



BUREAU OF
ECONOMIC
GEOLOGY



TEXAS

The University of Texas at Austin

Critical Mineral Initiatives

UT Energy Week
Austin, Texas
March 1st, 2022

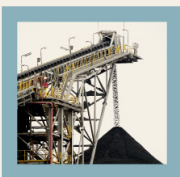
Tristan Childress

tristan.childress@beg.utexas.edu

Bureau of Economic Geology
The University of Texas at Austin



U.S. DEPARTMENT OF
ENERGY



All the Metals We Mined

IN ONE CHART

Iron ore*
3,040,000,000 tonnes



Iron ore made up roughly 94% of the 3.2 billion tonnes of metals mined in 2019.



= 1,000,000 tonnes

Industrial metals
207,478,486 tonnes



Aluminum is the world's second-most used metal after iron, found in everything from electronic devices to aircraft parts.



Copper production is one-third that of aluminum, though it has several uses ranging from wiring to construction.



Manganese is mainly used in iron and steel manufacturing and is a key ingredient in lithium-ion batteries.



Chromium enhances the hardenability and corrosion resistance of stainless steel.



Burj Khalifa, 2722ft->

Iron ore:
3.0B

Total Metals 3,248,814,334 tonnes

Metals are the building blocks of the global economy. From iron ore to rare earths, here are all the metals we mined in 2019.



Metals vs. Ores

Ores are naturally occurring rocks that contain metals or metal compounds.

Metals are the valuable parts of ores that can be extracted and sold.

Tech and precious metals
1,335,848 tonnes



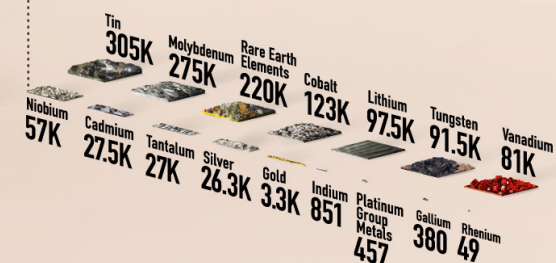
Niobium is a rare metal used in superalloys for jet and rocket engines.



Lithium and cobalt are critical ingredients of lithium-ion batteries for electric vehicles.



Indium is used to make indium tin oxide, an important part of touch screens, TVs, and solar panels.



Growing Global Demand

The Energy Transition



Telsa 100MW station, South Australia (30,000 homes for 1hr)



All the Metals We Mined

IN ONE CHART

Iron ore*
3,040,000,000 tonnes

Iron ore made up roughly 94% of the 3.2 billion tonnes of metals mined in 2019.

1,000,000 tonnes

Industrial metals
207,478,486 tonnes

Aluminum is the world's second-most used metal after iron, found in everything from electronic devices to aircraft parts.

Manganese is mainly used in iron and steel manufacturing and is a key ingredient in lithium-ion batteries.

Tech and precious metals
1,335,848 tonnes

Metals vs. Ores

Ores are naturally occurring rocks that contain metals or metal compounds.

Metals are the valuable parts of ores that can be extracted and sold.

Total Metals 3,248,814,334 tonnes



All the Metals We Mined

IN ONE CHART

Iron ore*
3,040,000,000 tonnes

Iron ore made up roughly 94% of the 3.2 billion tonnes of metals mined in 2019.

1,000,000 tonnes

Industrial metals
207,478,486 tonnes

Aluminum is the world's second-most used metal after iron, found in everything from electronic devices to aircraft parts.

Manganese is mainly used in iron and steel manufacturing and is a key ingredient in lithium-ion batteries.

Metals vs. Ores

Ores are naturally occurring rocks that contain metals or metal compounds.

Metals are the valuable parts of ores that can be extracted and sold.

Total Metals 3,248,814,334 tonnes

Our bottom-up assessment suggests that a concerted effort to reach the goals of the Paris Agreement (climate stabilisation at “well below 2°C global temperature rise”, as in the IEA Sustainable Development Scenario [SDS]) would mean a quadrupling of mineral requirements for clean energy technologies by 2040. An even faster transition, to hit net-zero globally by 2050, would require six times more mineral inputs in 2040 than today.



All the Metals We Mined

IN ONE CHART

Iron ore*
3,040,000,000 tonnes

Iron ore made up roughly 94% of the 3.2 billion tonnes of metals mined in 2019.

1,000,000 tonnes

Industrial metals
207,478,486 tonnes

Aluminum is the world's second-most used metal after iron, found in everything from electronic devices to aircraft parts.

Manganese is mainly used in iron and steel manufacturing and is a key ingredient in lithium-ion batteries.

Tech and precious metals
1,335,848 tonnes

Metals vs. Ores

Ores are naturally occurring rocks that contain metals or metal compounds.

Metals are the valuable parts of ores that can be extracted and sold.

Total Metals 3,248,814,334 tonnes



All the Metals We Mined

IN ONE CHART

Iron ore*
3,040,000,000 tonnes

Iron ore made up roughly 94% of the 3.2 billion tonnes of metals mined in 2019.

1,000,000 tonnes

Industrial metals
207,478,486 tonnes

Aluminum is the world's second-most used metal after iron, found in everything from electronic devices to aircraft parts.

Manganese is mainly used in iron and steel manufacturing and is a key ingredient in lithium-ion batteries.

Metals vs. Ores

Ores are naturally occurring rocks that contain metals or metal compounds.

Metals are the valuable parts of ores that can be extracted and sold.

Total Metals 3,248,814,334 tonnes



ELEMENTS

The Earth's natural resources power our everyday lives. VC Elements breaks down the building blocks of the universe.

Source: British Geological Survey (2019), USGS Mineral Commodity Summaries (2021)

*Ore production does not reflect actual metal production as metals only make up a certain portion of ores. Graphic excludes semi-metals and metalloids. Magnesium is contained in zinc.

We live in a material world.



ELEMENTS

The Earth's natural resources power our everyday lives. VC Elements breaks down the building blocks of the universe.

Source: British Geological Survey (2019), USGS Mineral Commodity Summaries (2021)

*Ore production does not reflect actual metal production as metals only make up a certain portion of ores. Graphic excludes semi-metals and metalloids. Magnesium is contained in zinc.

We live in a material world.

GEOLOGY

International Initiative



USGS
science for a changing world



Australian Government
Geoscience Australia



Canada
Geological Survey of Canada
Natural Resources Canada

Data Types in Each Discipline

Topography—3D elevation lidar data

Geology—USGS and State geological survey maps

Geophysics—Aeromagnetic, radiometric, and gravity data

Geochemistry—Rocks, soils, and stream sediments

Mineral deposit databases—USMIN, MRDS, ARDF

Coreholes—Geophysical logs and core samples

**EARTH
MRI
DATA
INTEGRATION**

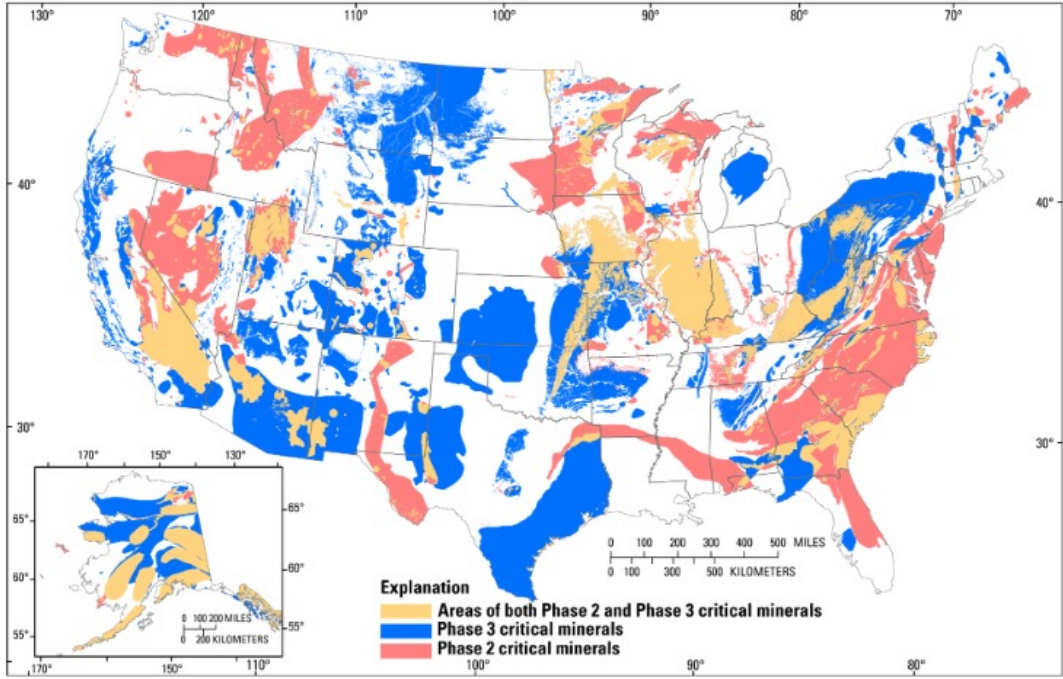
Applications

Mineral deposits

Groundwater resources

Energy

Natural hazards



Explanation

- Areas of both Phase 2 and Phase 3 critical minerals
- Phase 3 critical minerals
- Phase 2 critical minerals

Earth MRI Project Phase Critical Minerals

<u>Phase 2</u>	<u>Phase 3</u>
Aluminum	Antimony
Cobalt	Barite
Graphite (natural)	Beryllium
Lithium	Chromium
Niobium	Fluorspar
Platinum group elements	Hafnium
Rare earth element group	Helium
Tantalum	Magnesium
Tin	Manganese
Titanium	Potash
Tungsten	Uranium
	Vanadium
	Zirconium

Sources:
Dicken and others, 2021, USGS data release, <https://doi.org/10.5066/P9WA7JZY>
Dicken and Hammarstrom, 2020, USGS data release, <https://doi.org/10.5066/P95CO8LR>

Law 11-15-2021

Added 10's of millions of \$ for critical mineral and supply chain research and development

Distributed through DoD, DoE, USGS, National Labs...

40201 EARTH MAPPING RESOURCES INITIATIVE	40204 USGS ENERGY AND MINERALS RESEARCH FACILITY	40207 BATTERY PROCESSING AND MANUFACTURING	40210 CRITICAL MINERALS MINING AND RECYCLING RESEARCH
40202 NATIONAL COOPERATIVE GEOLOGIC MAPPING PROGRAM	40205 RARE EARTH ELEMENTS DEMONSTRATION FACILITY	40208 ELECTRIC DRIVE VEHICLE BATTERY RECYCLING AND SECOND-LIFE APPLICATIONS	
40203 NATIONAL GEOLOGICAL AND GEOPHYSICAL DATA PRESERVATION PROGRAM	40206 CRITICAL MINERALS SUPPLY CHAINS AND RELIABILITY	40209 ADVANCED ENERGY MANUFACTURING AND RECYCLING GRANT PROGRAM	40211 21ST CENTURY ENERGY WORKFORCE ADVISORY BOARD

Mining – a gradual process

USA Development

AUTOS MARCH 1, 2021 / 11:49 AM / UPDATED 8 MONTHS AGO

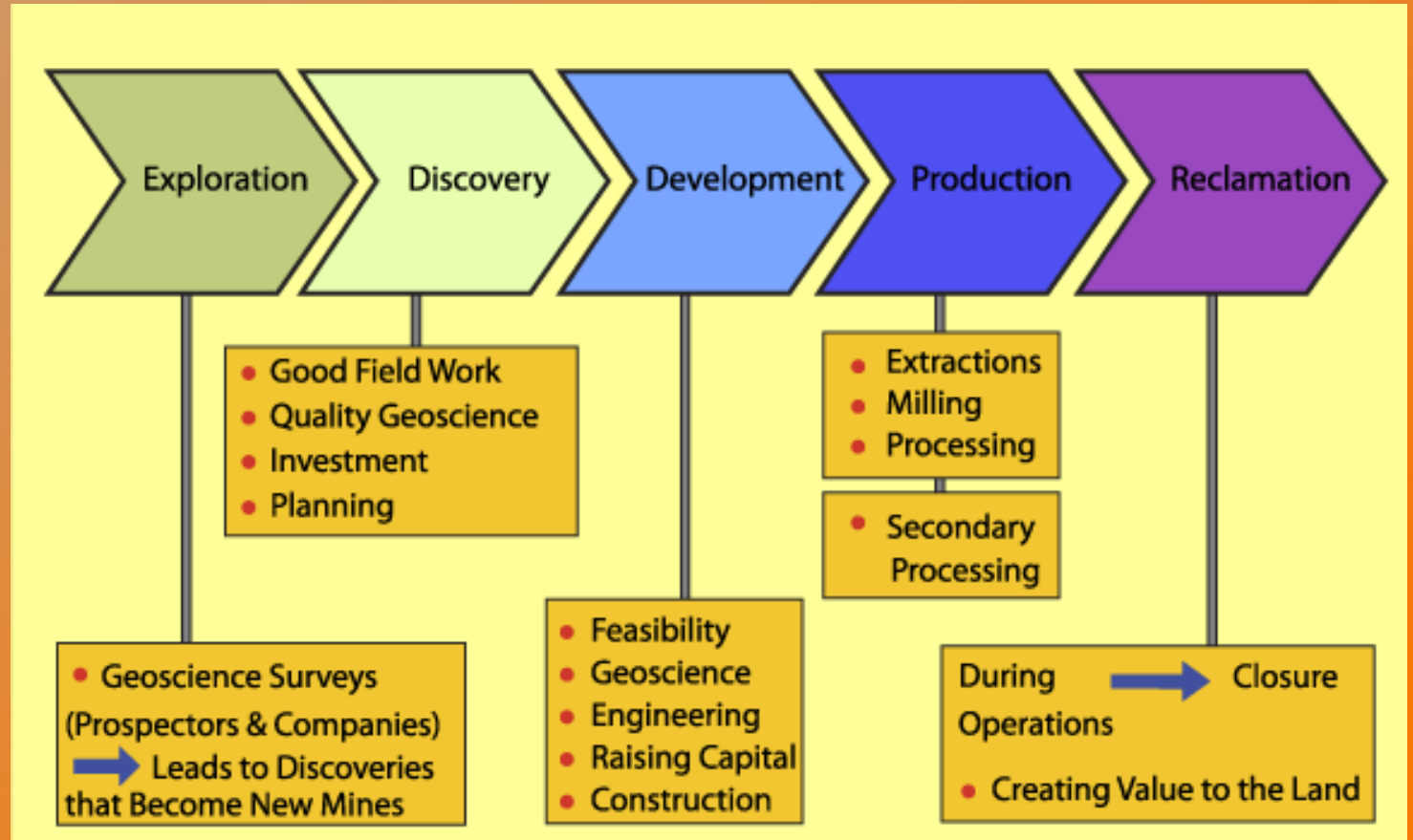
To go electric, America needs more mines.
Can it build them?

By Ernest Scheyder

8 MIN READ

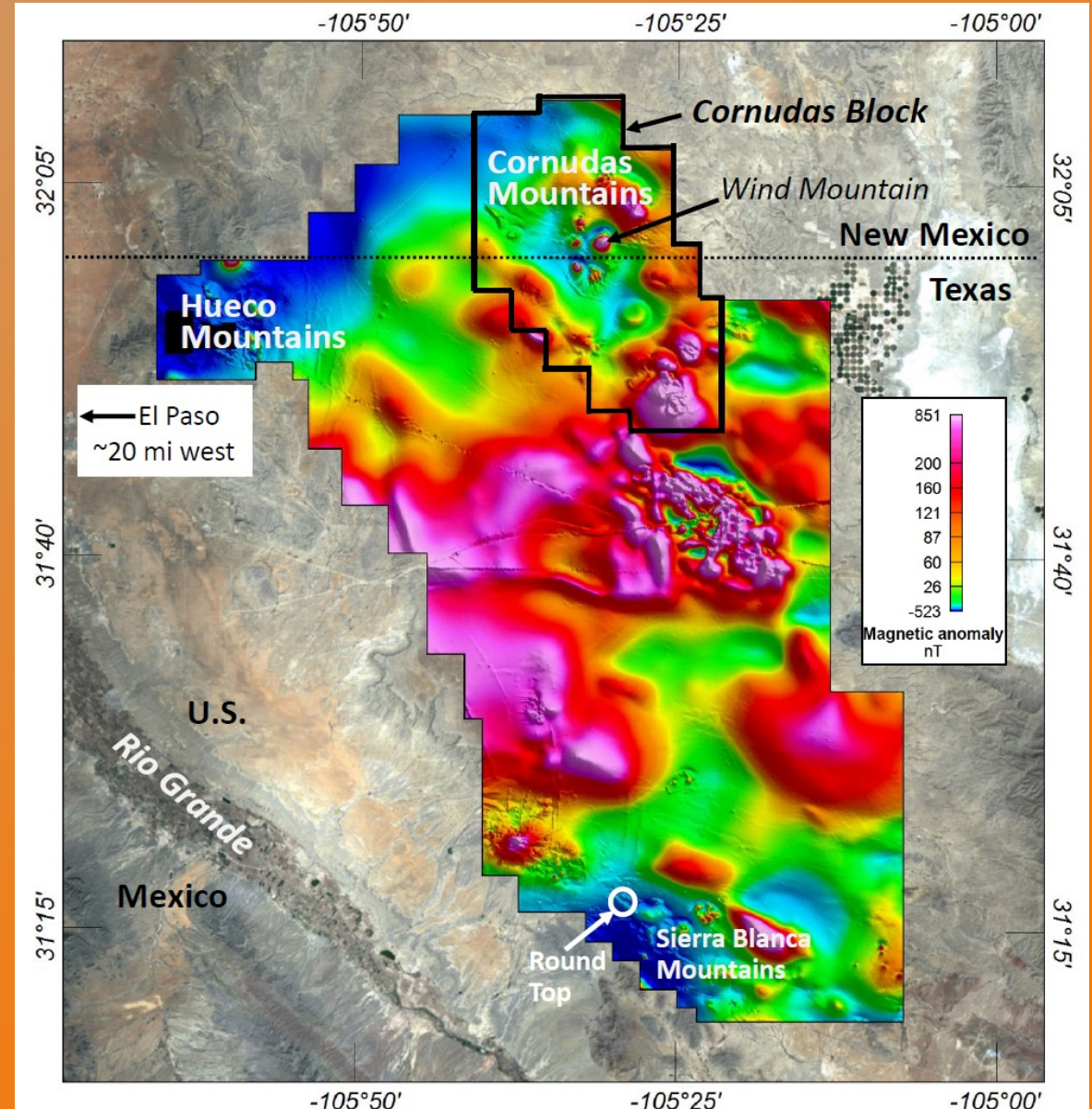
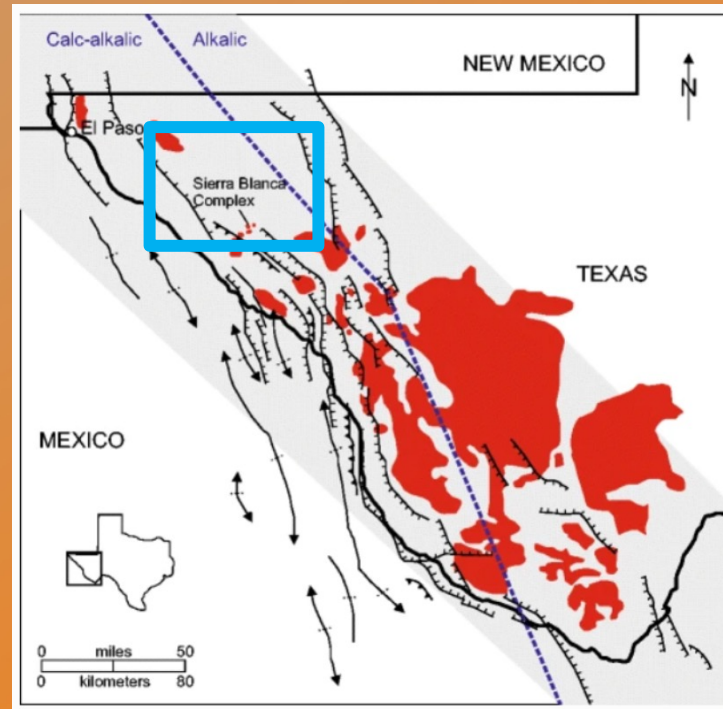


- **~10 years from idea to breaking ground**
- Investment in basic geological and geophysical datasets can lead to **6x investment** from private sector to improve public datasets (ACIL Allen Consulting, 2015), demonstrated by Canada and Australia



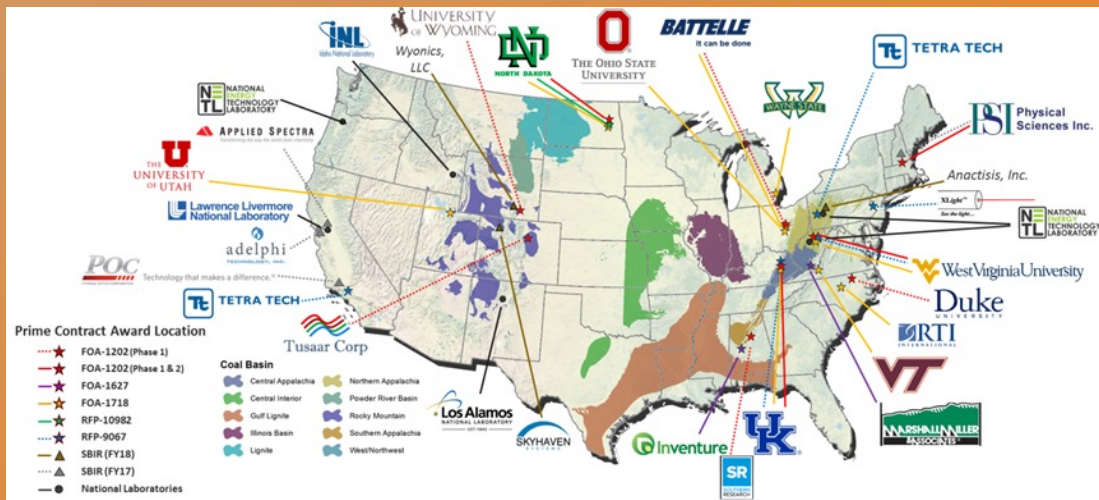
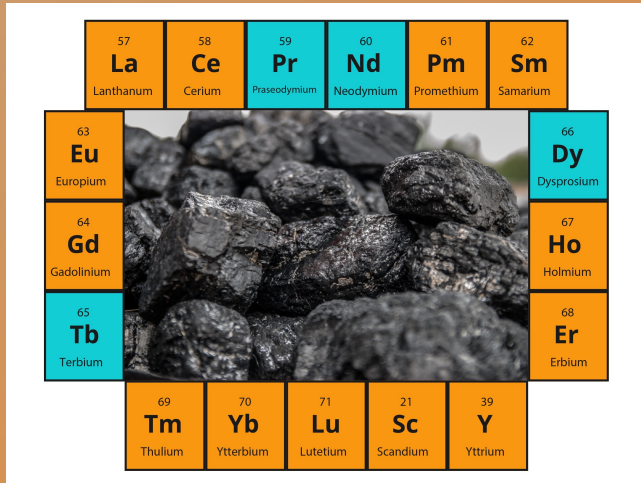
West Texas – USGS Aerial Surveys

- Large magmatic province extending from NM, through West TX, into Mexico
- Newer proven resources of REE
 - Round Top, Sierra Blanca, TX
 - 303k tonnes rare earth oxides



Texas Coal – REE and CM Potential

DOE Carbon Ore, Rare Earth and Critical Minerals (CORE-CM) Initiative for U.S. Basins



Industrial Waste – REE and CM Potential

Wastes from mining, refining, and manufacturing are being assessed for their critical mineral potentials across US.

Other "unconventional" sources of metals include heavy sands, lithium brines, black shales, and even seawater.

Red mud, an alumina refining by-product, constitutes millions of tons of waste house along the Texas coast, and is a potential new resource of REEs, Al, and other metals.



Holistic Life Cycle Analysis



CE
COMPARING
ELECTRICITY
OPTIONS

Research Plan

Electricity Options Being Compared



1) Combined Cycle Gas Turbine (CCGT)



2) Wind Generation
3) Wind + Battery



4) Solar Generation
5) Solar + Battery

Base Case Functional Unit:
500 MW capacity CCGT, generating 3 TWh/yr of electricity

<https://www.beg.utexas.edu/minerals>

<https://www.beg.utexas.edu/ceo>

<https://www.beg.utexas.edu/carbon-ore-rare-earth-and-critical-minerals>