



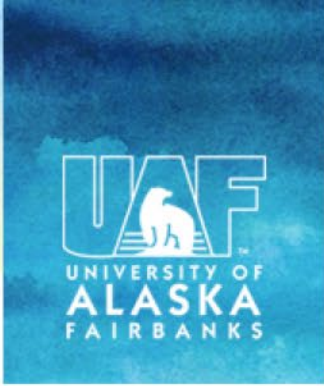
BRINGING ALASKA'S CORE-CM POTENTIAL INTO PERSPECTIVE

DE-FE0032050

Brent J Sheets

**Director, Petroleum Development Lab
Institute of Northern Engineering**

*U.S. Dept. of Energy
National Energy Technology Laboratory
Resource Sustainability Project Review Meeting
April 2-4, 2024*



CARBON ORE, RARE EARTH, & CRITICAL MINERALS

Vision: Bring Alaska's CORE-CM potential into perspective

Mission: Establish a CORE-CM industry in Alaska by working with industry and other stakeholders to ID **OPPORTUNITIES** and **ADDRESSES CHALLENGES**



[This Photo](#) by Unknown Author is licensed under [CC BY-NC-ND](#)

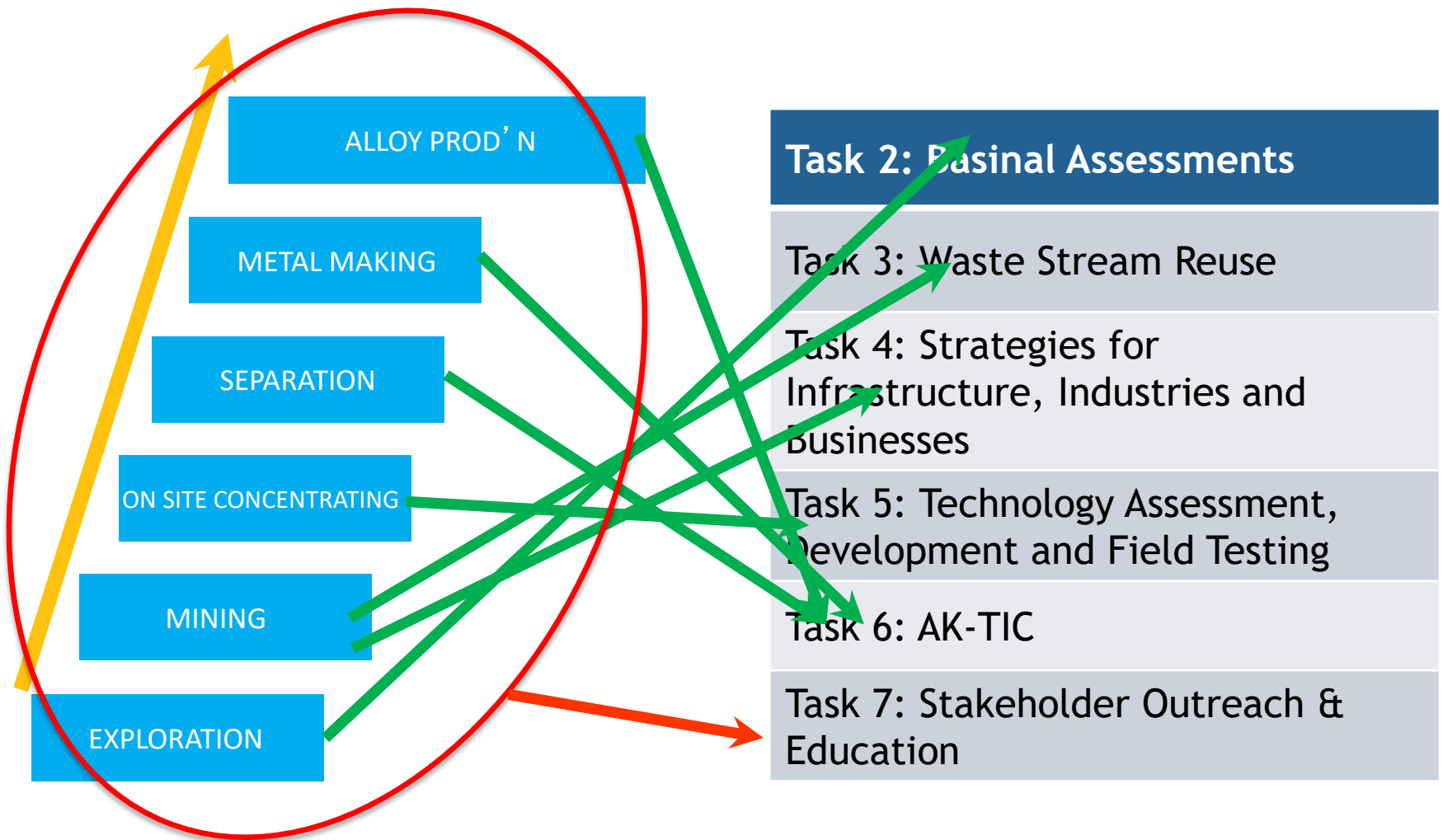


OVERVIEW

| NETL Objective from the FOA | | UAF/DGGS Task Equivalent |
|---|---|--|
| 1. Basinal Assessment of CORE-CM Resources | = | Task 2: Basinal Assessments |
| 2. Basinal Strategies for Reuse of Waste Streams | = | Task 3: Waste Stream Reuse |
| 3. Basinal Strategies for Infrastructure, Industries and Businesses | = | Task 4: Strategies for Infrastructure, Industries and Businesses |
| 4. Technology Assessment, Development and Field Testing | = | Task 5: Technology Assessment, Development and Field Testing |
| 5. Technology Innovation Centers | = | Task 6: AK-TIC |
| 6. Stakeholder Outreach and Education | = | Task 7: Stakeholder Outreach & Education |

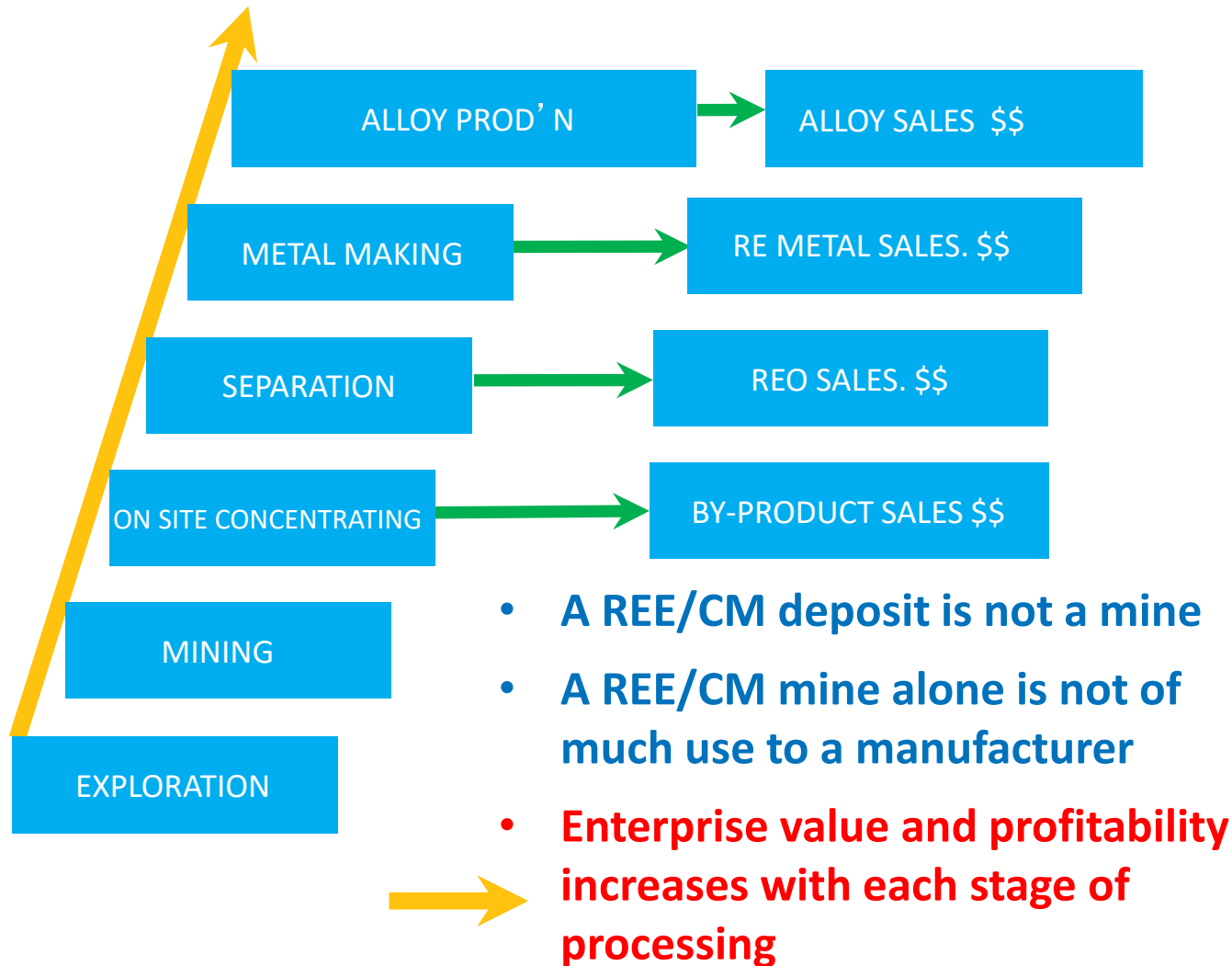
REE VALUE CHAIN VS. PROJECT TASKS

Where does a particular business fit into the value chain?



REE/CM VALUE CHAIN

Where does a particular business fit into the value chain?

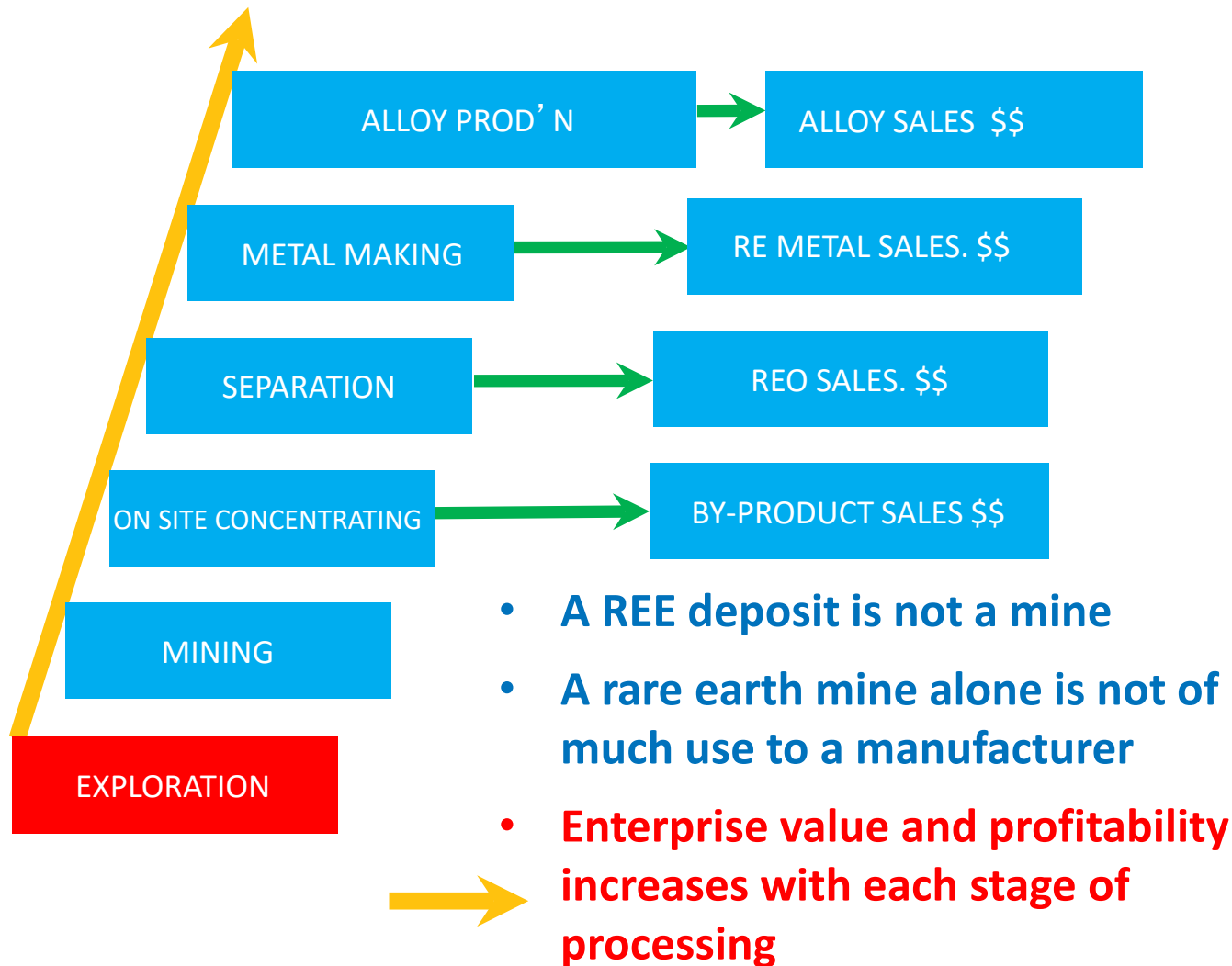


Graphic adapted from Great Western Minerals Group, Ltd, Jack Lifton Technology Metals Research, LLC (after ESP Research)



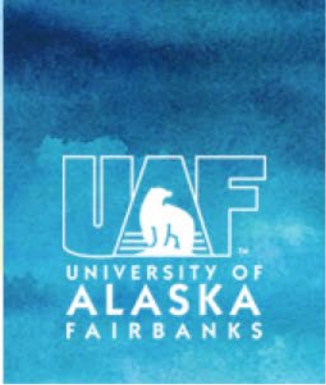
REE VALUE CHAIN

Where does a particular business fit into the value chain?



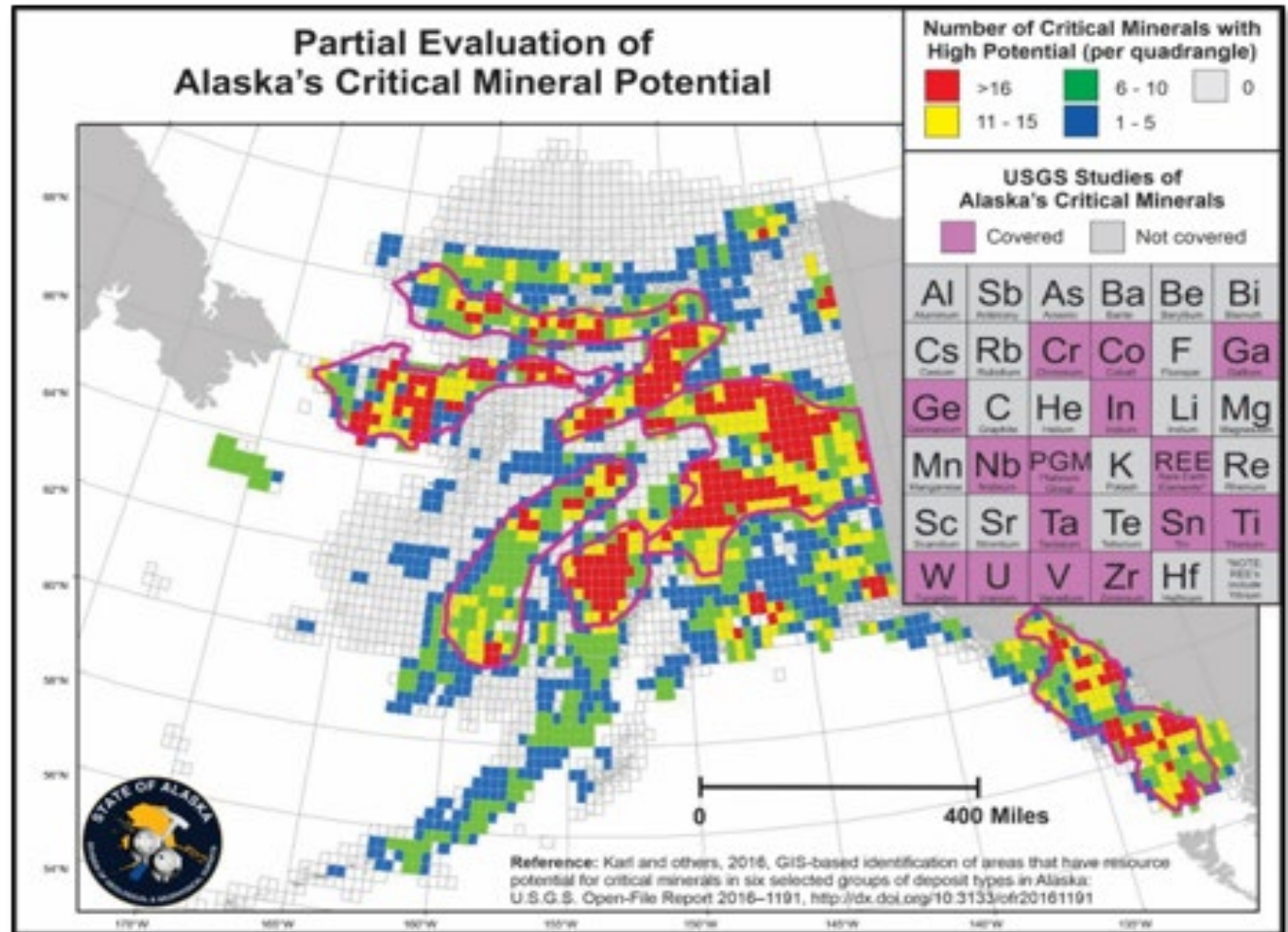
Graphic Courtesy of Great Western Minerals Group, Ltd, Jack Lifton
Technology Metals Research, LLC (after ESP Research)





WHERE DOES DGGs DECIDE TO LOOK?

- Placer concentrations derived from REE/CM enriched provenance.
- Epigenetic precipitation
- Mineralized geothermal systems
- Air fall volcanic contributions.



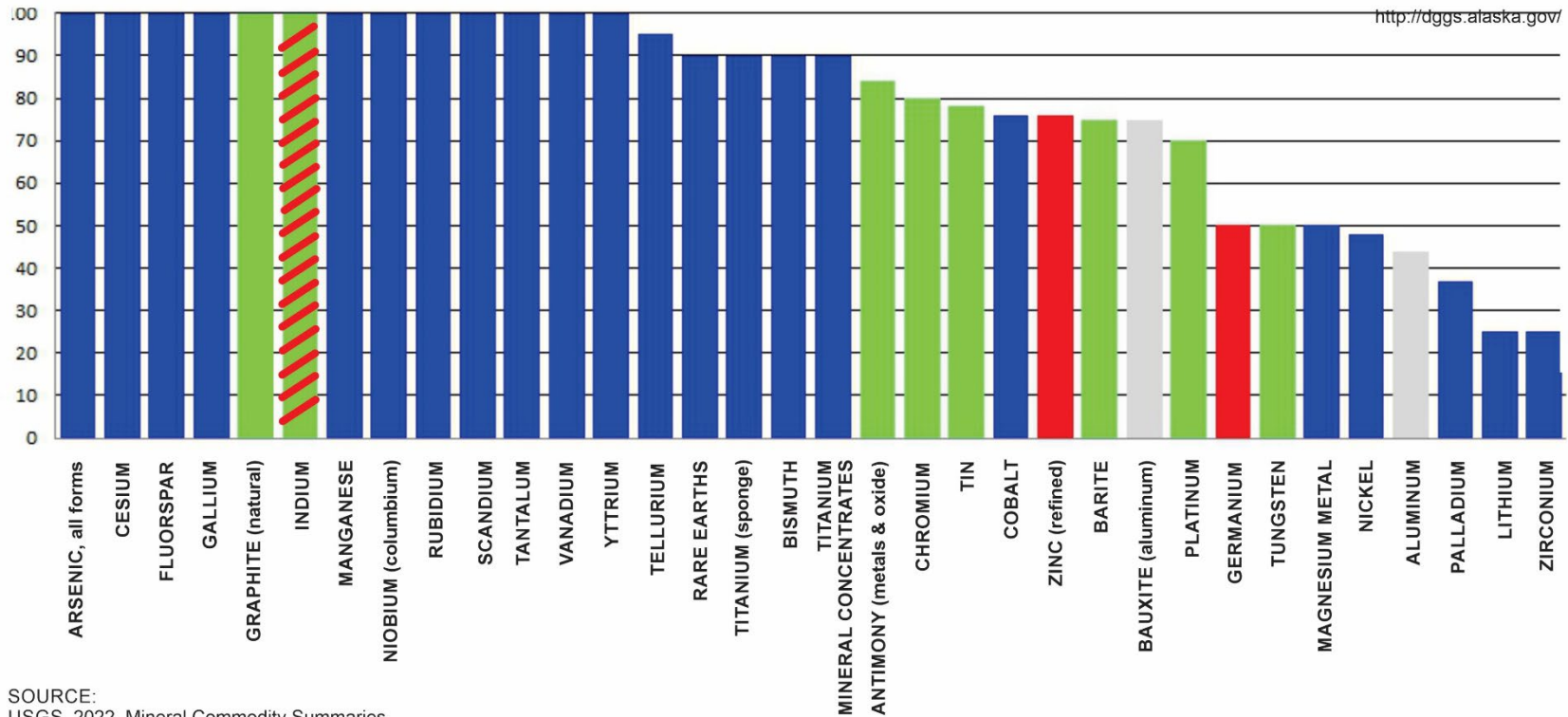
BACKGROUND—ALASKA'S CRITICAL MINERAL POTENTIAL

2021 U.S. Critical Minerals Import Reliance



NOTE:
Does not include beryllium and hafnium as these commodity data are not available.

<http://dgg.s.alaska.gov/>



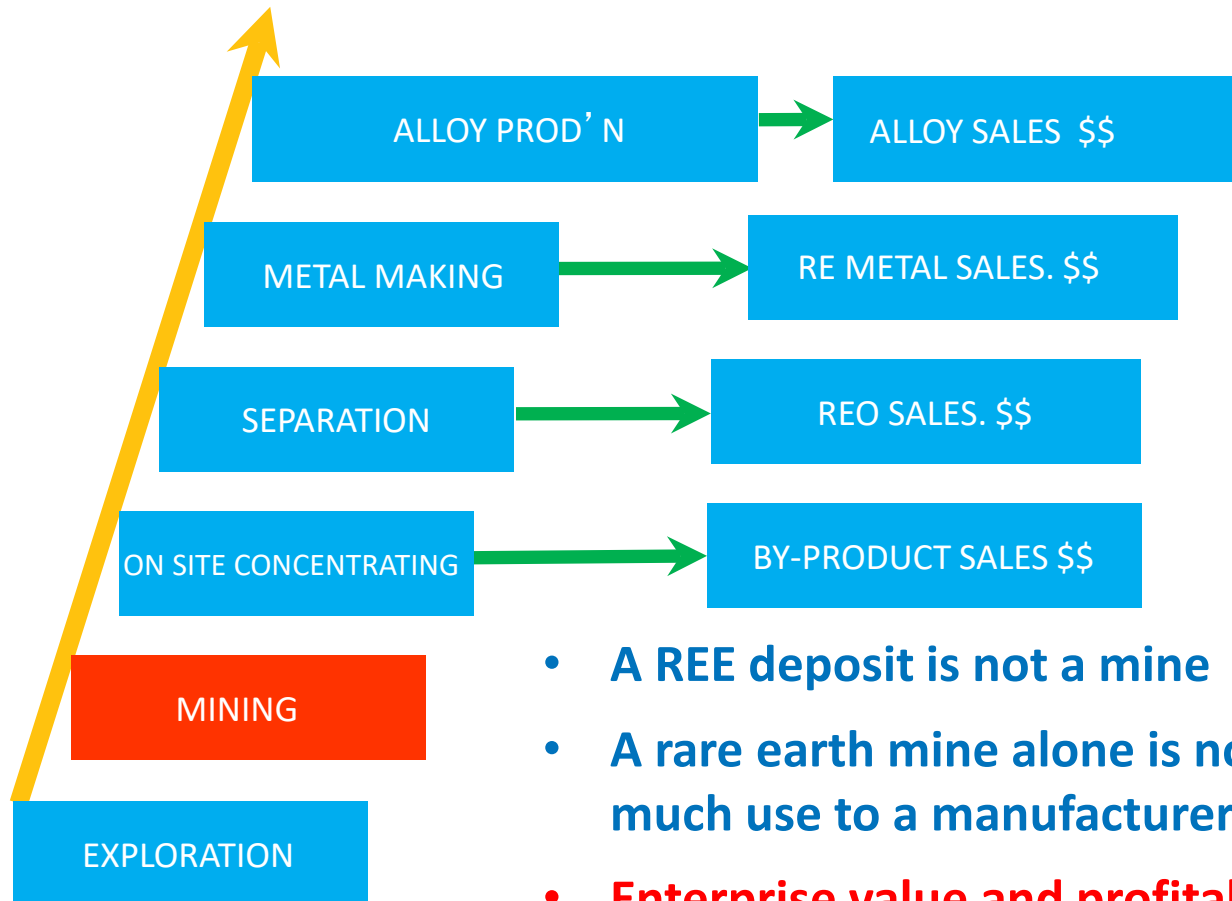
SOURCE:
USGS, 2022, Mineral Commodity Summaries

ALASKA



REE VALUE CHAIN

Where does a particular business fit into the value chain?

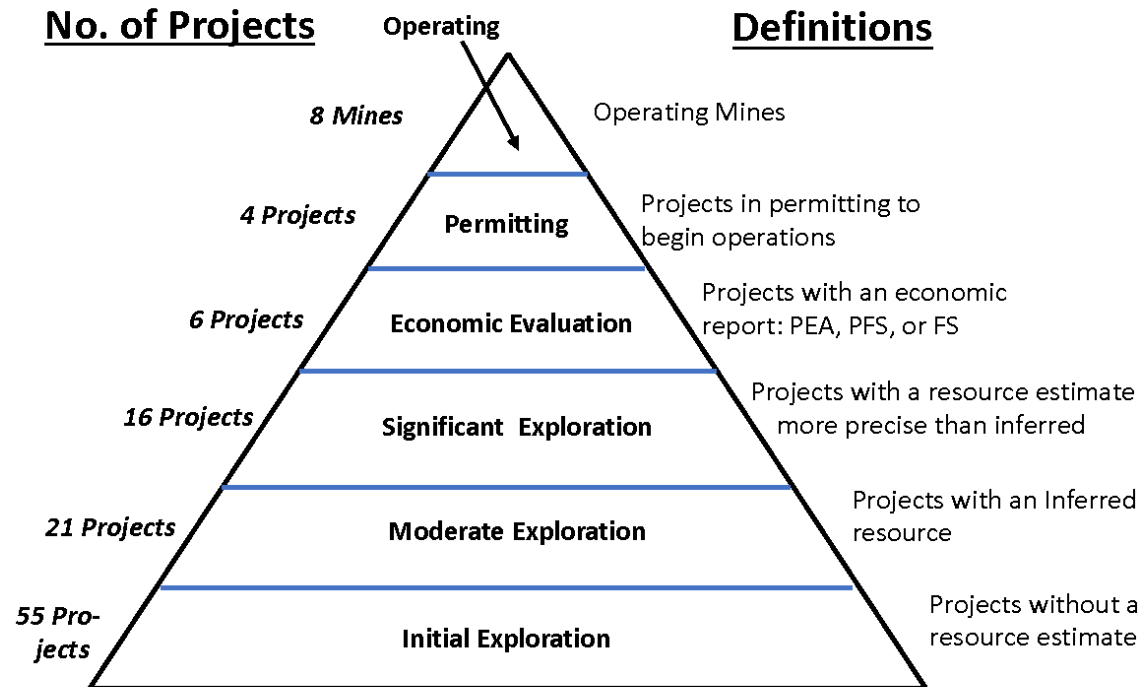


- A REE deposit is not a mine
- A rare earth mine alone is not of much use to a manufacturer
- **Enterprise value and profitability increases with each stage of processing**

Graphic Courtesy of Great Western Minerals Group, Ltd, Jack Lifton Technology Metals Research, LLC (after ESP Research)

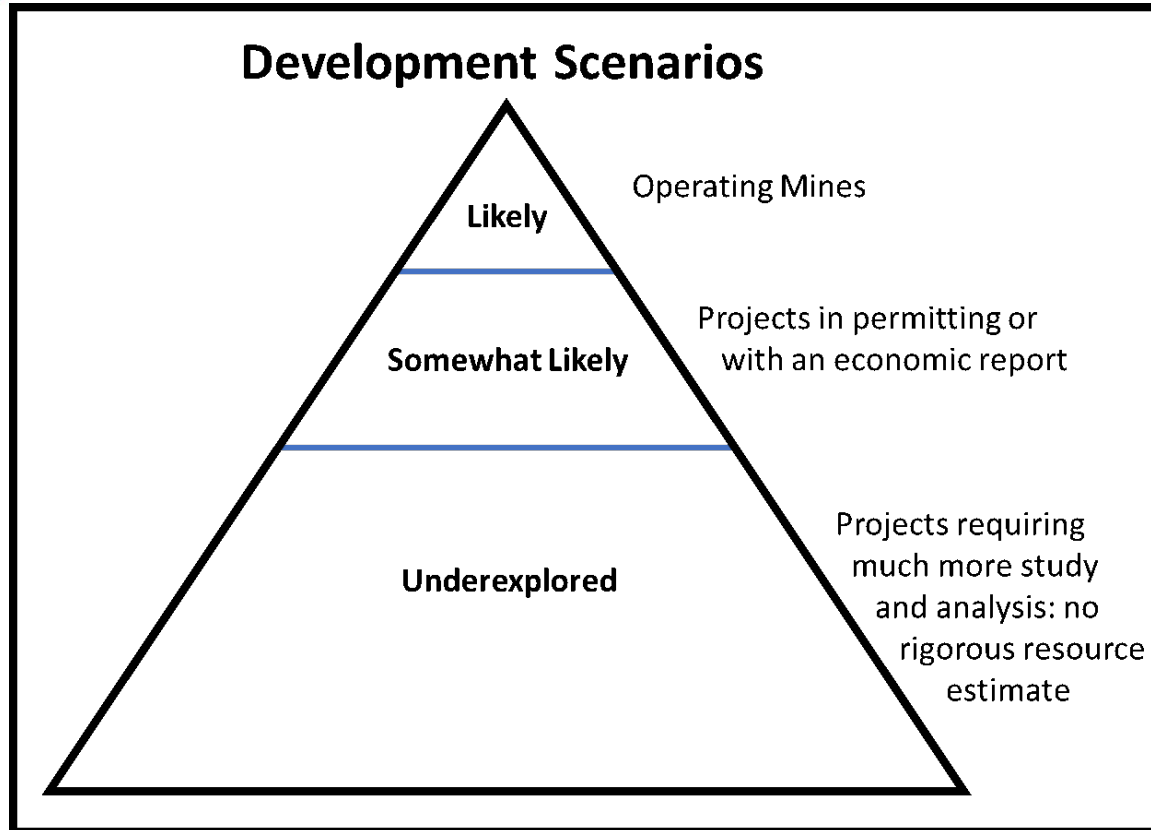


OPPORTUNITIES



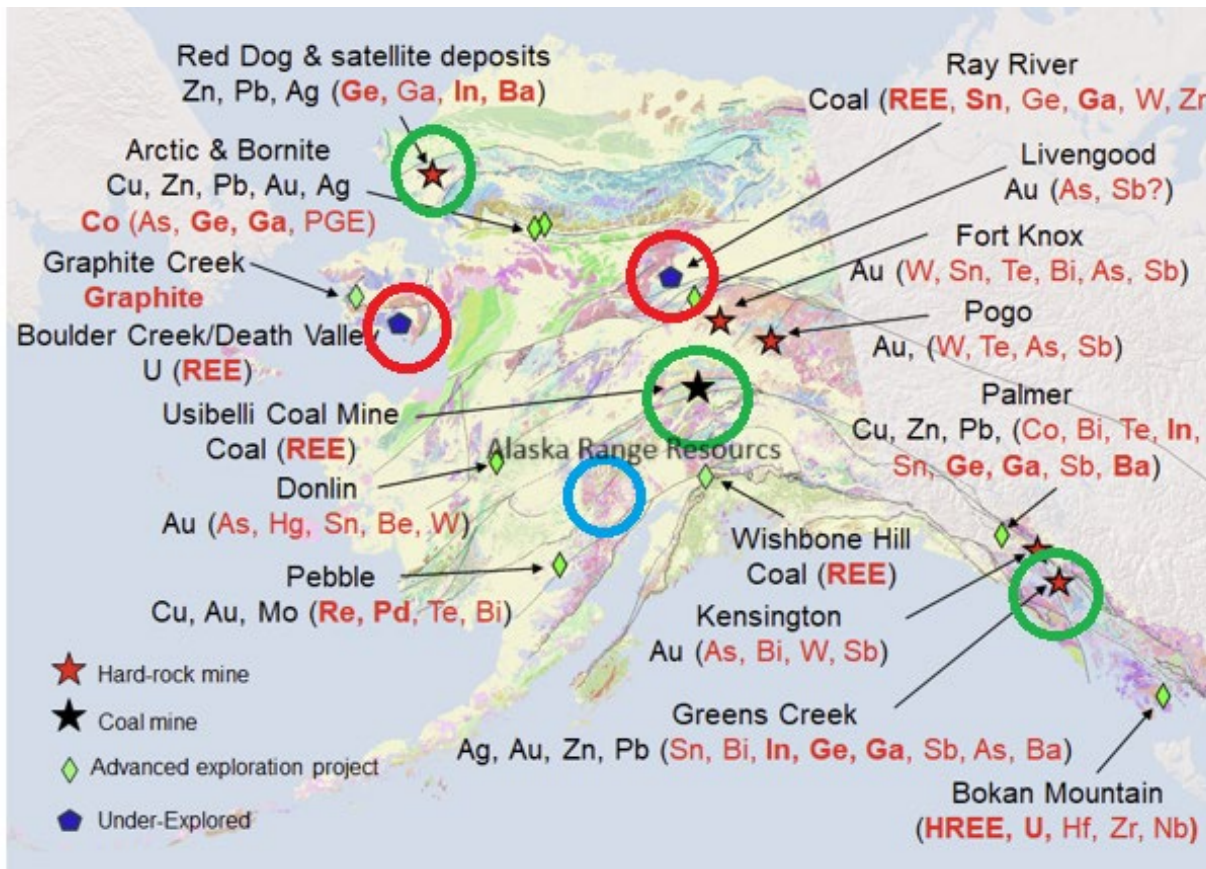
The Economic Potential of Alaska's Mining Industry. Bob Loeffler and Brett Watson. March 8, 2022. Institute of Social and Economic Research; University of Alaska, Anchorage. Appendix A. Available: <https://iseralaska.org/publications/?q=Economic%20Potential%20of%20the>

OPPORTUNITIES



After: The Economic Potential of Alaska's Mining Industry. Bob Loeffler and Brett Watson. March 8, 2022. Institute of Social and Economic Research; University of Alaska, Anchorage. Appendix A.
Available:
<https://iseralaska.org/publications/?q=Economic%20Potential%20of%20the>

DEVELOPMENT SCENARIOS (SELECTED EXAMPLES)



Likely:

- Usibelli Coal Mine
- Red Dog Mine
- Greens Creek Mine

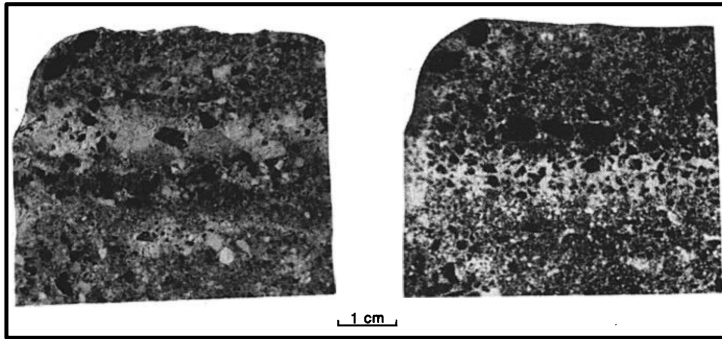
Somewhat Likely:

- Alaska Range Resources
(Sc>150ppm,
Sb>50ppm)

Underexplored:

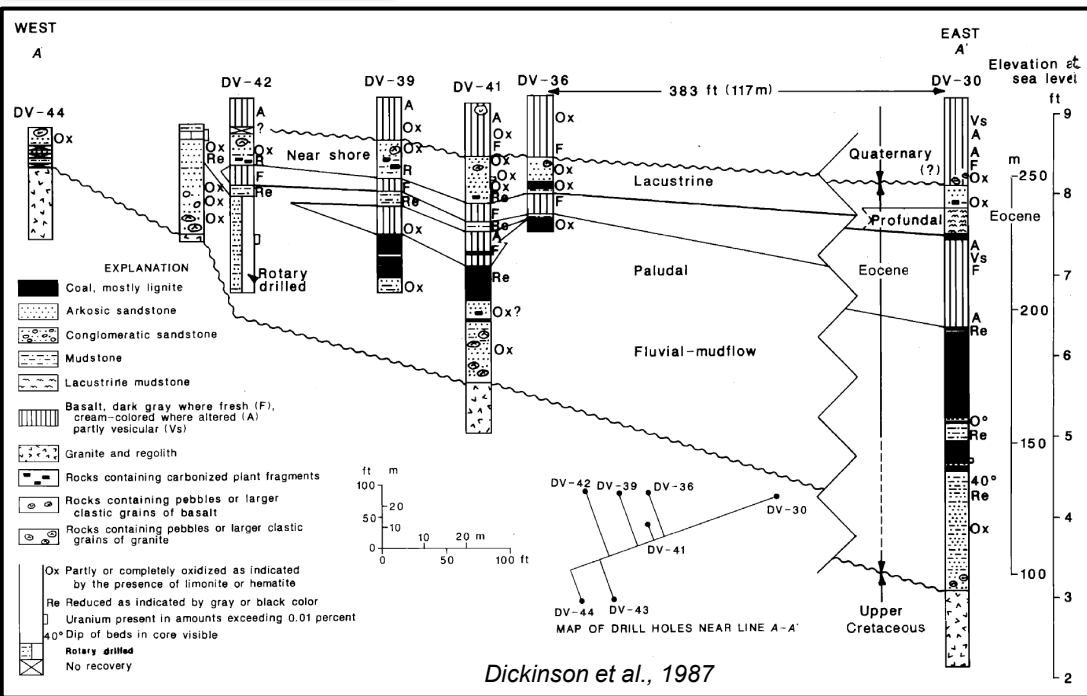
- Boulder Creek
- Ray River
- Fortymile Country

EPIGENETIC MINERALIZATION

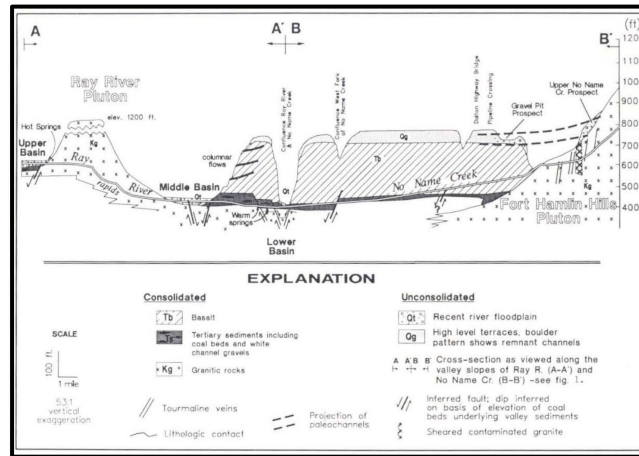
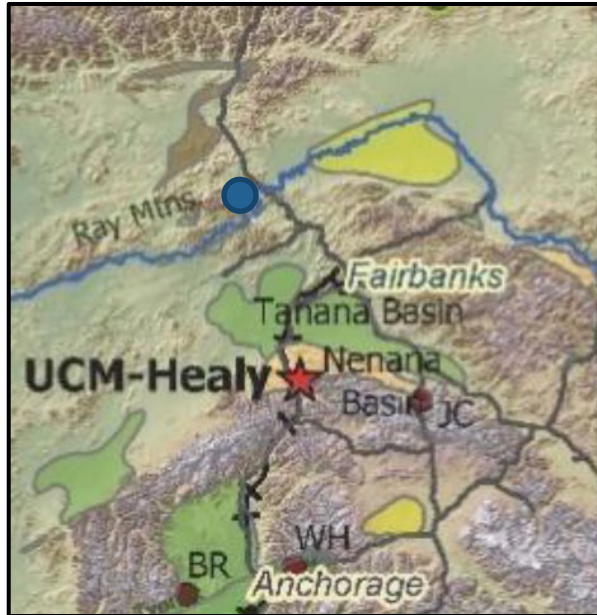


Boulder Creek

- Paleocene coals up to 175 feet thick occur in a graben
- 7,680 Btu/lb; 3.3% ash content (as received); 0.52% total sulfur
- Coal has 37 ppm Uranium (30X global avg.); Ss has epigenetic U-mineralization averaging 0.27% and a calculated resource of 1,000,000+ lbs of U_3O_8
- Coal includes 360ppm tungsten, among the highest reported in U.S.
- Likely leached from the U-rich Darby pluton and precipitated in reducing environment of carbonaceous rocks
- Interbedded and overlying basalt may have contributed to mineralization



GEOHERMAL MINERALIZATION



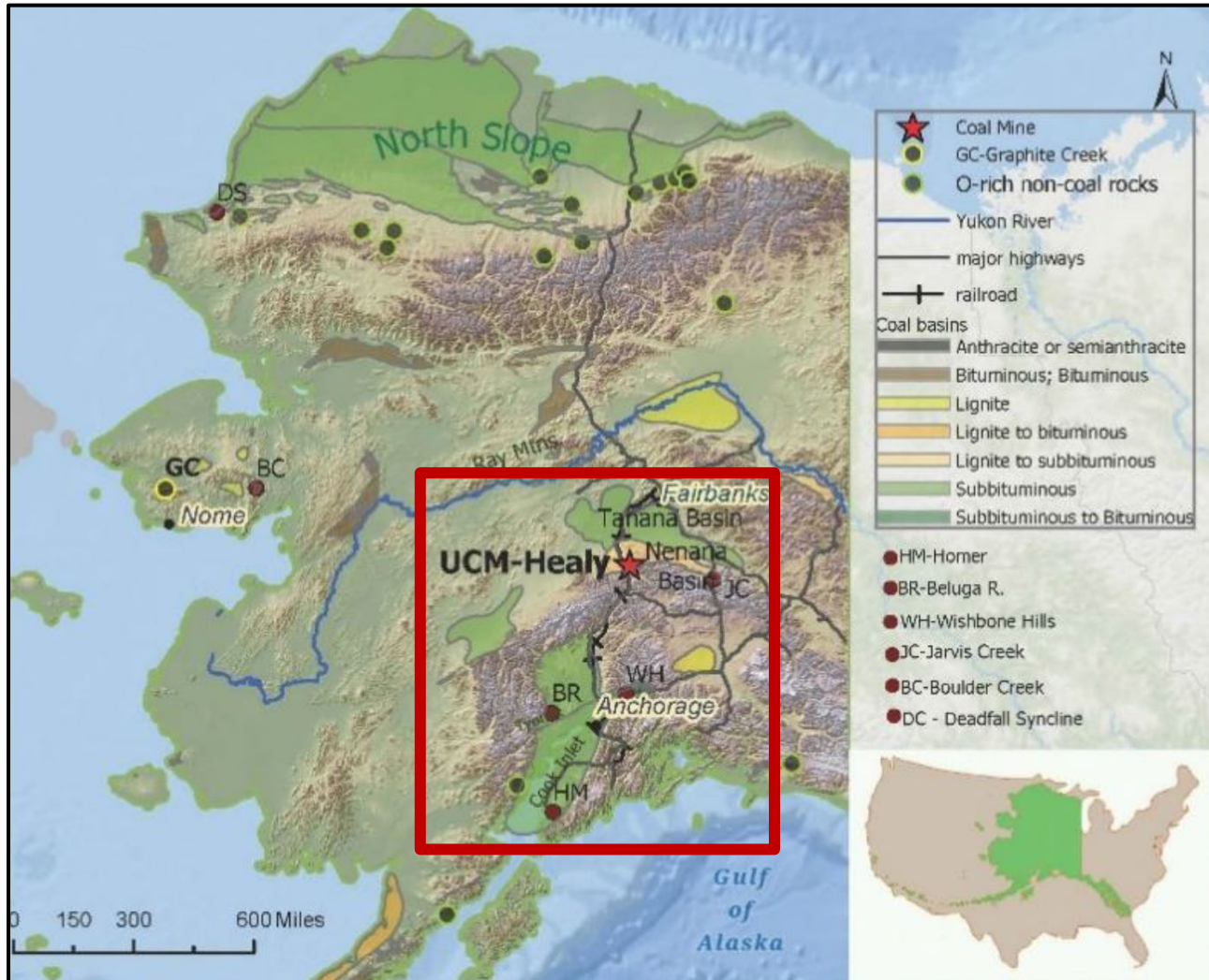
Ray Mountains

- Eocene Lignite A to Subbituminous B coal seams up to 18' thick in fault bounded grabens
- Capped by basalt
- W, Ge, and Pb range as high as 1%
- Au, Ga, and U are elevated, and most samples contain anomalous Zr and REE's

| Map Location Number | Sample Number | Coal Ash ¹ | | | | | | Whole Coal | | | | | |
|---------------------|---------------|-----------------------|---------------------|---------------------|--------------------|------------------|---------------------|----------------|-----------------|----------------|----|-----------------|--|
| | | % Ash | W | Pb ² | U ³ | Ga | Ge | W ⁴ | Pb ⁴ | U ³ | Ga | Ge ² | |
| 1 | RM26004 | 14.68 | 2,300 ⁴ | 332 | 3,090 ⁵ | 820 ² | 12,200 ⁶ | -- | -- | -- | -- | -- | |
| 2 | RM26097 | 5.95 | 11,000 ⁴ | 248 | 94 ⁵ | 70 ² | 700 ² | 375 | 17 | 5.4 | -- | 50 | |
| 3 | RM27598 | -- | 1,000 ⁴ | 325 | 155 | -- | <5 ² | 175 | 79 | 46.8 | -- | <5 | |
| 4 | RM25739 | -- | 1,900 ⁴ | -- | -- | -- | -- | 26 | -- | 13.0 | -- | <10 | |
| 5 | RM25445 | 6.70 | 3,790 ⁵ | 375 | 322 | -- | 322 ⁷ | -- | -- | -- | -- | -- | |
| 6 | RM25446 | 8.70 | 2,730 ⁵ | 255 | 171 | -- | 1,433 ⁷ | -- | -- | -- | -- | -- | |
| 7 | PB10386 | 9.00 | 3,420 ⁴ | -- | 467 | -- | <310 ⁹ | -- | -- | -- | -- | -- | |
| 8 | RM26098 | 10.09 | 7,400 ⁴ | 120 | 450 ⁵ | 110 ² | 300 ² | 325 | 16 | 35.3 | -- | 20 | |
| 9 | RM25447 | 8.10 | 5,190 ⁵ | 970 | 311 | -- | 143 ⁷ | -- | -- | -- | -- | -- | |
| 10 | RM25448 | 15.90 | 1,660 ⁵ | 18,800 ⁶ | 299 | -- | 108 ⁷ | -- | -- | -- | -- | -- | |
| 11 | RM27560 | -- | -- | -- | -- | -- | -- | 90 | 28 | 28.2 | -- | 70 | |
| 12 | RM25449 | 39.10 | 424 ⁴ | 1,000 | 147 | -- | 48 ⁷ | -- | -- | -- | -- | -- | |
| 13 | PB10384 | 18.00 | 85 ⁵ | -- | 78 | -- | <230 ⁷ | -- | -- | -- | -- | -- | |
| 14 | RM25450 | 6.20 | 308 ⁵ | 5,400 | 44 | -- | 18 ⁷ | -- | -- | -- | -- | -- | |
| 15 | RM26358 | 6.38 | 3,700 ⁴ | 54 | 52 ⁷ | 92 ² | 140 ² | 65 | 12 | 4.5 | -- | 30 | |
| 16 | RM24723 | 3.32 | 19,400 ⁴ | 133 | -- | 53 ⁷ | 15 ⁹ | -- | -- | -- | -- | -- | |
| 17 | RM27563 | -- | 3,690 ⁶ | -- | -- | -- | -- | 125 | 8 | 15.7 | -- | 70 | |
| 18 | RM24727 | 6.57 | 14,900 ⁴ | 50 | -- | 137 ⁷ | 900 ^{6,8} | -- | -- | -- | -- | -- | |
| 19 | RM24726 | 9.52 | 5,500 ⁴ | 554 | -- | 181 ⁸ | 100 ^{6,8} | -- | -- | -- | -- | -- | |
| 20 | RM24725 | 9.92 | 1,900 ⁴ | <2 | -- | 133 ⁸ | <100 ^{6,8} | -- | -- | -- | -- | -- | |
| 21 | RM27564 | -- | 7,130 ⁶ | -- | -- | -- | -- | 275 | 10 | 27.7 | -- | 150 | |



AIRFALL VOLCANIC ASH



- 50+ coal fields deposited in a variety of tectonic settings - which ones might be the most prospective?
- Slow deposition during peat formation results in limited clastic dilution
- Airfall volcanic material is interpreted to be an important control on REE/CM detrital concentrations in coal
- Common mineral phases include phosphates such as monazite and apatite, various titanites, and zircon, among others

CENOZOIC ARC VOLCANISM IN SOUTHERN ALASKA

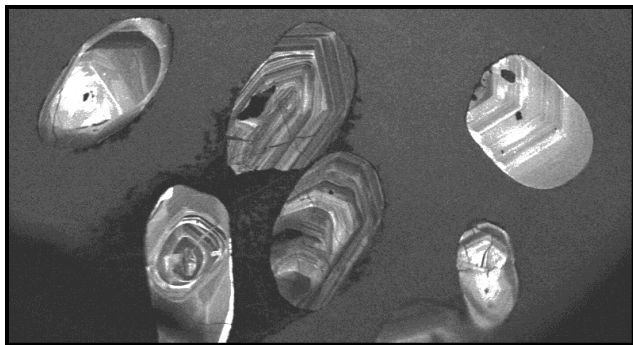
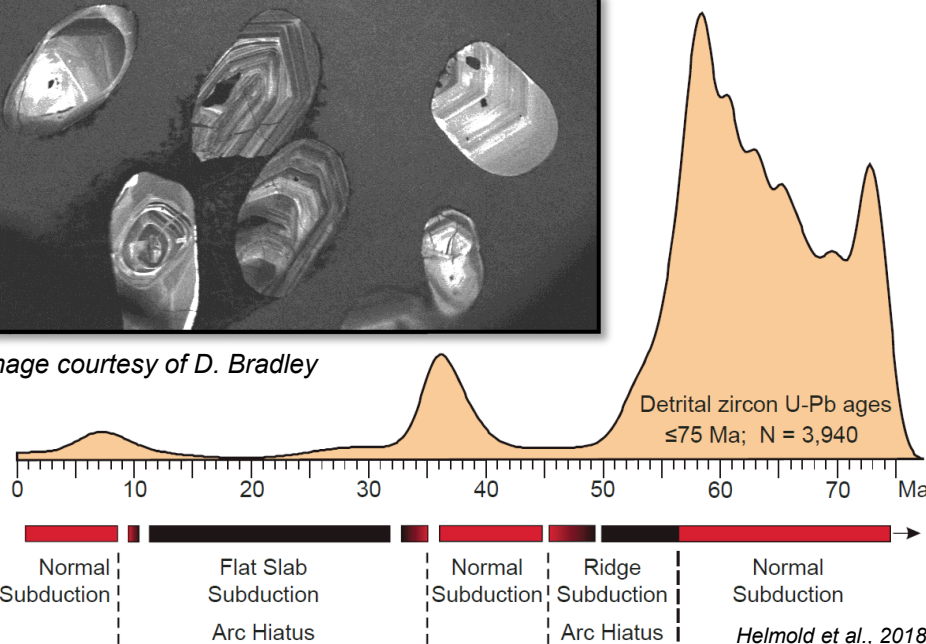
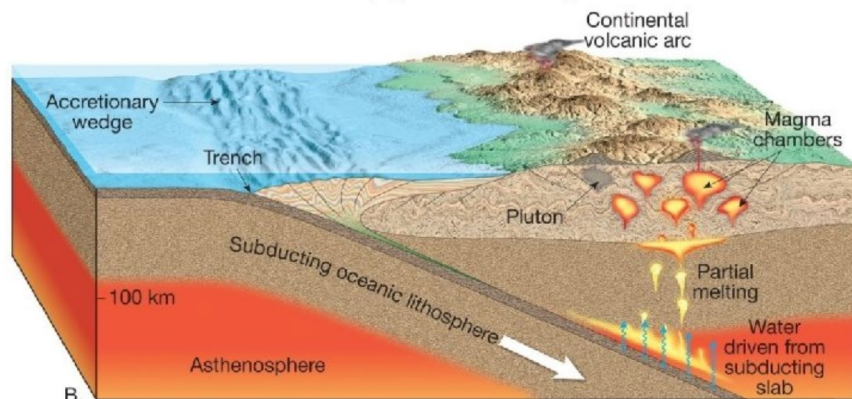
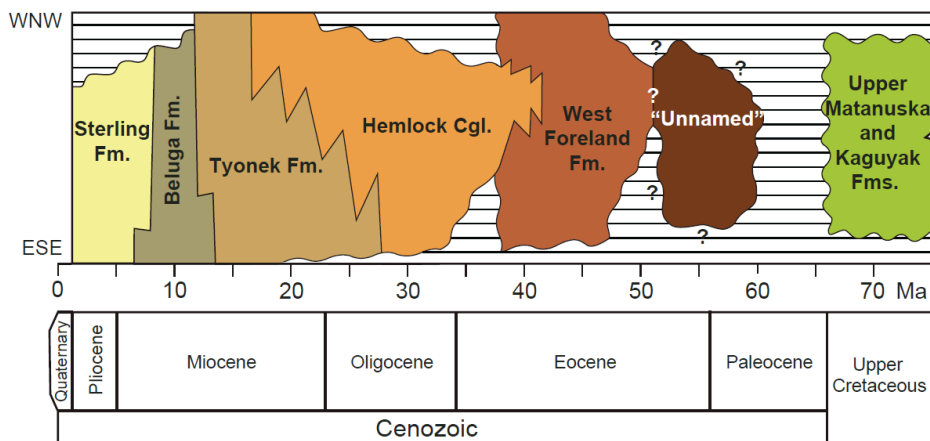


Image courtesy of D. Bradley

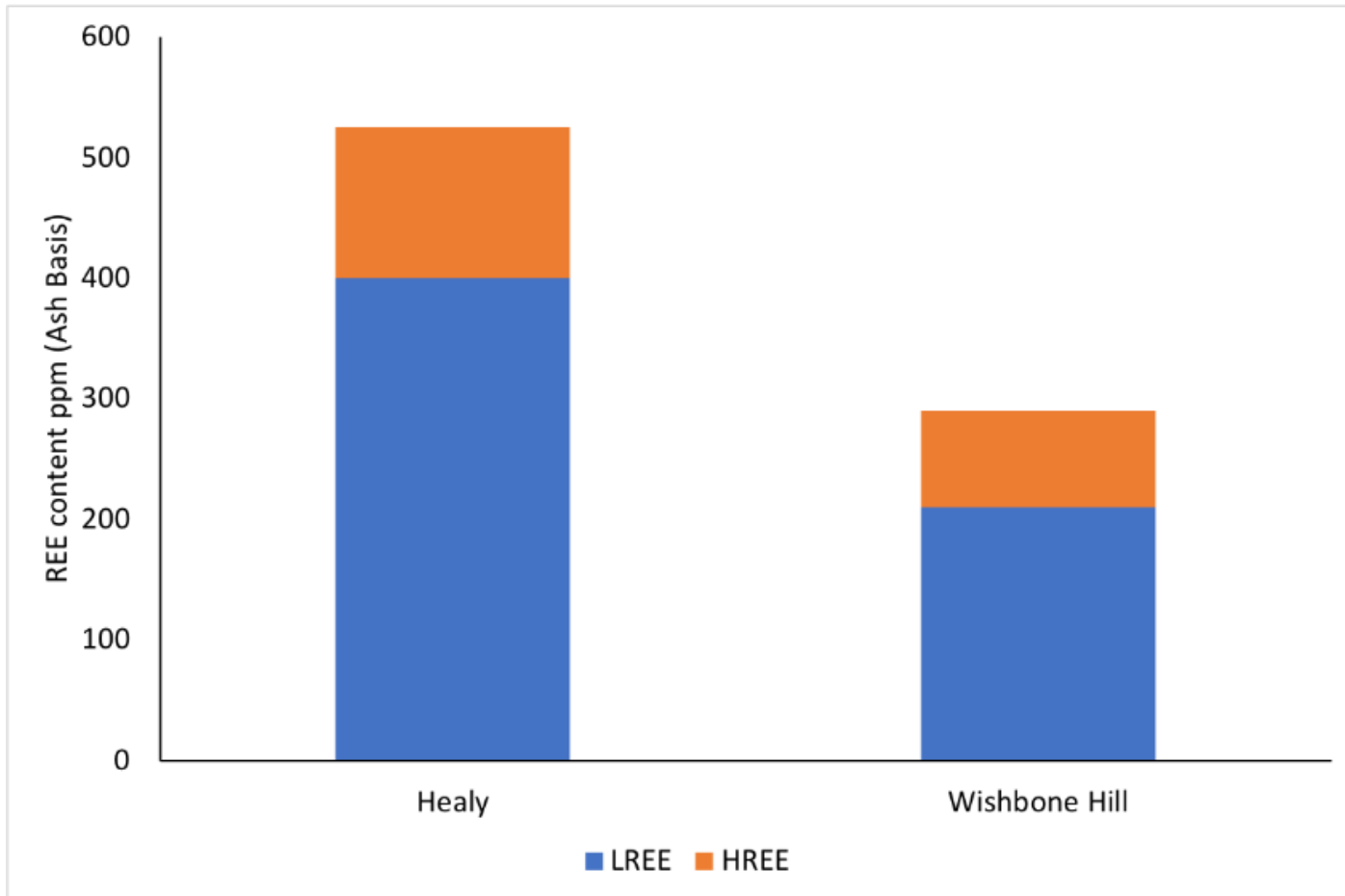


Sedimentary basins provide reliable record of waxing and waning of arc volcanism

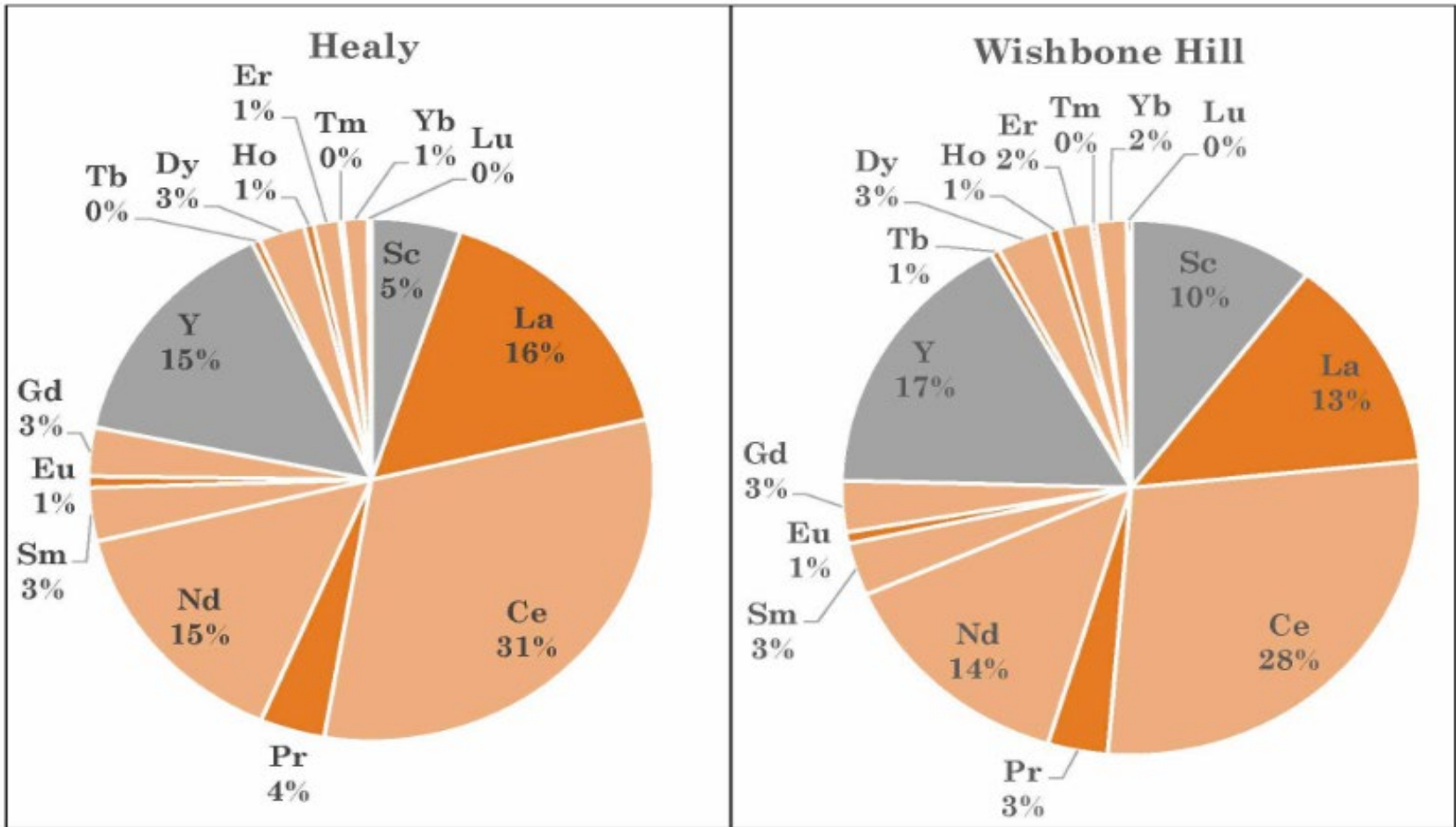
- Robust signal of zircon crystallization in the Paleocene and late Eocene
- Notable early to middle Eocene gap coincident with proposed ridge subduction
- Very few Oligocene and Miocene zircons suggesting minimal igneous activity



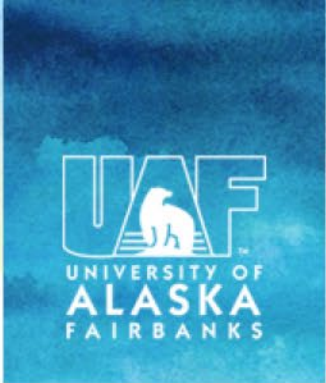
USIBELLI COAL MINE



USIBELLI COAL MINE



TEAM MEMBERS & STAKEHOLDERS



ucore®
RARE METALS



Doyon
Limited



THE STATE
of ALASKA
GOVERNOR MIKE DUNLEAVY



UNIVERSITY
of ALASKA
ANCHORAGE

FGX™



Graphite One 



EQUIPPED TO
DO MORE.™



SOUTHEAST
CONFERENCE



Ahtna



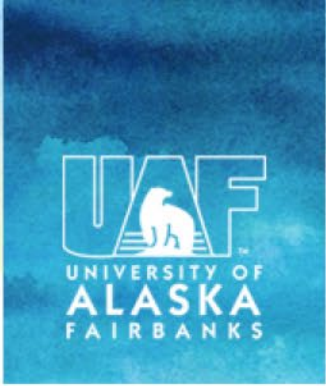
THE
UNIVERSITY
OF UTAH

NANA

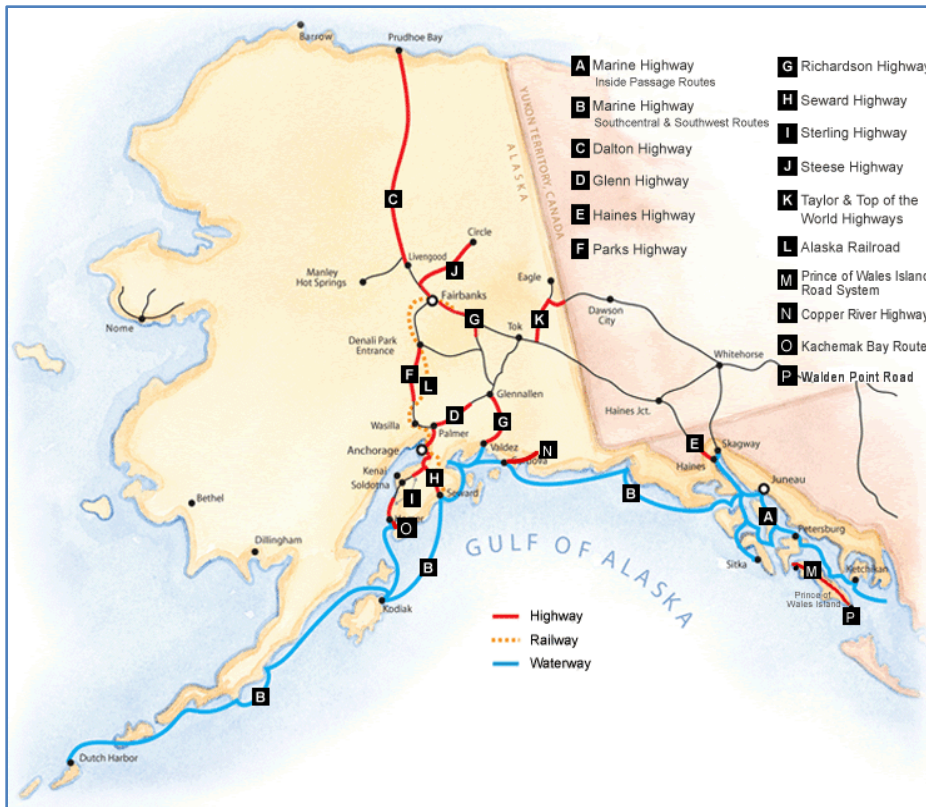


Green Leaf
CARBON TECHNOLOGIES

UCM
USIBELLI
COAL MINE



INFRASTRUCTURE

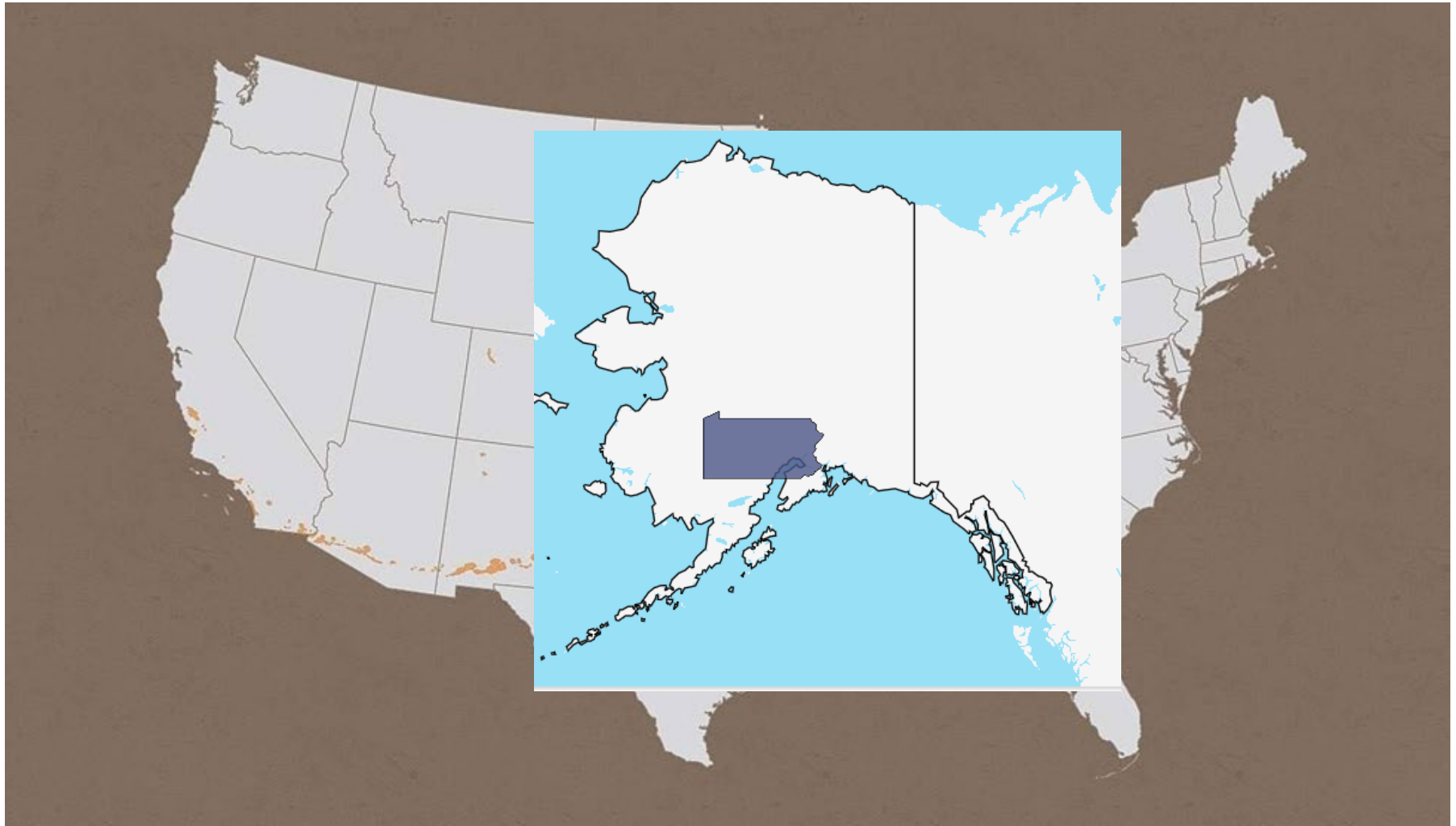


Lane Miles (U.S. DOT)

| | |
|------------|---------|
| Alaska | 35,927 |
| Penn. | 252,115 |
| Minnesota | 293,788 |
| Illinois | 306,803 |
| California | 400,218 |
| Texas | 698,839 |

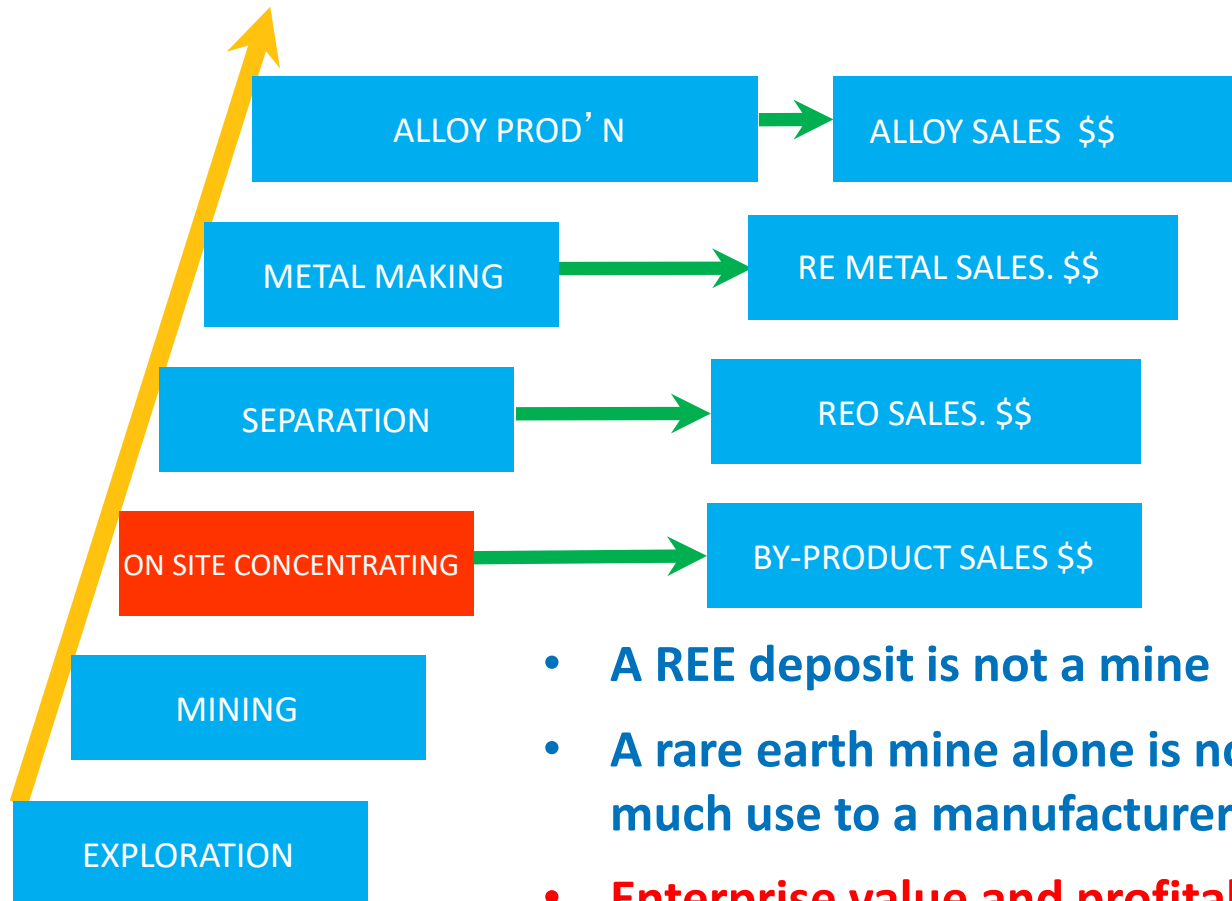


ALASKA IS AT THE END OF THE LOGISTICS



REE VALUE CHAIN

Where does a particular business fit into the value chain?



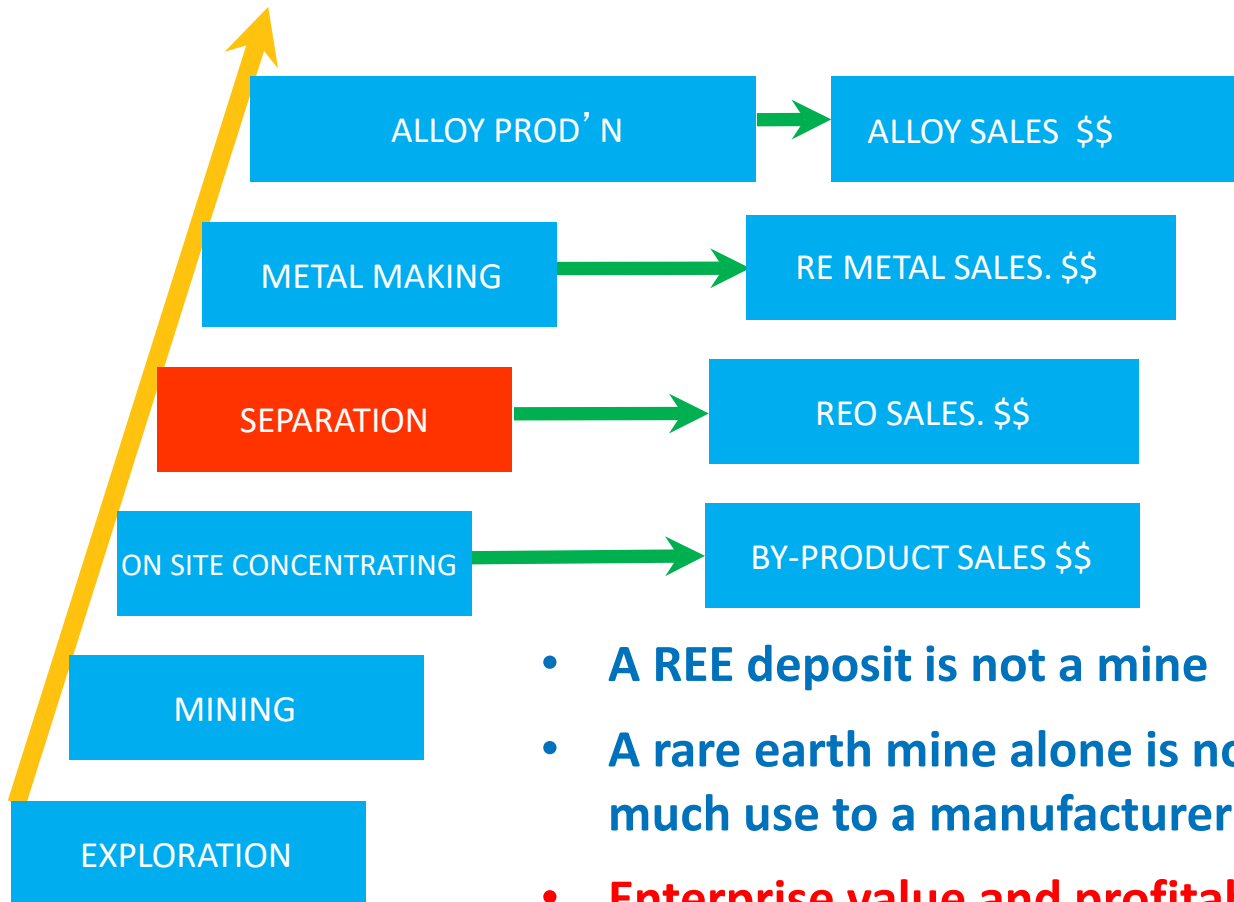
- A REE deposit is not a mine
- A rare earth mine alone is not of much use to a manufacturer
- **Enterprise value and profitability increases with each stage of processing**

Graphic Courtesy of Great Western Minerals Group, Ltd, Jack Lifton Technology Metals Research, LLC (after ESP Research)



REE VALUE CHAIN

Where does a particular business fit into the value chain?



- A REE deposit is not a mine
- A rare earth mine alone is not of much use to a manufacturer
- **Enterprise value and profitability increases with each stage of processing**

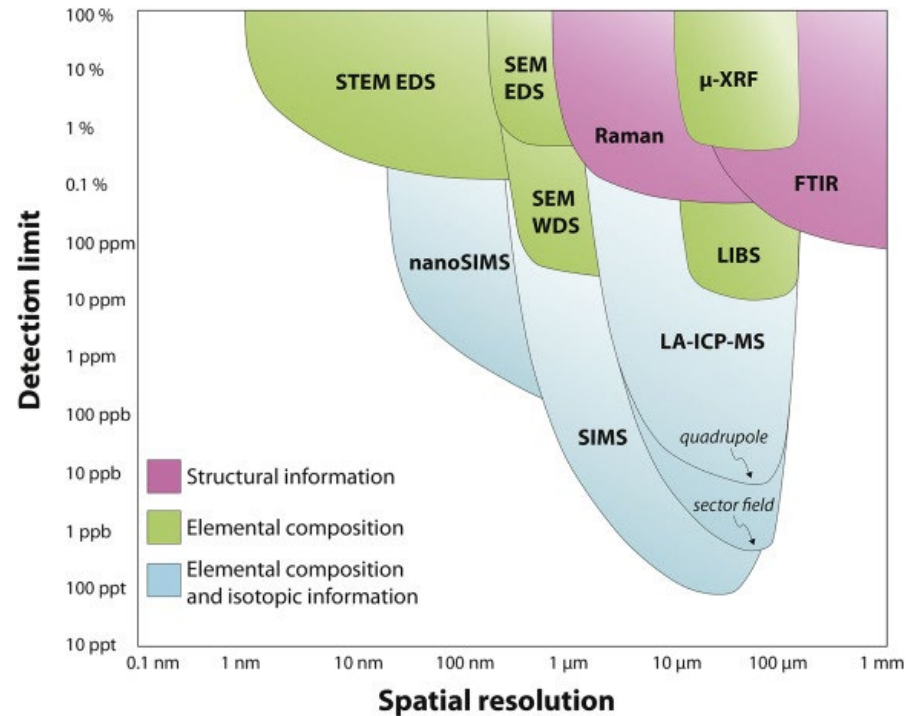
Graphic Courtesy of Great Western Minerals Group, Ltd, Jack Lifton Technology Metals Research, LLC (after ESP Research)





NEW ICP/MS

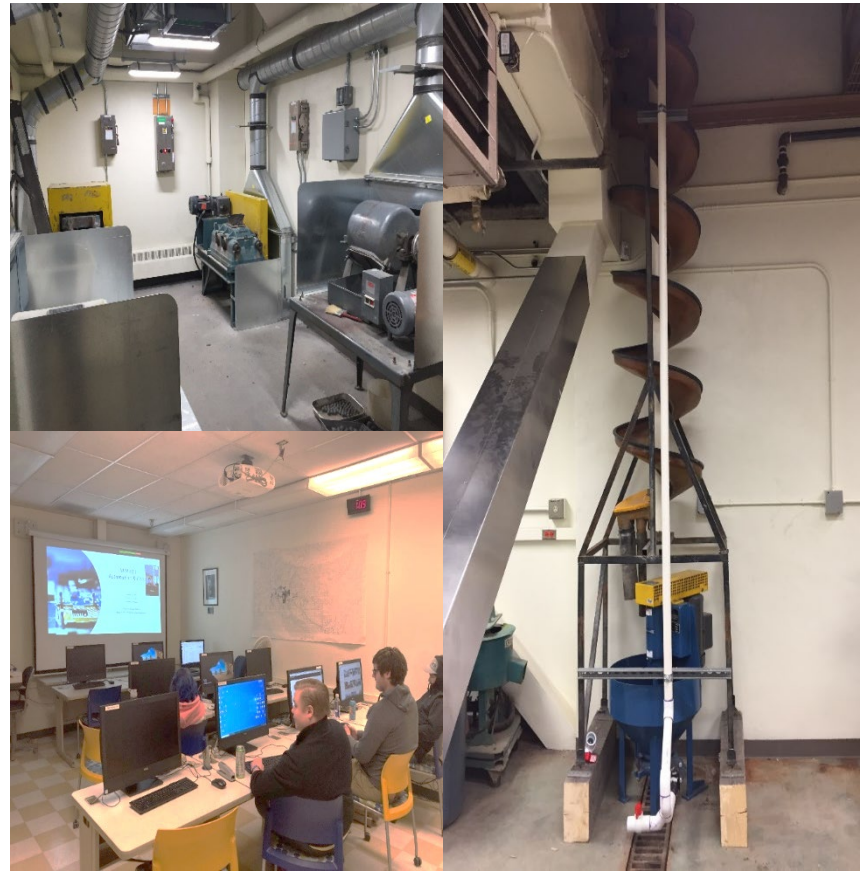
- New ICP-MS Laser Ablation system and Microwave-assisted digestion system are expected to be installed by Spring 2024.
 - U-Pb age dating will be available once the equipment is operational
- INE is actively recruiting and reviewing candidates to manage the instrumentation and new lab space.

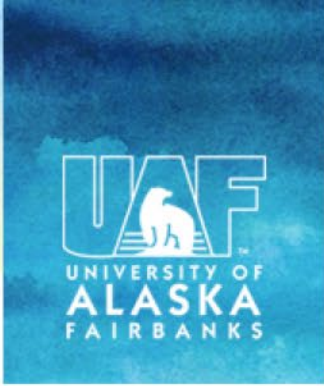




MINERAL INDUSTRIAL RESEARCH LAB

- Mineral Processing
- Mine Design
- Mine Automation
- Ventilation Systems
- Rock Mechanics
- District Studies





GEOPHYSICAL INSTITUTE

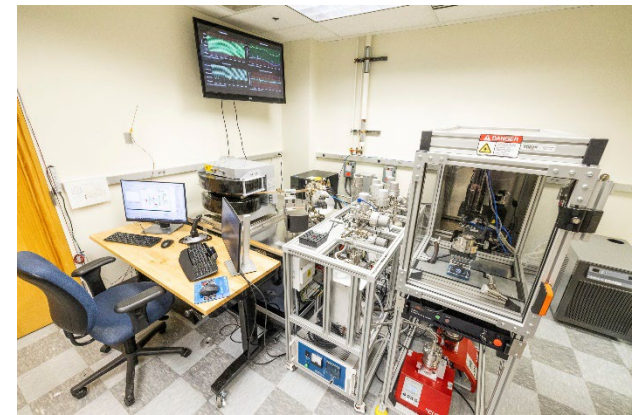


Spatially resolved LIBS analysis for real-time chemical analysis in atmosphere

*Fluid Inclusion microscope
Petrographic microscopes
Rock Prep facility*

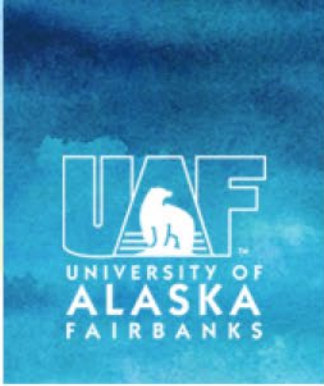


*EPMA, SEM, XRD,
XRF*

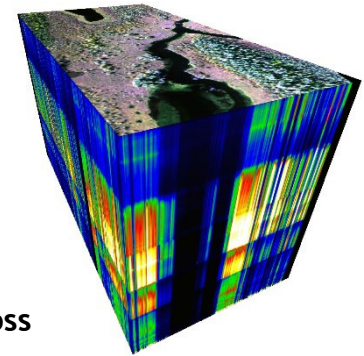
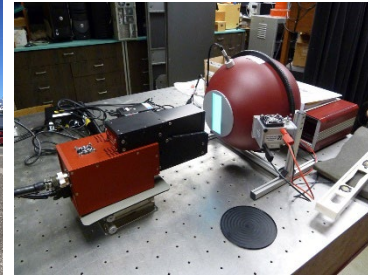
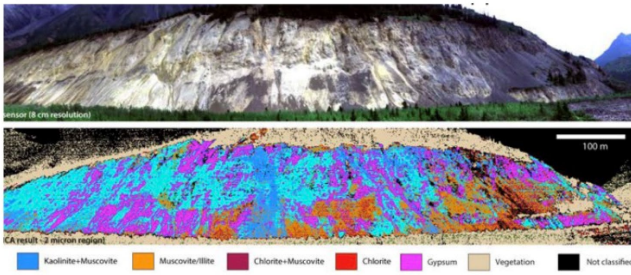


New Noble Gas Mass Spectrometer Sample Preparation facilities

Chemical and isotopic analysis, Petrology, Mineralogy, Geochronology, Structure, Field Mapping, Experimental Petrology



REMOTE SENSING / HYPERSPPECTRAL



MOTIVATION

- Hyperspectral imaging is a **powerful remote sensing tool** to obtain accurate information on minerals exposed to the surface.
- Extract **Critical Mineral Compositional information** from airborne measurements.
- **Quantify or constrain** physical and chemical properties such as element chemistry or mineral abundances.

FACILITIES

- **HyLab** deploys laboratory and field spectrometers for obtaining spectral signatures.
- **Aircraft equipped with visible and near infrared** as well as thermal imaging sensors.
- Ability to map targets from micrometer to kilometer scales.
- Resources to **calibrate** sensors.
- Expertise to generate **value-added data products**.

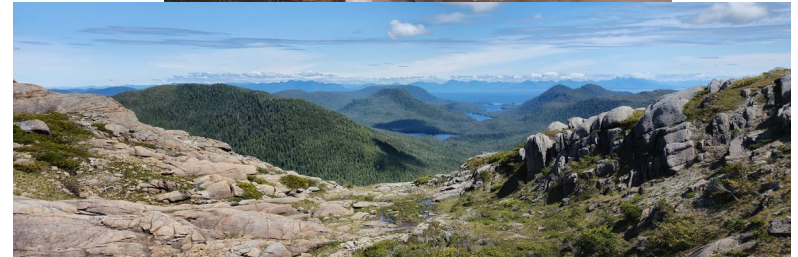
SERVING ALASKA

- UAF's HyLab helps to **cross the practical, logistical, and financial barriers** that the State of Alaska and DGGS has faced in using this important technique for a variety of applications such as critical minerals exploration, and to serve the needs of Alaskan communities.



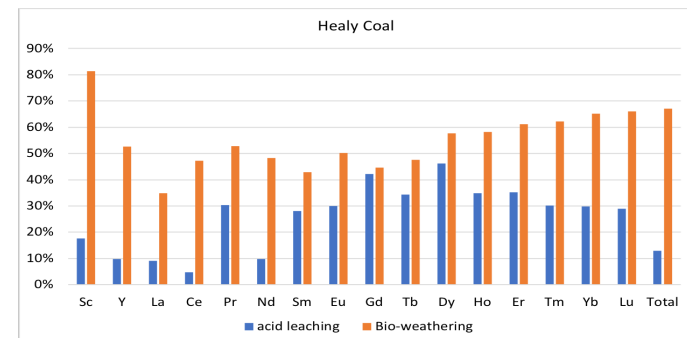
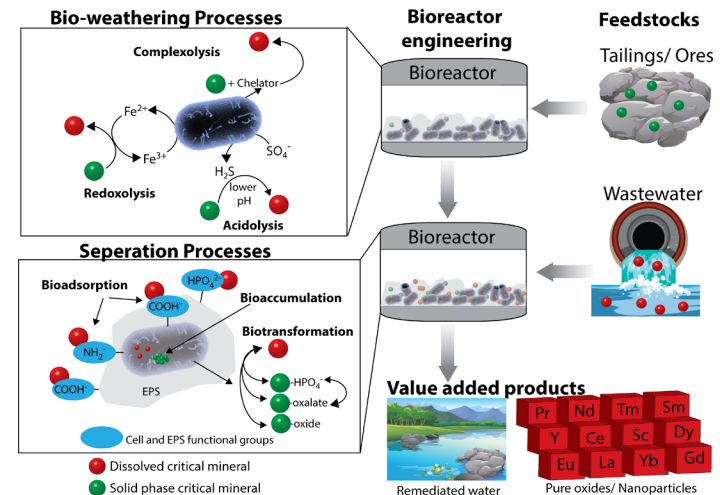
HYDROGEOCHEMISTRY LABORATORY

- Globally renowned interdisciplinary research team in lithium resources and environment (North and South America)
 - Closed-basin brines
 - Oil field brines
 - Volcano-sedimentary clay deposits
 - Industry supported research
- Environmental and exploration geochemistry of metals in mined and unmined terrains across Alaska



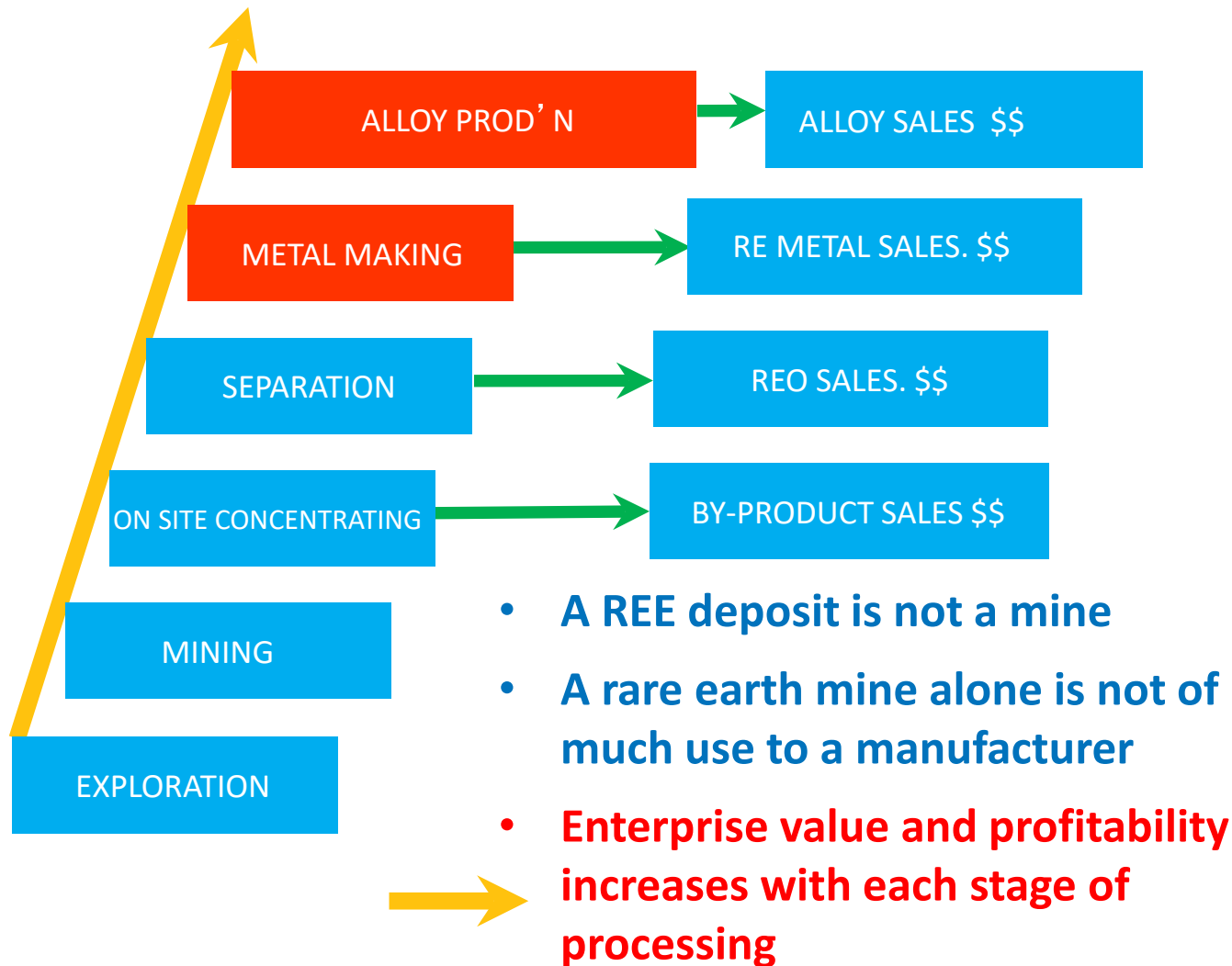
BIOSEPARATION LAB

- Bioseparation research on rare earth elements (REE) extraction and separation
- Improved recoveries over acid leaching
- Launched research on separating individual REEs
- Ongoing research, development and design for a stainless steel bioreactor for REE recovery



REE VALUE CHAIN

Where does a particular business fit into the value chain?



Graphic Courtesy of Great Western Minerals Group, Ltd, Jack Lifton Technology Metals Research, LLC (after ESP Research)





SUMMARY

| UAF/DGGS Task Equivalent | Status |
|--|---|
| Task 2: Basinal Assessments | Ongoing. Significant findings already! |
| Task 3: Waste Stream Reuse | (1) Alkali Activation of Coal Ash for Sustainable Construction; (2) Tailing pile at Greens Creek Mine; (3) Creating value from low-value coal |
| Task 4: Strategies for Infrastructure, Industries and Businesses | (1) Developing biological approaches for resource recovery & for waste remediation; (2) Remote power for Mines (sister project) |



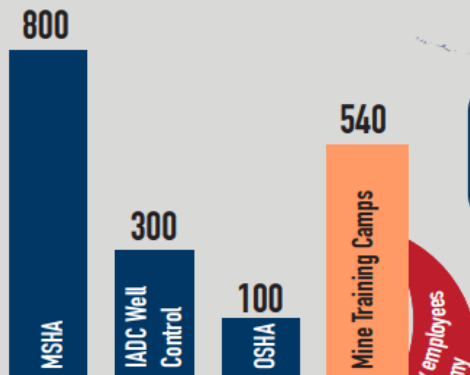
SUMMARY (CONTINUED)

| UAF/DGGS Task Equivalent | Status |
|--|--|
| Task 5: Technology Assessment, Development & Field Testing | (1) Onsite beneficiation; (2) Investigating batch mining for Alaska Range Resources |
| Task 6: AK-TIC | Building capacity within the State by investing in new equipment and hiring subject matter experts. |
| Task 7: Stakeholder Outreach & Education | (1) Held two annual events; (2) Working with two mine training programs; (3) Initiating outreach to villages; (4) Actively participate in AMA meetings and serve as frequent speaker; (5) Newsletters. |

WORKFORCE DEVELOPMENT

Skills Development

Certifications by program



1,740

certifications/
competencies
issued each year

*aids new employees
to the economy*

Economic Impact



\$21.5M

Graduates' salaries
into Alaska's
economy since 2015.

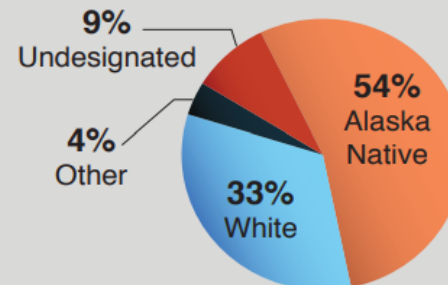
Job Placement



85%

of participants
employed within
1 year

Job Seekers





MEET THE TEAM

- Brent Sheets, UAF
- Jim Patten, UAF
- Marwan Wartes, DGGS
- Tathagata Ghosh, UAF
- Rajive Ganguli, Univ. of Utah
- Brandon Briggs, UAA
- Eric Peterson, ESP
- Keith Hanneman, UAF
- Nina Harun, DGGS
- Cory Ortiz, UAS
- Justin Seavey, Usibelli Coal Mine
- Joe Renk, NETL Program Manager
- And 36 more!





THANK YOU

Brent J Sheets

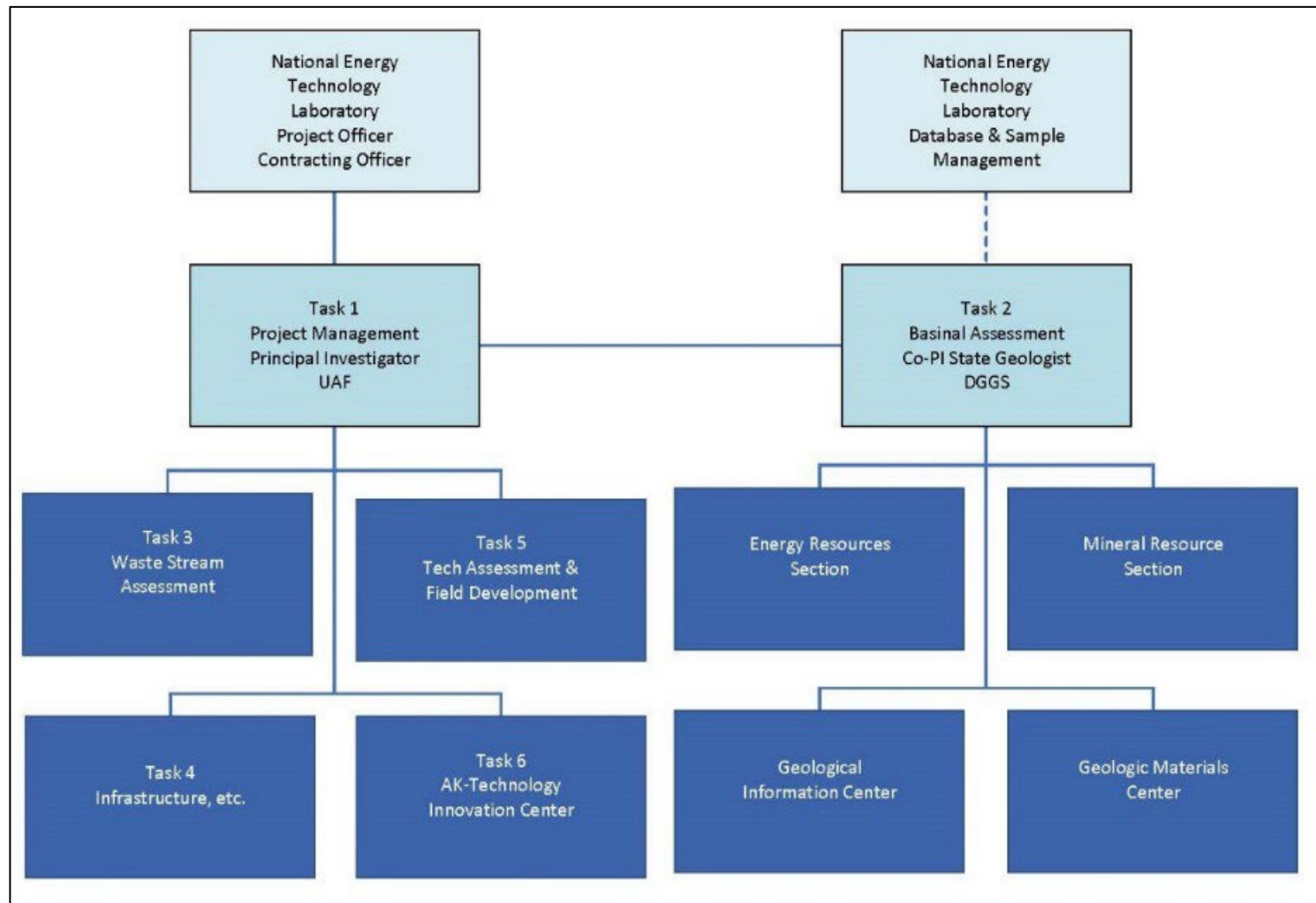
907-750-0650

bjsheets2@alaska.edu





ORGANIZATION CHART





GANTT CHART

