THE USGS EARTH MAPPING RESOURCES INITIATIVE (EARTH MRI): USING AIRBORNE METHODS TO MAP CRITICAL MINERAL POTENTIAL

Jamey Jones, Earth MRI Science Coordinator

U.S. Department of the Interior
U.S. Geological Survey

USGS photo of silica carbide

The U.S. has focused on critical mineral resources since 2018

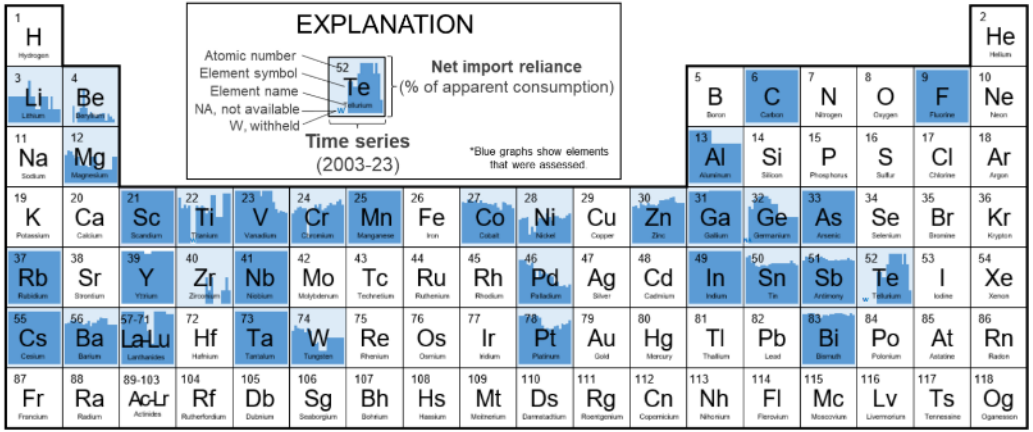
Critical mineral resources are those that are essential to the U.S. economy and national security, have a supply chain that is vulnerable to disruption, and serve an essential function in the manufacturing or a product

- Initiated by Presidential Executive Order 13817 (2018)
- Critical minerals defined by the Energy Act of 2020
- USGS published the first list of 35 critical minerals in 2019 and a revised list in 2021 that contains 50 individual mineral commodities

Zinc and lead ore

Graphite

Revised list individually lists the rare-earth elements and platinum-group elements by specific element forms; added Ni and Zn; removed He, potash, Re, Sr, and U



Nassar and Fortier, 2021, USGS OFR 2021-1045

The U.S. has focused on critical mineral resources since 2018

Critical mineral resources are those that are essential to the U.S. economy and national security, have a supply chain that is vulnerable to disruption, and serve an essential function in the manufacturing or a product

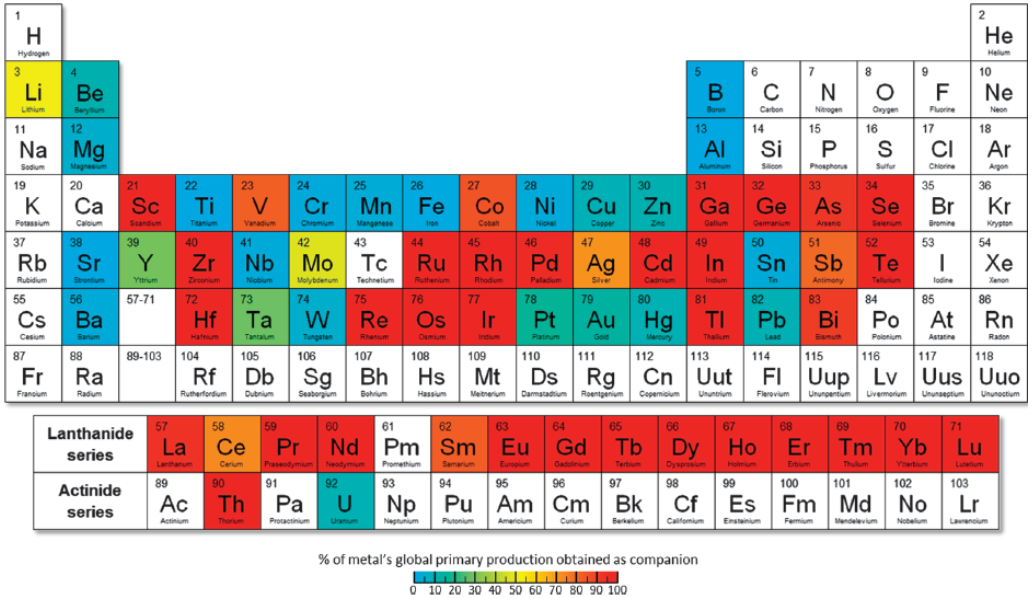
- Initiated by Presidential Executive Order 13817 (2018)
- Critical minerals defined by the Energy Act of 2020
- USGS published the first list of 35 critical minerals in 2019 and a revised list in 2021 that contains 50 individual mineral commodities

Copper ore

Aluminum ore

Many, if not most, critical mineral commodities occur as coproducts or byproducts of other associated commodities

Example → **tellurium** for photovoltaic films is produced as byproduct of **copper** processing
gallium for semiconductors is produced through mining and processing **aluminum** or **zinc**

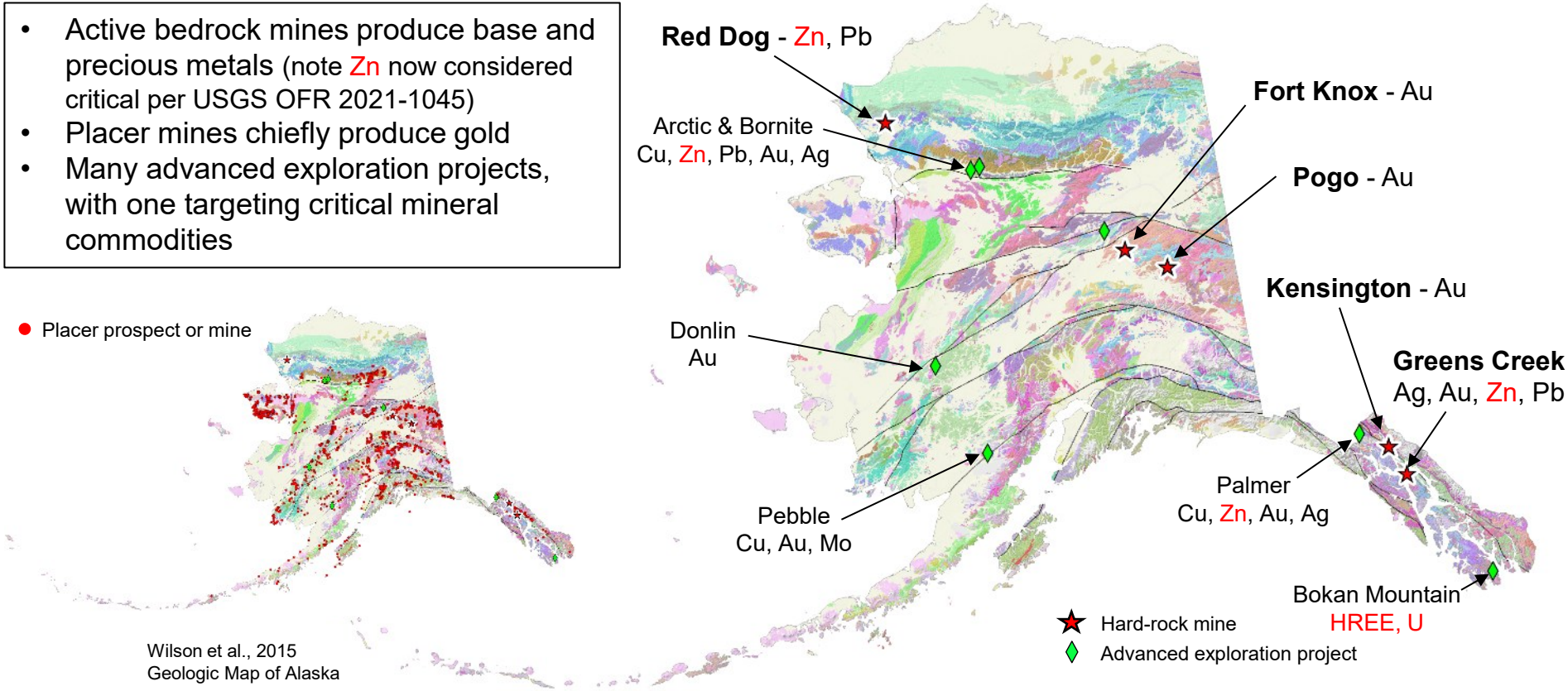


Nassar et al., 2015, Industrial Ecology

USGS
science for a changing world

Alaska hosts world class mines and undeveloped mineral resources

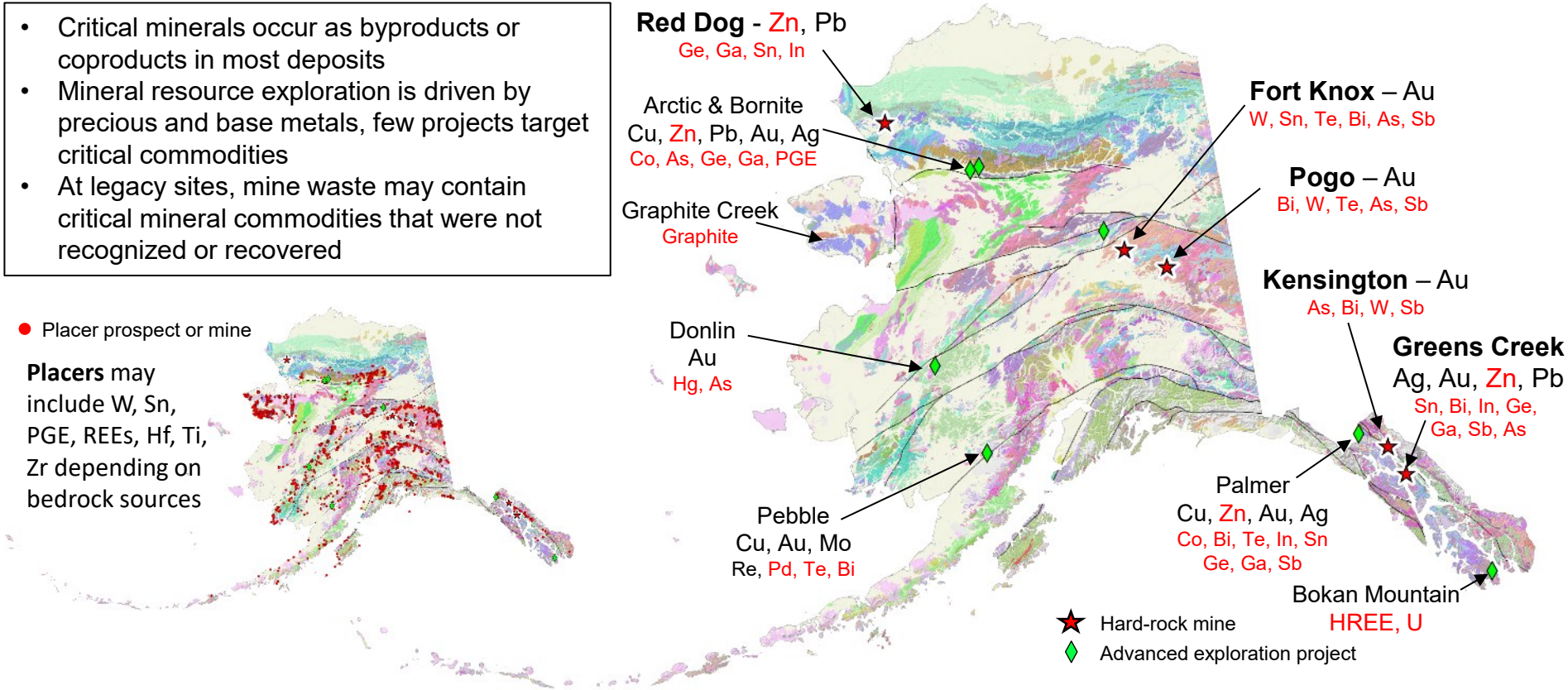
- Active bedrock mines produce base and precious metals (note Zn now considered critical per USGS OFR 2021-1045)
- Placer mines chiefly produce gold
- Many advanced exploration projects, with one targeting critical mineral commodities



USGS
science for a changing world

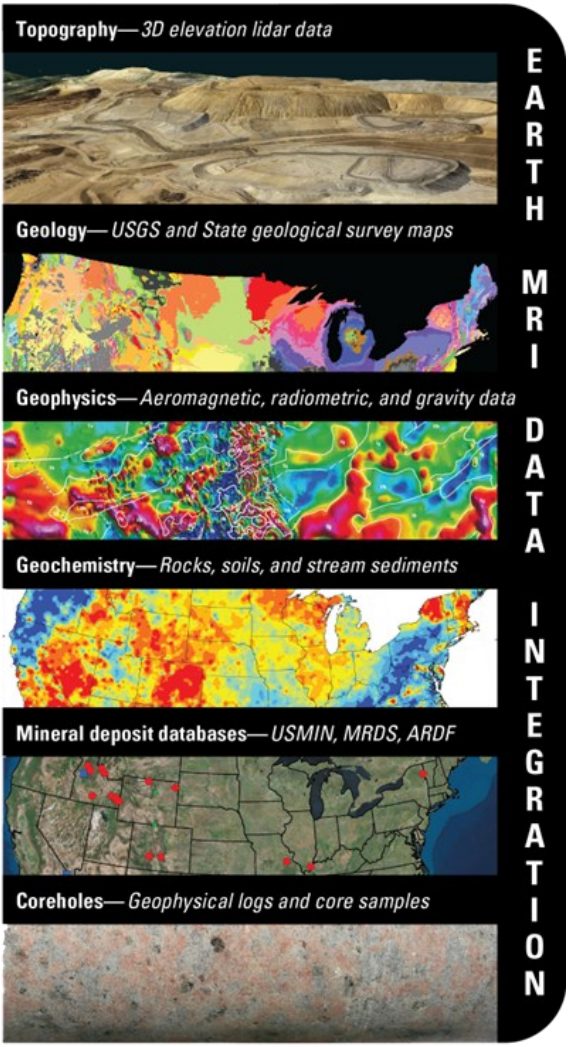
Alaska has known and suspected critical mineral potential

- Critical minerals occur as byproducts or coproducts in most deposits
- Mineral resource exploration is driven by precious and base metals, few projects target critical commodities
- At legacy sites, mine waste may contain critical mineral commodities that were not recognized or recovered



USGS science for a changing world

We do not have sufficient data to map and assess these resources and support decision-making!



Earth Mapping Resources Initiative

Goal: Modernize mapping of the United States through framework geoscience data, presently focused on identifying areas that may have the potential to contain ***critical mineral*** resources

$10.8M	Annual appropriation (beginning FY19)
$64M	Infrastructure Investment and Jobs Act (IIJA/BIL; FY22-26)
$74.8M	Total for FY25

$5M	2023 Disaster Relief Supplemental for industrial minerals in Florida and Puerto Rico

Applications:

- Mineral resources
- Energy resources
- Natural hazards
- Water resources
- Land use planning
- Infrastructure

Partners:

- State geological surveys
- Federal agencies (e.g., DARPA, DOE, NASA, BLM, USFS, NPS)
- Tribes
- Industry
- NGOs

Earth MRI Data and Interpretations

Collecting fundamental geoscience data including:

- **High-resolution elevation (lidar) surveys (3DEP)**
- **Airborne geophysical surveys (magnetic, radiometric, electromagnetic)**
- Detailed geologic mapping and regional geochemical mapping by State surveys
- **Remote sensing/hyperspectral surveys**
- Mine waste inventory and characterization with State partners
- Preservation of minerals data and geochemistry of archived materials (NGGDPP)
- *Other large data needs?*

https://www.usgs.gov/special-topics/earth-mri

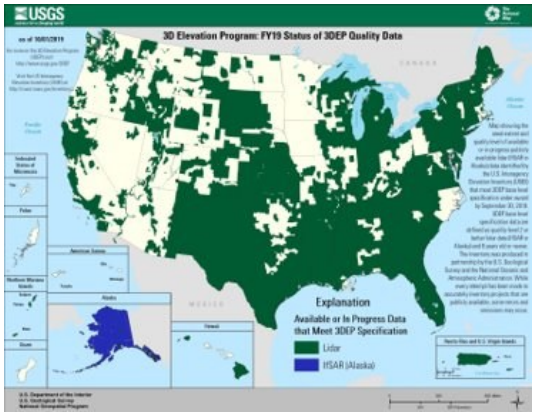
USGS

Lidar acquisition nearing completion for conterminous U.S.

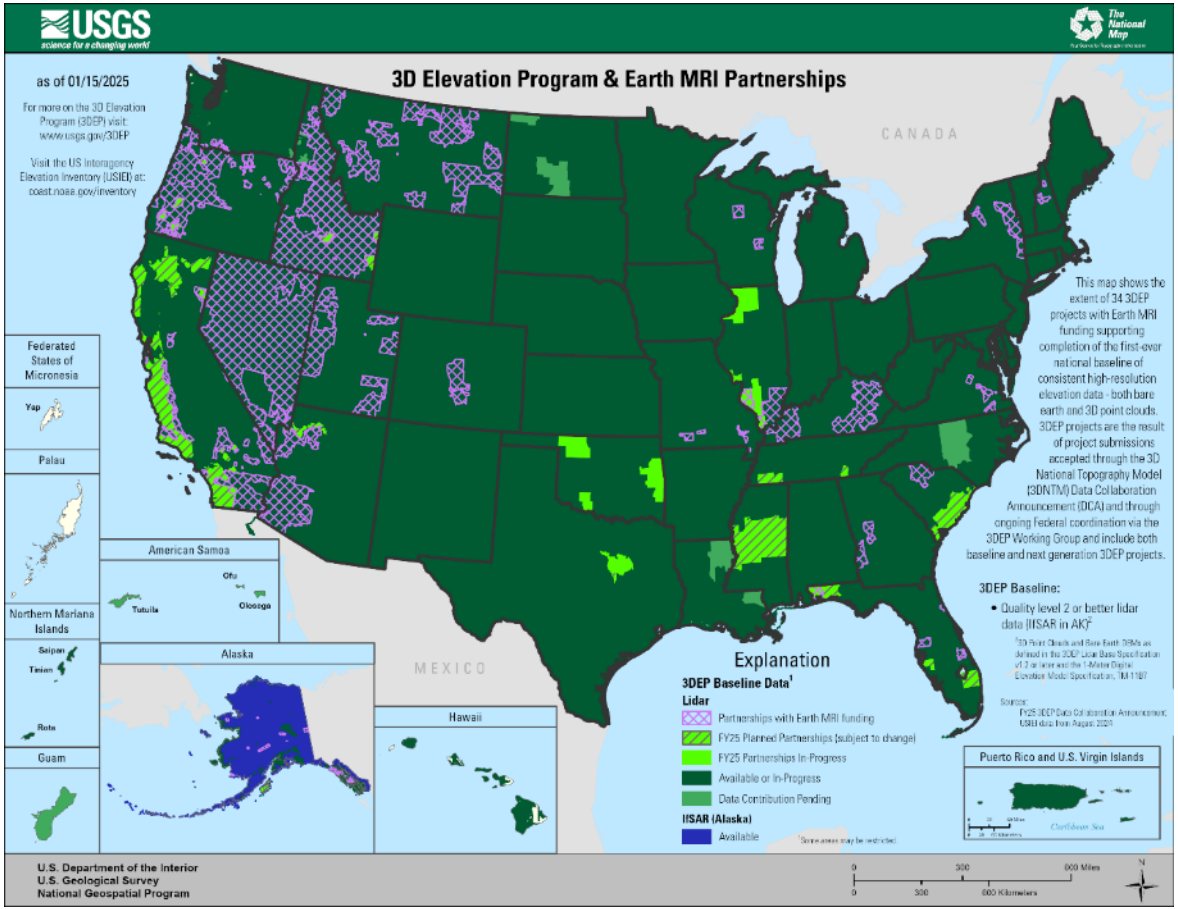
Earth MRI partners with National Geospatial Program/3DEP to acquire new lidar to aid geologic mapping

Additional funding leveraged through partnerships

New lidar acquisition in progress for Alaska to support mine waste mapping and measurement



FY2019 Pre-Earth MRI



www.usgs.gov/3DEP

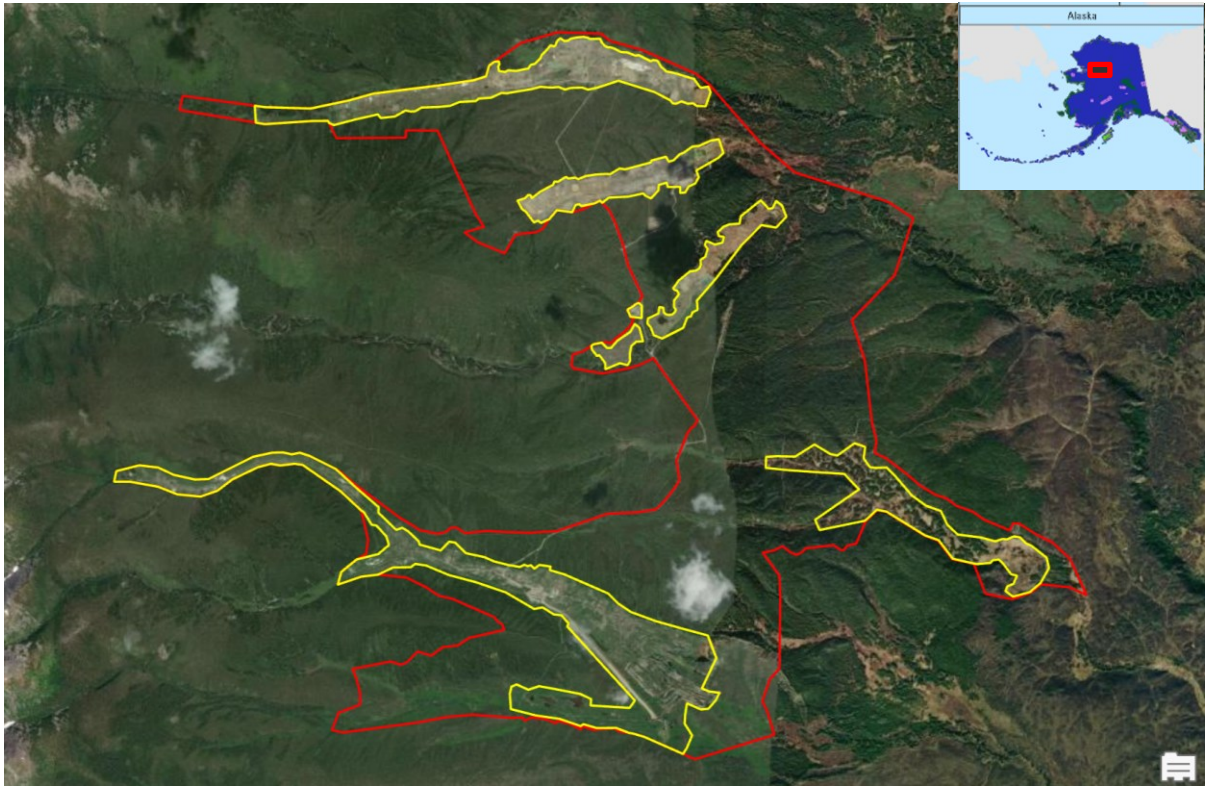
Lidar in Alaska will be used to measure mine waste

Example site: Hogatza River

Decimeter-resolution **Worldview Imagery** via ArcGIS online allows delineation of mine sites and disturbance footprint at 1:10,000 scale

Red outlines map disturbance footprint, yellow outlines map potential resource

High-resolution geochemistry in progress



USGS science for a changing world

Bender, 2024, USGS data release

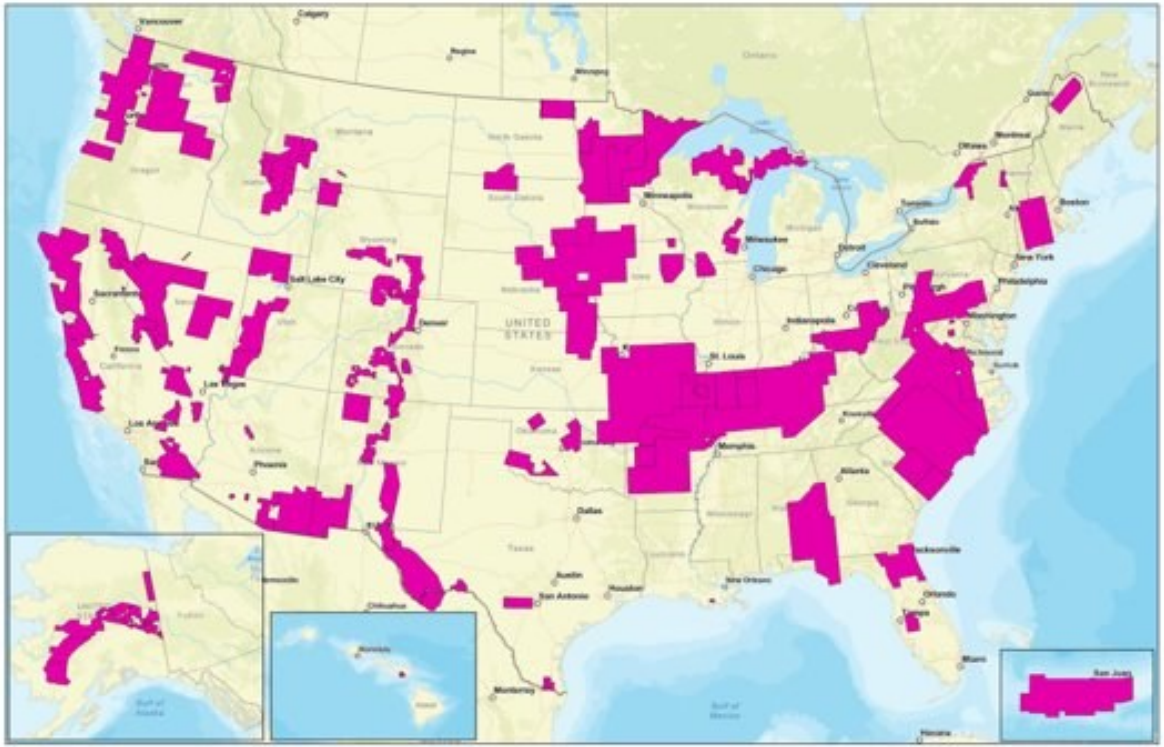
Geophysical data provide foundation for regional mapping and modeling

Airborne magnetic, radiometric, and electromagnetic surveys are designed to meet core data needs *and* state priorities

FY19-22 mag-rad surveys cover an area the size of Texas (~268k sq mi)

FY23 and 24 mag-rad surveys cover nearly 300k sq mi (2x Montana)!

FY2019 Pre-Earth MRI



Current high-quality coverage planned, in progress, and/or completed (through FY24)

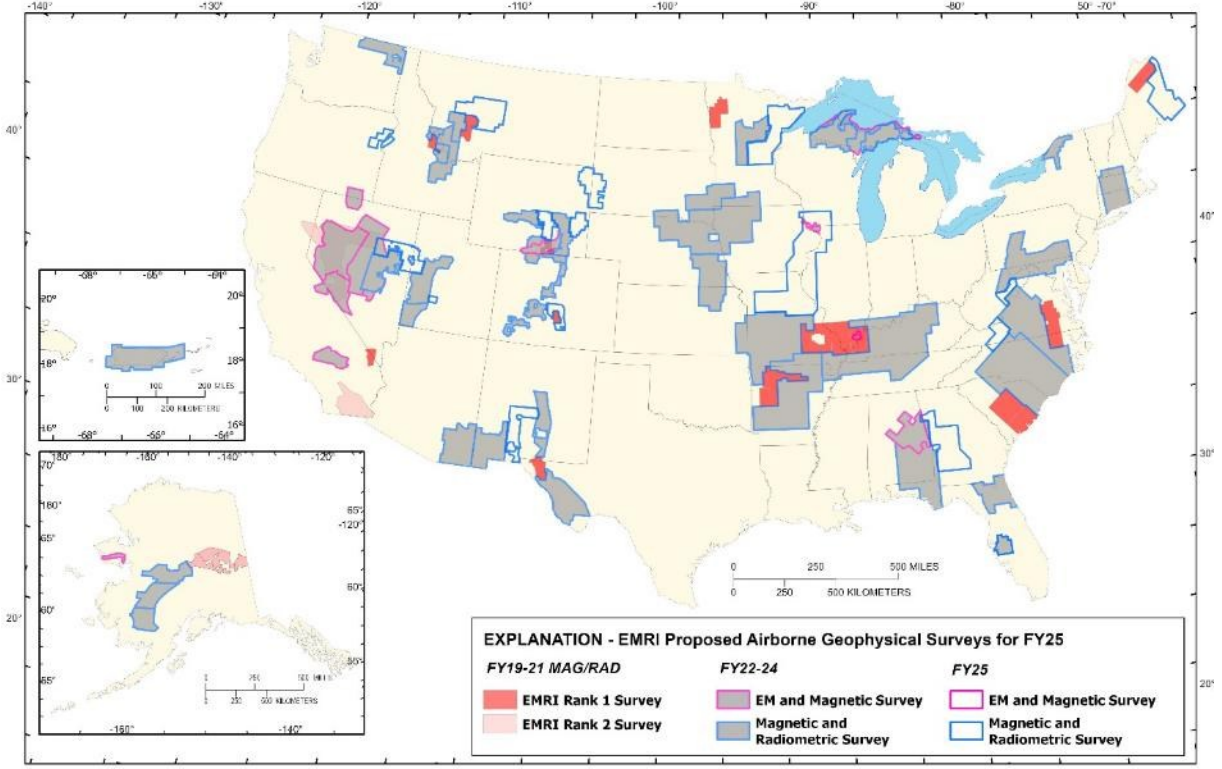
Geophysical data provide foundation for regional mapping and modeling

Airborne magnetic, radiometric, and electromagnetic surveys are designed to meet core data needs *and* state priorities

BIL funding has allowed for multi-year efforts that will result in seamless, high-quality regional coverage

Surveys consider both below- and above-ground resources (i.e., mine waste)

Ideally, state projects including geologic mapping, geochemical reconnaissance, and/or mine waste are linked with survey planning and design

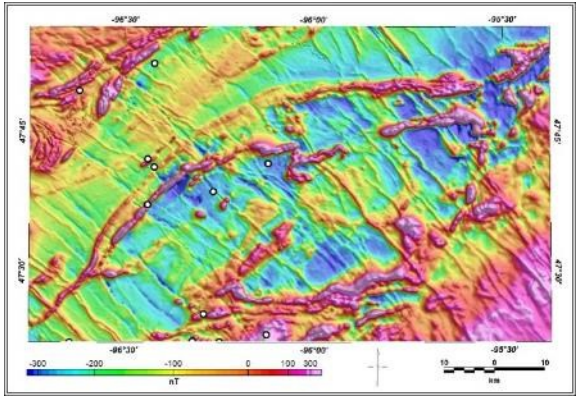


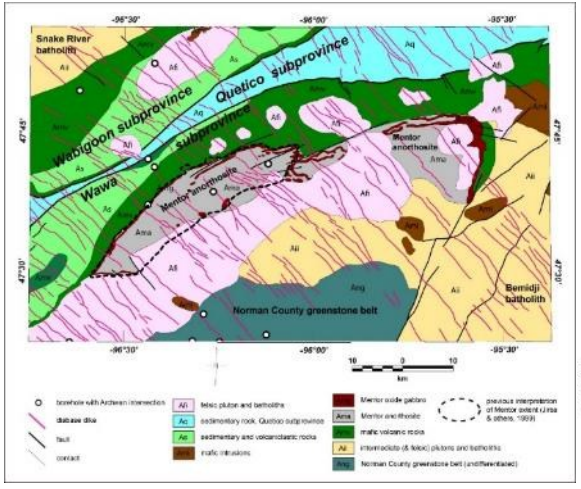
Current Earth MRI Airborne Geophysics (2025) planned, in progress, and/or completed

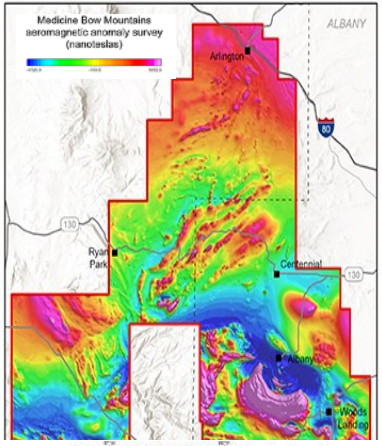
USGS science for a changing world

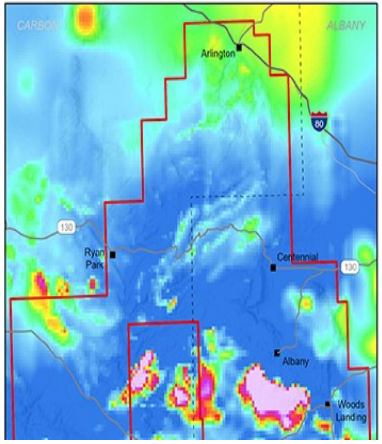
Data quality improves geophysical and geologic interpretations

Ben Drenth and MN Geological Survey

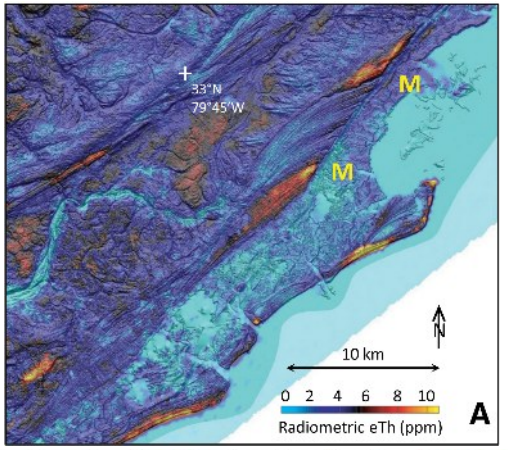


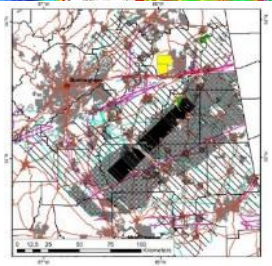






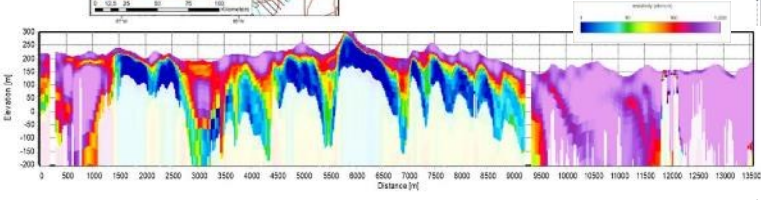
Anji Shah and the South Carolina Geological Survey, GSA Today

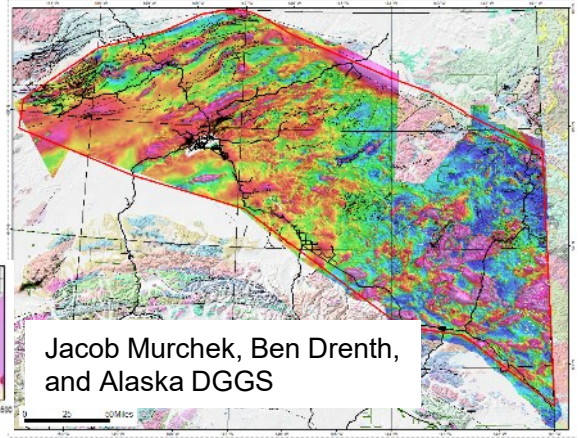




Ben Drenth and Wyoming Geological Survey (above)

Patricia MacQueen, Paul Bedrosian, and Alabama Geological Survey (below)





Jacob Murchek, Ben Drenth, and Alaska DGGS

Airborne hyperspectral surveys covering the western U.S.

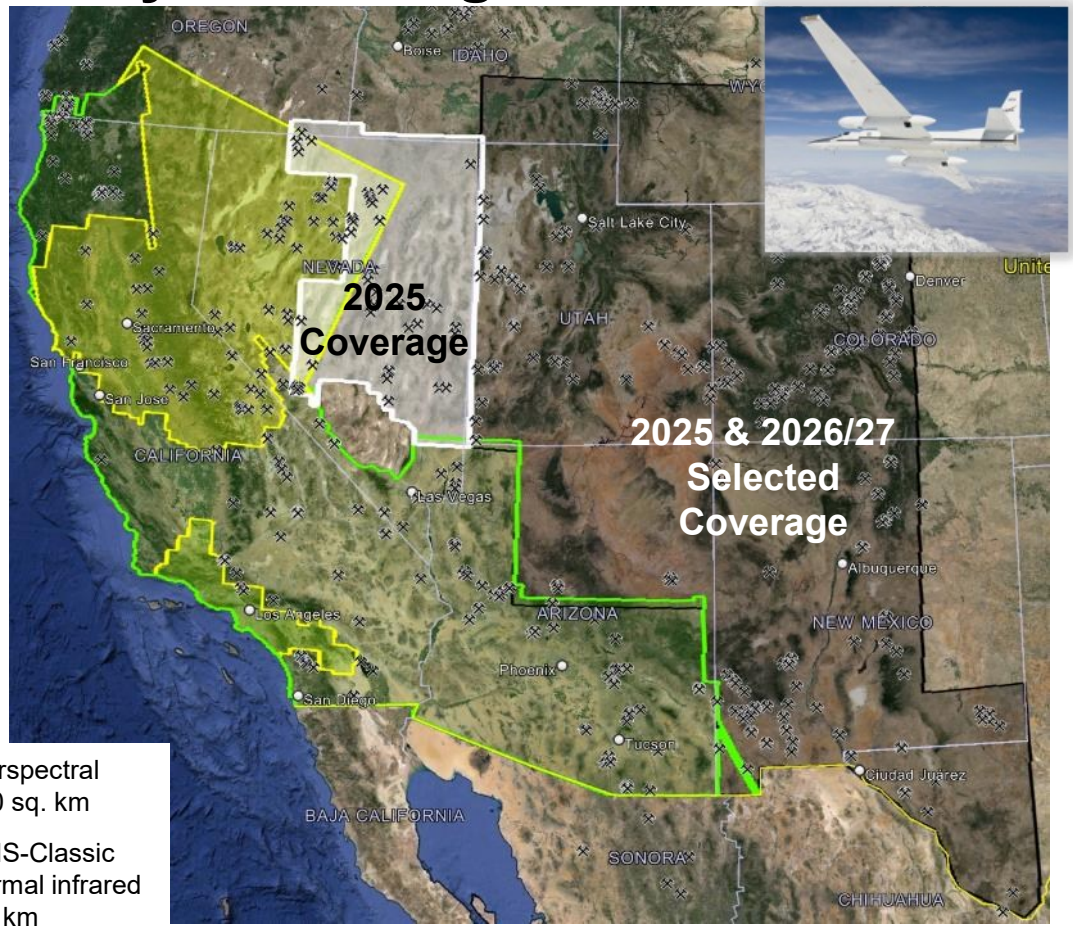
Regional coverage with multiple sensors over ~500,000 sq km of the arid west

To date the southwestern U.S. has the largest, contiguous terrestrial area of hyperspectral data at such fine spatial resolution (15 m)

Data collection in partnership with NASA at approximately $4M per year

Data will highlight the location and formation of critical minerals related to hydrothermal alteration and rock weathering

Data will also aid mapping of rock-forming minerals to support geologic mapping and mine waste studies

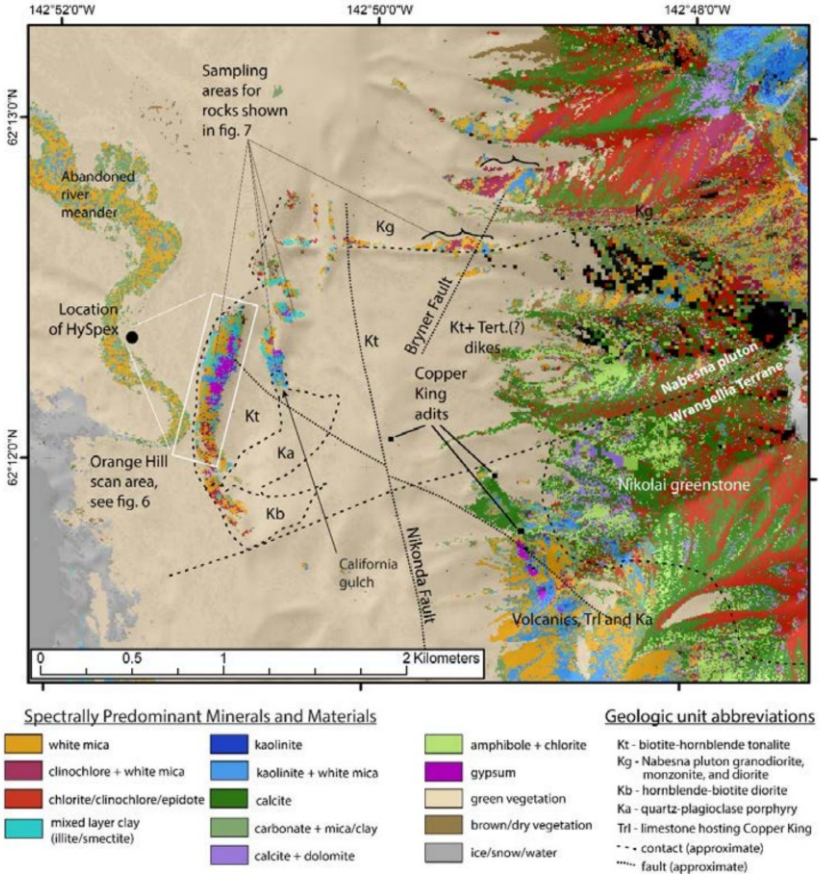


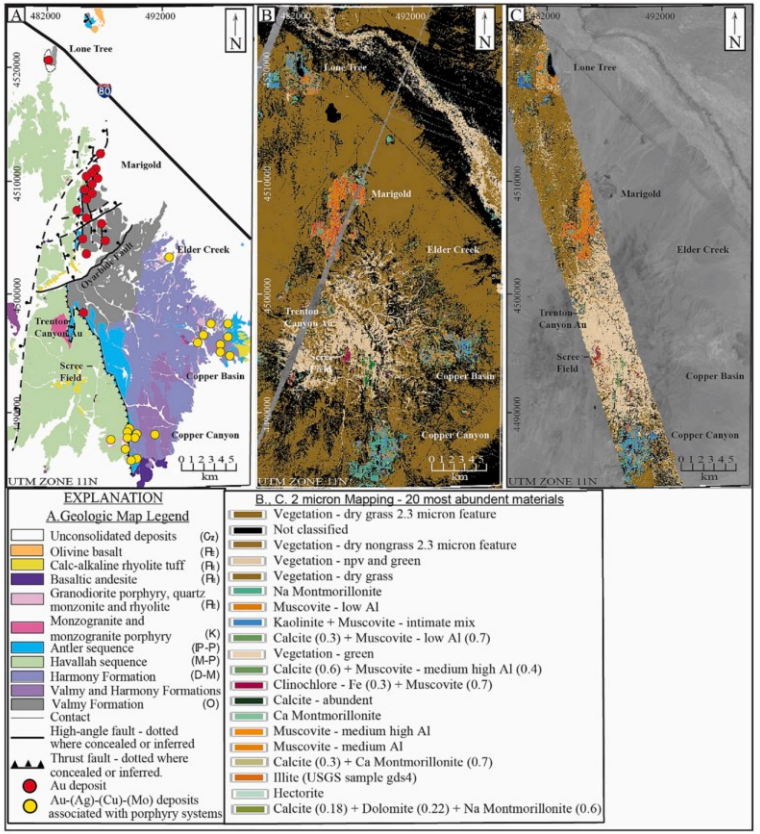
2018	Previously collected NASA hyperspectral data (AVIRIS-Classic). ~325,000 sq. km
2023 2024	USGS Earth MRI 2023-24 AVIRIS-Classic hyperspectral and MASTER thermal infrared multispectral data. ~483,000 sq. km

USGS
science for a changing world

Preliminary information - subject to revision.

Hyperspectral data aid in surface mineral mapping





Hyperspectral mapping of magmatic-hydrothermal sericite, Battle Mountain mining district, Nevada

Journal of Geochemical Exploration 259 (2024) 107395

John M. Meyer [a,b,*], Elizabeth A. Holley [b], Raymond F. Kokaly [a]

[a] U.S. Geological Survey, Geology, Geochemistry, and Geophysics Science Center, Denver Federal Center, Denver, CO 80225, USA
[b] Department of Mining Engineering, Colorado School of Mines, 1600 Illinois Street, Golden, CO 80401, USA

USGS science for a changing world

Kokaly and others, 2017, Nabesna area, Alaska

Airborne hyperspectral surveys also target mine waste

In Arizona and New Mexico, multispectral data collection at multiple resolutions/altitudes

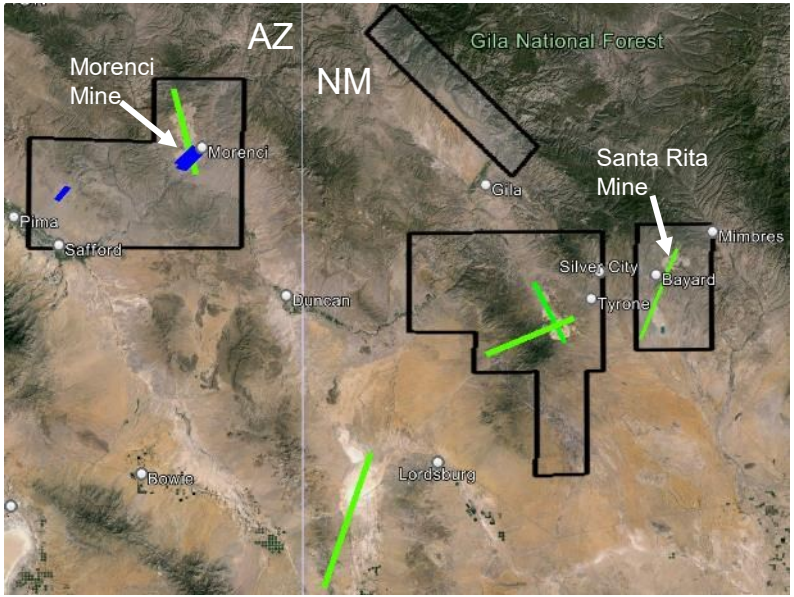
AVIRIS-3 VSWIR hyperspectral data collected by NASA on June 15, 2024

Medium altitude (19.5 kft ASL) with ~2 m pixel size

Low altitude (9.5 kft ASL) with ~1 m pixel size

Earth MRI contracted commercial hyperspectral data VSWIR and TIR

Left: False color-composite from AVIRIS-3 data, Chino Mine, NM.
Below: Photo of Morenci mine, AZ, taken during hyperspectral survey.
Courtesy of Michael Eastwood, Adam Chlus, & the AVIRIS-3 team at the Jet Propulsion Laboratory/NASA



Additional mine waste areas were covered in AZ by Dean Riley, Univ. of Arizona, leveraging the deployment of the commercial instruments to the region. Dr. Riley is a collaborator on the EMRI hyperspectral acquisitions.

USGS
science for a changing world

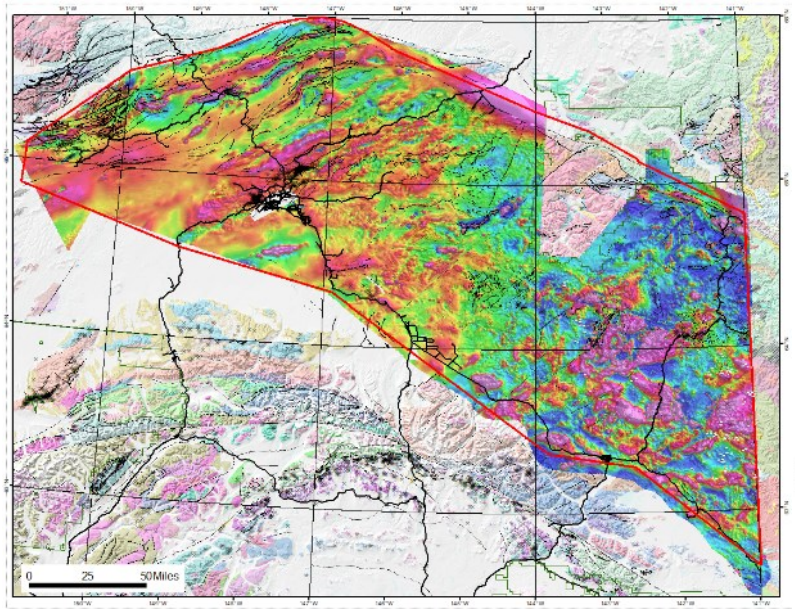
From data collection to delivery, integration, and analysis

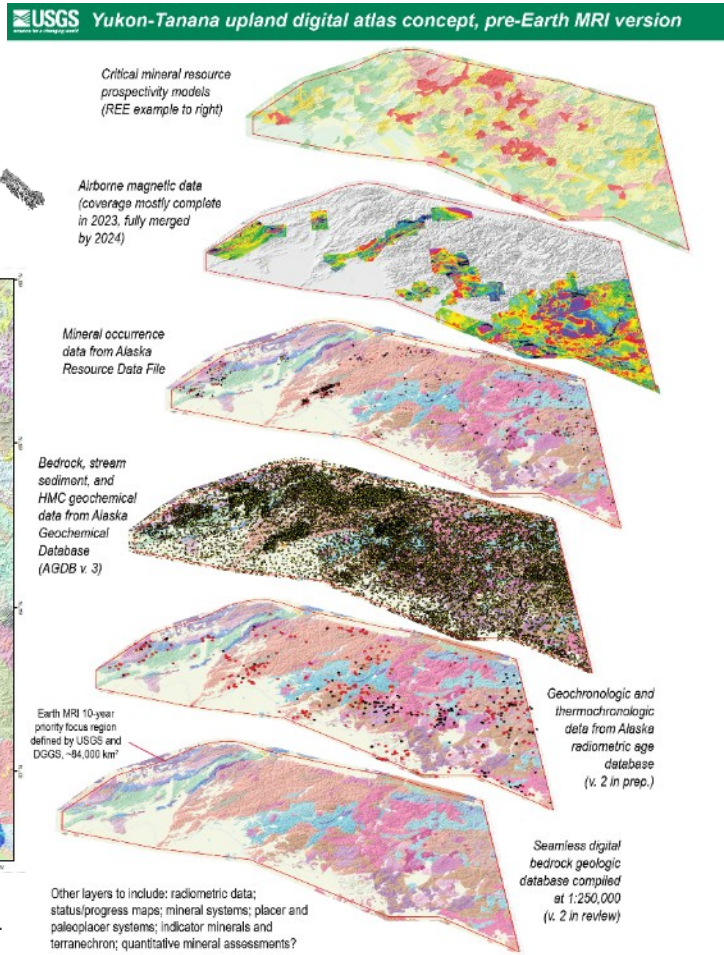
We have identified several core requirements for internal use, namely for mineral resource assessments

What do other stakeholder communities want or need?

- Visualization?
- Data analysis?
- Data integration?
- Data download?
- Map output?

What do other data types or framework applications are of interest?





Murchek, J.T., Drenth, B.J., and Emond, A.M., 2024, Yukon-Tanana Upland airborne magnetic geophysical data merge, version 2023: U.S. Geological Survey data release, https://doi.org/10.5066/P14UWTR3.

USGS science for a changing world

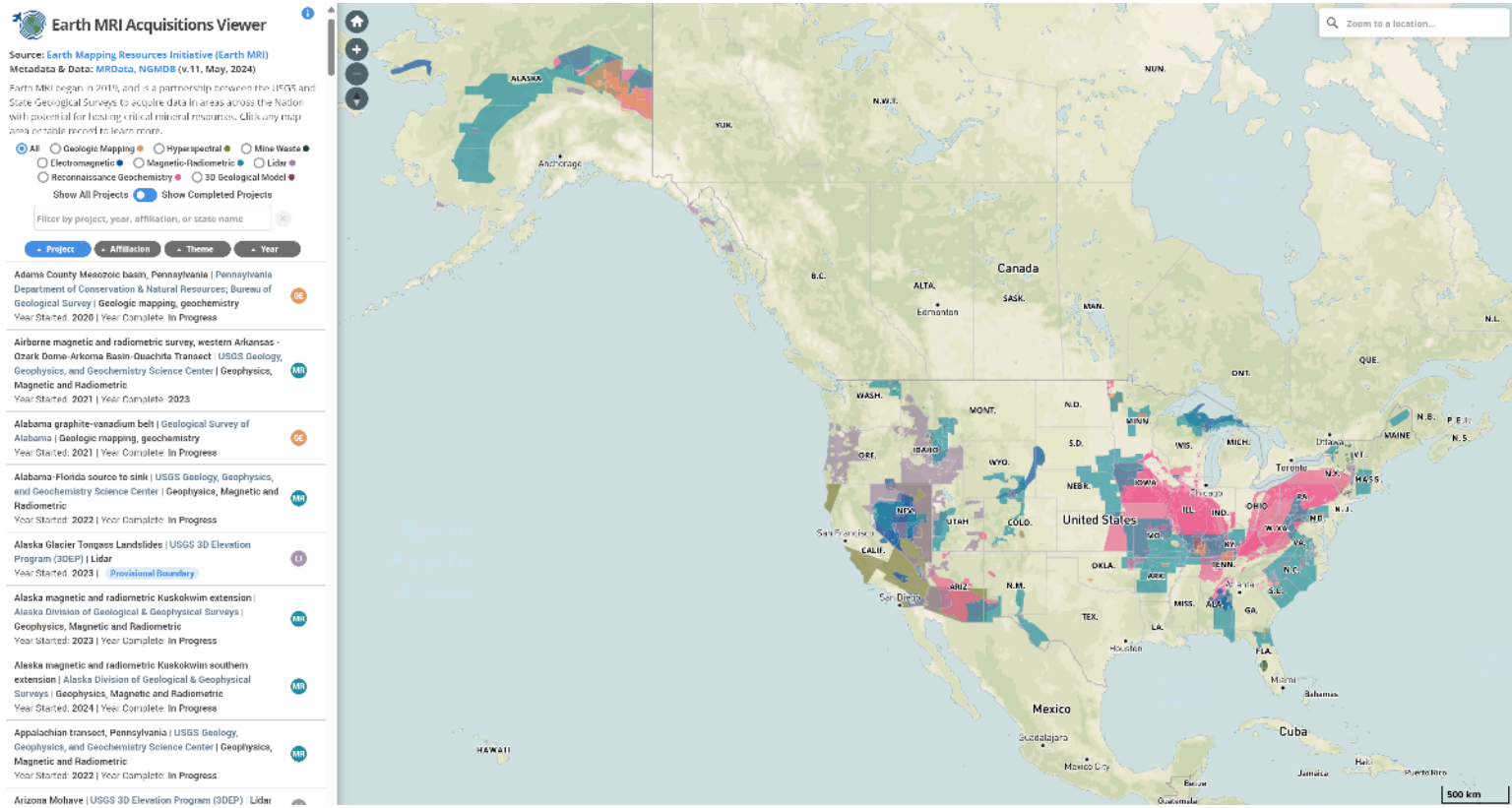
Earth MRI Acquisitions Viewer provides project information

Updated quarterly to include new projects and/or project status updates

Keywords include critical commodities linked to focus area mineral system(s)

Project descriptions link to data and any associated publications

Building new functions into this system based on user feedback



https://ngmdb.usgs.gov/emri

USGS
science for a changing world

EARTH MRI: The First 5 Years

The Earth Mapping Resources Initiative (Earth MRI) is modernizing the Nation's mapping and geoscience data, benefitting regions, states and local communities.

40
States and Territories partnered with Earth MRI

3 times
more of the Nation covered by high-quality geophysical surveys

$21.5 million
directly to States for geologic and geochemical mapping

$129 million
invested in data acquisition across the Nation

Transforming Knowledge of Mineral Resource Potential

Earth MRI geophysical and geochemical data are providing a better understanding of mineral resources in below-ground deposits and mine wastes across the Nation, including of rare earth element resources in the Hicks Dome area of Illinois and Kentucky.

Revealing Hidden Hazards

Geophysical data collected in South Carolina have provided details about deep fault structures in the state that have caused earthquakes in the past. These data are also being used to map heavy mineral sands and soils in the southeast and assess their resource potential.

Strengthening Local Geoscience

Earth MRI is helping to reinvigorate State geologic surveys like Michigan's, which has been able to newly invest in building a skilled geoscience workforce, forge new state and regional partnerships, and conduct vital research on the state's mineral and other geologic resources.

Informing Resource Management

States like Nevada are using Earth MRI data to holistically understand the state's natural resources, including the state's potential for critical minerals like lithium, geothermal energy potential, and groundwater and soil qualities.

A Tool for Rebuilding and Resiliency

After the destruction of Hurricane Fiona, Earth MRI geophysical surveys are helping Puerto Rico identify future landslide threats and find local geologic materials that could be used to rebuild and strengthen infrastructure.

2019
The USGS Mineral Resources Program launches Earth MRI. Data collection begins.

2020
Earth MRI develops a national map of areas with critical mineral potential to guide data collection.

2021
The Bipartisan Infrastructure Law invests $320 M in Earth MRI over five years, accelerating data collection.

2022
Earth MRI incorporates a focus on mine wastes and new methods including hyperspectral mapping.

2023
Earth MRI flies its first geophysical surveys focused on landslide potential and construction materials.

U.S. Department of the Interior
U.S. Geological Survey

July 2024

USGS Contacts:

Jamey Jones
Earth MRI Science Coordinator
jvjones@usgs.gov

Colin Williams
Mineral Resources Program Coordinator
colin@usgs.gov