

U.S. Department of Energy
Office of Fossil Energy and Carbon Management
DE-FE0032051

**Carbon Ore, Rare Earth, and Critical Minerals (CORE-CM) Assessment of San Juan
River-Raton Coal Basin**

8th Quarterly Research Performance Progress Report
Reporting Period: July 31 to October 31, 2023
Project Performance Period: 10/01/2021 – 09/30/2024

Submitted by:
Virginia T. McLemore
Principal Senior Economic Geologist/Minerals Outreach Liaison,
New Mexico Bureau of Geology and Mineral Resources
Email: virginia.mclemore@nmt.edu
November 23, 2023

Principal Investigator
Navid Mojtabai
Email: Navid.Mojtabai@nmt.edu
Telephone: 575-517-5836

Submitting Institution
New Mexico Institute of Mining and Technology
801 Leroy Place
Socorro, NM 87801
DUNS # 041358904

TABLE OF CONTENTS

1. ACCOMPLISHMENTS	3
<u>A.</u> Major goals and objectives	3
<u>B.</u> Accomplishments during 4 th quarter	5
Task 1.0 Project Management and Planning.....	7
Task 2.0 Basinal Assessment of CM and REE in the San Juan and Raton Basins.....	7
Task 3.0 Basinal Strategies for Reuse of Waste Streams	10
Task 4.0 Basinal Strategies for Infrastructure, Industries and Businesses	10
Task 5.0 Technology Assessment, Development and Field Testing	10
Task 6.0 Technology Innovation Centers	10
Task 7.0 Stakeholder Outreach and Education.....	11
2. PRODUCTS	11
A. Publications, conference papers, and presentations	11
B. Website(s) or other Internet site(s).....	13
C. Technologies or techniques	13
D. Inventions, patent applications, and/or licenses.....	13
E. Other products	14
3. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS	15
A. Individuals involved in project	15
B. Change in support levels of key persons.....	16
4. SPECIAL REPORTING REQUIREMENTS: Mandatory	16
5. BUDGETARY INFORMATION: MANDATORY	16
6. REFERENCES	16
7. APPENDICES	16
APPENDIX 1. List of SOPs and plans	16

1. ACCOMPLISHMENTS

The objective of this project is to determine the rare earth elements (REE) and critical minerals (CM) resource potential in coal and related stratigraphic units in the San Juan and Raton basins, New Mexico. We will conduct the following tasks: (1) a basinal assessment for CM and REE potential, using state-of-the-art technologies to estimate basin-wide CM and REE resources in coal and related stratigraphic units; (2) identify, sample, and characterize coal waste stream products; (3) conduct bench tests to develop a basinal reuse of waste strategy; (4) illustrate the current status of the feedstock supply of REE and CM to understand the basinal REE industry's capital expenditures and obstacles to expanding REE-related business development; (5) develop a life-cycle analysis to establish pathways, process engineering, and design requirements to upgrade REE processing industry, (6) evaluate technology gaps, (7) establish a Center of Excellence and Training Center (COE) for coal ash beneficiation at San Juan County; and (8) create REE research-based activities that can be shared during the NMBGMR summer geology teacher workshop and assemble REE research-related articles for an REE-centered issue of *Lite*. This project will delineate favorable geologic terranes and priority areas containing potential REE and CM deposits for the DOE mandate, which is also a priority of the NMBGMR and state of NM.

A. Major goals and objectives

The following are the major goals of this project as described in the approved Statement of Project Objectives (SOPO):

1. Identify and quantify the distribution of critical minerals (CM), including rare earth elements (REE), in coal beds and related stratigraphic units in the San Juan and Raton basins in New Mexico (including coal, coal refuse, ash, coal seam, interstitial clays/shales, volcanic ash beds, acid mine drainage, associated sludge samples, mine dumps, other nonfuel carbon-based products, process waters, etc.).
2. Identify possible sources of CM and REE in the basins.
3. Identify the coal mine and nonfuel carbon-based waste products that could contain CM and REE.
4. Characterize the CM and REE in these materials.
5. Determine the economic viability of extracting CM and REE from these materials
6. Test and develop new technologies in identifying and quantifying CM and REE in high-fidelity geologic models.

Table 1 describes the tasks and subtasks that will be undertaken to accomplish these goals and Table 2 provides a listing of the revised project milestones, along with anticipated delivery dates.

TABLE 1. List of tasks and subtasks

<p>Task 1.0 Project Management and Planning</p>
<p>Task 2.0 Basinal Assessment of CM and REE in the San Juan and Raton Basins</p> <p>Subtask 2.1 Identification of Sampling Sites</p> <p>Subtask 2.2 Collection and Review of Existing Data</p> <p>Subtask 2.3 Develop a Sampling Plan</p> <p>Subtask 2.4 Collect Samples</p> <p>Subtask 2.5 Sample Characterization</p> <p> Subtask 2.5.1 Bulk Rock Characterization</p> <p> Subtask 2.5.2 Micro-scale Characterization</p> <p> Subtask 2.5.3 3D Multiscale Petrography</p> <p> Subtask 2.5.4 In situ LIBS/RAMAN Analyses</p> <p>Subtask 2.6 Application of Machine Learning techniques for basin-wide resource assessment</p>
<p>Task 3.0 Basinal Strategies for Reuse of Waste Streams</p> <p>Subtask 3.1 Waste Streams Sampling and Characterization</p> <p>Subtask 3.2 Coal Ash</p> <p>Subtask 3.3 Technology Development of Basinal Reuse Strategy</p>
<p>Task 4.0 Basinal Strategies for Infrastructure, Industries and Businesses</p> <p>Subtask 4.1 Infrastructure Investigation</p> <p>Subtask 4.2 Competitiveness and Challenge</p> <p>Subtask 4.3 Life-Cycle Analysis</p>
<p>Task 5.0 Technology Assessment, Development and Field Testing</p> <p>Subtask 5.1 Identify and Assess Existing and Novel Technologies Specific to the Resource</p> <p>Subtask 5.2 Develop Plan for Field Testing</p>
<p>Task 6.0 Technology Innovation Centers</p> <p>Subtask 6.1 SonoAsh Center of Excellence</p>
<p>Task 7.0 Stakeholder Outreach and Education</p> <p>Subtask 7.1 New Mexico State and Regional Education</p> <p>Subtask 7.2 Lessons Learned and Narratives Constructed</p> <p>Subtask 7.3 Publications</p> <p>Subtask 7.4 Training and Conferencing with SJC and Sonoash COE</p>

TABLE 2. Revised List of Milestones (**bold=completed**)

Task/ Subtask	Milestone Title	Planned Completion	Verification method	Status
	Quarterly reports	Quarterly	Report every quarter	1-8th quarters completed (see https://geoinfo.nmt.edu/staff/mclemore/REEinCoalWeb.html)
	Year I interim report	Year 1	Submitted this report	completed
	Meeting with DOE manager	12/7/22, 4/11/23, 7/11/23	attend	Presentation given
1.0	A: Project Kick-off meeting	10/15/21	Attend, report	Completed (see https://geoinfo.nmt.edu/staff/mclemore/documents/CORE-CMprojectNMfinal.pdf)
2.1	B: Identification of Sampling Sites	Quarterly	Reports every quarter (quarterly reports), environmental questionnaire	Ongoing , planned in 2 phases Phase 1 (https://geoinfo.nmt.edu/staff/mclemore/SampleLocations1_23.xlsx), environmental questionnaire completed and revision submitted
2.2	C: Collection and Review of Existing Data	2 nd quarter	Map, description	Report completed (https://geoinfo.nmt.edu/staff/mclemore/documents/legacychemistryrpt23.pdf), ongoing activity, REE in produced waters (https://geoinfo.nmt.edu/staff/mclemore/ree_produced_waters_for_GIS.xlsx) and USGS coal chemistry (https://geoinfo.nmt.edu/staff/mclemore/REEcoal.mpk) are on the project web site; summary of data and preliminary interpretations https://geoinfo.nmt.edu/staff/mclemore/documents/McLemoreGSA22Wed10-12-22.pdf

2.3	D: Sampling Plan Database	10/31/2021, progress report 2 nd quarter. 3/31/2022	Sampling plan Database, web forms, reports.	Sampling plan is completed (https://geoinfo.nmt.edu/staff/mclemore/documents/samplingplan_v3.pdf). Database and data entry web pages are available and being updated.
2.4	E: Collect Samples	Quarterly	Report, database	Started sampling in April 2022 (see Table 3), permit to collect on Navajo Tribal Lands issued April 2023 and ended June 30, 2023
2.5	F: Characterization	Quarterly	Progress report quarterly, database	Ongoing once samples are collected, samples submitted to laboratories for chemical analyses, chemical analyses received (see Attachment 3) Chemical analyses at https://geoinfo.nmt.edu/staff/mclemore/NMTcoalChem_003.xlsx , preliminary report by Sandia https://geoinfo.nmt.edu/staff/mclemore/documents/Coal9Petrography.pdf
2.6	G: Application of Machine Learning techniques for Basin-wide Assessment	12/31/2022	Progress report quarterly, database, 1 st summary report completed	Completed , Submitted 8/9/2023
3.0	H: Sampling and Characterization of Waste Streams	Quarterly	Progress report quarterly, database	Ongoing , see 2.5, future activity
4.0	I: Results of Basinal Infrastructure, Industries and Business Assessment	03/31/2023	Progress report quarterly, database, publications	Future activity; 4.3 Life cycle analysis completed (see below) , Extraction techniques report completed https://geoinfo.nmt.edu/staff/mclemore/documents/January2023ExtractionTechnique.pdf

Accomplishments during 8th quarter

Task 1.0 Project Management and Planning

Project management activities during this quarter included the implementation of regular procedures including regular management and biweekly working group meetings. The team also has regular meetings of the New Mexico Bureau of Geology and Mineral Resources (NMBGMR) database group to develop the project database. Meetings with the DOE coordinator/manager have been held.

Task 2.0 Basinal Assessment of CM and REE in the San Juan and Raton Basins

Status:

Subtask 2.1 Identification of Sampling Sites (COMPLETED)

1. Sample sites include the coal fields and mines in the San Juan and Raton basins, shown in Figure 1. Potential sample sites listed https://geoinfo.nmt.edu/staff/mclemore/SampleLocations1_23.xlsx.
2. Received permit from Navajo Tribe to sample on Tribal lands April-July 2023, sampling began in April and completed in June

Subtask 2.2 Collection and Review of Existing Data (COMPLETED)

Legacy chemistry data have been collected. See preliminary results in Geological Society of America presentation by McLemore (<https://geoinfo.nmt.edu/staff/mclemore/documents/McLemoreGSA22Wed10-12-22.pdf>), DOE workshop presentation (<https://geoinfo.nmt.edu/staff/mclemore/documents/McLemoreDOE22Tues10-25-22.pdf>), group presentation on geochemistry (11/15.22), and report (<https://geoinfo.nmt.edu/staff/mclemore/documents/legacychemistryrpt23.pdf>).

Subtask 2.3 Develop a Sampling Plan (COMPLETED)

The field sampling plan is completed and revised (https://geoinfo.nmt.edu/staff/mclemore/documents/samplingplan_v5.pdf). Figure 1 shows the coal fields and mines in the area. Table 3 is a list of the coal fields.

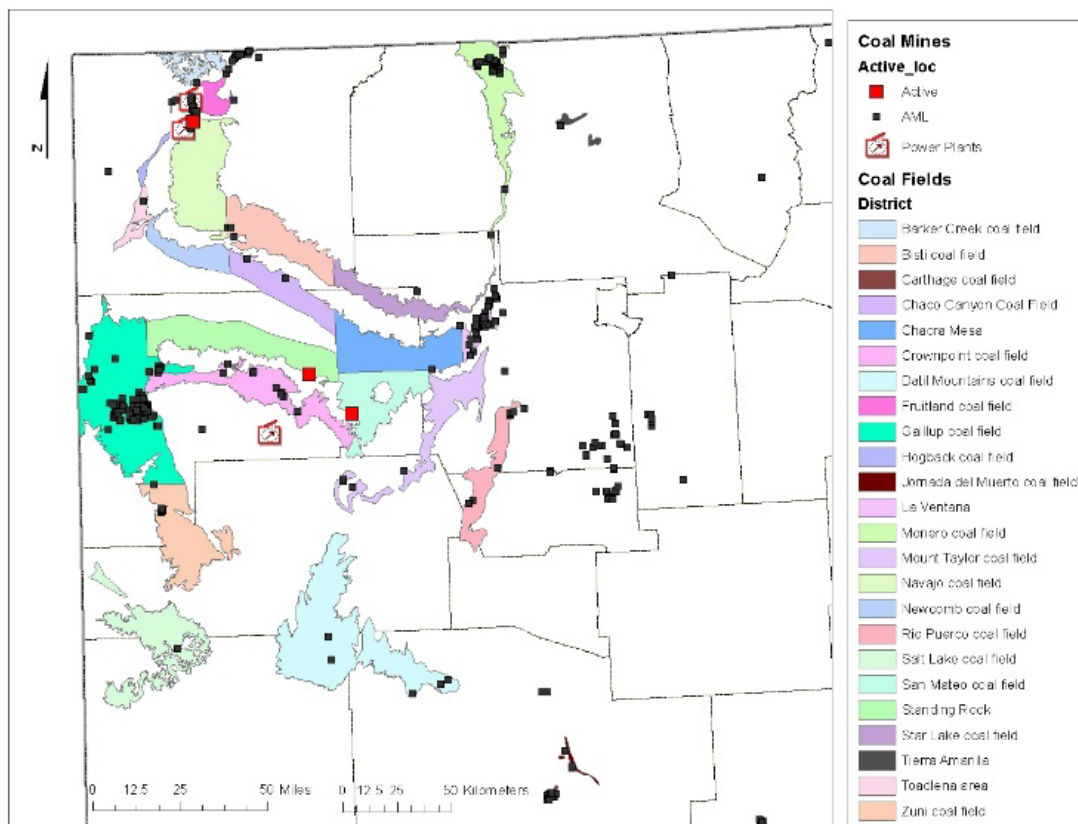


FIGURE 1. Location map of coal fields in the San Juan basin, New Mexico (modified from Hoffman, 2017). Active coal mines are surface operations. Lee Ranch mine suspended operations in 2016, but plans to reopen. Coal fields are summarized in Table 3. Only the Four Corners power plant remains open.

TABLE 3. Samples from coal fields in the San Juan and Raton basins. Coal fields and reserves are delineated by Hoffman (1996, 2017). District Id is from the New Mexico Mines Database (McLemore, 2010a, 2017). Representative samples have been and will be collected from each coal field. At least 3 samples will be collected from each coal field. Red=no analyses at this time.

District id	District (coal field)	Year of Initial Production	Year of Last Production	Estimated Cumulative Production	Formation	Number of samples analyzed	Number of coal analyzed	Demonstrated resources, million tons (Hoffman, 2017)
DIS257	Barker Creek		1905		Menefee	9	6	183
DIS150	Bisti	1980	1988	40,075,148	Fruitland	50	16	872
DIS208	Carthage	1861	1963		Crevasse Canyon, Tres Hermanos	2	2	30
DIS259	Chaco Canyon	1905			Menefee	2	1	46
DIS260	Chacra Mesa		1945		Menefee	25	8	140
DIS118	Crownpoint	1914	1951	20,758	Crevasse Canyon	12	8	663
na	Dakota	na	na	na	na	4	4	

District id	District (coal field)	Year of Initial Production	Year of Last Production	Estimated Cumulative Production	Formation	Number of samples analyzed	Number of coal analyzed	Demonstrated resources, million tons (Hoffman, 2017)
DIS262	Datil	1917	1940	66,980	Dakota	1	1	47
DIS155	Fruitland	1889	2001	3,137,957,050	Crevasse Canyon, Tres Hermanos	5	4	550
DIS119	Gallup	1882	2001	121,522,629,885	Fruitland	48	26	610
DIS156	Hogback	1907	1971	301,237	Crevasse Canyon			66
DIS264	Jornada del Muerto		1927		Menefee	6	3	0
DIS174	La Ventana	1904	1983		Crevasse Canyon	4	4	263
DIS146	Monero	1882	1970	5,277,552	Menefee	9	7	40
DIS016	Mount Taylor	1952	1953	69,948	Menefee	7	5	19
DIS157	Navajo	1963	9999	4,714,689,147	Crevasse Canyon	19	9	1340
DIS258	Newcomb				Fruitland		3	126
DIS021	Raton	1898	2002	954,470,032	Menefee	27	12	
DIS003	Rio Puerco	1937	1944	139,555	Vermejo, Raton			25
DIS009	Salt Lake	1987	1987	100,000	Crevasse Canyon	2	1	323
DIS121	San Mateo	1983	2001	954,470,032	Moreno Hill	9	5	385
DIS261	Standing Rock	1952	1958		Menefee	11	4	392
DIS158	Star Lake				Menefee	47	30	946
DIS263	Tierra Amarilla	1955	1955		Fruitland			4.5
DIS159	Toadlena				Menefee	16	6	0
DIS124	Zuni	1908	1926	16,010	Menefee	1	1	83
	coal ash					5		
	beach placer sandstone					40		
	uranium sandstone							
	Other samples					18		
	total samples					379	166	7153.5

Health and safety plan (COMPLETED)

HASP is complete (https://geoinfo.nmt.edu/staff/mclemore/documents/HASP_10.pdf). NMT requires all projects to have a **Safe and Inclusive Working Environment Plan for Off-Campus or Off-Site Research**, which has been added to the HASP.

Subtask 2.4 Collect Samples

Sampling was delayed due to poor weather, vacation schedules, closures of Federal land because of fire danger, and students not available because of school schedule. We started sampling in April 2022.

We have logged 3162 ft of core (33 holes). We have collected 211 samples (Table 3; Attachment 3, <https://geoinfo.nmt.edu/staff/mclemore/Attachment3-NETLREE-SEDSampleDataNM.xlsx>).

Additional samples are being collected.

Photographs of drill core are at <https://photoarchive.nmt.edu/> (you need to search by coal and sample)

Subtask 2.5 Sample Characterization

Chemical analyses was delayed due to obtaining quotes and proper paperwork required by NM Tech (completed August 2022)

Samples have been analyzed for major and trace elements (see Attachment 3,

https://geoinfo.nmt.edu/staff/mclemore/NMTcoalChem_003.xlsx

Sandia is working on characterization (will submit in the future)

Subtask 2.6 Application of Machine Learning techniques for basin-wide resource assessment

Las Alamos is working on machine learning analyses (1st summary report submitted)

Task 3.0 Basinal Strategies for Reuse of Waste Streams

Subtask 3.1 Waste Streams Sampling and Characterization

There is no update on this subtask.

Subtask 3.2 Coal Ash

We have collected 8 coal ash samples from Generating Plants.

Subtask 3.3 Technology Development of Basinal Reuse Strategy

There is no update on this subtask.

Task 4.0 Basinal Strategies for Infrastructure, Industries and Businesses

Subtask 4.1 Infrastructure Investigation

There is no update on this subtask.

Subtask 4.2 Competitiveness and Challenge

There is no update on this subtask.

Subtask 4.3 Life-Cycle Analysis (UPDATED AND COMPLETED, see 7th quarterly report)

Task 5.0 Technology Assessment, Development and Field Testing

Subtask 5.1 Identify and Assess Existing and Novel Technologies Specific to the Resource

There is no update on this subtask.

Subtask 5.2 Develop Plan for Field Testing

There is no update on this subtask.

Task 6.0 Technology Innovation Centers

Subtask 6.1 SonoAsh Center of Excellence

Memo written describing meetings with parties to establish COE.

Task 7.0 Stakeholder Outreach and Education

Subtask 7.1 New Mexico State and Regional Education

A short summary of the project was written for Gold Pan

(https://nmt.edu/advancement/goldpan_archives/2022_Summer_GoldPan_Digital2.pdf),
NMIMT Alumni Newsletter.

Another short summary of the project written for Lite Geology

https://geoinfo.nmt.edu/publications/periodicals/litegeology/51/lg_v51.pdf.

The NMBGMR Rockin' Around New Mexico was in Socorro, NM July 5-8, 2023

Other outreach activities see [REE in Coal \(nmt.edu\)](#)

Outline of outreach report completed

Subtask 7.2 Lessons Learned and Narratives Constructed

There is no update on this subtask.

Subtask 7.3 Publications and presentations

See Section 2 below

Subtask 7.4 Training and Conferencing with SJC and Sonoash COE

There is no update on this subtask.

2. PRODUCTS

A. Publications, conference papers, and presentations

1st quarter

Kickoff presentation October 15, 2021

(<https://geoinfo.nmt.edu/staff/mclemore/documents/CORE-CMprojectNMfinal.pdf>)

DOE Division of Critical Minerals Program Plan Rollout on December 8, 2021

(https://geoinfo.nmt.edu/staff/mclemore/documents/CORE-CMprojectNMDOEsummary12_21.pdf)

2nd quarter

New Mexico Geological Society abstract: Badonie, M.N. and McLemore, V.T., 2022, REE in coalbeds in the San Juan-Raton coal basins (abstr.): New Mexico Geological Society, Spring Meeting, <https://nmgs.nmt.edu/meeting/abstracts/view.cfm?aid=2838>. Poster at <https://geoinfo.nmt.edu/staff/mclemore/documents/NMSG.Poster2022COPY2.pdf>.

3rd quarter

Rockin' 22 Critical Minerals presentation

(<https://geoinfo.nmt.edu/staff/mclemore/documents/McLemoreRockinCM22.pdf>)

Rockin' 22 Critical Minerals activities

(<https://geoinfo.nmt.edu/staff/mclemore/documents/Rockin22.pdf>)

4th quarter

New Mexico Mining Association abstract and presentation: REE in the coal and associated strata in the San Juan and Raton Basins, New Mexico, 2022, Megan Badonie, Jakob Newcomer, Devlon Shaver Advised by: Dr. Virginia T. McLemore,

<https://geoinfo.nmt.edu/staff/mclemore/documents/NMAAPresentationNMMAFINAL2022.pdf>

McLemore, V.T., 2022, Rare Earth Elements (REE) in Late Cretaceous coal and beach-placer sandstone deposits in the San Juan Basin, New Mexico: Preliminary Observations (abstr.): Geological Society of America, Annual Conference, October, <https://gsa.confex.com/gsa/2022AM/meetingapp.cgi/Paper/378264>, presentation <https://geoinfo.nmt.edu/staff/mclemore/documents/McLemoreGSA22Wed10-12-22.pdf>

5th quarter

McLemore, V.T., 2022, Rare earth elements (REE) in Late Cretaceous coal and beach-placer sandstone deposits in the San Juan Basin, New Mexico: Preliminary results: presentation at the DOE National Energy Technology Laboratory Resource Sustainability Project Review Meeting, Oct. 25-27, 2022 <https://geoinfo.nmt.edu/staff/mclemore/documents/McLemoreDOE22Tues10-25-22.pdf>

6th quarter

Badonie, M., Newcomer, J., Shaver, S., and McLemore, V.T., 2023, REE in coal and associated strata in the San Juan and Raton Basins, New Mexico: Minexchange, 2023 SME Annual Conference Technical Program, preprint 23-055, 5 p., <https://geoinfo.nmt.edu/staff/mclemore/documents/23-055.pdf>

McLemore, V.T., 2023, Critical minerals in New Mexico, (abstr.), New Mexico Geological Society, Spring meeting, <https://nmgs.nmt.edu/meeting/abstracts/view.cfm?aid=2892>

Shaver, D.R., McLemore, V.T., and Owen, E., 2023, Alteration and geochemistry of clinkers in the San Juan Basin, New Mexico (abstr.): New Mexico Geological Society, Spring meeting, <https://nmgs.nmt.edu/meeting/abstracts/view.cfm?aid=2933>

Leo-Russell, M.R. and McLemore, V.T., 2023, A review of lithium as a critical industrial material and engagement prospects in New Mexico (abstr.), New Mexico Geological Society, Spring meeting, <https://nmgs.nmt.edu/meeting/abstracts/view.cfm?aid=2926>

Lempke, J., Frey, B., Goehring, B., and McLemore, V.T., 2023, Rare earth elements in humates mined in the San Juan Basin (abstr.): New Mexico Geological Society, Spring meeting, abstract <https://nmgs.nmt.edu/meeting/abstracts/view.cfm?aid=2954> presentation https://nmgs.nmt.edu/meeting/presentations/2023/2926/NMGS-Presentation-Lithium_LeoRussell-McLemore_1.pdf

Badonie, M.N. and McLemore, V.T., 2023, Rare earth elements and critical minerals in coal and related strata in the San Juan Basin in northern New Mexico (abstr.): New Mexico Geological Society, Spring meeting, <https://nmgs.nmt.edu/meeting/abstracts/view.cfm?aid=2939>

Lempke, J., Frey, B., Goehring, B., and McLemore, V.T., 2023, Rare earth elements in humates mined in the San Juan Basin (abstr.): New Mexico Geological Society, Spring meeting, <https://nmgs.nmt.edu/meeting/abstracts/view.cfm?aid=2954>

McLemore, V.T. and Gysi, A., 2023, Critical minerals in New Mexico: Earth Matters, winter 2023, https://geoinfo.nmt.edu/publications/periodicals/earthmatters/23/n1/em_v23_n1.pdf

7th quarter

- Owen, E.J. and McLemore, V.T., 2023, Distribution of REE in selected deposits in New Mexico: Forum on the Geology of Industrial Minerals, presentation, <https://geoinfo.nmt.edu/staff/mclemore/documents/ejo.FGIM23AustinDistributionofREEinselectedNMdeposits0.1.pdf>
- McLemore, V.T., 2023, Industrial minerals in the San Juan Basin, New Mexico: Forum on the Geology of Industrial Minerals, presentation, https://geoinfo.nmt.edu/staff/mclemore/documents/fgim23-ppt_sm.pdf
- Shaver, D., 2023, Coal mining history of New Mexico (abstr.): Mine History Association annual meeting, Socorro, NM, June 2023, <https://geoinfo.nmt.edu/staff/mclemore/documents/CoalMiningHistoryNewMexico.pdf>
- McLemore, V.T., 2023, Rare Earth Elements and Critical Minerals in Late Cretaceous Coal and Related Strata in the San Juan and Raton Basins, New Mexico: Lite Geology, v. 51, https://geoinfo.nmt.edu/publications/periodicals/litegeology/51/lg_v51.pdf
- Matt Powell, Guangping Xu, Mark J Rigali, Virginia McLemore, Shuya We² and Robert Happney, 2023, Microwave Digestion for Rare Earth Elements (REE) Quantification in Coal and Coal Ash (abstr.): Goldschmidt2023 conference, July, 2023

8th quarter

- McLemore, Virginia, Owen, Evan, Badonie, Megan, Shaver, Devlon, and Newcomer, Jakob, 2024, Rare Earth Elements (REE) And Other Critical Minerals In Late Cretaceous Coal And Related Strata In The San Juan Basin, New Mexico: Preliminary Observations (abstr.): Geological Society of America, Annual Meeting, <https://gsa.confex.com/gsa/2023AM/top/papers/index.cgi?username=392235&password=680673&personid=227838>
- Shaver, D. and McLemore, V., 2024, Alteration and Geochemistry of Clinkers in the San Juan Basin, New Mexico (abstr.): SME Annual Conference, abstract accepted
- McLemore, V.T. and Owen, E., 2024, Geochemistry of Critical Minerals In Mine Wastes In New Mexico (abstr.): SME Annual Conference, abstract and preprint accepted
- McLemore, V.T., Owen, E., Badonie, M., Shaver, D., and Newcomer, J., 2024, Rare Earth Elements (REE) And Other Critical Minerals In Late Cretaceous Coal And Related Strata In The San Juan And Raton Basins, New Mexico: Preliminary Observations (abstr.): SME Annual Conference, abstract and preprint accepted
- Owen, E.J and McLemore, V.T., 2023, Mineralogy and geochemistry of heavy mineral beach-placer sandstones in New Mexico(abstr.): SME Annual Conference, abstract and preprint accepted

B. Website(s) or other Internet site(s)

See project web page at <https://geoinfo.nmt.edu/staff/mclemore/REEinCoalWeb.html>

C. Technologies or techniques

No update

D. Inventions, patent applications, and/or licenses

No update

E. Other products

1st quarter

- Sampling plan
- Health and safety plan
(https://geoinfo.nmt.edu/staff/mclemore/documents/HASP_v2.pdf)
- SOP17 Drillhole logging
<https://geoinfo.nmt.edu/staff/mclemore/documents/SOP17DrillholeLoggingupdated.pdf>

3rd quarter

- Revised sampling plan
(https://geoinfo.nmt.edu/staff/mclemore/documents/samplingplan_v5.pdf)
- REE in produced waters
(https://geoinfo.nmt.edu/staff/mclemore/ree_produced_waters_for_GIS.xlsx) and USGS coal chemistry (<https://geoinfo.nmt.edu/staff/mclemore/REEcoal.mpk>)
- McLemore attended Mining and Metallurgical Society of America AML summit in Phoenix April 6-7, 2022
- Rockin' was held in Farmington July 5-8, 2022

6th quarter

- Participated on the DOE working subgroups (Characterization, Infrastructure, Social Justice)
- Submitted request for extension until Dec. 2024
- Submitted request, budget, and work plan for \$500,000 extension ending Dec 2024

7th quarter

- Attended DOE 2023 Carbon ore, rare earth, and critical minerals (CORE-CM) initiative workshop #2, June 2023
- Mining in New Mexico with emphasis on Critical Minerals, Leadership Academy, May 2023, <https://geoinfo.nmt.edu/staff/mclemore/documents/LeadershipMining2023.pdf>
- GSA Earth Scope—had two interns from 2-yr colleges for the summer (one will present on coal mine wastes)
- Rockin' was held in Socorro July 5-8, 2023
- Abstracts being written for presentation at Geological Society of America (Oct, 2023) and Society of Mining, Metallurgy, and Exploration (Feb, 2024) annual meetings

8th quarter

- 1 thesis being written (Megan Badonie)
- Outline of final report completed and sent to team for review

Preliminary conclusions

- The New Mexico coal, humate, and clinker deposits are relatively low in REE (<325 ppm TREE), Li (<90 ppm), V (<168 ppm), Co (<51 ppm), Ni (<108 ppm), Zr (<557 ppm), Hf (<14 ppm), and many other critical minerals compared to normal economic deposits.

- However, some of these rocks are enriched in Al₂O₃ (as much as 40%) and Sr (as much as 3740 ppm), both critical minerals.
- Common minerals hosting the critical minerals in these rocks include clay minerals, zircon, and rutile/anatase.
- Potential geologic sources of REE and other critical minerals in New Mexico coal, humate, and clinker deposits include Proterozoic granitic and metamorphic rocks (such as those found in the Zuni and Nacimiento Mountains), the Jurassic-Cretaceous arc volcanism and magmatism forming the Mogollon Highlands to the south and west, and recycling of older sediments, although hydrothermal or weathering fluids could concentrate some of the critical minerals.
- Whole-rock and trace element geochemical data of beach placer sandstone deposits show expectedly high values of critical minerals such as TiO₂ (29.4%), total REE + Y (1.4%), Zr (>1%), and Hf (0.16%).
- More chemical and mineralogical analyses are required to fully understand the distribution and origin of REE and critical minerals in these deposits.
- As the demand for some of these elements increases because of increased need and short supplies, the dollar value per ton of ore rises, enhancing deposit economics. Ultimately, economic potential will most likely depend upon production of more than one commodity, maybe even from coal, humate, and clinker deposits.

3. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

A. Individuals involved in project

New Mexico Tech

Dr. Navid Mojtabai (PI) is a professor and department chair in the Mineral Engineering Department at New Mexico Tech - Tasks 1, 3, 5, and 7.

Dr. Virginia McLemore (Co-PI) is the Principal Senior Economic Geologist for the NMBGMR - Tasks 1, 2, 3, 5 and 7.

Dr. Robert Balch (PM) is the Project manager for this project and is the Director of the PRRC – Task 1, 2, 4 and 7.

Dr. William Ampomah (Co-PI) is a Research Engineer and Section Head at PRRC – Task 1, 4, 5 and 7.

Dr. Sai Wang is a Research Associate at PRRC - Tasks 4.

Dr. William Chavez is a professor in the Mineral Engineering department at New Mexico Tech – Task 2 and 3.

Mr. Mark Leo-Russell is the NMBGMR database specialist - Task 2 and 3.

Mr. Mark Mansell: is the NMBGMR GIS specialist - Task 2.

Ms. Cynthia Connolly is the Education Outreach Manager at the NMBGMR – Task 7.

Dr. Shari Kelley is a senior field geologist and geophysicist at the NMBGMR – Task 2 and 7.

Mr. Christopher Armijo is the NMBGMR computer specialist - Task 1 and 2.

Mr. Brian Wheeler is the NMBGMR fleet manager - Tasks 2 and 3.

Ms. Gretchen Hoffman is the NMBGMR emeritus coal geologist - Task 2 and 3.

Mr. Evan Owen is Economic Geologist at NMBGMR- Task 2 and 3.

Sandia National Laboratories(SANL)

Dr. Jason Heath is a hydrogeologist at SANL. –Task 2 and 5.

Dr. Guangpring Xu is an experimental geochemist at SANL - Tasks 2, 3 and 5.

Dr. Mark J Rigali

San Juan College

Dr. John Burris: is a Professor of Geology and Department Chair at San Juan College - Tasks 7.
Summer Begay
Craig J. Williams

Los Alamos National Laboratory (LANL)

Dr. Kirsten Sauer is a Scientist at LANL - Task 5.
Dr. Hakim Boukhalfa is a Senior Scientist at LANL – Task 5
Dr. Sam Clegg is Senior Scientist at LANL – Task 2
Dr. Brent Goehring

SonoAsh

Mr. Claudio Arato is the CTO of SonoAsh company - Task 3, 4, 5, 6 and 7.
Mr. Brad MacKenzie is the VP of SonoAsh company – Task 4 and 6
Bruce Sifton

B. Change in support levels of key persons

Dr. Rajesh Pawar had shifted his responsibilities on this project to Dr. Kirsten Sauer.
Craig Williams and Summer Begay are now representing San Juan College.
Evan Owen added to project at NMBGMR to assist with Tasks

4. SPECIAL REPORTING REQUIREMENTS: Mandatory

No update

5. BUDGETARY INFORMATION: MANDATORY

See separate report

6. REFERENCES

7. APPENDICES

APPENDIX 1. List of SOPs and plans

(see <https://geoinfo.nmt.edu/staff/mclemore/REEinCoalWeb.html> for copies as they are completed)

Number	Name	Description
HASP	Health and Safety Plan (HASP)	Health and safety plan for field and laboratory work (https://geoinfo.nmt.edu/staff/mclemore/documents/HASP_v2.pdf)
FSP	Field Sampling Plan (FSP)	Field sampling plan (https://geoinfo.nmt.edu/staff/mclemore/documents/samplingplan_v3.pdf)
SOP 1	Data management	entering, reporting, verification, and validation of data to the database
SOP 2	Photography	procedures taking photographs in the field and laboratory
SOP 3	GPS surveying	Procedures for use of handheld GPS surveying
SOP 4	Sampling outcrops, rock piles, and drill core	field procedures for taking surface solid samples
SOP 17	Drillhole logging	procedures for drilling, logging, and sampling of subsurface samples (solids) (https://geoinfo.nmt.edu/staff/mclemore/documents/SOP17DrillholeLoggingupdated.pdf)
SOP 6	Soil paste pH and paste conductivity	laboratory procedures for soil paste pH and paste conductivity
SOP 7	Field measurements of water	field procedures for measuring water flow, pH, conductivity, alkalinity, temperature when collecting water samples
SOP 8	Surface water and seep sampling	field procedures for collecting samples of surface and seep water samples
SOP 9	Petrographic analysis	laboratory procedures for describing petrographic samples
SOP 10	Electron microprobe analyses	laboratory procedures use for analyses using the electron microprobe
SOP 12	X-ray diffraction (XRD) analyses	laboratory procedures for mineralogical analyses by x-ray diffraction (XRD)