CORE-CM Project - Rare Earth Elements and Critical Minerals in the San Juan and Raton Basins, northern New Mexico

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Dr. Navid Mojtabai and Dr. William Chavez

Core – CM Project Team Members

Bureau of Geology Staff

Dr. Virginia McLemore's Economic Geology Team

My Family

Presentation Outline

- Introduction
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- Purpose of Study
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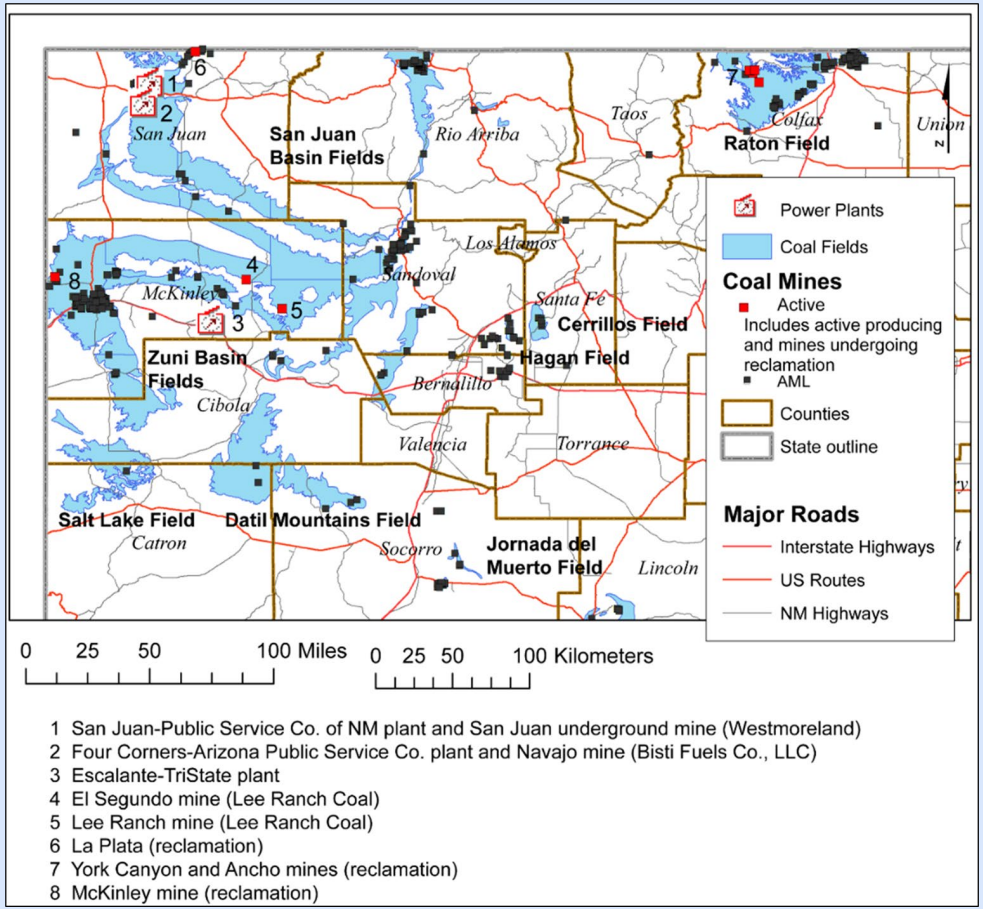
- Procedures
  - Sampling Work
  - Drill core Logging
  - Compiling Existing/Historical Data
- Legacy Data
  - Beach Placer Sandstone
  - Coal
- Economic Resource Calculation
- Future Plans
- Preliminary Conclusions
- Questions/Comments

Introduction

CORE - CM Project

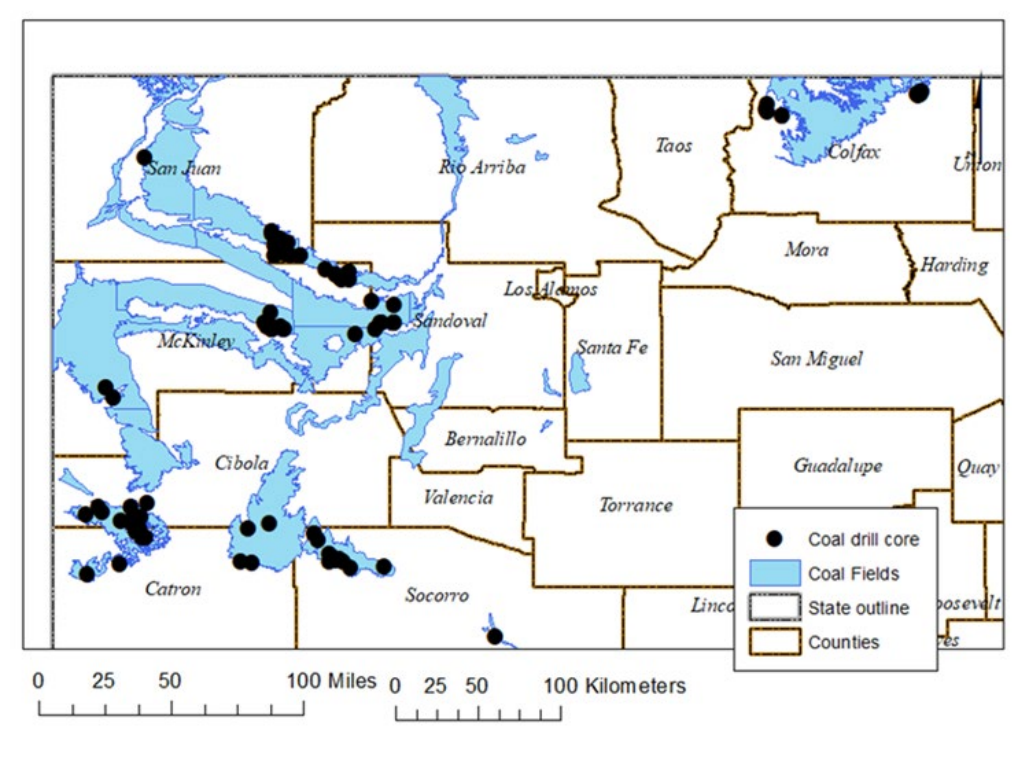
- Carbon Ore, Rare Earth Elements (REE), and Critical Minerals (CM).
- DOE awarded New Mexico Tech contract
    - Examine REE and CM in the San Juan and Raton coal basins
- Structural coal basins contain elevated concentrations of REE and CM



CORE-CM Project Area, San Juan and Raton coal fields

Main Objective

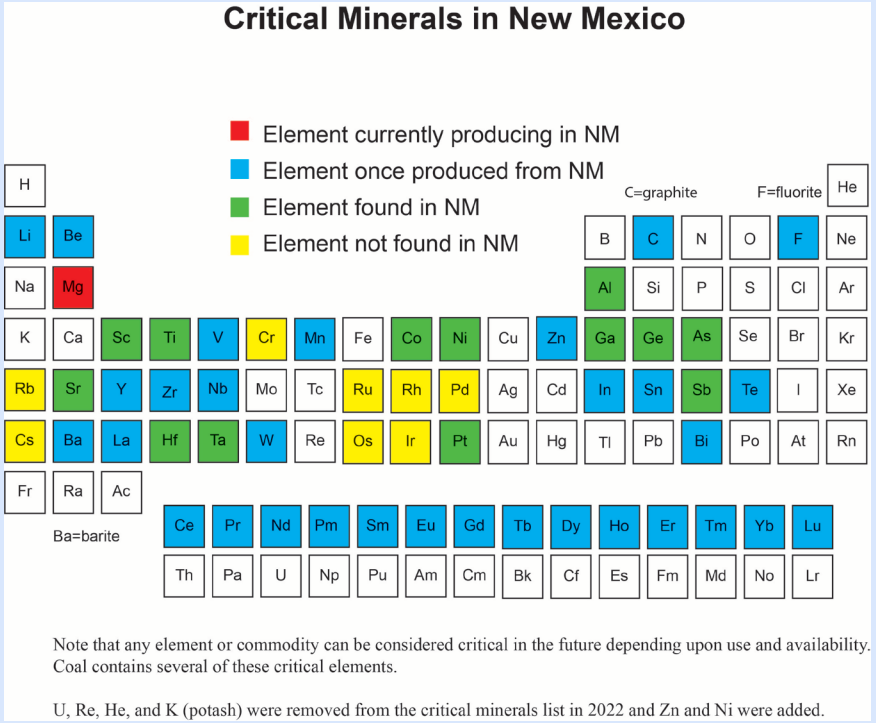
- Basinal assessment of CORE-CM resources in the San Juan and Ration coal basins
    - Identify/quantify distribution of REE and CM
        - Coal beds
        - Related stratigraphic units
    - Identify/quantify sources of REE and CM



Map of coal fields and drill-core locations in northern, New Mexico

Purpose of Study

- REE and CM are non-renewable resources
  - Essential to US economic and national security
- Supply potentially susceptible to disruption - Covid
- Highly Important to U.S. green/clean energy development
  - Continued advancement of green technology
- Identifying and producing REE and CM in New Mexico may directly benefit the economy



2022 Elemental Table of Critical Minerals significant to New Mexico

Coal In New Mexico

- 12th in Coal Production in U.S. 2020
  - 10,249,000 short tons
- 15th in estimated recoverable coal reserves in U.S.
  - 65 million short ton reserve at mines
- Used in electrical generating plants
  - 1 in NM and a few in Arizona
- 2 Surface Mines
  - El Segundo
  - Navajo
- Resources in the Raton, Sierra Blanca Fields

Farmington, Daily Times. San Juan Underground Mine, 2018. Closed approximately 2 weeks ago.

Procedures - Sampling Work

Sample collection

- Coal seams, stratigraphic units above/below coal seams
- Coal waste from active and Abandoned Mine Land sites
- Fly and bottom ash
- Waste rock piles
- Logged Drill core

Current Samples collected

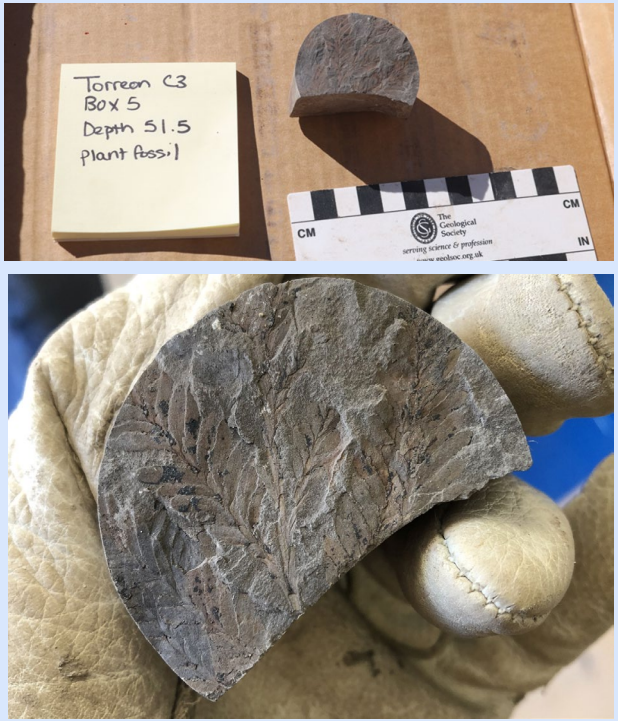
- Navajo Mine, Fruitland
- El Segundo Mine/Lee Ranch, Grants
- Black Springs Humate Mine, Cuba
- Mt. Taylor
- Raton
- La Ventana
- Star Lake
- PNM Generating Station, Waterflow

Procedures- Drill Core Logging

- 3162 feet logged, 33 holes
  - Logged/Photographed
- Logging geological information.
  - Lithology
    - Sandstone, siltstone, mudstone, coal, and shale
  - Color
  - Grain size and shape
  - Textures
    - Bedding, foliation, stratification
  - Mineral Composition
  - Weathering/alteration
  - Hardness/fractures
  - Other relevant notes
    - Odors, contamination, fossils, mineralizations

Torreon Wash, Sandoval County, NM - Boxes C5 and C6. Well ID - 6393 and 6376. Both collected from Menefee Formation (Photos by M.Badonie)

Procedures - Drill Core Logging



Drill core hole: Torreon C3, Fern plant fossil (Photos by M.Badonie)

Drill core hole: Torreon C3 - Bedding Textures (Photo by M.Badonie)

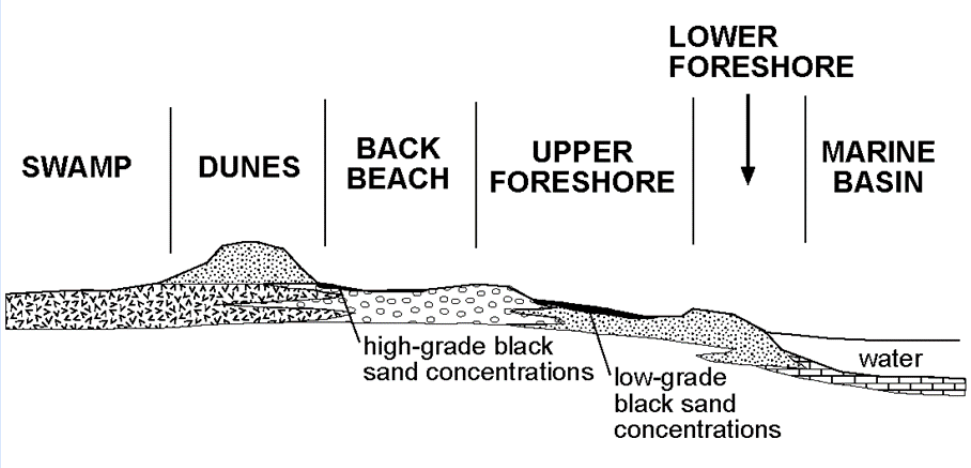
Drill core contains gypsum (Photo by M.Badonie)

Procedure - Compiling Historical and Existing Data

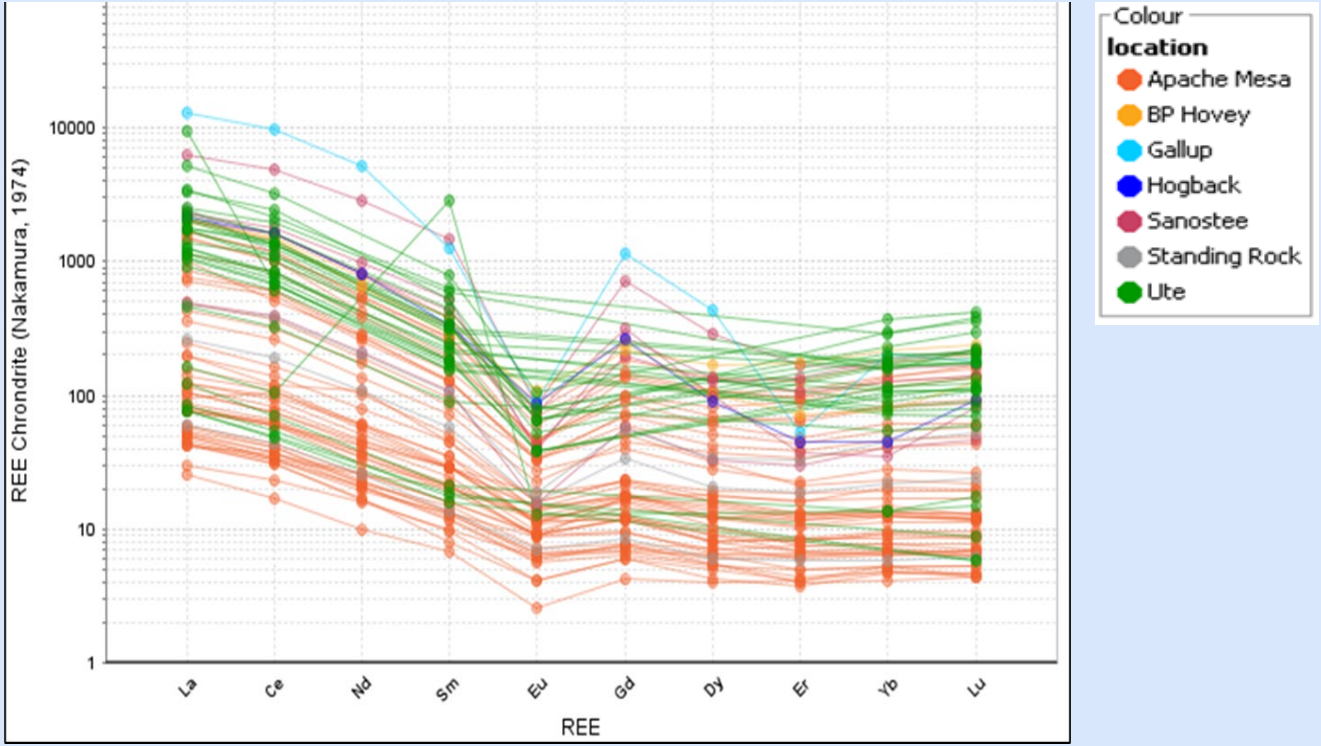
- Drill core, geologic maps, hand samples, and past reports.
- A database is being created
  - Historical and incoming data
  - Public access through New Mexico Bureau of Geology
- Interpretation of legacy geochemistry
  - Uncertainity with sample source
    - Coal vs. Ash

Beach – Placer Sandstone Deposits

- Beach-placer sandstone deposits
  - Accumulations of heavy, resistant minerals (i.e. high specific gravity)
  - Form on upper regions of beaches or in long-shore bars in a marginal-marine environment.

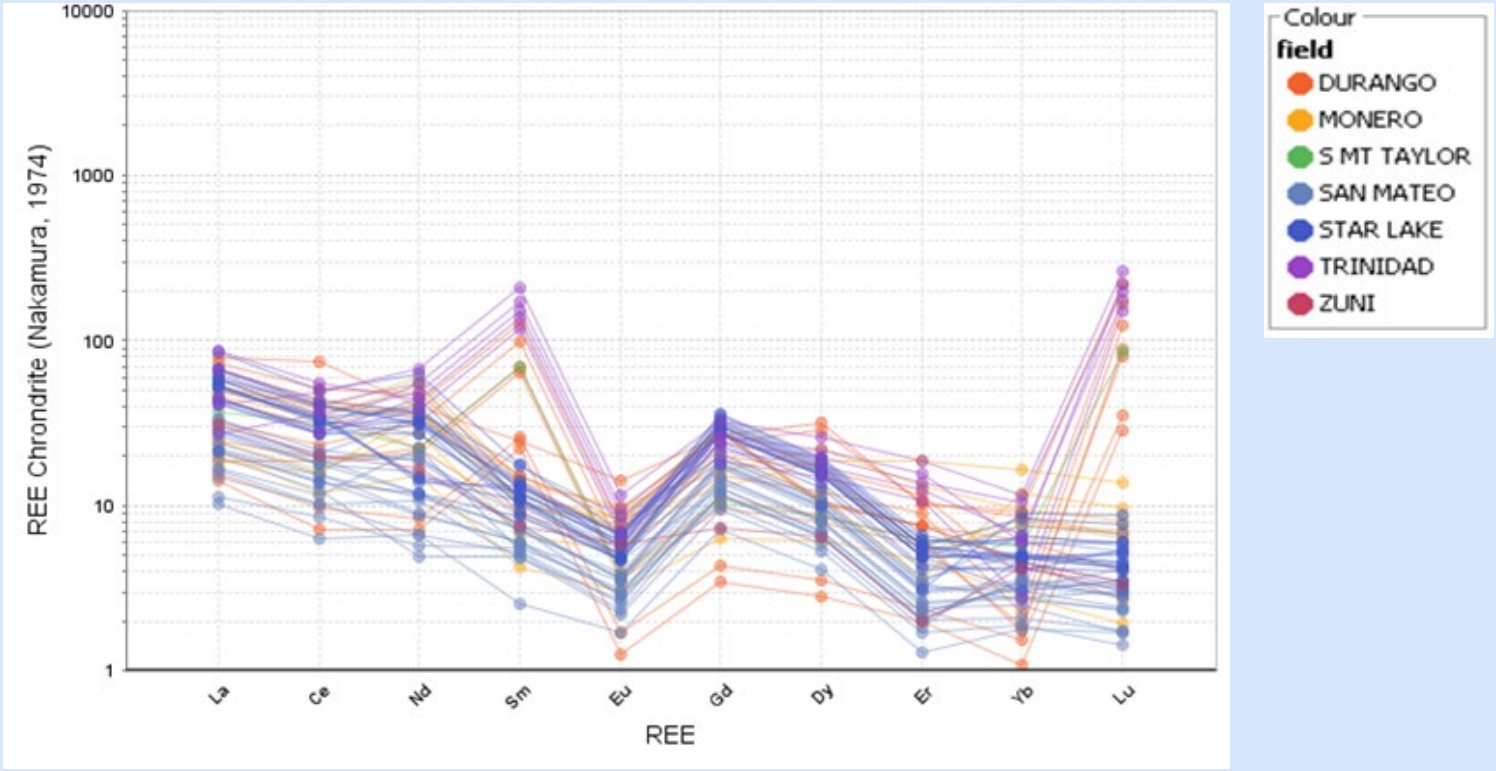


Legacy Data - Beach Placer Sandstone Deposits



Chondrite – normalized REE plot of selected heavy mineral, beach-placer deposits. Note upper scale of REE chondrite is 100,000 (Affolter, 2009, Data from McLemore, et all, 2014, and Nakamura, 1974).

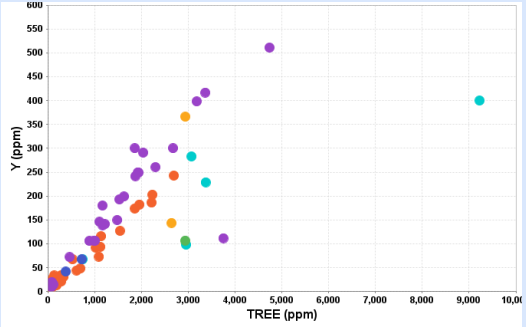
Legacy Data – REE Content from Coal Deposits

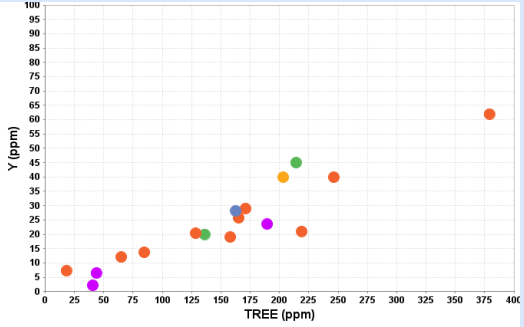


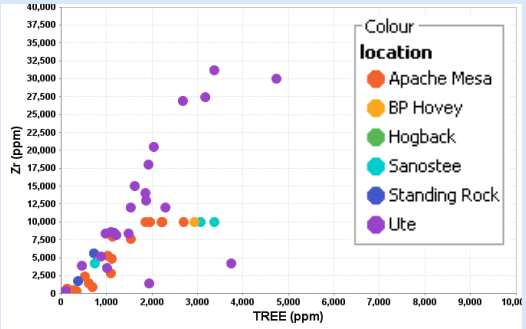
Chondrite-normalized plot of REE content from coal mines throughout New Mexico. Elevated Sm and Lu requires further investigation. Note upper scale of REE chondrite is set at 10,000 (Data from Affolter, 2009).

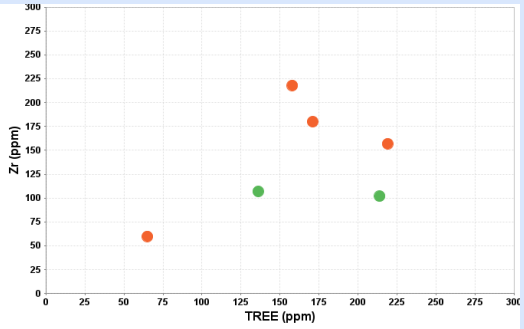
Geochemistry of Beach – Placer Sandstone and Coal Deposits

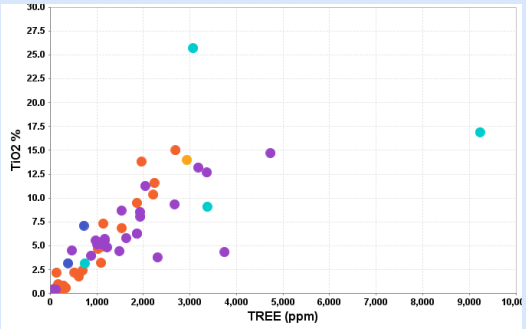
- Correlation plots of TREE vs Y, Zr, and TiO2 for Beach placer sandstone deposits.
- Mineralogy:
  - Yttrium = Monazite
  - Zirconium = Zircon
  - Titanium Oxide = Rutile, Ilmenite, and Anatase
- Left: Data from McLemore et al., 2016 and coal/shale/ash deposits
- Right: New unpublished data; Taggart et al. 2016) (note different scales)

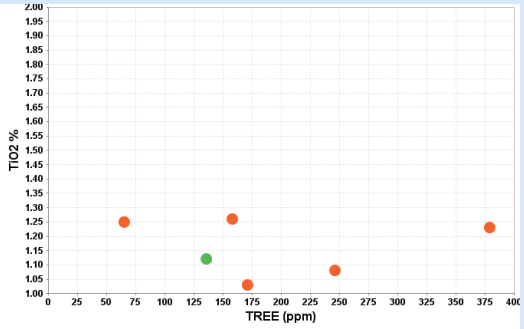












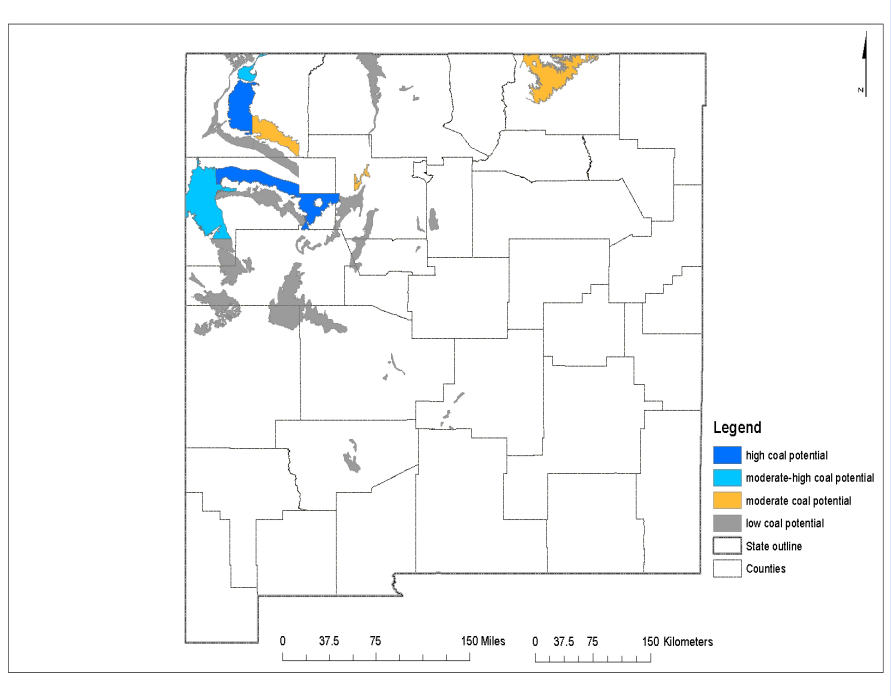
Economic Resource Calculations and Coal Boundaries

Resources Potential

- Calculate coal volume potential resources
  - Once chemistry data comes available
    - Apply REE and CM chemistry
      - ❑ Resource estimate in the San Juan and Raton Basins
  - Establishing procedure using
    - Arcgis maps to calculate volume

Coal Boundaries

- Drill Core coordinates show core collected outside of coal field boundary
  - Rechecking the boundaries - collection latitude and longitude
  - Based on coal thickness in seams



Coal potential map of New Mexico coal fields (Hoffman, 2018)

Future Plans

1. Collect more samples of coal, humates, clinkers, beach placer sandstones, etc.
    a.) Every coal field within the San Juan and Raton Basins
2. Make detailed approximations of available coal stores in the coal fields
3. Prep samples for trace element chemical analyses
    a.) LIBS/Raman spectroscopy
    b.) Electron microprobe
    c.) Thin sections
4. Geochemical interpretation upon receiving chemistry data
5. Use the information to survey and map

    A.) Possible locations for REE and CM mining locations

Preliminary Conclusions

- Most of the REE's are relatively low in concentration in the San Juan coal samples as compared to economic deposits from legacy data. Additional sampling and geochemical analysis underway.
- San Juan and Raton Basin coals exhibit LREE enrichment in chondrite normalized REE patterns, like many other coal deposits found around the world.
- The San Juan coal samples show a positive correlation between total REE and Si as well as other critical elements. A strong correlation may suggest the elements are within similar mineral phases that contain total REE and CM.
- Beach-placer sandstone deposits are found in coal fields throughout New Mexico. These beach-placer sandstones exhibit LREE enrichment in chondrite normalized REE patterns, and are more enriched in total REE than the coal deposits.


Questions? Comments?
Thank you!

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