases that lead to discriminatory practices against people of color.

Click on a state below to go to it’s geological survey’s website, or view the full list of state geological surveys.
Critical minerals are the building blocks for the clean and digitized economy. Learn about Canada’s critical minerals list, actions and initiatives that help promote Canada’s competitiveness, and resources related to critical minerals in Canada.

Critical minerals are vital to growing Canada’s clean, modern economy

Canada is primed to capitalize on the rising global demand for critical minerals, driven in large part by their role in the transition to a low-carbon and digitized economy. Essential for renewable energy and clean technology applications (batteries, permanent magnets, solar panels and wind turbines), they are also required inputs for advanced manufacturing supply chains, including defence and security technologies, consumer electronics, agriculture, medical applications and critical infrastructure. Economies that quickly secure a position in shifting supply chains will be well situated for long-term economic growth and prosperity.
Development of critical and strategic minerals in Québec

May 31, 2021:
Critical and Strategic Minerals in Quebec - Quebec grants $ 3.35 million to support the production and upgrading of critical and strategic minerals
https://www.quebec.ca/nouvelles/actualites/details/les-mineraux-critiques-et-strategiques-au-quebec-quebec-acorde-335-m-au-soutien-de-la-production-et-de-la-revalorisation-de-mineraux-critiques-et-strategiques-31883

5N Plus is a leading global producer of specialty semiconductors and performance materials.
https://www.5nplus.com/?lang=en
BERLIN, April 28 (Reuters) - With an eye on rapidly rising demand from Germany's electric vehicle industry, power and mining companies alike are striving to bring to the surface lithium trapped in underground springs of boiling hot water thousands of metres below the Rhine river.


Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)
[Federal Institute for Geosciences and Natural Resources]

Mineral commodities
https://www.bgr.bund.de/EN/Themen/Min_rohstoffe/min_rohstoffe_node_en.html

Mining Conditions and Trading Networks in Artisanal Copper-Cobalt Supply Chains in the Democratic Republic of the Congo (2021) (PDF, 6 MB)

Commodity TopNews 64 (2020): COVID-19 Crisis threatens responsible mineral supply chains - a case study based on the DR Congo (PDF, 2 MB)

Commodity TopNews 61 (2019): Tin from Myanmar – A Scenario for Applying the European Union Regulation on Supply Chain Due Diligence (PDF, 3 MB)

Porsche To Build EV Battery Plant In Germany
Porsche's new German battery plant will also develop and build performance batteries.
https://www.torquenews.com/9900/porsche-build-ev-battery-plant-germany
Algerian Geological Survey Agency
Ministère de l’Energie et des Mines Agence du Service Géologique de l’Algérie
https://asga.dz/

Livret Des Ressources Minérales https://asga.dz/livret-des-ressources-minerales/

Bulletins Sommaires Échanges https://asga.dz/bulletins-sommaires-echanges/

Using mobile GIS applications to support mineral resource investigations in the Eglab region, Algeria
https://pubs.er.usgs.gov/publication/70206933

Bulletin du Service géologique national.
- Princeton University Library Catalog: https://catalog.princeton.edu/catalog/5427215
- USGS Library Catalog: https://www.usgs.gov/core-science-systems/usgs-library/

He - Hélium : Algeria is #3 in world: 8.2 billion cubic meters
https://pubs.er.usgs.gov/publication/mcs2021
Every American Born Will Need...

3.19 MILLION POUNDS
of minerals, metals, and fuels in their lifetime

©2020 Minerals Education Coalition

Learn more at www.MineralsEducationCoalition.org

https://mineralseducationcoalition.org/
A Crosswalk of Mineral Commodity End Uses and North American Industry Classification System (NAICS) codes
Open-File Report 2015-1163
https://pubs.er.usgs.gov/publication/ofr20151163
https://pubs.usgs.gov/of/2015/1163/ofr20151163_tables1-77.xlsx

Table 14. End uses of cobalt and corresponding North American Industry Classification System (NAICS) codes.

<table>
<thead>
<tr>
<th>End use</th>
<th>NAICS</th>
<th>Quantity</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
<td>1,080</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>Catalyst</td>
<td>5,490</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Petroleum</td>
<td>324</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plants</td>
<td>325</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigments</td>
<td>6,220</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Glass, porcelain, ceramics</td>
<td>325</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pew, sbl</td>
<td>325</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enamelware</td>
<td>325</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tire, adhesive, gags, divs (paint incl)</td>
<td>328</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel, niobium, tantalum, molybdenum</td>
<td>328</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accretion and analysis (paint incl)</td>
<td>328</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedstock, smelting, refining, smelting</td>
<td>2,444</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal feed</td>
<td>331</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereal processing, milling</td>
<td>334</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee treatment</td>
<td>325</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vine, strawberry</td>
<td>325</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magazine, periodical publishing, printing</td>
<td>324</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical, electronic</td>
<td>20,150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batteries</td>
<td>16,474</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>Portable devices</td>
<td>334</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid electric vehicles</td>
<td>335</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric vehicles</td>
<td>335</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnets</td>
<td>4,270</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>Generators</td>
<td>321</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind turbines</td>
<td>321</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instrumentation</td>
<td>321</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motors</td>
<td>321</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotating machines</td>
<td>321</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static transformers</td>
<td>321</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top performance electrical machines</td>
<td>321</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telephones</td>
<td>327</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cables</td>
<td>327</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machinery</td>
<td>7,995</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>Textile materials</td>
<td>7,893</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>Computer software</td>
<td>325</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machining panel</td>
<td>325</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood furniture</td>
<td>333</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Textiles</td>
<td>333</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The principal economic sources of rare earths are the minerals bastnasite, monazite, and loparite and the lateritic ion-adsorption clays. The rare earths are a relatively abundant group of 17 elements composed of scandium, yttrium, and the lanthanides. The elements range in crustal abundance from cerium, the 25th most abundant element of the 78 common elements in the Earth's crust at 60 parts per million, to thulium and lutetium, the least abundant rare-earth elements at about 0.5 part per million. The elemental forms of rare earths are iron gray to silvery lustrous metals that are typically soft, malleable, and ductile and usually reactive, especially at elevated temperatures or when finely divided. The rare earths' unique properties are used in a wide variety of applications.

From PP-1802-O: “The rare-earth elements (REEs) are 15 elements that range in atomic number from 57 (lanthanum) to 71 (lutetium); they are commonly referred to as the “lanthanides.” Yttrium (atomic number 39) is also commonly regarded as an REE because it shares chemical and physical similarities and has affinities with the lanthanides. Although REEs are not rare in terms of average crustal abundance, the concentrated deposits of REEs are limited in number”
## Rare-Earth Elements

**https://pubs.er.usgs.gov/publication/pp1802O**

<table>
<thead>
<tr>
<th>Table 03. Active rare-earth mines, by deposit type.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Deposit</strong></td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Bayan Obo</td>
</tr>
<tr>
<td>Dahuixiang (Dahaiou)</td>
</tr>
<tr>
<td>Maoniuping</td>
</tr>
<tr>
<td>Weishan</td>
</tr>
<tr>
<td>Mountain Pass</td>
</tr>
<tr>
<td>Mount Weld</td>
</tr>
</tbody>
</table>

### Peralkaline igneous

- **Karnasurt Mountain, Lovozero deposit**  
  **Northern region, Russia**  
  Loparite concentrate contains 30 to 35 percent REO  
  Zaitsev and Kogarko (2012)

### Heavy-mineral sand deposits

- **Buena Norte mining district**  
  **East coast of Brazil**  
  Historic and active producer of REEs from monazite in coastal sands  
  NA

### Ion-adsorption clay deposits

- **Dong Pao Mine**  
  **Vietnam**  
  Mine is reportedly in a late stage of development. Laterite clays overlie syenite intrusions  
  NA

### South China clay deposits

- **Jiangxi, Hunan, Fujian, Guangdong, and Guangxi Provinces, southern China**  
  About 0.05 to 0.4  
  Numerous small mines. Little ore information is available. Best source of data may be Chi and Tian (2008)  
  Clark and Zheng (1991), Bao and Zhao (2008); Chi and Tian (2008)
Library Classification Systems

U.S. Geological Survey Library Classification System

https://pubs.usgs.gov/bul/b2010/ &
https://usgs.primo.exlibrisgroup.com/discovery/search?vid=01USGSL_INST:01USGSL_INST

SECTION 5 – MINERAL RESOURCES, MINERAL INDUSTRIES, AND ECONOMIC GEOLOGY

(401) Congresses

(402) Mineral resources agencies and mining bureaus of countries, states, and provinces (Includes maps text by bureaus of mines and mineral resources not classified elsewhere.)

EXAMPLES:

402(100) Canada. Mineral Resources Division
402(274) Arizona. Dept. of Mineral Resources
402(120) Nova Scotia Dept. of Mines

(403) Mineral resources and mining industries (textbooks and general works)

403.1 Mineral technology (Includes economic aspects of mineral technology)

(404) Economic aspects of mineral resources and mining industries including economic geology

405 Encyclopedias and catalogs (for mineral locations)

406 Nomenclature and classification

407 History (Includes mining history)

408 General mineral and metal statistics

409 Essays, collections, and special topics

410 Ore deposits (Includes metal deposits: metallogeny, origin and formation of ores; all other aspects of ore deposits including geochemical and thermodynamic aspects)

411 Lodes, veins, dikes

412 Rock-forming minerals

413 Trace elements (minor and accessory elements)

414 Placer deposits

415 Economic aspects of metal deposits (Includes analyses for economic use)

416 Microscopic determination

420 Mines and mining

421 Mining law and legislation

422 Economic aspects of mines and mining (Includes mine prospectuses and reports)

422.5 Mining company and corporate annual reports

424 Mine surveying

425 Mining methods and working

425 Mining subsidence

426 Geophysical prospecting

426.4 Other specific prospecting methods (Includes electric, nuclear (radiometric), gravity, magnetotelluric, torsion balance methods, and so forth)
Library Classification Systems

Library of Congress Library Classification System

Geology = Subclass QE
QE1-996.5 Geology
QE1-350.62 General Including geographical divisions
QE351-399.2 Mineralogy
QE420-499 Petrology
QE500-639.5 Dynamic and structural geology
QE521-545 Volcanoes and earthquakes
QE601-613.5 Structural geology
QE640-699 Stratigraphy
QE701-760 Paleontology
QE760.8-899.2 Paleozoology
QE901-996.5 Paleobotany

Chemistry = Subclass QD
QD1-999 Chemistry
QD1-65 General
QD71-142 Analytical chemistry
QD146-197 Inorganic chemistry
QD241-441 Organic chemistry
QD415-436 Biochemistry
QD450-801 Physical and theoretical chemistry
QD625-655 Radiation chemistry
QD701-731 Photochemistry
QD901-999 Crystallography

Mining = Subclass TN
TN1-997 Mining engineering. Metallurgy
TN275-325 Practical mining operations. Safety measures
TN331-347 Mine transportation, haulage and hoisting. Mining machinery
TN400-580 Ore deposits and mining of particular metals
TN600-799 Metallurgy
TN799.5-948 Nonmetallic minerals
TN950-997 Building and ornamental stones

Red = Call Numbers I use for Mineral Research Inquiries at Princeton University:
Database of the Geologic Map of North America: Adapted from the Map by J.C. Reed, Jr. and others (2005)
Data Series 424
Prepared in cooperation with the Geological Society of America
By: Christopher P. Garrity and David R. Soller

https://ngmdb.usgs.gov/gmna/

Generalized Geologic Map of the United States, Puerto Rico, and the U.S. Virgin Islands
https://pubs.usgs.gov/atlas/geologic/

Mineral Resources Online Spatial Data
https://mrdata.usgs.gov/

Earth MRI: https://www.usgs.gov/special-topic/earthmri

Examples:
Earth MRI, Critical Minerals – Focus Areas: https://mrdata.usgs.gov/earthmri/focus-areas/
Indigenous Communities

Saint Regis Mohawk  
https://www.srmt-nsn.gov/environment/remediation-restoration/superfund

General Motors Superfund Site  
https://www.srmt-nsn.gov/environment/remediation-restoration/superfund/general-motors-superfund-site

Reynolds Metals Superfund Site (Alcoa East)  
https://www.srmt-nsn.gov/environment/remediation-restoration/superfund/reynolds-metals-superfund-site

My most Asked Question = Uranium and Navajo Nation

Jan 13, 2021: Navajo Nation, New Mexico reach settlements over 2015 mine spill  

USGS Gold King Mine:  
Thank you! Questions?

Emily C. Wild
Princeton University Library
ewild@princeton.edu
Schedule a Research Consultation: Mon – Fri