Transforming Uinta Basin Earth Materials for Advanced Products

DE-FE0032046

Michael L. Free

University of Utah

U.S. Department of Energy

National Energy Technology Laboratory
Resource Sustainability Project Review Meeting
October 25 - 27, 2022

Project Overview (Part I)

- Funding (DOE $1,535k and Cost Share $487k)
- Overall Project Performance Dates (9/16/21-8/16/24)
- Project Participants (contracted for funding)

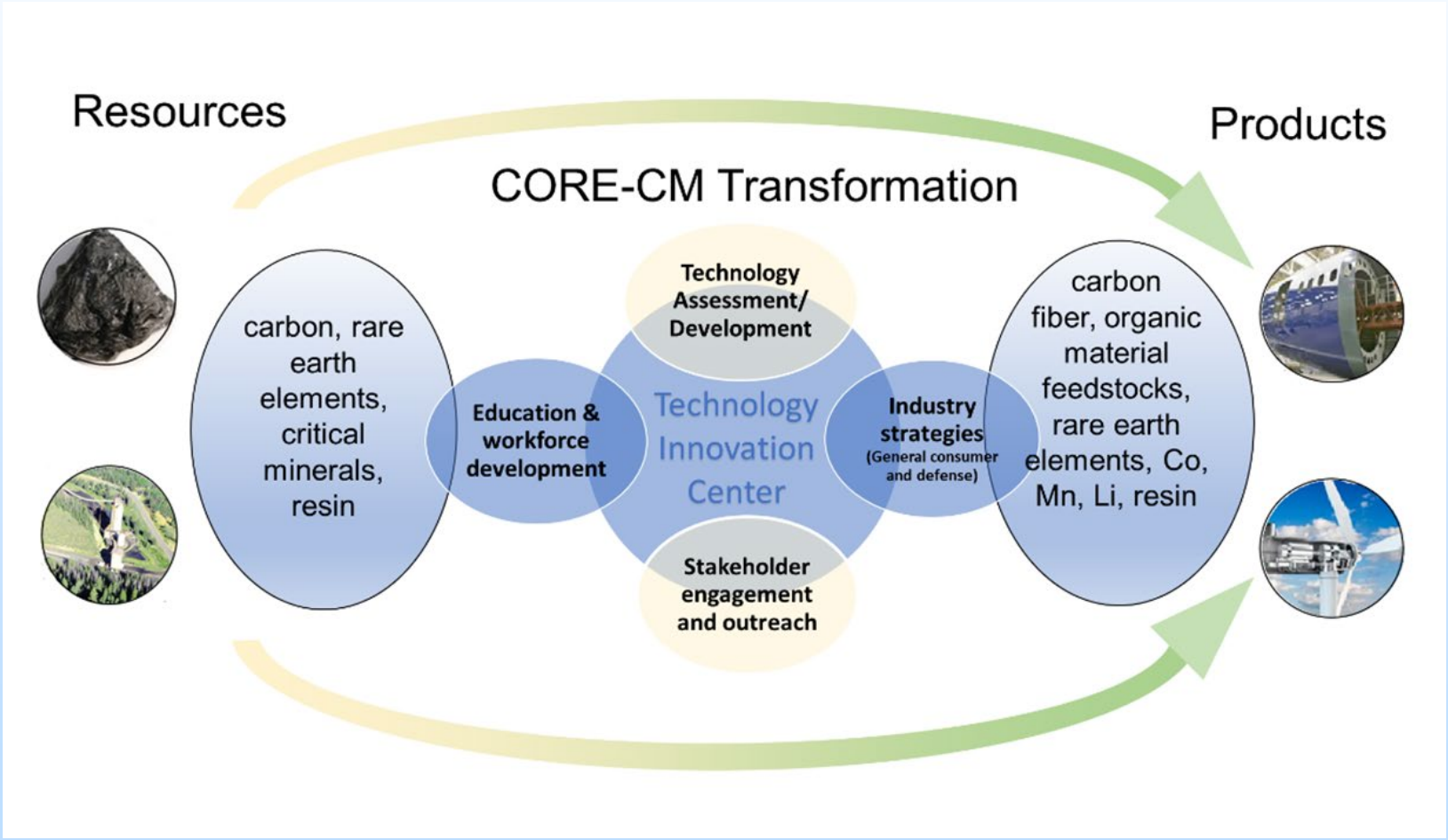
University of Utah (UofU), Utah Advanced Materials Manufacturing Initiative (UAAMMI), Institute for Advanced Composites Manufacturing Innovations (IACMI) (UAMMI subcontract), Utah Geological Survey (UGS), Colorado Geological Survey (CGS) (CSM subcontract), Colorado School of Mines (CSM), JWP Consulting, LLC (JWP), Utah State University – Eastern (USUE) Los Alamos National Lab (LANL), Wolverine Fuels (WF)

Project Overview (Part II)

- Overall Project Objectives: The objectives of this project are to quantify, assess, and plan to enable the transformation of Uinta Basin region earth resources, such as coal, oil shale, resin, rare earth elements (REE), critical minerals (CM), and waste into higher value metal, mineral, and nonfuel carbon-based products. These objectives will be accomplished for Phase I by completing *1) basinal assessments and initial planning, 2) a basinal assessment for waste stream reuse with associated plan development, 3) basinal strategies development for infrastructure, industries, and business, 4) a technology assessment, development, and field-testing plan, 5) a technology innovation center plan, and 6) a stakeholder outreach and education plan.*

Our DOE CORE-CM Project Vision

The Objective: Transform Uinta Basin Resources Into Advanced Products



DOE CORE-CM Uinta Basin Team

- University of Utah
- UAMMI
- IACMI
- Colorado School of Mines
- Los Alamos National Lab
- Wolverine Fuels
- Utah State University
- Utah Geological Survey
- Colorado Geological Survey
- JWP Consulting LLC
- Arcadia Minerals Inc.
- Black Mountain Resources
- Carbon County
- Ekomatter, LLC
- Emery County
- Energy Fuels
- FGX
- K. Marc LeVier and Associates, LLC
- Monsanto
- Iperion X
- North American Coal Corp
- RAMACO
- Red Leaf Resources Inc.
- Seven County Infrastructure Coalition
- The Graphene Council
- University of Alaska
- UT Gov. Off. Economic Development
- UT Gov. Off. Energy Development
- Vermeer
- Utah Mining Association

Main researchers: Lauren Birgenheier, Eric Eddings, Michael Free, Ryan Gall, Rajive Ganguli, Andrew Giebel, Brent Goehring, Tulinda Larsen, Jan Miller, Swomitra Mohanty, Michael Nigra, Jim Patten, Pratt Rogers, Prashant Sarswat, Patrick Taylor, Michael Vanden Berg, Xuming Wang, Jessica Wempen

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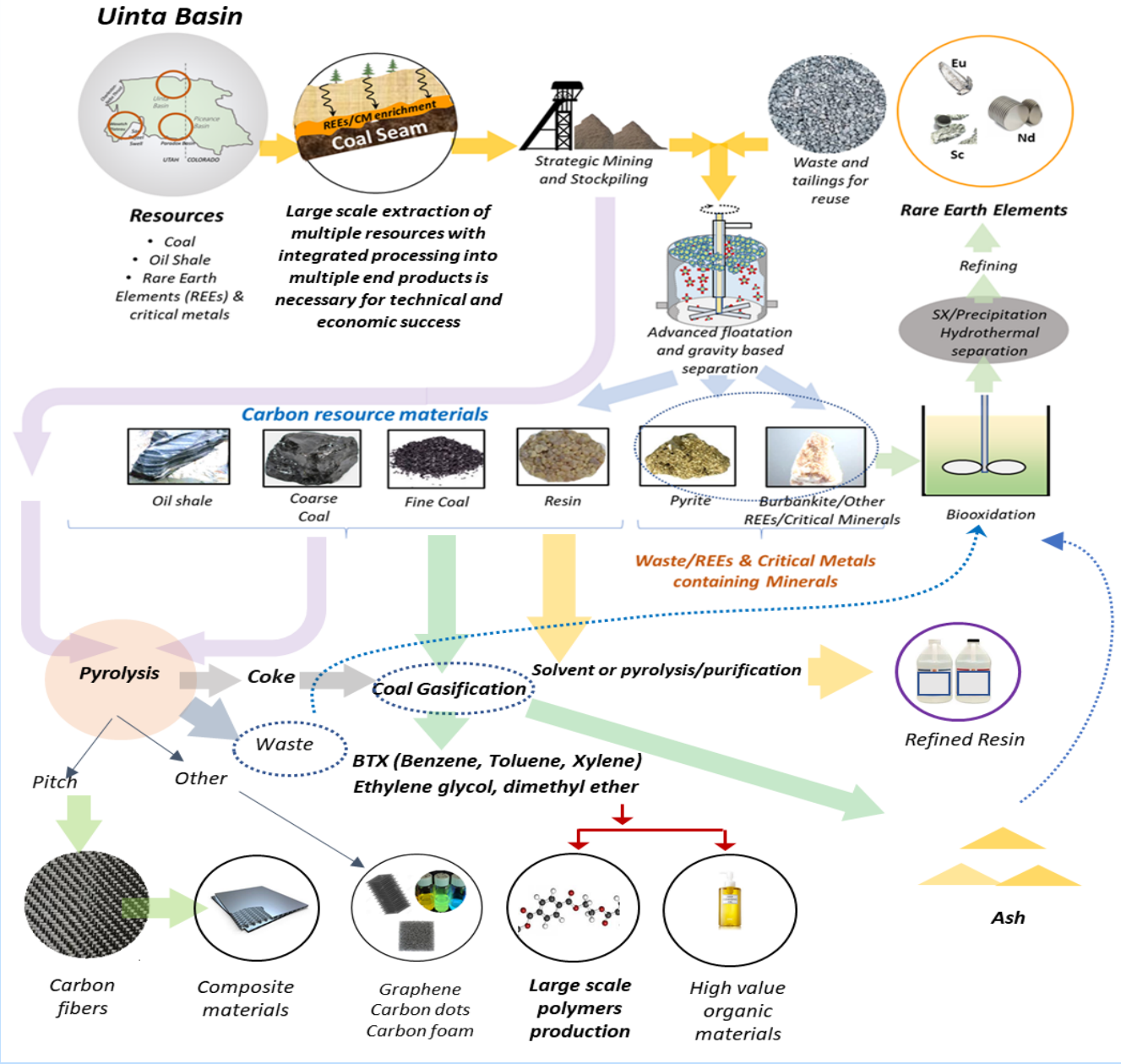
Initial Conceptual Plan

The Uinta Basin's rich resources of carbon and critical minerals can be converted through innovative local processing (see figure) to nonfuel products such as:

- Carbon fiber
- Polymers
- Graphene
- Resin
- Rare Earth Element Metals
- Critical Materials

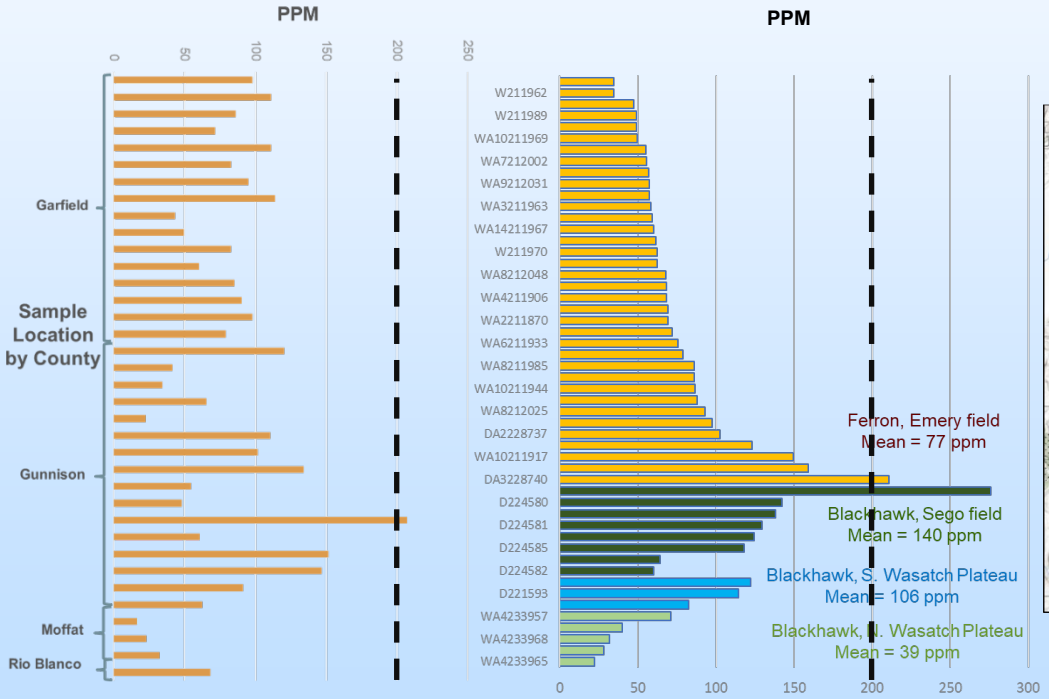


Previous Uinta Region data on REE-enriched coal

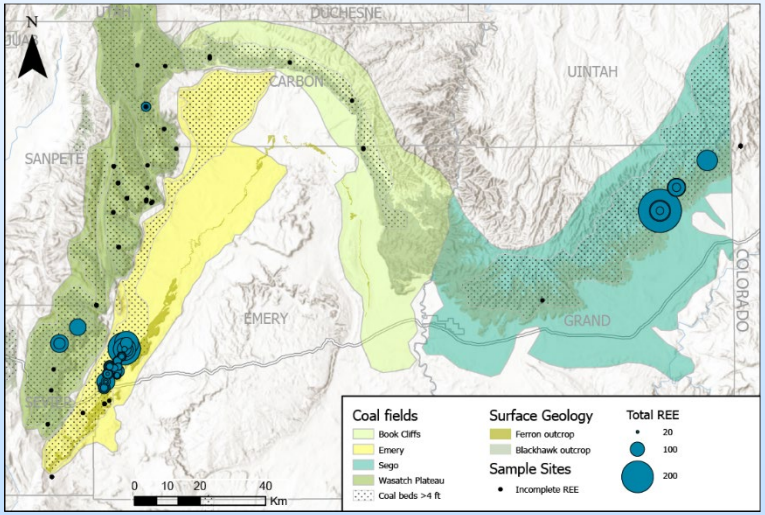
Sparse previous USGS CoalQual data, only 3 of 88 samples >200 ppm REEs

W Colorado, coal total REE

Utah, coal total REE

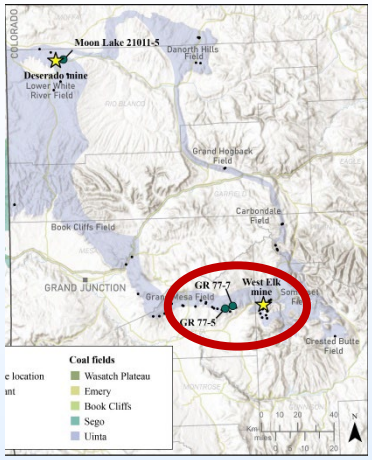


regional total REE



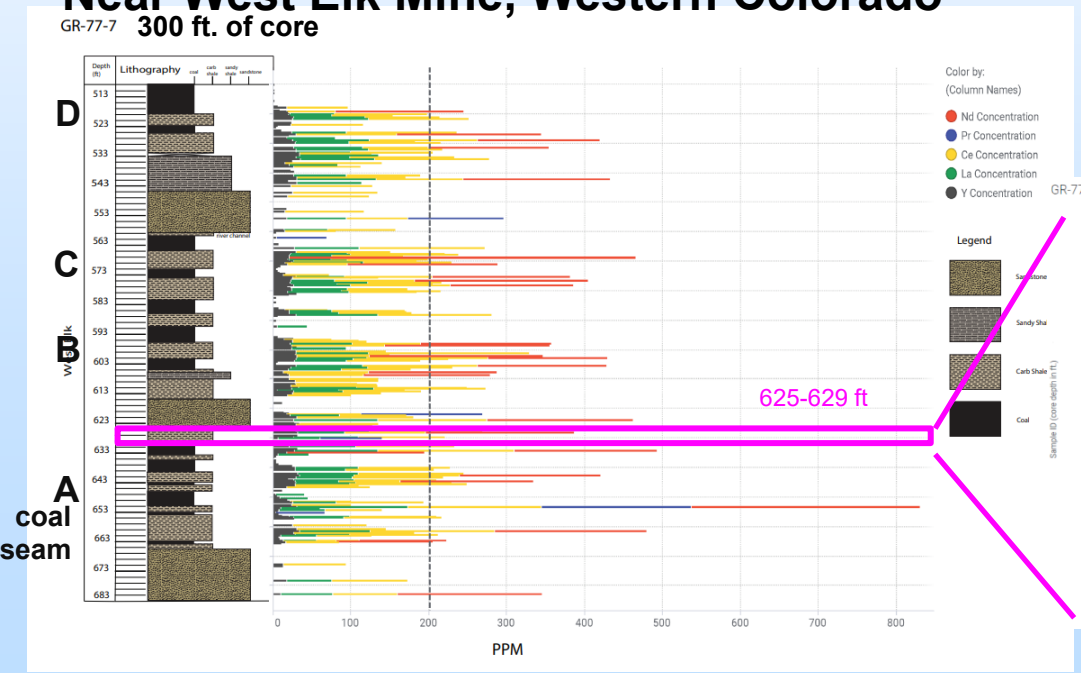
Carbonaceous shales adjacent to coal seams are REE-enriched

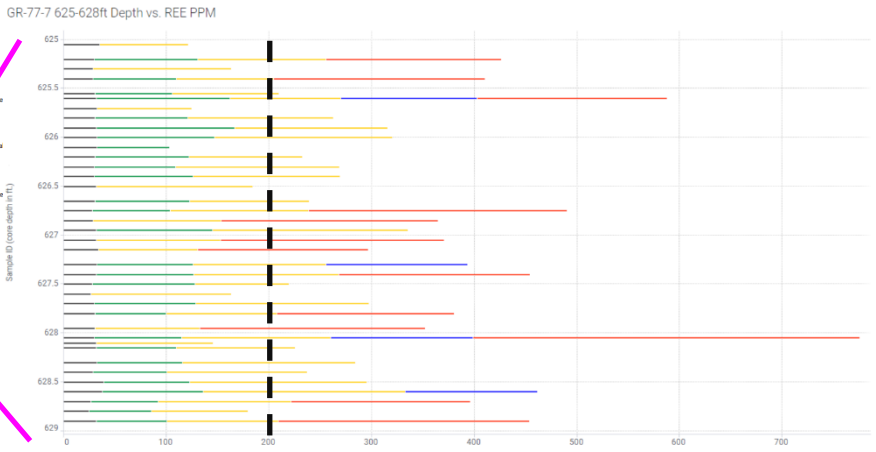
The sum of only Ce, La, Nd, Pr, and Y by XRF analysis averages above 300 ppm for a 4-feet thick layer.



Near West Elk Mine, Western Colorado

average	**310**	**ppm**
max	775	ppm
min	103	ppm



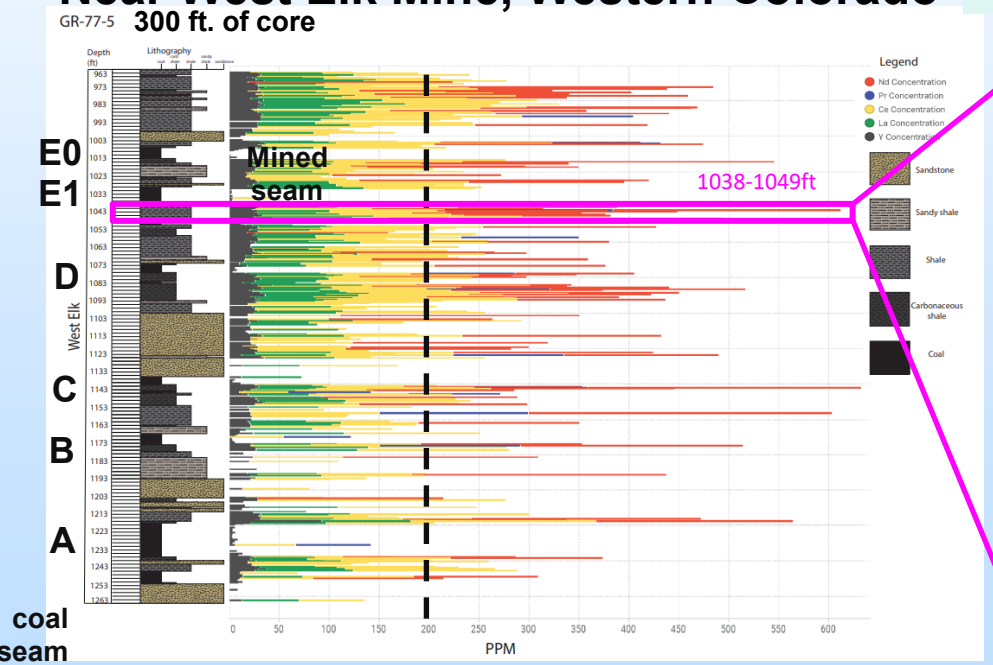


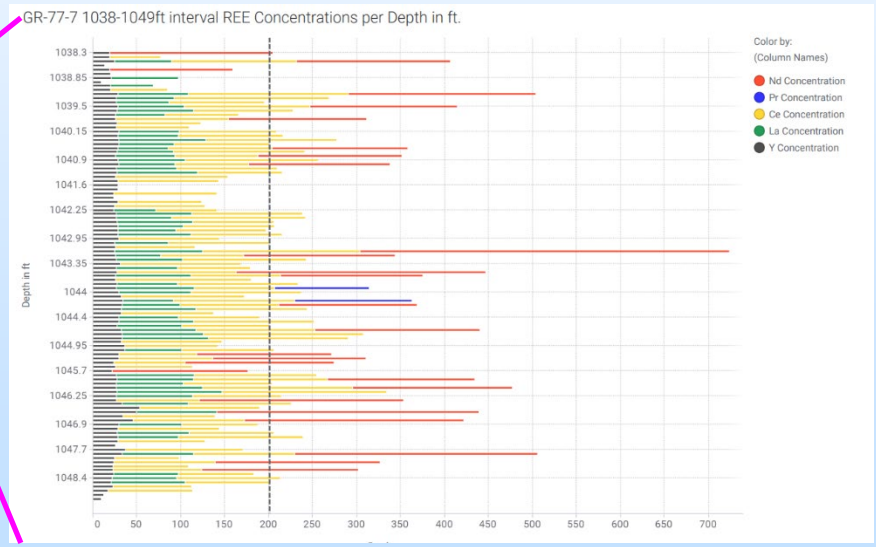
Carbonaceous shales adjacent to coal seams in some areas are REE-enriched

The sum of only Ce, La, Nd, Pr, and Y by XRF analysis averages above 200 ppm for an 11-feet thick layer.

average	**207**	**ppm**
max	723	ppm
min	10	ppm

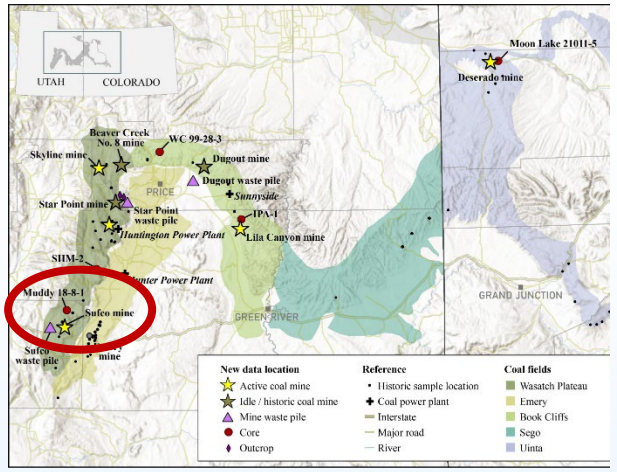
Near West Elk Mine, Western Colorado GR-77-5



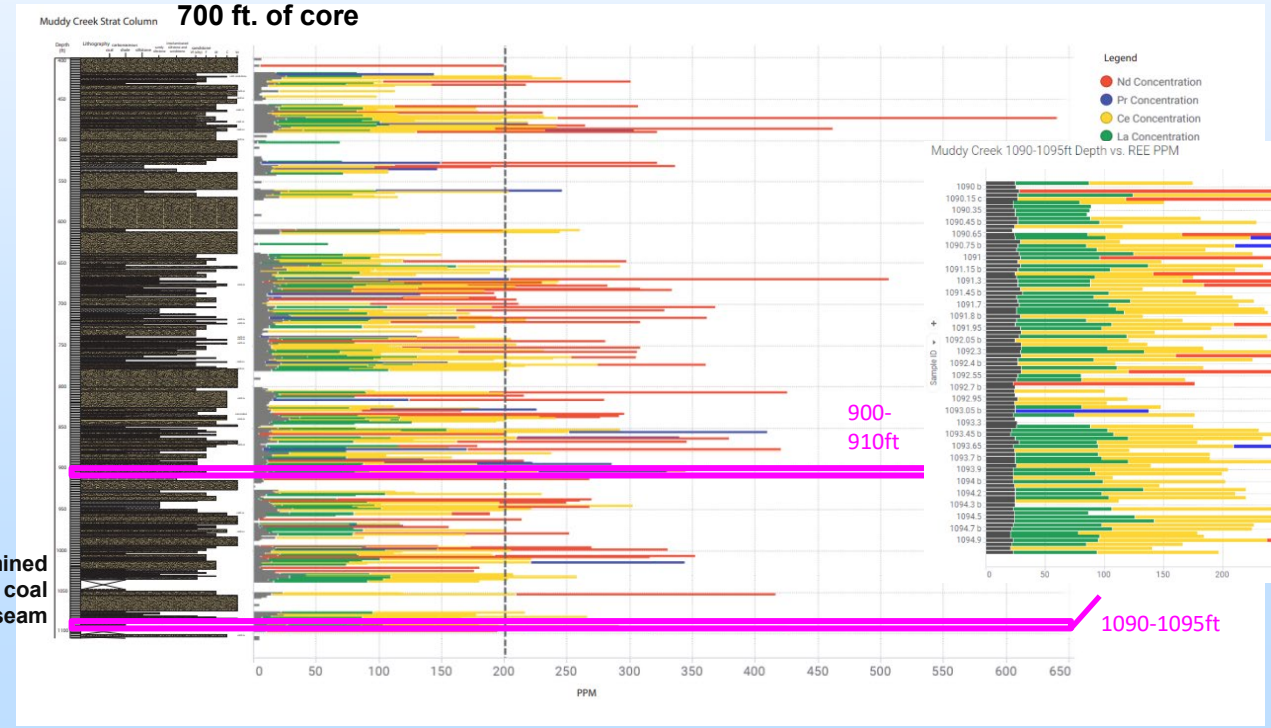


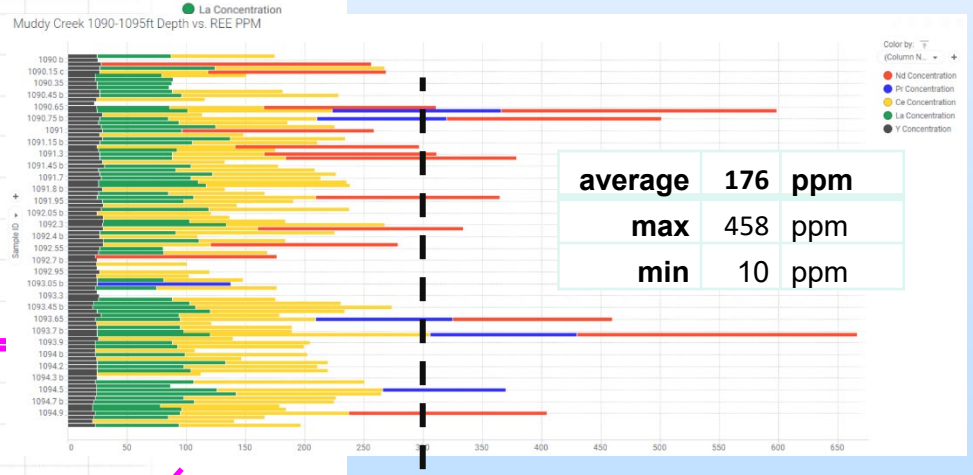
Carbonaceous shales adjacent to some coal seams are REE-enriched

The sum of only Ce, La, Nd, Pr, and Y by XRF analysis averages above 175 ppm for thick layers (5 ft + 10 ft).



Near Sufco Mine, Wasatch Plateau, Utah

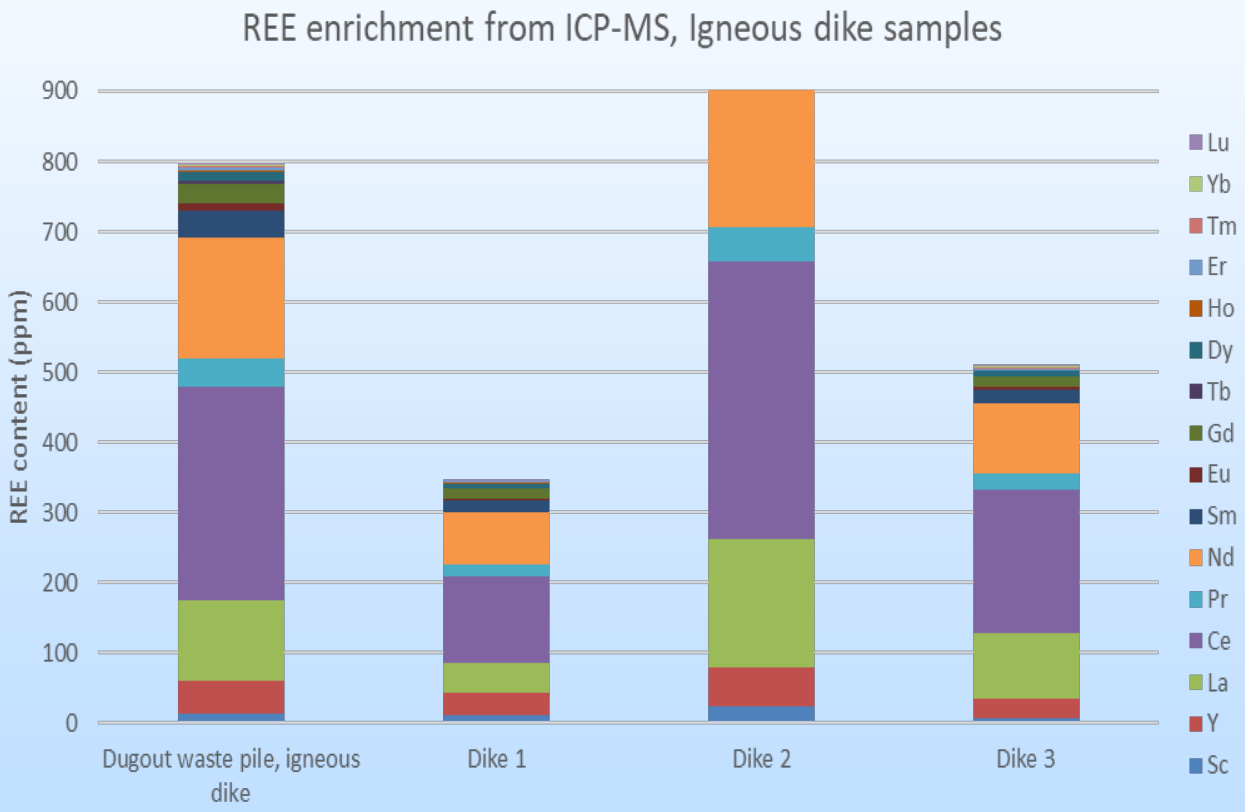




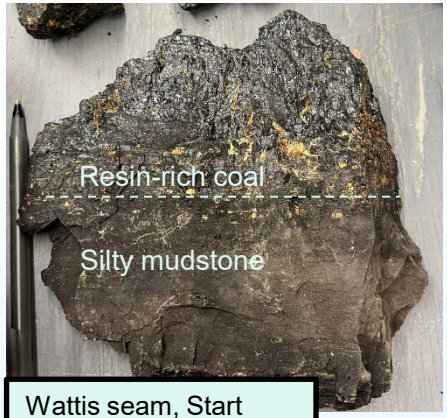
average	**176**	**ppm**
max	458	ppm
min	10	ppm

Igneous dikes in active mines are REE-enriched

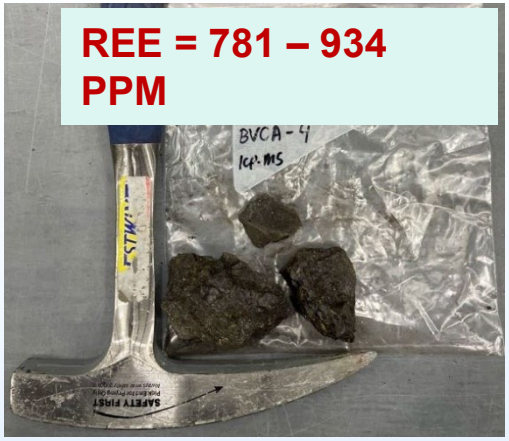
Northern Wasatch Plateau, Utah

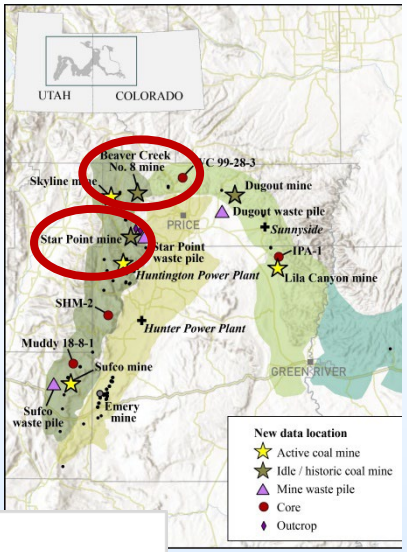


Most coals are not REE-enriched, except for a few

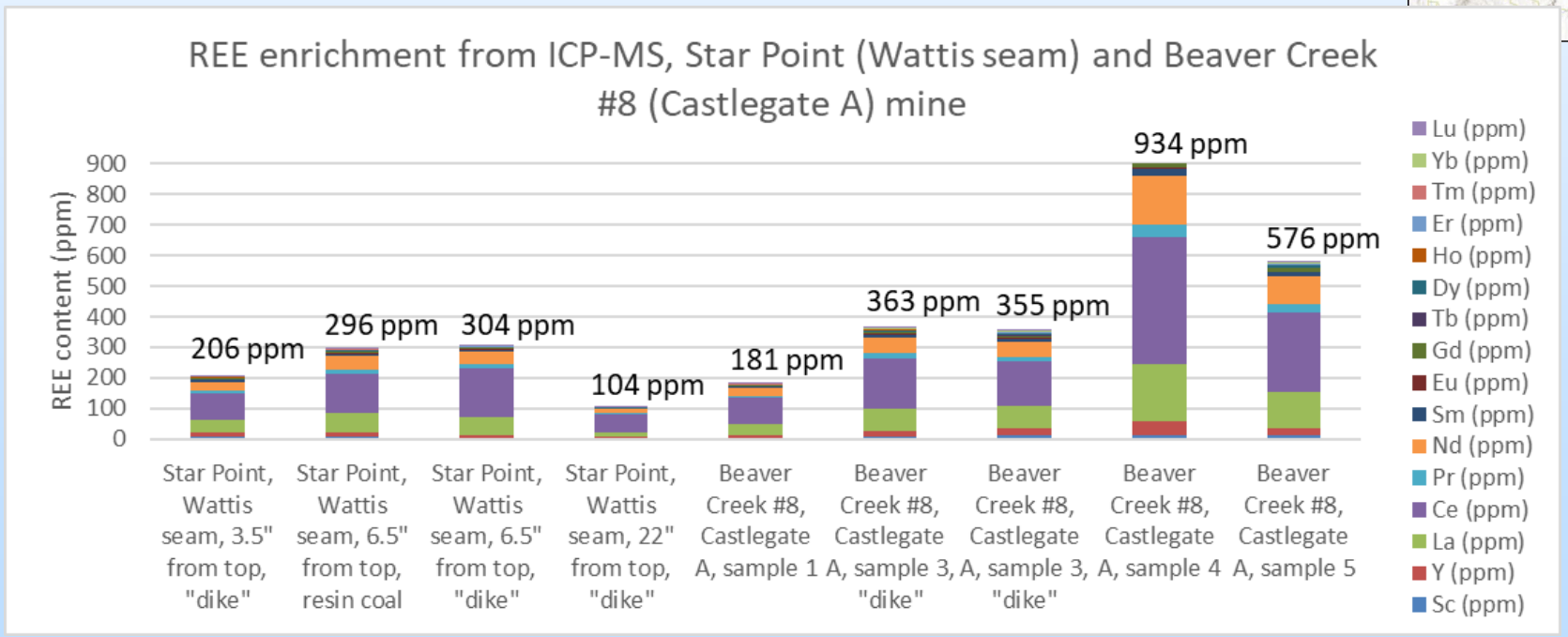


Wattis seam, Start Point mine

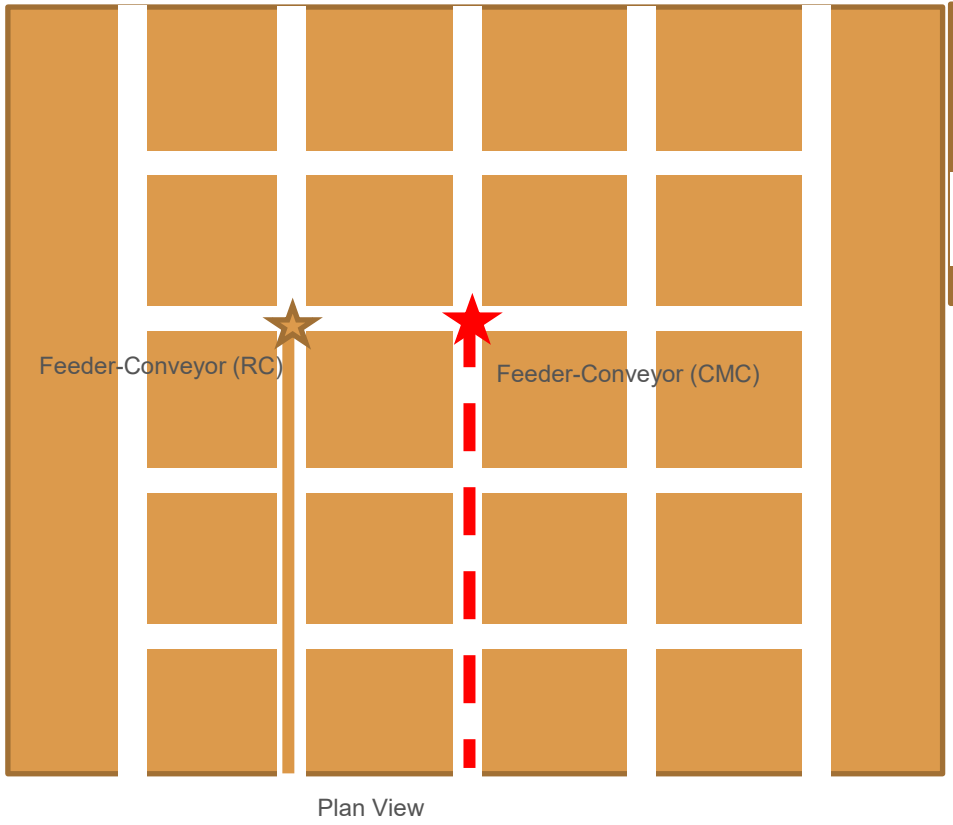


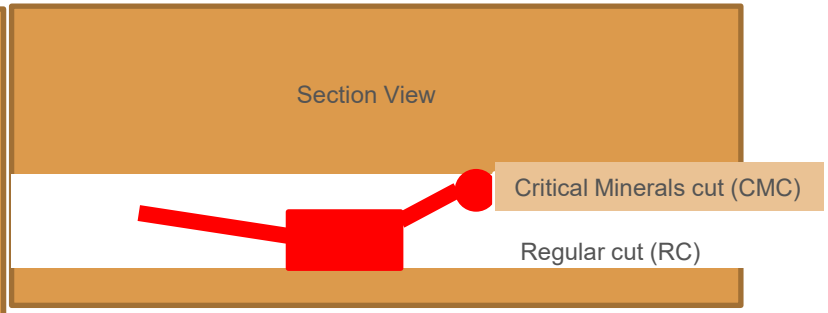


Northern Wasatch Plateau, Utah



Potential Mining Options
Room and Pillar





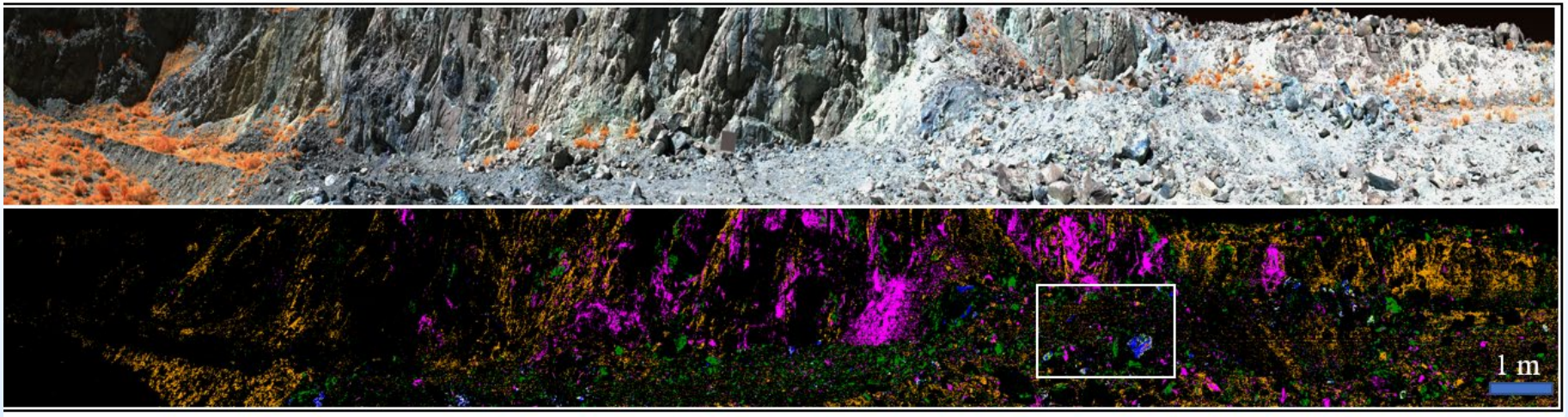
- Continuous (Room and Pillar)
  - can be applied more readily to mineral deposits that are not uniform
  - coal recovery is typically <~50%

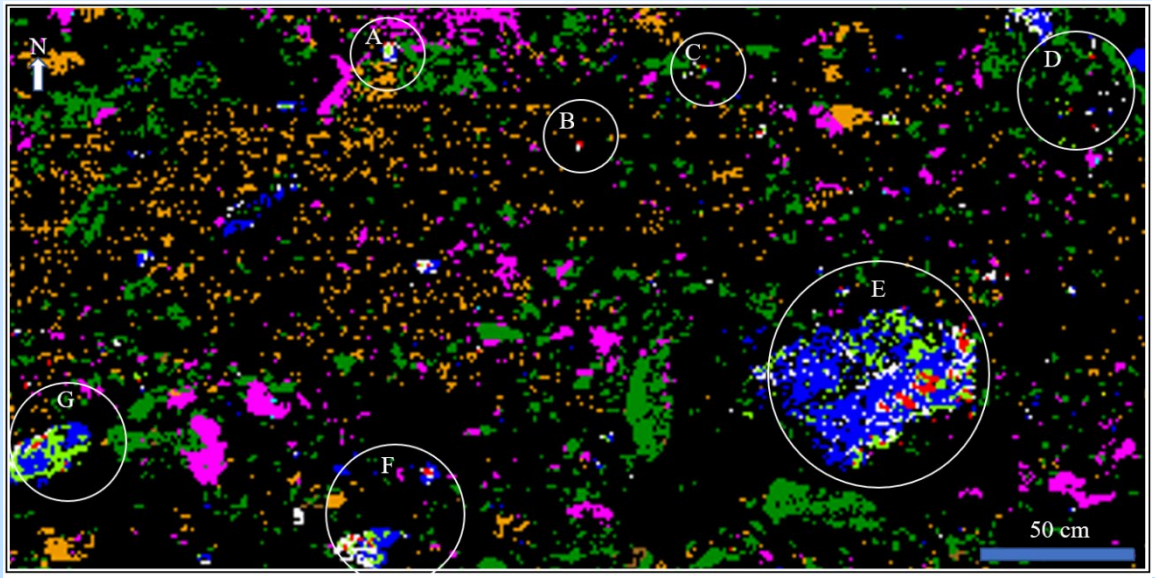
Selective Mining

- Extracting non-fuel minerals will require selectivity
  - Within seam
  - Above/below seams
- Highwall miners are used extract narrow bands of coal from the surface
  - They make small cuts (holes) into the seam

youtube.com and caterpillar.com

Imaging spectroscopy to identify alteration minerals in a tungsten skarn deposit, Gold Hill, Utah

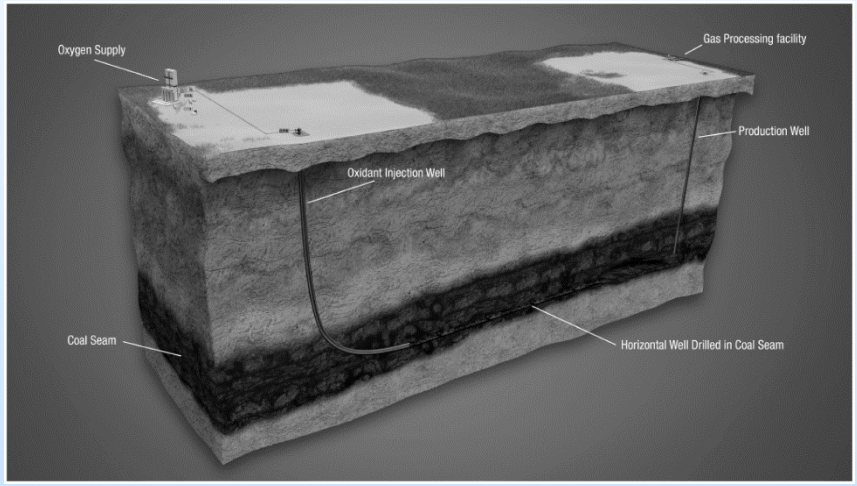




Not classified
Actinolite
Epidote
Chlorite-hornblende
Montmorillonite
Phengitic illite
Nontronite

Vesuvianite
Diopside
Zoisite
Tremolite
Calcite-tourmaline
Andradite garnet

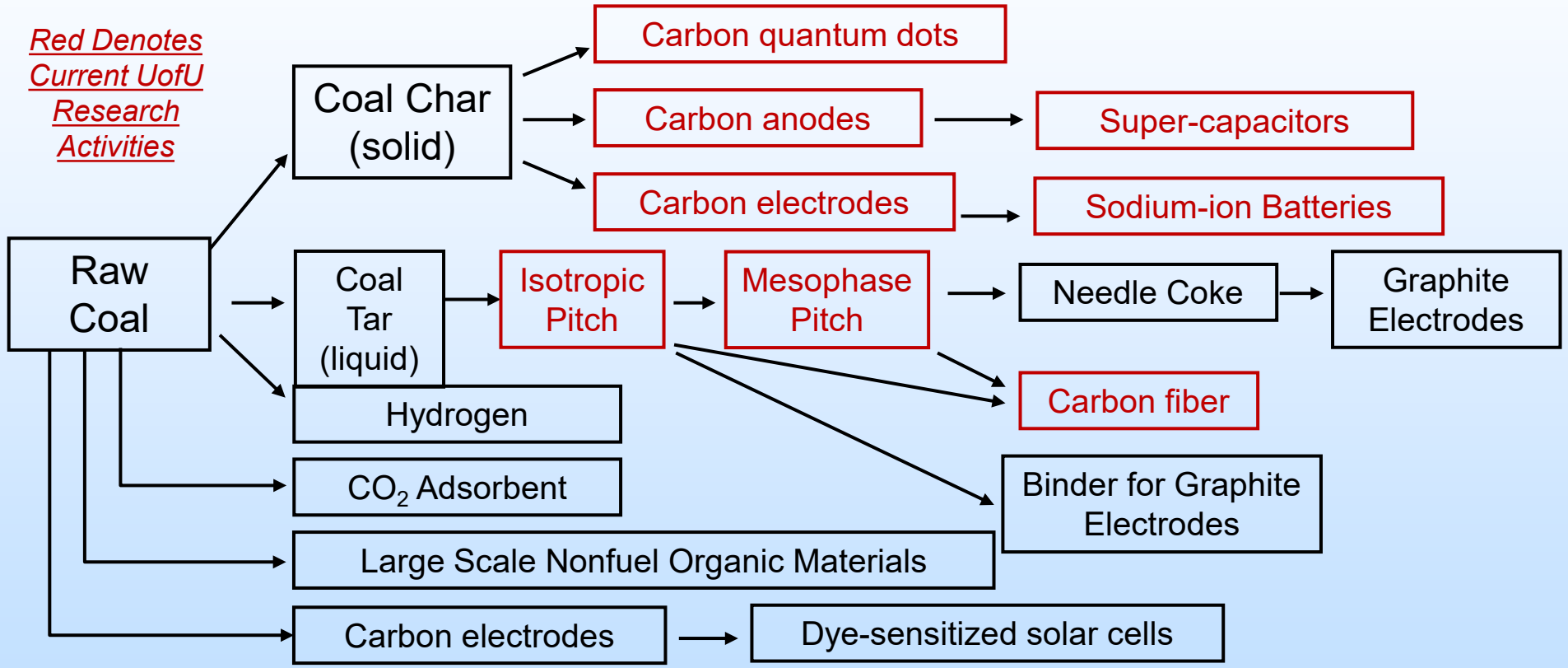
Extraction methods for deep coal seams – Alternative processing for unminable coal – directional drilling



https://onepetro.org/SPEURCE/proceedings/13URCE/All-13URCE/SPE-167025-MS/178351

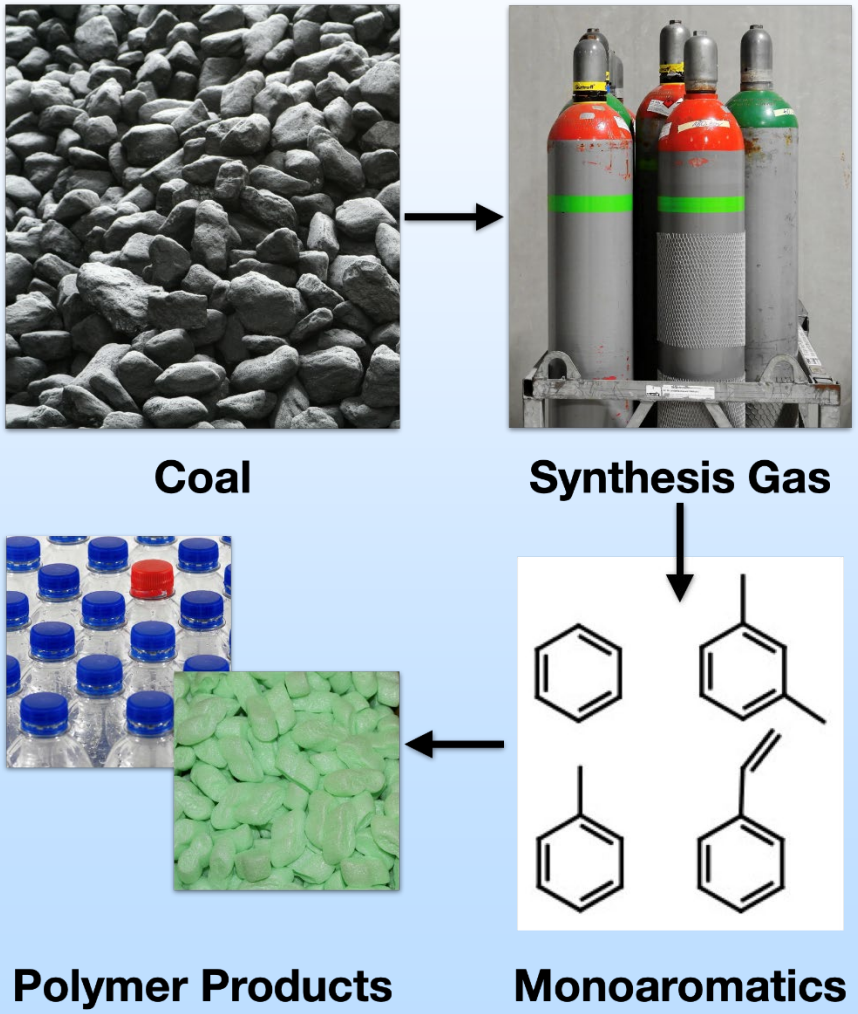
https://www.rockdrillsales.com/fullpanel/uploads/files/hdd%20product%20catalogue_us-format.pdf

Some Carbon Products from Coal



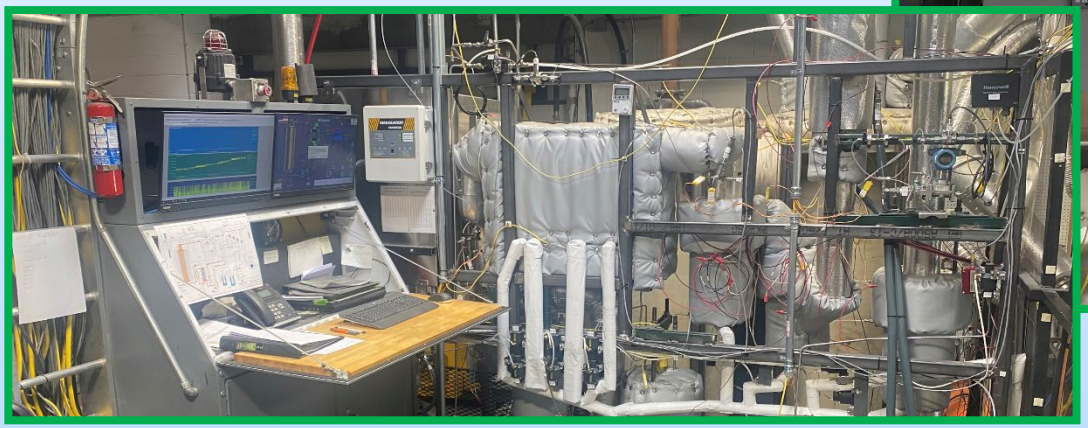
Coal to polymer building blocks

- Coal can be used as a carbon source to produce monoaromatics building blocks for polymer synthesis.
- Investigate the composition of the syngas produced by the Uinta Basin coal.
- Fischer-Tropsch synthesis and aromatization reactions will produce monoaromatics.
- Opportunities for novel catalyst design.



Carbon Ore Low Temperature Pyrolysis Facility

- Instrumented reactors to test batches from 10 to 500 pounds
- Extensive expertise in fuel-based organic chemistry, reactor-based processes, mathematical modeling and simulation, process engineering and design
- World-leading expertise in oil-shale; recently applied to coal



Green Leaf
CARBON TECHNOLOGIES
A Division of Red Leaf Resources

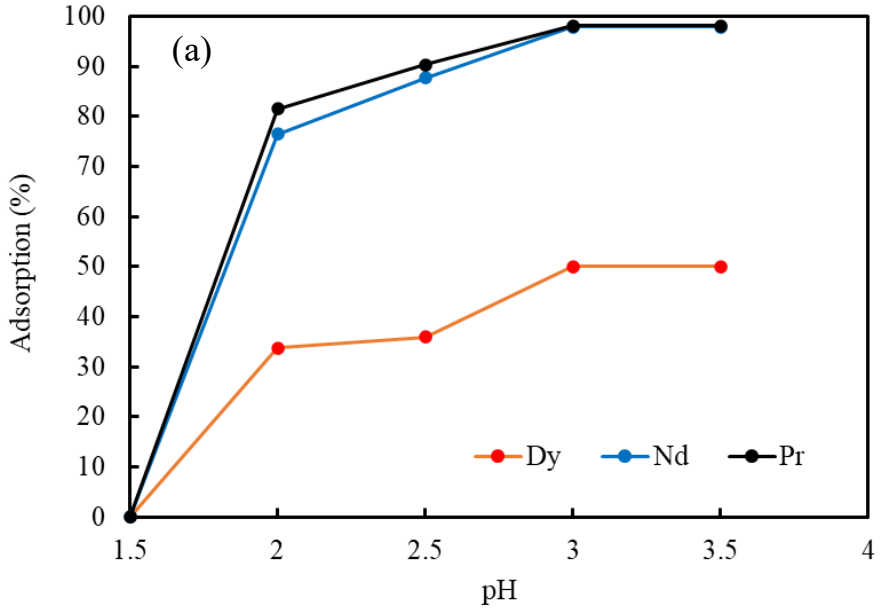
REE/CM extraction

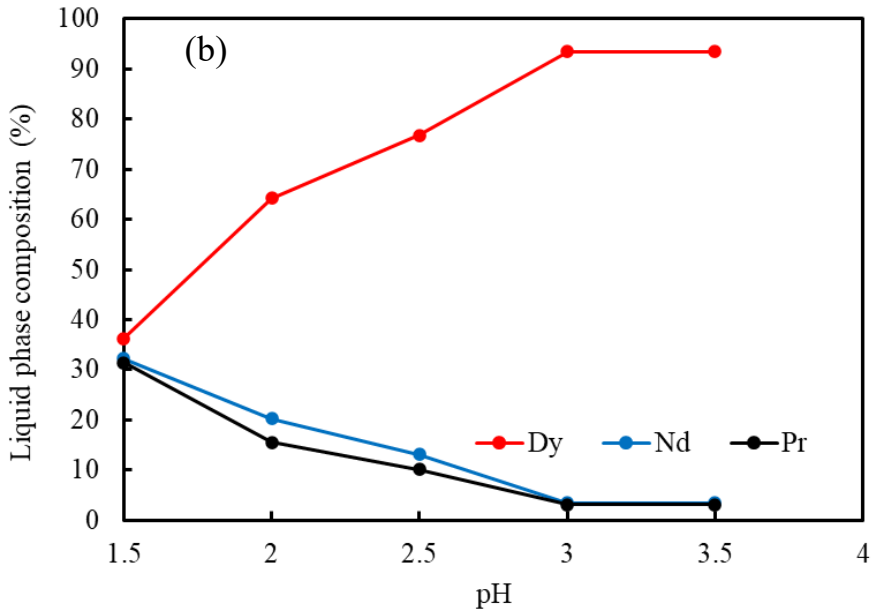
Leaching reactor shown above, and small leaching columns shown on the right.

Ordered Mesoporous Materials for separation

- Ordered mesoporous materials (OMMs) structural and morphological properties, namely high specific surface area, tunable pore size, large pore size, as well as stable and interconnected frameworks with active pore surfaces for functionalization, make them useful for enhanced absorption with an enhanced reactional interface for guest species and functionalization.
- These properties provide both exchange specificity as well controlled conditions can be used for selective loading and stripping of desired species.
- Appropriate sequencing of new technologies with existing technologies has the potential to reduce the number of separation stages that are needed to produce multiple products

At pH 3: 50% dysprosium is separated and enriched into 93.4% composition





Effect of pH on (a) adsorption (%), (b) composition in the liquid phase (%).
At 23°C room temperature and 0.00625 mol/L per REEs salt.

The results show that light REEs (Nd & Pr) can be separated from heavy REEs (Dy) using mesoporous materials

Method

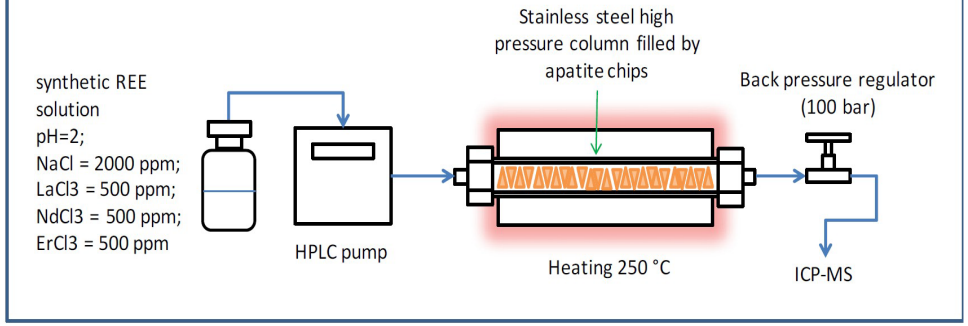
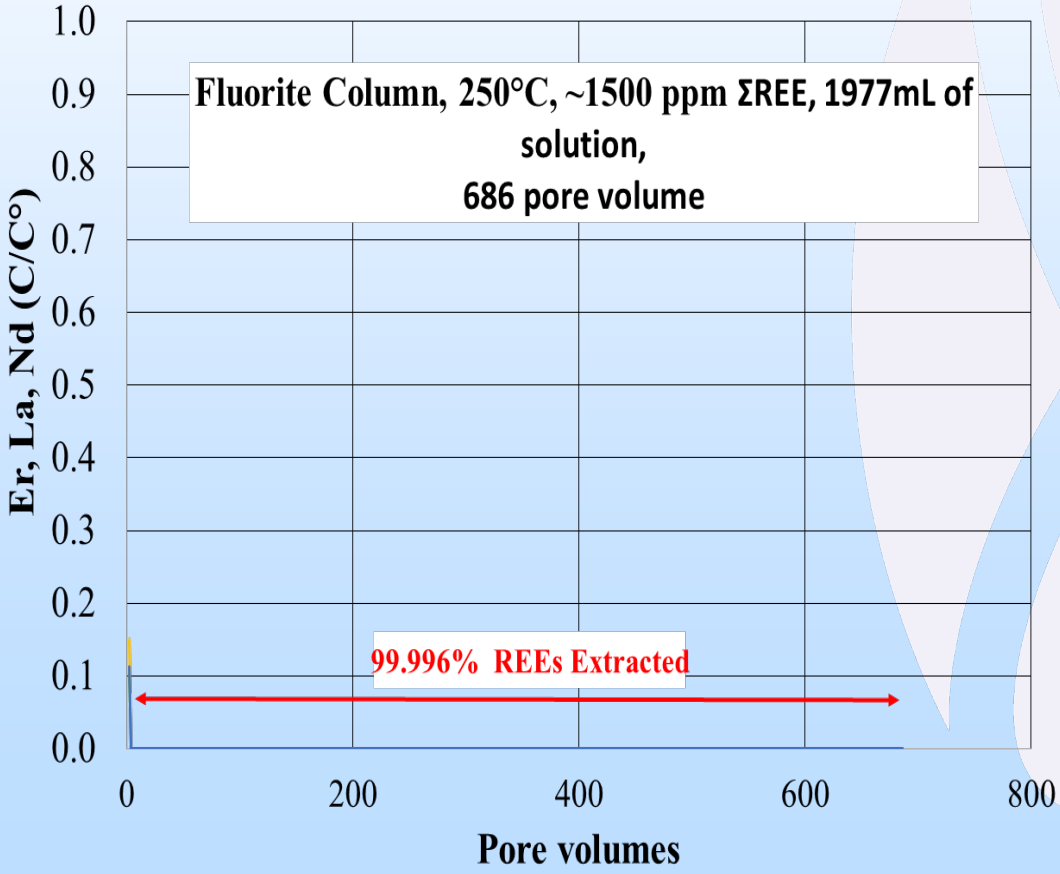
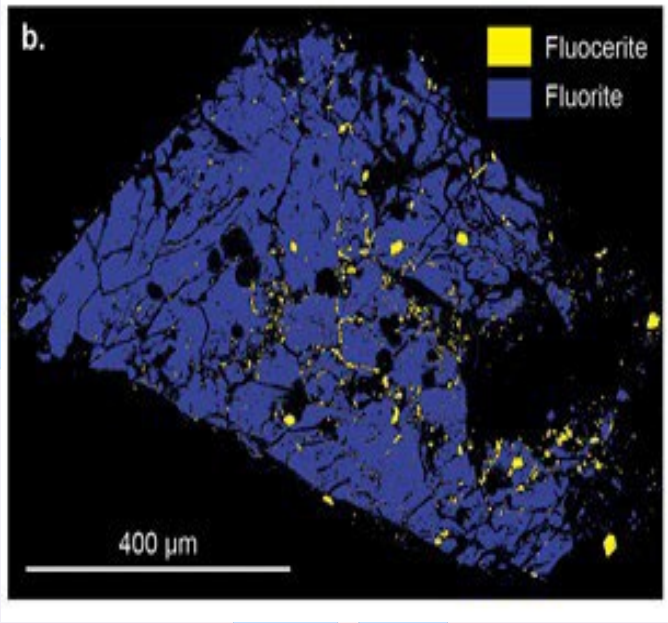


Figure 2. Design of the proof-of-concept experiments mimicking extraction and separation mechanisms illustrated in Figure 1.

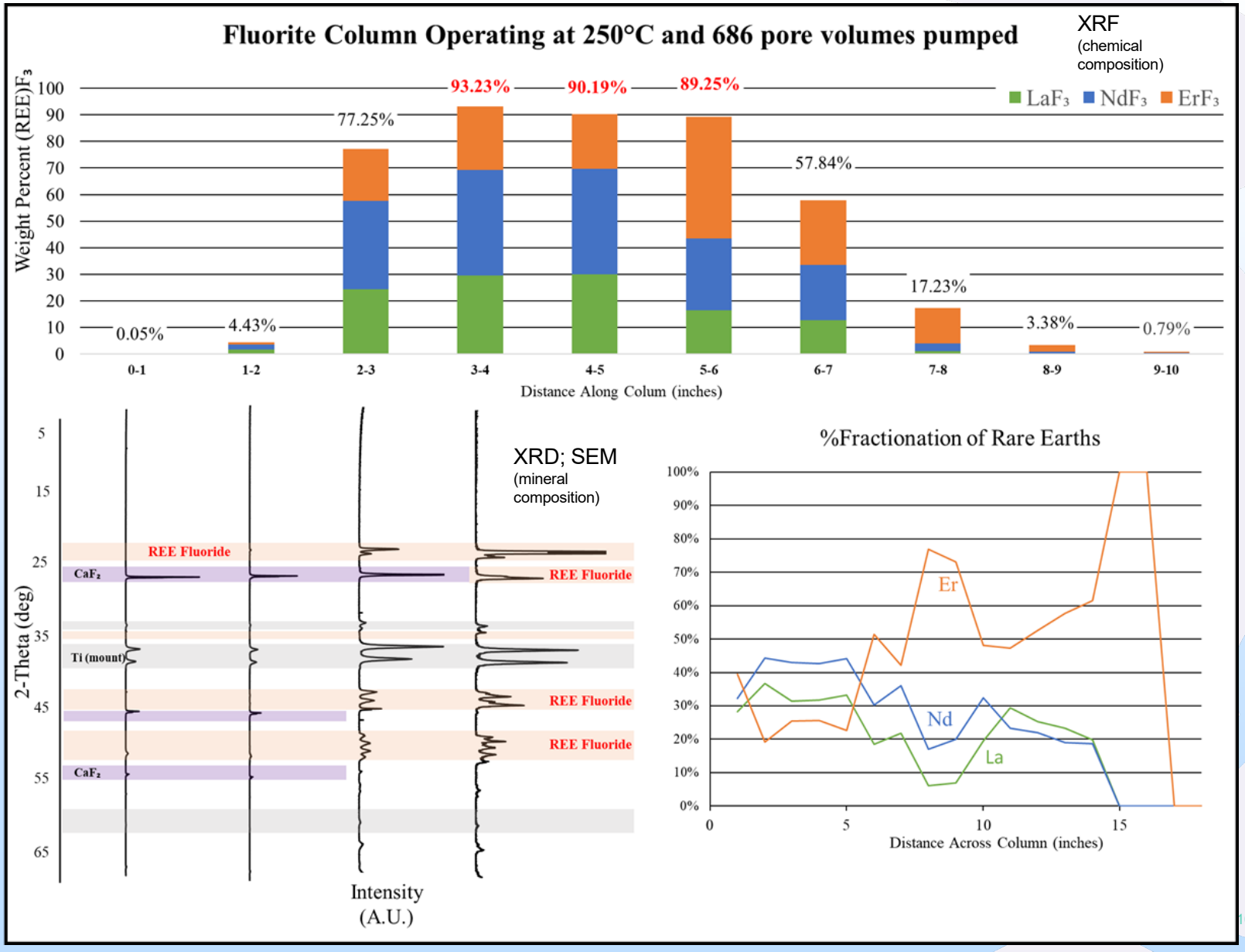
Titanium, stainless steel or monel high

apatite or fluorite



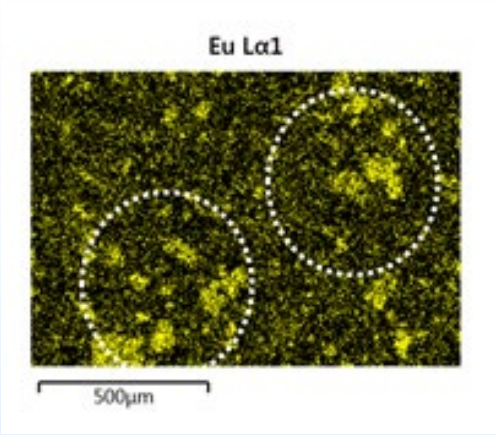


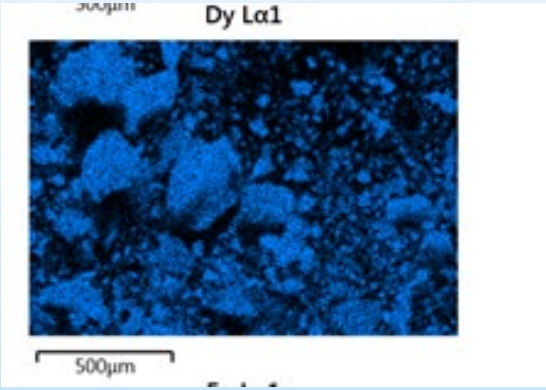
Fluorite (CaF_2) - filled columns

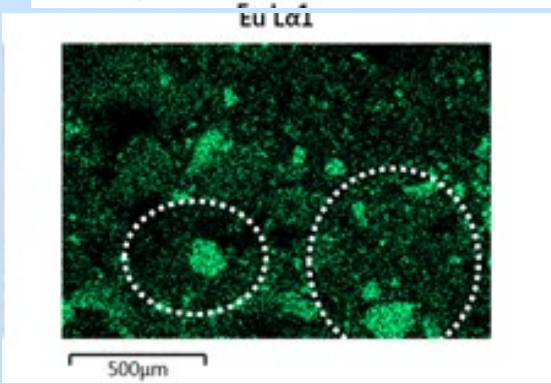


Precipitation

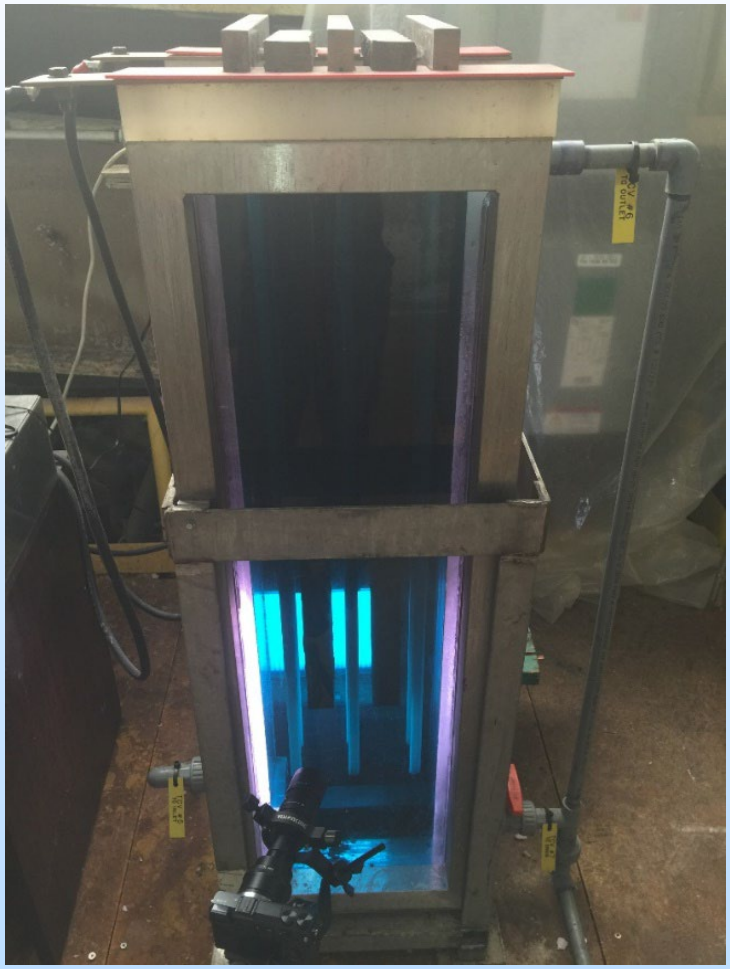
Initial precipitate after removing iron shows enriched rare earth elements.





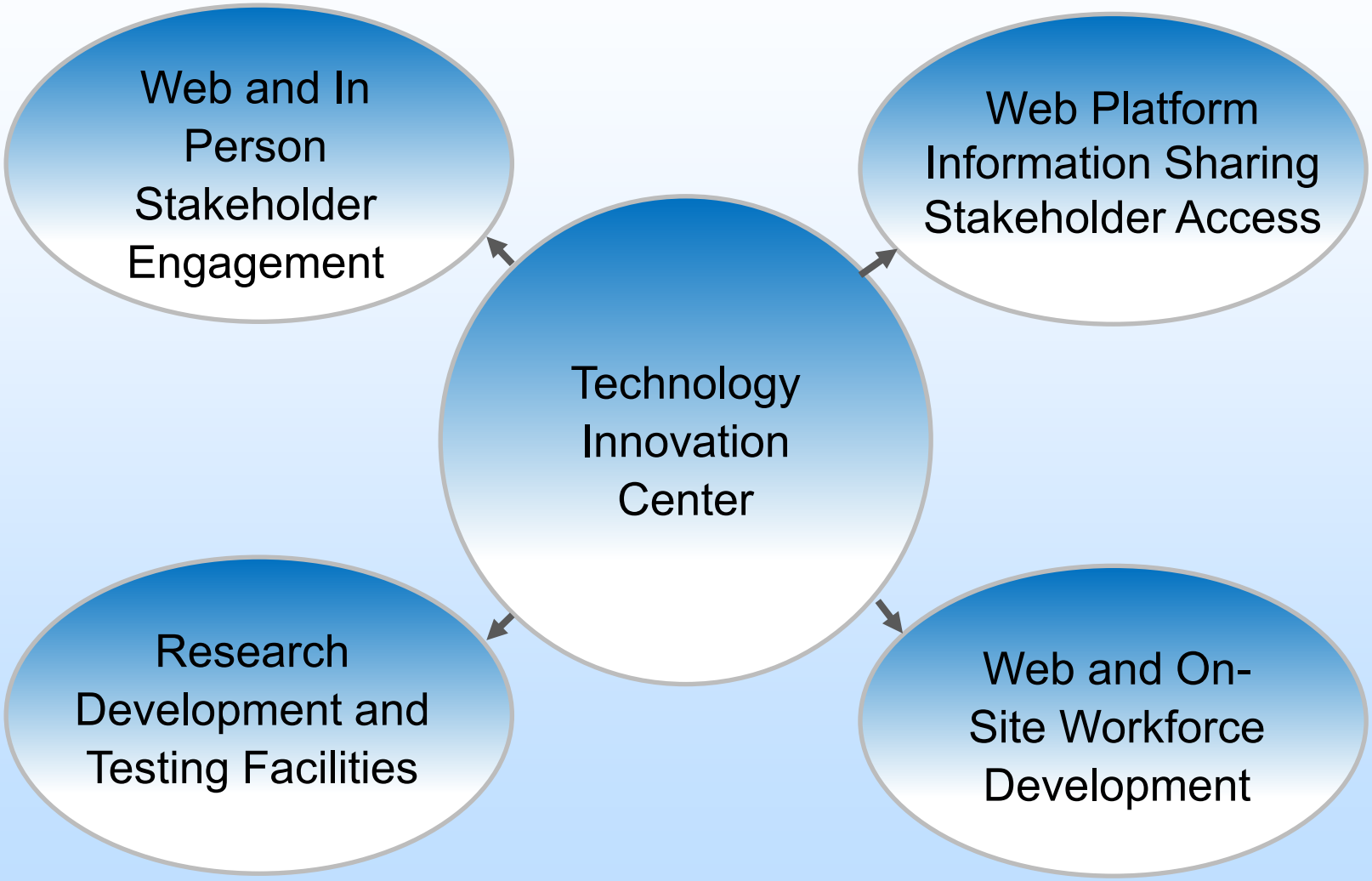


Electrolytic Processing



Through controlled conditions, metals can be recovered and purified through electrolysis.

Our DOE CORE-CM TIC Vision



Outreach, stakeholder engagement, workforce development Utah Advanced Materials and Manufacturing Initiative (UAMMI)

- Stakeholder/Community Outreach
  - Partnerships & operations
  - Local and state governments
  - Indigenous communities
  - Coal community
  - Local industry
  - Webinars, workshops, listening sessions, etc.
- Workforce Development
  - Assessment and profile of workforce in Uinta Basin
  - Identification of skills and qualification for new industries
  - Education, training and other programs to support transition to new jobs

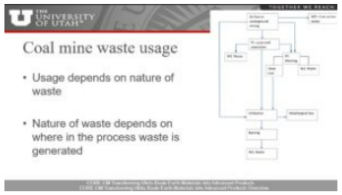
Website
uammi.org/core-cm

Presentations Technology Discussions Workforce Development

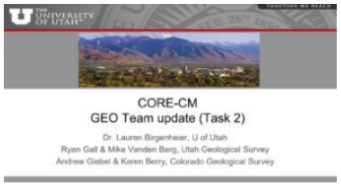
https://www.uammi.org/core-cm/

Dr. Michael Free, University of Utah and Dr. Tulinda Larsen, UAMMI

April 21, 2022



MARCH 2022 UPDATE



CORE-CM GEO TEAM UPDATE (TASK 2)

Dr. Lauren Birgenheier, U of Utah

Ryan Gall & Mike Vanden Berg, Utah Geological Survey

Andrew Giebel & Karen Berry, Colorado Geological Surve

Join the CORE-CM Stakeholders

Utah's CORE-CM

Stakeholder Outreach – Q1 2022 – Q2 2022

Technology Discussions – Coming Soon

Workforce Development – Coming Soon

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UTAH ADVANCED MATERIALS + MANUFACTURING INITIATIVE

Stakeholder Breakdown

	Individuals	Industry	Edu/Academia (Teacher/ Admin/Etc)	Government/ Civic	Service Provider	Association	Indigenous	Uinta Basin Community Members
End Q1	77	14	4	7	1	3	0	0
End Q3	233	19	10	29	9	16	1	31

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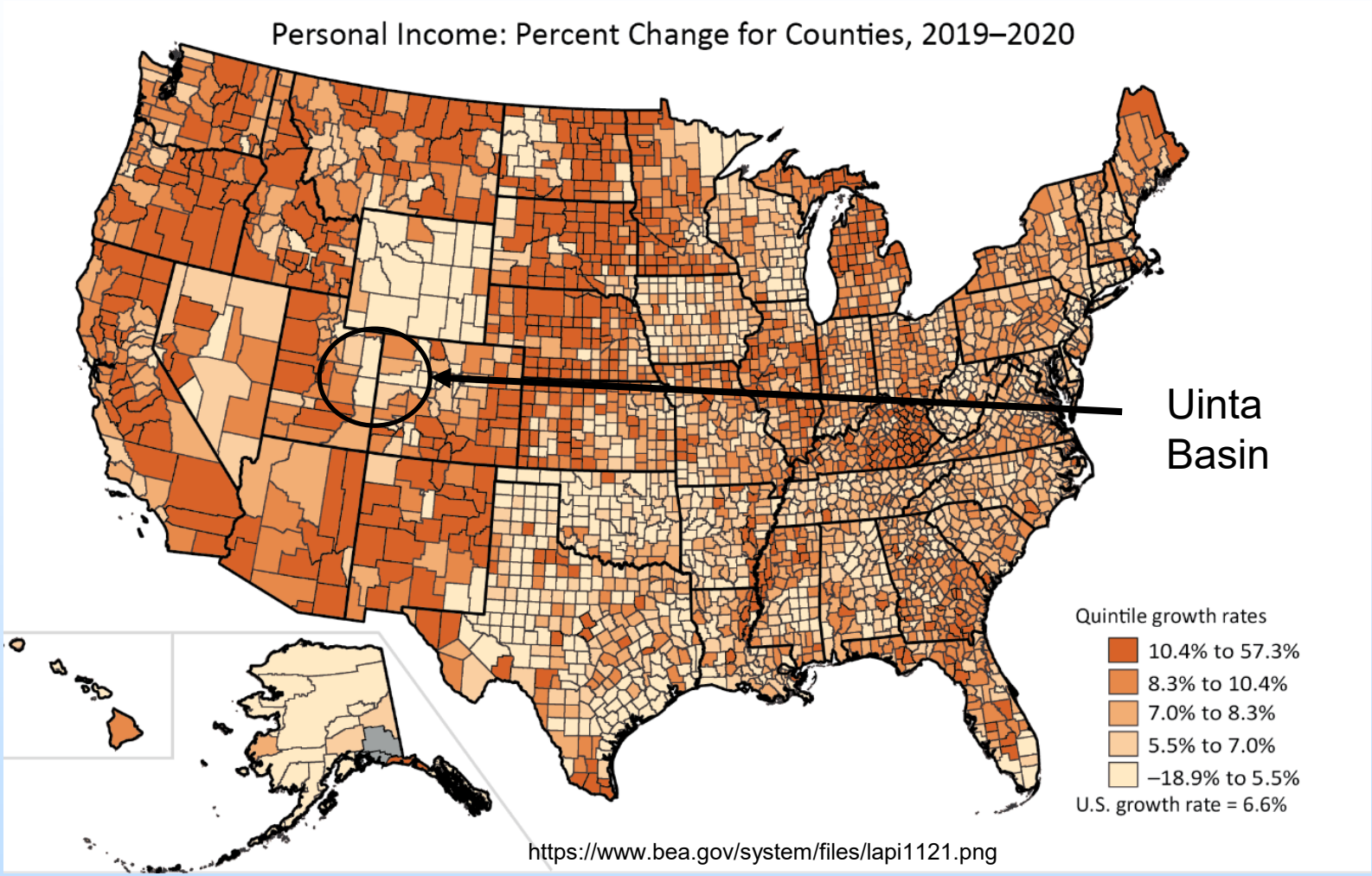
Social/Environmental Justice



https://www.bea.gov/system/files/lapi1121.png

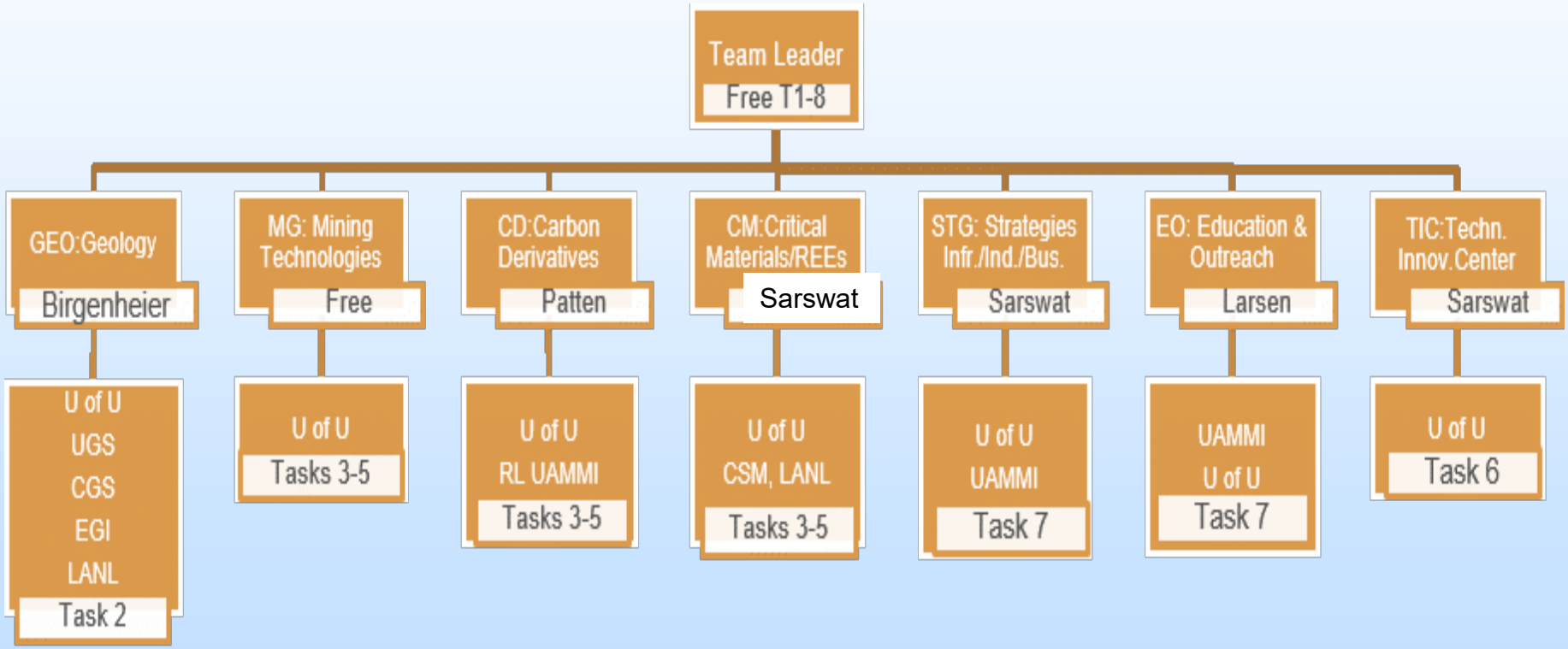
New industries and expanded educational opportunities could help to reverse declining income trends in the region.

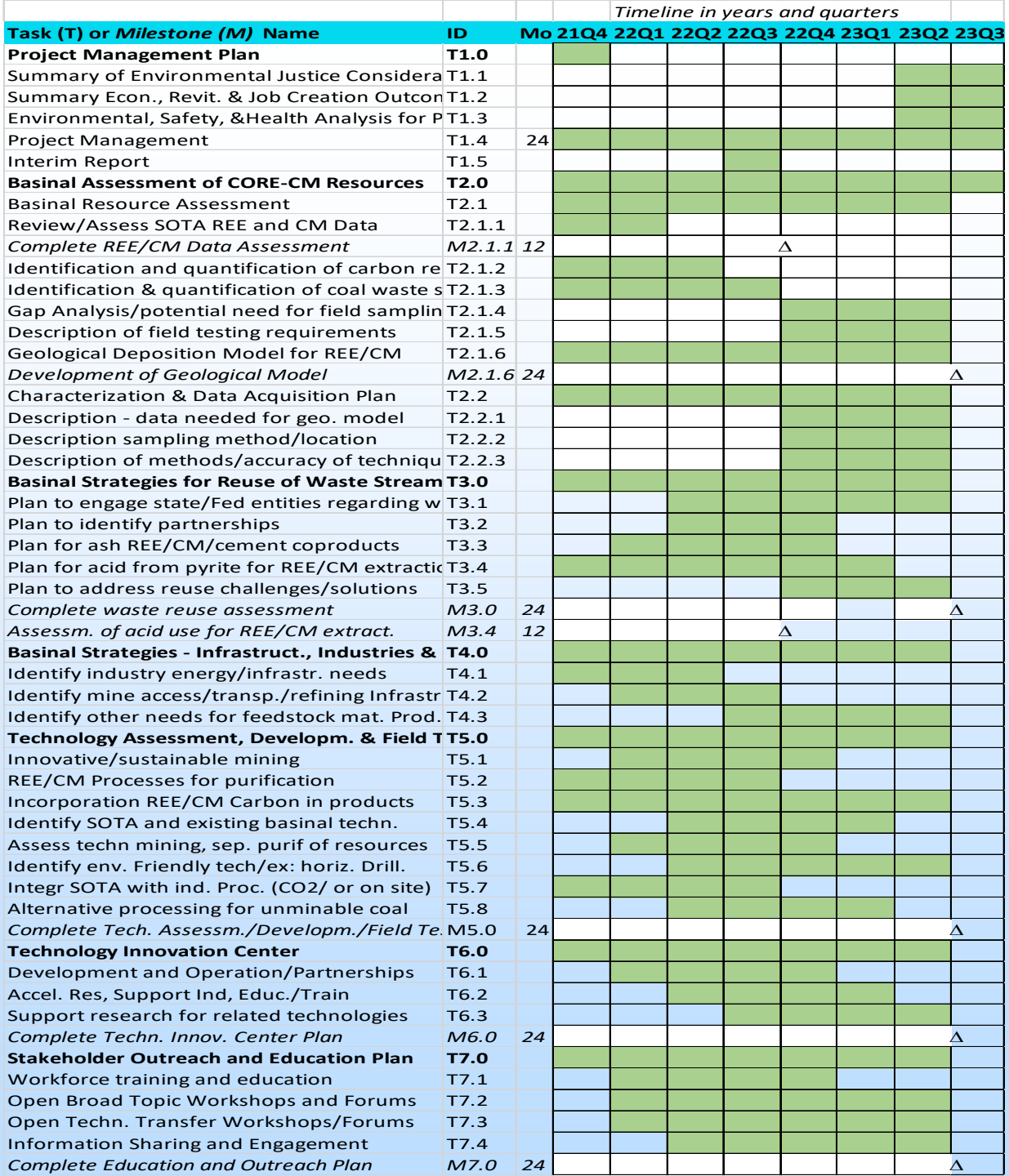
Summary Slide

Uinta Basin REE/CM resources are more abundant than previously known.

Integrated methodologies using existing technologies can be used to: locate, assess, mine, process, recover, and purify Uinta Basin REE/CM/Carbon materials from Uinta Basin into value added products including resin, polymers, carbon fiber, rare earth elements, and critical metals/minerals.

Organization Chart




Timeline in years and quarters
Task (T) or Milestone (M) Name
ID
Mo
21Q4
22Q1
22Q2
22Q3
22Q4
23Q1
23Q2
23Q3
Project Management Plan T1.0
Summary of Environmental Justice Considera T1.1
Summary Econ., Revit. & Job Creation Outcon T1.2
Environmental, Safety, &Health Analysis for P T1.3
Project Management T1.4 24
Interim Report T1.5
Basinal Assessment of CORE-CM Resources T2.0
Basinal Resource Assessment T2.1
Review/Assess SOTA REE and CM Data T2.1.1
Complete REE/CM Data Assessment M2.1.1 12
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Gantt Chart