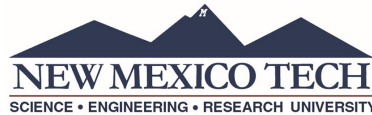# CORE-CM project - Rare Earth Elements and Critical Minerals in the San Juan and Raton Basins, northern New Mexico

Authors: Megan Badonie, Virginia McLemore, Jakob Newcomer, and Devlon Shaver
Presented by: Megan Badonie, Jakob Newcomer, and Devlon Shaver

Presentation Outline

- Introduction/Main Objective

- Purpose of Study

- Procedures

  - Sampling Work

  - Drill core Logging

  - Compiling Existing/Historical Data

- Legacy Data

- Student Research Assistant Projects

  - Economic Resource Calculation

  - Humates

  - Fluid Migration

  - Volcanic Ash

  - Clinker Coal-Red Dog Formation

- Future Plans

- Preliminary Conclusions

- Q/A

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

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 statgraphic units
    - Identify/quantify sources of REE and CM
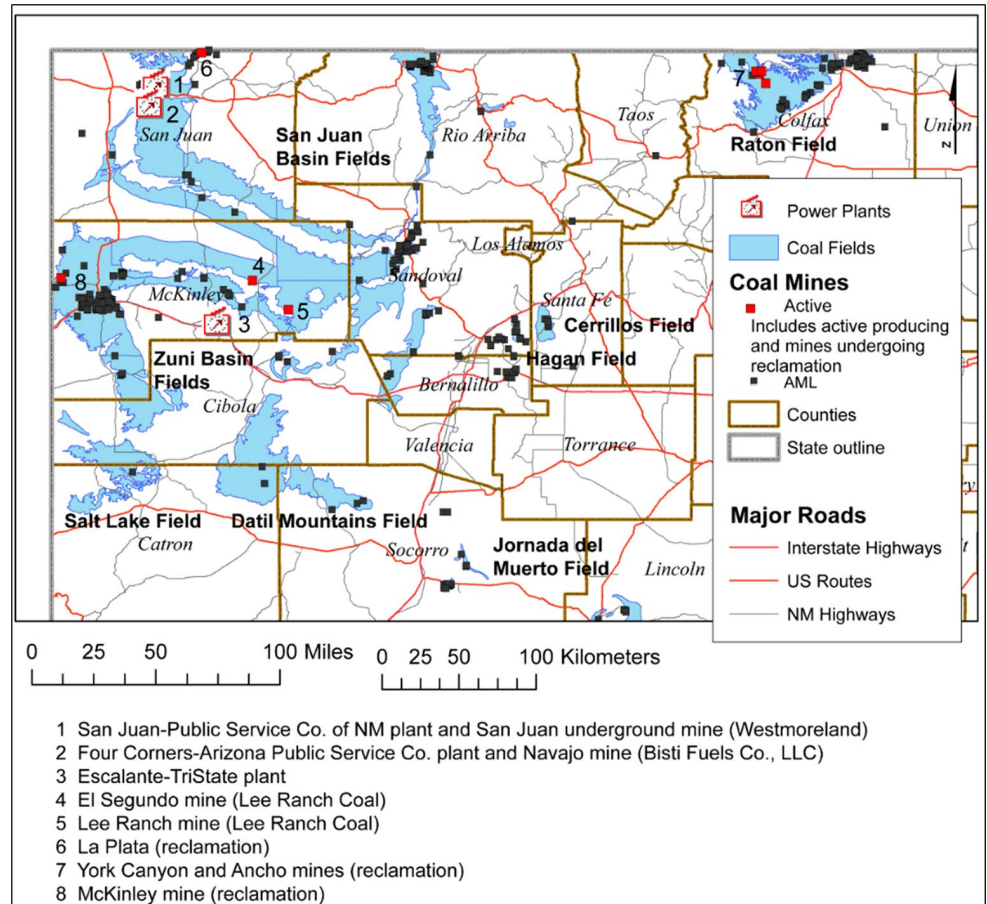
CORE-CM Project Area, San Juan and Raton coal fields (Hoffman, 2017)

Purpose of Study

- REE and CM are non-renewable resources
  - Essential to US economic and national security
- Supply potentially susceptible to disruption
- Highly Important to U.S. green/clean energy development
  - Continued advancement of technology
- Identifying and producing REE and CM in New Mexico may directly benefit the economy
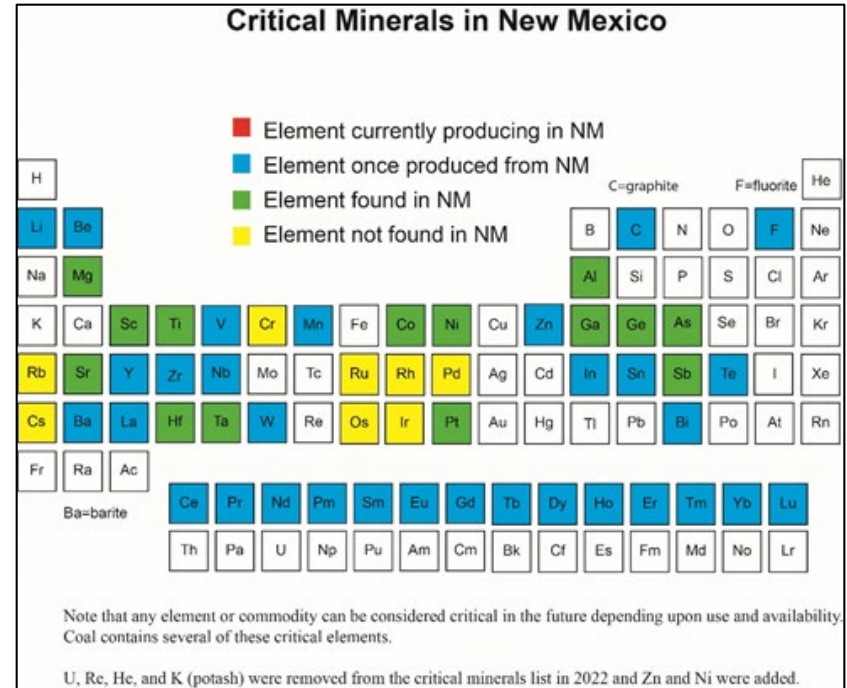
Elemental Table of Critical Minerals significant to New Mexico
(https://geoinfo.nmt.edu/resources/minerals/critical/home.html)

Procedures - Sampling Work

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

Current Samples collected
- Navajo Mine, Fruitland
- El Segundo Mine/Lee Ranch, Grants
- Black Springs Humate Mine, Cuba
- Mt. Taylor
- Raton
- La Ventana
- Star Lake
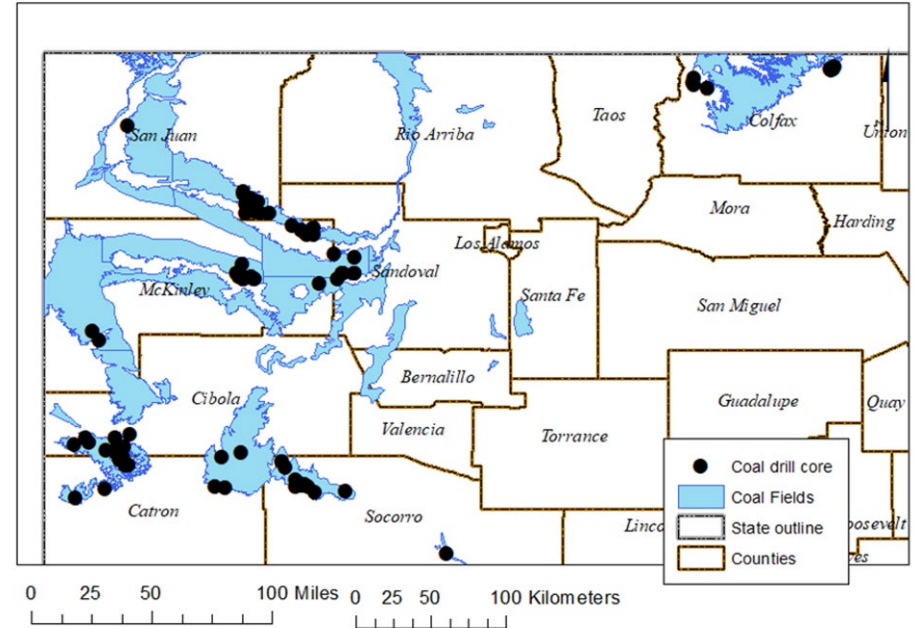
Map of coal fields and drill-core locations in northern, New Mexico (McLemore, 2017)

Procedures- Drill Core Logging

- > 2655 feet logged
  - 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 mineralization (Photo by M.Badonie)

Procedure - Compiling Historical & Existing Data

- Existing and Historical Data
    - Drill core, geologic maps, hand samples, and past reports.
    - A database is being created
        - Historical and incoming data
        - Public access
    - Interpretation of legacy geochemistry
    - Check for samples
        - Every coal field in San Juan and Raton basins.
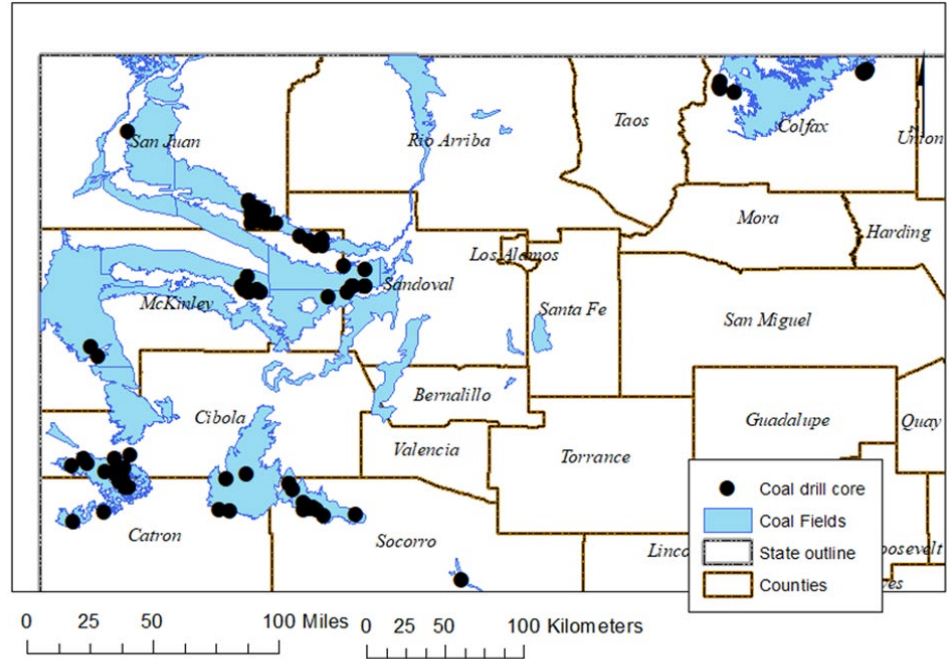
Map of Coalfields and Drill Core Locations in northern, New Mexico (McLemore, 2017)

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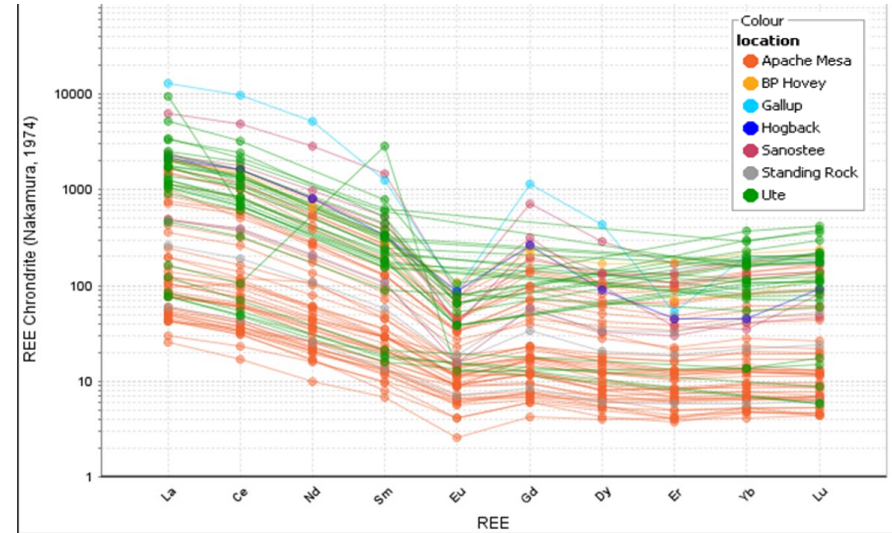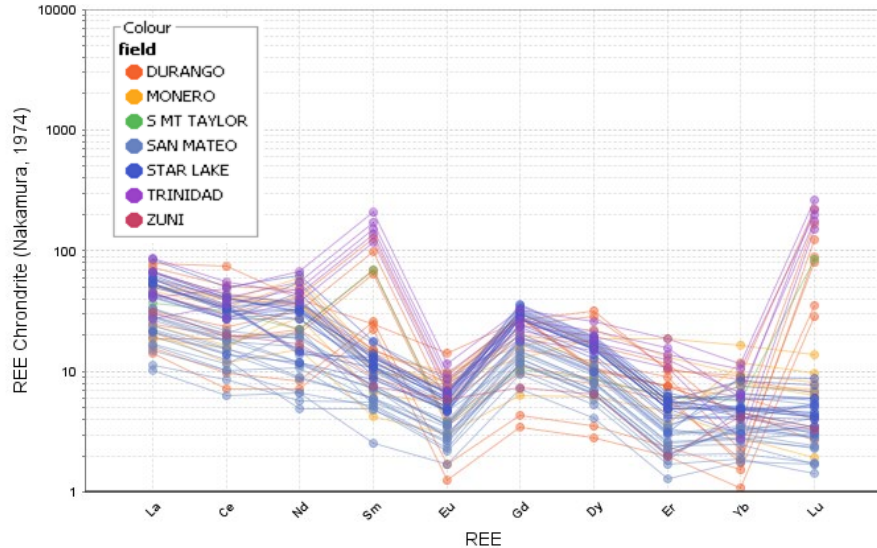
(Left) Chondrite-normalized plot of REE content from coal mines throughout New Mexico. Elevated Sm and Lu requires further investigation. Note upper scale of REE chondrite is set at 10,000 (Data from Affolter, 2009).

(Right): 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).

Economic Resource Calculations/ Coal Boundaries - M.Badonie

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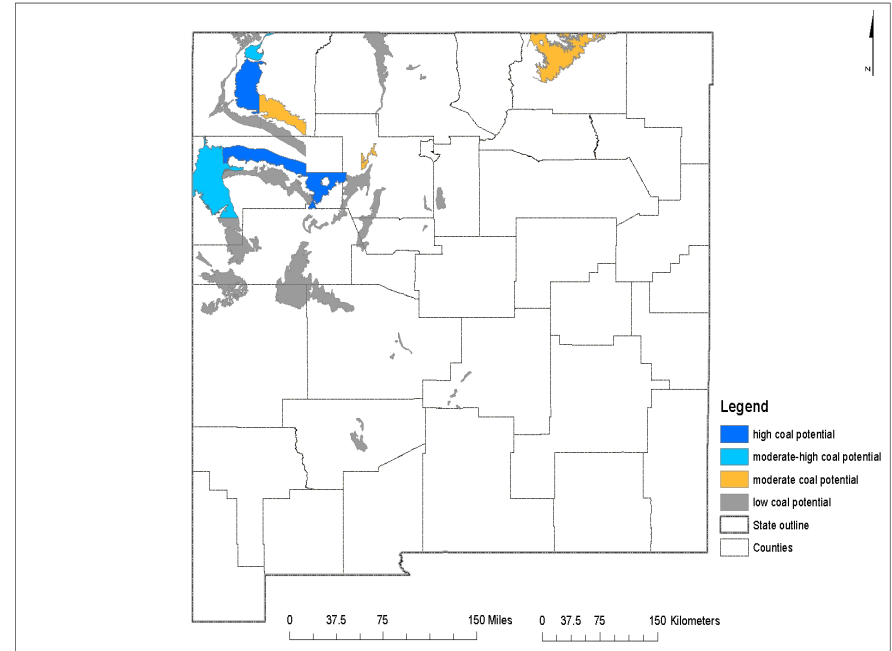
Coal potential map of New Mexico coal fields (Hoffman, 2018)

Humate Analysis- J. Newcomer

- Humates are high humic acid content materials found in soils. They are concentrated in weathered coal zones.
- These large, complex, and water soluble organics can bind to and transport salts, metals, and hydrophobic compounds.

Humate in outcrop, Black Springs Mine, Cuba NM (Photo by J. Newcomer)

Fluid Migration- J. Newcomer

- Samples were (and will be) collected from igneous dikes adjacent to coal and other sediments.
- Samples of igneous and sedimentary material will be analyzed for evidence of fluid migration and element leaching into surrounding sediments.

Igneous dike cross cutting dark sediments. South of Raton, NM (Photo by J. Newcomer)

Volcanic Ash Associated with Coal- J. Newcomer

- Samples collected from field and drill core
- Samples will be dated with $^{40}Ar/^{39}Ar$ method
- Samples will be analyzed for evidence of elemental migration into coal

Ash layers within coal, El Segundo Mine
(Photo by J. Newcomer)

Clinker – D. Shaver

- Clinker Coal Is the result of coal seam fires.

- Clinker is formed by burning coal in place

  - Prehistoric man made fires

  - Lightning strikes/wildfires

  - Possible volcanic eruptions

  - Natural spontaneous combustion (pyrite)

- Very hard, durable

- Concentrate REE and CM like residual ashes from coal burning

Clinker Sample (Photo credit: https://www.usgs.gov/media/images/clinker-coal-1)

Red Dog Formation - Clinker piles, El Segundo Mine (Photo by D.Shaver)

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.

Acknowledgments

References

- Affolter, R.H., 2009, Quality characterization of Cretaceous coals from the Colorado Plateau coal assessment area; in Chapter G of Geologic assessment of coal in the Colorado Plateau: Arizona, Colorado, New Mexico, and Utah: U.S. Geological Survey, Professional Paper 1625

- Hoffman, G. K., 1996, Coal resources of New Mexico, New Mexico Bureau of Mines and Mineral Resources, Resource Map, v. 20, 22 p., 1 sheet, scale 1:1,000,000.

- Hoffman, Gretchen K., 2017, Energy and Mineral Resources of New Mexico: Coal Resources, 80 pages, ISBM: 978-1-883905-38-5

- Hoffman, Gretchen, 2018, Coal potential map of New Mexico coal fields

- McLemore, V.T., 2017b, Heavy mineral, beach-placer sandstone deposits at Apache Mesa, Jicarilla Apache Reservation, Rio Arriba County, New Mexico; *in* The Geology of the Ouray-Silverton Area, Karlstrom, K.E., Gonzales, D.A., Zimmerer, M.J., Heizler, M., and Ulmer-Scholle, D.S.: New Mexico Geological Society 68th Annual Fall Field Conference Guidebook, p.. 123-132.

- McLemore, V.T., 2020, Critical minerals in New Mexico; work needed to realize resources: Mining Engineering, v. 72, no. 2, pp. 31-31, https://me.smenet.org/abstract.cfm?preview=1&articleID=9501&page=31

- McLemore, V.T., 2021, REE in Coal: New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology Student Seminar.

- Nakamura, N., 1974, Determination of REE, Ba, Fe, Mg, Na, and K in carbonaceous and ordinary chondrites: Geochimica et Cosmochimica Acta, v. 38, p. 757–775.

- Pillmore, C.L. (1991). "Geology and Coal Resources of the Raton Coalfield". US Geological Survey Bulletin. 1972(D). doi:10.3133/b1972

Questions? Comments?

Thank you!