New Mexico Geological Society

Proceedings Volume
The Energy Transition
2024 Annual Spring Meeting
Macey Center
New Mexico Tech
Socorro, NM

NEW MEXICO GEOLOGICAL SOCIETY
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April 19, 2024

The Energy Transition in New Mexico

Ken Wisian, ***Featured Speaker***

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New Mexico Geological Society
2024 Annual Spring Meeting
April 19, 2024

Introduction
Auditorium: *8:00 AM - 8:15 AM*

Earth Science Achievement Award
Auditorium: *8:15 AM - 8:30 AM*

The Energy Transition in New Mexico:
Auditorium: *8:30 AM - 10:30 AM*
Chair: Shari Kelley

STATUS OF THE RIOSOL TRANSMISSION LINE PROJECT
—Dennis Loria
8:30 AM - 8:45 AM
RESERVOIR CHARACTERIZATION AND MANAGEMENT OF THE RADIUM SPRINGS GEOTHERMAL SYSTEM FOR HEATING A LARGE GEOTHERMAL GREENHOUSE AT MASSON RADIUM SPRINGS FARM
—James C. Witcher
8:45 AM - 9:00 AM
USING NEW MEXICO'S UNIQUE GEOLOGY, HYDROLOGY, AND TOPOGRAPHY TO DEVELOP PUMPED-STORAGE HYDROELECTRIC (PSH) FACILITIES IN SUPPORT OF RENEWABLE ENERGY GENERATION, STORAGE, AND DISTRIBUTION
—R. Keith Julian
9:00 AM - 9:15 AM
MAPPING GEOTHERMAL RESOURCES USING AI/ML
—Tracy Kliphuis, Hope Jasperson, and Velimir Vesselinov
9:15 AM - 9:30 AM
EVOLUTION OF HYDRAULIC FRACTURE PERMEABILITY IN EGS CONSIDERING NATURAL FRACTURE COMPRESSIBILITY AND STRENGTH OF THE SURROUNDING ROCK
—Matthew L. McLean, D. Nicolas Espinoza, and Bulbul Ahmmed
9:30 AM - 9:45 AM
3D SEISMIC IMAGING AND FAULT DETECTION AT THE LIGHTNING DOCK GEOTHERMAL FIELD
—Lianjie Huang
9:45 AM - 10:00 AM
RAPIDLY PROSPECTING FOR ADVANCED, ENHANCED, AND CAGED GEOTHERMAL POWER GENERATION
—Luke P. Frash, Bulbul Ahmmed, and Bijay K C
10:05 AM - 10:15 AM
THE RIO GRANDE RIFT, MINING, AND GEOTHERMAL ENERGY
—Frederick Henderson
10:15 AM - 10:30 AM

Hydrology and Geomorphology:

Chair: Mark Leo-Russell

Galena Room: *9:30 AM - 10:30 AM*

DETERMINING KEY FACTORS IN WELL SELECTION CRITERIA FOR NAVAJO TECHNICAL UNIVERSITY-NEW MEXICO TECH-NAVAJO NATION WATER PURIFICATION PROJECT (N^4WPP)

—Taylor Cecelia Yazzie, Bonnie Frey, Daniel Cadol, Ranalda Tsosie, Laila Sturgis, Emily Woolsey, and Abhishek Roychowdhury

9:30 AM - 9:45 AM

GEOHYDROLOGIC FRAMEWORK OF THE MONUMENT DRAW TROUGH IN SOUTHEASTERN NEW MEXICO: IMPLICATIONS FOR WATER RESOURCE USES FOR MUNICIPAL DRINKING WATER AND THE OIL AND GAS INDUSTRY

—Paul Drakos, Meghan Hodgins, and Jim Riesterer

9:45 AM - 10:00 AM

GEOMORPHOLOGY OF THE SOUTHERNMOST WEST MESA ESCARPMENT, PETROGLYPH NATIONAL MONUMENT, ALBUQUERQUE, NEW MEXICO

—William C. Haneberg and Sean D. Connell

10:00 AM - 10:15 AM

LATE HOLOCENE CLIMATE CHANGE AND THE EXPANSION AND CONTRACTION OF THE CHIHUAHUAN DESERT BASED ON SOIL, GEOMORPHIC, ISOTOPIC, AND MACROBOTANICAL EVIDENCE AT THE CAÑADA ALAMOSA ARCHAEOLOGY PROJECT, NEW MEXICO

—Curtis Monger, Karl Laumbach, Julia Kelson, Virginia McLemore, and Richard Holloway

10:15 AM - 10:30 AM

Break

Upper Lobby: *10:30 AM - 10:45 AM*

Honoring Charles Chapin and Don Owen

Auditorium: *10:45 AM - 11:00 AM*

Keynote Address:

Main auditorium: *11:00 AM - 12:00 PM*

RURAL GEOTHERMAL POTENTIAL: A CASE STUDY FOR PRESIDIO COUNTY TEXAS

Ken Wisian

Lunch

On your own (if not attending mixer): *12:00 PM - 1:30 PM*

Critical Minerals:

Auditorium: *1:30 PM - 3:45 PM*

Chair: Virginia McLemore

LITHIUM CLAY DEPOSITS IN THE MCDERMITT CALDERA, NEVADA - OREGON: CHARACTERISTICS AND CONTRIBUTIONS FROM CLOSED-HYDROLOGIC SYSTEM DIAGENESIS (CHSD) AND POSSIBLE HYDROTHERMAL ACTIVITY

—Christopher D. Henry

1:30 PM - 1:45 PM

Petrographic and Paragenetic Analysis of Arsenide Five-Element Vein Mineralization in the Black Hawk District, Grant County, New Mexico
—Zohreh Kazemi Motlagh, Virginia T. McLemore, Evan Owen, and William Chávez
1:45 PM - 2:00 PM

Geochronology and Critical Mineral Potential of Selected Laramide Porphyry and Related Deposits in Southwest New Mexico
—Kyle T. Stafford, Virginia T. McLemore, and Nels A. Iverson
2:00 PM - 2:15 PM

Alteration and Geochemistry of Clinkers in the San Juan Basin, New Mexico
—Devlon R. Shaver and Virginia T. McLemore
2:15 PM - 2:30 PM

A stream-sediment geochemical survey for critical minerals in the Zuni Mountains, Cibola and McKinley Counties, New Mexico
—Virginia T. McLemore, Evan J. Owen, Brielle Hunt, and Exploration Geochemistry Fall Class
2:30 PM - 2:45 PM

The behavior of Er in hydrothermal fluids at supercritical conditions, varying pH and salinity and applications to REE mineralization in IOA deposits
—Charles Kershaw, Nicole Hurtig, Alexander Gysi, Artas Migdisov, Larua Waters, and Daniel Harlov
2:45 PM - 3:00 PM

Apatite Rare Earth Elements Chemistry and Fluid Inclusion Study in Hydrothermal Veins of the Lemitar Mountains Carbonatite, New Mexico
—Eric L. Ruggles, Nicole Hurtig, Alexander Gysi, Virginia T. McLemore, and Jay Thompson
3:00 PM - 3:15 PM

Comparative Mineralogy of the 5-Element Arsenide Vein Systems of the Black Hawk District, Grant County, New Mexico
—Jakob Newcomer, Virginia McLemore, Nicole Hurtig, and Zohreh Kazemi Motlagh
3:15 PM - 3:30 PM

Geochemistry of critical minerals in mine waste at Hillsboro and Steeple Rock districts, New Mexico
—Abena Serwah Acheampong-Mensah, Virginia T. McLemore, Nicole Hurtig, and Alexander Gysi
3:30 PM - 3:45 PM

General Geologic Topics:

Chair: Dan Koning

Galena Room: *1:30 PM - 3:15 PM*

Newly discovered stromatolites and bimodal magmatism at ~1.23 Ga in the Burro Mountains of New Mexico: Mesoproterozoic rifting formed a shallow ocean basin in southwestern Laurentia
—Amit Millo, Jeff Amato, and Jordan Bell
1:30 PM - 1:45 PM

Incorporating automated earthquake detection methods for real-time earthquake monitoring in Delaware Basin, southeastern New Mexico
—Urbi Basu, Susan Bilek, and Mairi Litherland
1:45 PM - 2:00 PM
Learn, Connect, Protect: The National Cave and Karst Research Institute's 2024 Education and Outreach Program
—Devra E. Heyer and Daniel S. Jones
2:00 PM - 2:15 PM
Normal Faults in the San Juan Basin: Preliminary Report on Their Prevalence and Significance
—Kevin M. Hobbs
2:15 PM - 2:30 PM
Age Constraints On Late Cretaceous Dinosaurs: Geochronologic And Stratigraphic Analysis Of The Mcrae Formation Within The Laramide Love Ranch Basin, New Mexico
—Emma E. Schantz and Jeffrey M. Amato
2:30 PM - 2:45 PM
Lake Socorro and the 7.4-7.0 Ma fluvial integration of the ancestral Rio Grande through the Socorro Basin, south-central New Mexico
—Daniel J. Koning, Matthew T. Heizler, and Richard M. Chamberlin
2:45 PM - 3:00 PM
Geochemical Evolution and ^{40}Ar/^{39}Ar Geochronology of the Uvas Basaltic Andesite: Insights into the Early Rio Grande Rift
—Lee H. Hughes, Jeffrey M. Amato, and Julia Ricci
3:00 PM - 3:15 PM

Posters:

Upper Lobby: *3:00 PM - 5:00 PM*

Extracting Aluminum Oxide From Kaolinite
—Janin Essary, Virginia McLemore, and Paul Fuierer
Booth: *1*
Assessing microbial communities associated with critical minerals in historic mine waste in central New Mexico
—Mackenzie B. Best, Daniel S. Jones, and Virginia McLemore
Booth: *2*
Hydrothermal Rare Earth Elements (REE) Partitioning into Fluorite: A Fluid Inclusion Study from the Gallinas Mountains REE-bearing Fluorite Deposit, NM
—Aadish Velmani, Alexander Gysi, and Nicole Hurtig
Booth: *3*
Stratigraphic Analysis for Correlativity of Geophysical and Geochemical Properties With Lithology: Rare Earth Element Occurrence in the Late Cretaceous Fruitland Formation
—Sam Fire, Valentina Robledo, and Virginia T. McLemore
Booth: *4*
Investigating Critical Minerals in Laramide Copper Porphyry Systems of New Mexico
—Isabella Cerchiaro Sanchez, Anita Appah, Kyle Stafford, Virginia McLemore, and Evan Owen
Booth: *5*

Humates Used as a Filtering Medium for Uranium
—Brianna Whitney Detsoi, Bonnie Frey, and Virginia McLemore
Booth: *6*
Rare earth elements and major constituents in surface water from Lee Ranch Mine
—John J. Lempke, Bonnie Frey, and Virginia McLemore
Booth: *7*
Reconnaissance Survey of Volcanic Caves and Cave Microbial Communities at Capulin Volcano National Monument, Nm
—Joseph R. Hoberg, Anika Baloun, Jimmy Swift, Abigail Brown, Georgia N. Schneider, Patricia E. Seiser, and Daniel S. Jones
Booth: *8*
Developing Accessible Resources for Education and Training in Cave Science
—Daniel M. Runyan, Devra Heyer, Raquel Lugo, and Daniel S. Jones
Booth: *9*
Developing Accessible Visualizations of Geophysical and Geochemical Processes for Cave and Karst Education.
—Raquel Lugo, Devra Heyer, Daniel S. Jones, and Valerie Davis
Booth: *10*
Evaluating chemical weathering in a small catchment in New Mexico's Black Range to explore implications for limestone dissolution and regional solution caves.
—Sharon B. Minnix, Daniel S. Jones, and Veronica Prush
Booth: *11*
Nitrogen, Sulfur, and Carbon-Cycling Capabilities of Microbial Communities From Desert Cave Systems
—Katelyn Mary Green, Abigail R. Brown, Zoe E. Havlena, Mackenzie B. Best, Diana E. Northup, and Daniel S. Jones
Booth: *12*
Geologic Mapping in New Mexico: An Update on the New Mexico STATEMAP Program
—Matthew J. Zimmerer, Michael Timmons, Phil Miller, Jake Ross, Siânin Spaur, and Daniel Lavery
Booth: *13*
Hydrologic Response of the Gallinas River to the Spring Snowmelt Post-2022 Hermits Peak/Calf Canyon Fire; Y2
—Jennifer Lindline and Mary Frances Bibb
Booth: *14*
Eliminating human error during drilling: the first step toward automating optimized geothermal drilling
—Noah Frederick Hobbs, Bulbul Ahmmed, Luke Philip Frash, and Meng Meng
Booth: *15*
Evaluating Segmentation Behavior Along the Alamogordo Fault, central New Mexico, Using Neotectonic Mapping, Soil Chronosequences, and Geodynamic Modeling
—George Pharris, Veronica Prush, and John Naliboff
Booth: *16*

QUANTIFYING DEFORMATION OF CARBONATE ROCKS ALONG THE ALAMOGORDO FAULT, SOUTH-CENTRAL NEW MEXICO
—Antonio Chavez, George Pharris, and Veronica B. Prush
Booth: *17*
STRATIGRAPHY AND PROVENANCE OF THE BACA FORMATION IN THE BACA AND CARTHAGE-LA JOYA BASINS, CENTRAL NEW MEXICO
—Kristen Hashberger, Ryan Leary, and Veronica Prush
Booth: *18*
NEW ^{40}AR/^{39}AR DETRITAL SANIDINE GEOCHRONOLOGY FROM THE EOCENE SAN JOSE FORMATION, EASTERN SAN JUAN BASIN, NORTHWESTERN NEW MEXICO
—Nicole Joy Salladin, Thomas A. Valenzuela, Brian A. Hampton, Kevin M. Hobbs, Matt T. Heizler, and Julia Ricci
Booth: *19*
GEOLOGIC MAPPING, STRUCTURAL ANALYSIS, AND MICROPROBE ANALYSIS OF THE MAZATZAL PROVINCE IN THE SALINAS PEAK REGION, SAN ANDRES MOUNTAINS
—Alexis Osegueda Salmeron, Jeffrey Amato, and Gideon Kuykendall
Booth: *20*
PRELIMINARY GEOCHRONOLOGICAL RESULTS FROM THE FRA CRISTOBAL RANGE OF SOUTH-CENTRAL NEW MEXICO – REVISION OF CRETACEOUS-AGE UNITS TO SANTA FE GROUP
—Kyle K. Gallant, Veronica Prush, and Shari Kelley
Booth: *21*
APPLICATIONS OF UAS MULTISPECTRAL IMAGERY IN THE EARTH AND ENVIRONMENTAL SCIENCES - GEOSPATIAL APPLICATIONS IN NATURAL SCIENCES LABORATORY
—Michael S. Petronis, Joesph P. Zebrowski, Marine S. Foucher, and Jennifer Lindline
Booth: *22*
PALEOMAGNETIC DATA AND EMPLACEMENT STYLE OF TRACHYANDESITE INTRUSIONS ASSOCIATED WITH THE ERUPTION OF THE GÓRY SUCHE RHYOLITIC TUFFS, POLAND
—Madison Marie Allcorn, Marine S. Foucher, Michael S. Petronis, Marek Awdankiewicz, and Sam Poppe
Booth: *23*
SURFACE WATER AND SNOWPACK MODELING WITH EMPHASIS ON POST-WILDFIRE HYDROLOGIC IMPACTS IN THE SANTA FE WATERSHED, NM
—Joseph Kuljis
Booth: *24*
MULTIYEAR MONITORING OF AN EXPERIMENTAL WATERSHED AND SEISMIC MODELING OF BEDLOAD TRANSPORT IN GRAVEL-BED ALLUVIAL CHANNEL
—Loc Luong and Daniel Cadol
Booth: *25*
EXPLORATION FOR CRITICAL MINERALS RESOURCES IN THE ZUNI MOUNTAINS, NM
—Brielle Hunt, Virginia McLemore, Evan Owen and Nicole Hurtig
Booth: *26*
POST-WILDFIRE DEBRIS FLOW RISK ASSESSMENT MAPPING FOR INTERBASIN WATER TRANSFERS IN THE SOUTHERN AND CENTRAL ROCKY MOUNTAINS.
—Abelino Fernandez Leger and Daniel Cadol **Booth:** *27*

Abstracts

GEOCHEMISTRY OF CRITICAL MINERALS IN MINE WASTE AT HILLSBORO AND STEEPLE ROCK DISTRICTS, NEW MEXICO

Abena Serwah Acheampong-Mensah[1], Virginia T. McLemore[2], Nicole Hurtig[1] and Alexander Gysi[1]

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Most of our electronic equipment, such as smartphones, laptops, computer chips, wind turbines, hybrid and electric cars, etc., depend on rare earth elements (REE) and other critical minerals. This coupled with the anticipated rise in demand for critical minerals and the potential shortage of production capacity from China and other nations has made it necessary to examine New Mexico (NM) mine wastes for critical mineral and future mining potential. In the 274 mining districts in NM, including those for coal, uranium, metals, and industrial minerals, there are tens of thousands of inactive or abandoned mine features. These features range in depth from shallow prospect pits to 500-feet-deep mine shafts. To comprehend its composition, accurately estimate its volume, and determine its potential economic value, it is imperative to categorize these wastes. Hence this project seeks to: 1) characterize and estimate the critical mineral endowment of mine wastes in two mining districts in NM (i.e., Copper Flat at Hillsboro and Carlisle-Center mines in Steeple Rock district), 2) “beta-test” USGS procedures for sampling mine wastes. Future mining of mine wastes that potentially contain critical minerals can help pay for reclamation and clean up these sites. Critical mineral endowment of mine wastes in two mining districts in New Mexico (Copper Flat at Hillsboro and Carlisle-Center mines in the Steeple Rock district) were characterized and estimated. Potential critical minerals at these deposits include As, Bi, Te, Zn, Co, Ni, Mg, Mn, and fluorite. pH and particle size of samples were analyzed to determine weathering and migration potential of heavy metals. Soil pH was also measured to determine the potential for acid rock drainage for several mine waste. The S present in samples from Carlisle-Center mines are mostly acid forming and can potentially cause acid mine drainage that can dissolve other minerals. Samples from Copper Flat that are nonacid forming may be used as back fill material. Most of the waste rock pile at Copper Flat is characterized by a relatively coarse sand fraction. Difference in particle size fractions and the distribution along the slope are generally influenced by natural occurrences (e.g., gravity and pre-mining hydrothermal alteration) and operational activities such as material piling or dumping. Further studies includes analyses of geochemistry of different particle fractions to ascertain any existing correlation between mineralogy and particle size. Also, a bulk density test should be conducted to compute for the mass of mine waste piles and thus estimate the critical mineral endowment of the studied mine waste areas.

PALEOMAGNETIC DATA AND EMPLACEMENT STYLE OF TRACHYANDESITE INTRUSIONS ASSOCIATED WITH THE ERUPTION OF THE GÓRY SUCHE RHYOLITIC TUFFS, POLAND

Madison Marie Allcorn[1], Marine S. Foucher[1], Michael S. Petronis[1], Marek Awdankiewicz and Sam Poppe

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Volcanism in the Intra-Sudetic Basin occurred in the Carboniferous and culminated in the Permian with caldera forming eruptions along the present-day Czech-Polish border. Volcanism was followed by the emplacement of trachyandesite intrusions that outcrop sparsely in the region. The apparent intrusive geometry includes laccoliths and sills emplaced along an accurate belt that rings the remains of an ignimbrite caldera that erupted the Góry Suche Rhyolitic Tuffs (GSRT). The GSRT outcrop within a NW-SE trending belt that is 50 km long and up to 10 km wide. It is estimated to have an eruption volume in the hundreds of cubic kilometers, similar to that of the northern New Mexico Bandelier Tuff ignimbrites which are the result of a super volcano eruption from one of Earth's largest and youngest calderas, the Valles Caldera. The exposed floor and ceiling of several GSRT intrusive bodies reveal that they are a single laccolith while others occur as stacked sills, and/or inclined sills crosscutting the intrusive rocks. The intrusions are dominated by coherent cores with thin envelopes of intrusive breccias and peperites along the margins. The host rocks along the contacts are strongly tilted and folded, with fold amplitudes ranging from decimeters to meters in length. The sedimentary host rocks adjacent to trachyandesites are variably recrystallized and locally silicified but lack signs of contact metamorphism. Our research aims to better understand the complex geometries and emplacement dynamics of trachyandesite intrusions exposed at two active quarries, Gardzien and Tlumaczów, and two partly flooded quarries, Swierki and Gluszyca, along the Polish-Czech border. The rock types at the four locations are similar and may indicate that the intrusions at the four quarries are connected at depth. These field sites provide a unique opportunity for the National Science Foundation supported International Research Experience for Student 2024 team to further our studies. The goals of this research are to better understand the magma plumbing system and igneous geometry. Preliminary anisotropy of magnetic susceptibility (AMS) data indicate that most of the sampled sites yield an oblate magnetic fabric. The inferred magma flow directions reveal a complex flow pattern throughout the quarry. AMS data from outcrops located near the floor and roof of the intrusion yield oblate magnetic fabrics that parallel the contacts. Prolate susceptibility ellipsoids are rare. Preliminary rock magnetic experiments suggest that the magnetic fabric is composed of multidomain grains of low-Ti titanomagnetite compositions, some evidence of maghemite, and another magnetic mineral phase potentially an iron-sulfide phase. Paleomagnetic data yield a high coercivity, characteristic remanent magnetization carried by titanohematite, that plots near the expected late Paleozoic direction, and a secondary component of magnetization, carried by titanomagnetite. The active quarries at Gardzien and Tlumaczów provide three-dimensional exposure of trachyandesite intrusive geometries and contact relationships. The ongoing exploration will offer additional insight into the nature of Permian igneous activity associated with the Góry Suche caldera eruption and emplacement of the post-caldera trachyandesite intrusions specifically and catastrophic caldera-forming eruptions in general.

INCORPORATING AUTOMATED EARTHQUAKE DETECTION METHODS FOR REAL-TIME EARTHQUAKE MONITORING IN DELAWARE BASIN, SOUTHEASTERN NEW MEXICO

Urbi Basu[1], Susan Bilek[2] and Mairi Litherland[3]

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Recent increases in seismicity due to anthropogenic activities in southeast New Mexico, USA have demonstrated the need for timely earthquake detection and updated catalogs of seismicity in this region. Previously, earthquake detection and location in this region was performed manually; automated detection methods can improve efficiency, accuracy, and completeness of earthquake catalogs, which is essential in understanding and reacting to induced seismicity. This study tested several existing automated earthquake detection tools from general waveform template matching technique to more sophisticated machine learning algorithms to assess the efficiency of these tools in event detection within our seismic network in southeast New Mexico. The study incorporated continuous waveform data of multiple seismic stations from multiple seismic networks such as New Mexico Tech seismic network, USGS, Nanometrics research network, and the Texas seismological network and evaluated the detections from multiple stations to generate an earthquake detection catalog. Standard template matching results are compared with global deep learning tools, the EQTransformer (Mousavi et., 2020) and the PhaseNet auto picker (Zhu and Beroza, 2019). The automated detections from the three methods are compared with an earthquake catalog derived for the study period through manual analyst review. We used these catalog comparisons, specifically the numbers of missed and false detections, in conjunction with ability to implement the automated tool within our routine network operations to select an appropriate automated tool for the network. EQTransformer had the lowest false detection rate of 13%, whereas PhaseNet detected the most number of events amongst the three methods. Considering the ease of implementation, false detection rate and computational resources required, EQTransformer was preferred as the automated earthquake detection tool for our real-time earthquake monitoring workflow. The chosen automated tool was further applied to continuous dataset for the year 2020 to build more detailed and complete catalogs for the seismically active southeast New Mexico. This automation will advance our ability to provide the timely earthquake detection and location that is needed in this significant region of the Delaware basin.

References:

Mousavi, S. M., Ellsworth, W. L., Zhu, W., Chuang, L. Y., & Beroza, G. C. (2020). Earthquake transformer—an attentive deep-learning model for simultaneous earthquake detection and phase picking. *Nature communications*, *11*(1), 3952.

Zhu, W., & Beroza, G. C. (2019). PhaseNet: a deep-neural-network-based seismic arrival-time picking method. *Geophysical Journal International*, *216*(1), 261-273.

Keywords: Induced Seismicity, automated earthquake detection, machine learning

ASSESSING MICROBIAL COMMUNITIES ASSOCIATED WITH CRITICAL MINERALS IN HISTORIC MINE WASTE IN CENTRAL NEW MEXICO

Mackenzie B. Best[1], Daniel S. Jones[1] and Virginia McLemore[2]

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Critical minerals and the elements they contain are at the forefront of the transition to clean energy and technological advancement. As such, global demand for these commodities is at an all-time high. To help meet domestic demand in the US, there is a push to quantify critical minerals in the US in both active and inactive mining sites and districts. New Mexico has a long history with mining, and many of its districts, though currently inactive, at one time produced mineral commodities that may be associated with critical minerals. These historic districts range widely in age, and many were operating when metallurgical processing technologies were in their infancy and, as a result, contain substantial critical mineral resources in their tailings and waste rock. Microbial communities that have developed in the decades since might have contributed to metal mobilization, but also represent a resource for bioremediation or potential 'green mining' of these deposits in the future. After extensive method development, we have begun characterizing the microbial communities inhabiting these waste rock piles using modern molecular microbiological techniques, and will present new data about the composition and abundance of microorganisms in historic mine waste. Preliminary data analysis indicates that microbial communities more closely resemble local soil microbiomes than traditional acid rock drainage (ARD) or bioleaching microbial communities. This is particularly evident when comparing the microbial community composition and diversity of waste rock piles that were topped with a soil cover to those with no soil cover. However, rare sulfur- and metal-oxidizing populations exist, and the waste rock piles contain abundant undescribed microorganisms with unknown metabolic capabilities. Our preliminary results show that there is a correlation between microbial communities and mine waste type, and we will continue to explore how waste geochemistry controls microbial diversity and the occurrence specific microbial populations.

Investigating Critical Minerals in Laramide Copper Porphyry Systems of New Mexico

Isabella Cerchiaro Sanchez[1], Anita Appah[1], Kyle Stafford[1], Virginia McLemore[2] and Evan Owen[2]

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The term "copper porphyry" refers to large, low-grade copper deposits associated with intermediate to felsic plutons with visible large crystals (porphyritic texture). Understanding porphyry copper systems has revolutionized exploration, mining, and processing techniques. The Southwest North American porphyry copper province, encompassing parts of Arizona, New Mexico, far western Texas (US), and Baja California, Sonora, Sinaloa, and Chihuahua (Mexico), is a prime example, known for its rich deposits of copper, molybdenum, gold, and silver. In New Mexico, these deposits are concentrated in the southwest portions of the state in Sierra, Grant, and Hidalgo Counties. Beyond copper, these porphyry systems harbor valuable critical minerals. Studies have identified potential byproducts recoverable during copper processing. Examples include Platinum Group Elements, tellurium, indium, gallium, cobalt, nickel and selenium that are found as micro-inclusions or as solid solution in minerals. Some of these critical minerals are obtained from the anode slimes that are produced as a result of copper smelting and refining. Additionally, various critical minerals have been identified in New Mexico's copper porphyry mining districts. These include copper ore minerals, zinc, fluorine, manganese, beryllium, bismuth, niobium, rare earth elements (REE), tellurium, and tungsten. Geochemical data from the Eureka, Hillsboro, Copper Flat, Sylvanite, and Tres Hermanas districts were used for this analysis, as well as existing literature from mining and mineralogical records. This study seeks to investigate critical mineral potential in the Laramide porphyry systems in New Mexico by logging existing drill core from various Laramide mining districts, whole rock and trace element geochemical analyses, and other means.

Keywords:

Critical minerals, copper porphyry, Laramide

QUANTIFYING DEFORMATION OF CARBONATE ROCKS ALONG THE ALAMOGORDO FAULT, SOUTH-CENTRAL NEW MEXICO

Antonio Chavez[1], George Pharris[1]and Veronica B. Prush[1]

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Understanding how deformation is distributed within crustal rocks is central to studies of earthquake hazards and deformation processes. To address this question, we investigate how deformation is distributed in carbonate bedrock adjacent to the Alamogordo fault in south-central New Mexico. Our study area is Mule Canyon in the foothills of the Sacramento Mountains near Alamogordo, New Mexico.

To quantify fault activity, we produced a 1:5,000 neotectonic map documenting the offset of Quaternary geomorphic surfaces. To assess bedrock fracture densities, we analyzed the number of fractures, their orientations, and the types of veining we observed at 14 points within the canyon. All bedrock measurements were made within the Montoya Formation, a crystalline dolomite with lenses of massive quartz. At each point, a 1.4-meter circle was drawn on the bedrock surface, and the number of fractures was recorded. We also measured the orientation (strike and dip) of bedding and fractures, bedding thicknesses, and any development of secondary mineral precipitation. The data from the neotectonic mapping and bedrock fracture analysis correlates the number of fractures with the distance from the Alamogordo fault. We observed a decrease in the number of fractures and karst features in the bedrock with increasing distance from the fault zone.

Keywords:

Faults, Carbonates, Alamogordo fault, Alamogordo

Humates Used as a Filtering Medium for Uranium

Brianna Whitney Detsoi[1], Bonnie Frey[2] and Virginia McLemore[2]

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In New Mexico there were as many as 28 uranium mining districts that were active from 1951-1980. In these mining districts there were many sites and areas that have been contaminated with uranium. Contamination at mine sites extends to soils, sediments and water. The cost of remediation is well into the millions of dollars and can be a burden on the nearby communities. I am exploring the possibility of using a resource for filtration that is readily available around the world: humates. Humates are a byproduct of coal that is mostly comprised of plant material that is rich in minerals; commonly used in agriculture. Humates are abundant in coal mines around the world and when not used for agricultural purposes, they tend to be cast aside. Preliminary batch capacity testing has demonstrated that the humates are capable of pulling uranium out of solution.

Keywords:

Environmental, Uranium Remediation, Filters, Humates

Geohydrologic Framework of the Monument Draw Trough in Southeastern New Mexico: Implications for Water Resource Uses for Municipal Drinking Water and the Oil and Gas Industry

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The City of Jal (COJ or the City), located in the Permian Basin in southeastern New Mexico, obtains its entire drinking water supply from the Tertiary - Quaternary-age Pecos Valley Alluvial (PVA) aquifer and obtains non-potable (higher total dissolved solids [TDS]) water for Jal Lake and municipal parks from the Triassic Santa Rosa Sandstone aquifer. The City is therefore entirely reliant on groundwater for its water supply and produces water from wells drilled to depths ranging from 400 to 800 ft. The same aquifers that COJ relies on are also the target for use in non-conventional oil and gas (O&G) development (hydraulic fracturing, AKA fracking), and wells that produce water for the O&G industry are located in close proximity to COJ wells.

In an effort to better understand this aquifer system, we have conducted a basin analysis of the northern Monument Draw Trough, a collapse structure within the Delaware Basin (one of the subbasins within the Permian Basin), utilizing natural gamma logs from the New Mexico Oil Conservation Division (OCD) on-line database, lithologic and borehole geophysical data from the COJ exploratory drilling program, New Mexico Office of the State Engineer (NMOSE) well records, geologic mapping, and an aquifer testing program using new and existing COJ production wells. Our analysis focused on the upper 2500 ft of Permian and Triassic evaporite and clastic sedimentary rocks overlain by eolian, fluvial, and lacustrine sediments of the PVA that fill the Monument Draw Trough, which was formed as a result of dissolution of Permian evaporite deposits resulting in the collapse of overlying younger strata. Our analysis demonstrates that collapse of the Permian/Triassic sediments was accommodated, at least in part, by brittle deformation resulting in juxtaposition of PVA and Santa Rosa aquifers against lower permeability lithologies. Basin-bounding faults that delineate a large graben structure can be traced across a series of six east-west cross sections drawn on one-mile spacing, and unit contacts in two north-south cross sections match those determined from the east-west cross sections. Structure contour mapping of the top of the Permian Rustler Formation provides additional evidence for the location of these structures. Several other faults within the basin delineate additional horst and graben structures. GGI's documentation of brittle deformation in a salt-collapse structure provides important new information for understanding these features.

PVA isopach and saturated thickness maps developed from our basin analysis are used in conjunction with the geometric mean of hydraulic conductivity determined from aquifer tests conducted on COJ wells and other wells in the basin to develop a transmissivity array for the PVA in the vicinity of Jal administrative basin for on-going development of a regional groundwater model. Mapped Triassic outcrops and well data are utilized to delineate the northern extent of the saturated PVA in hydrologic communication with the portion of the aquifer tapped by COJ wells. The Santa Rosa Sandstone is absent or unsaturated on the upthrown side of the western basin-bounding fault. Delineation of the northern extent of the PVA and the western extent of the Santa Rosa Sandstone identified through this basin analysis suggests that the water resources available to the City of Jal and other stakeholders in the region are more limited than previously estimated.

Keywords: Jal, PVA, Santa Rosa, Monument Draw

EXTRACTING ALUMINUM OXIDE FROM KAOLINITE

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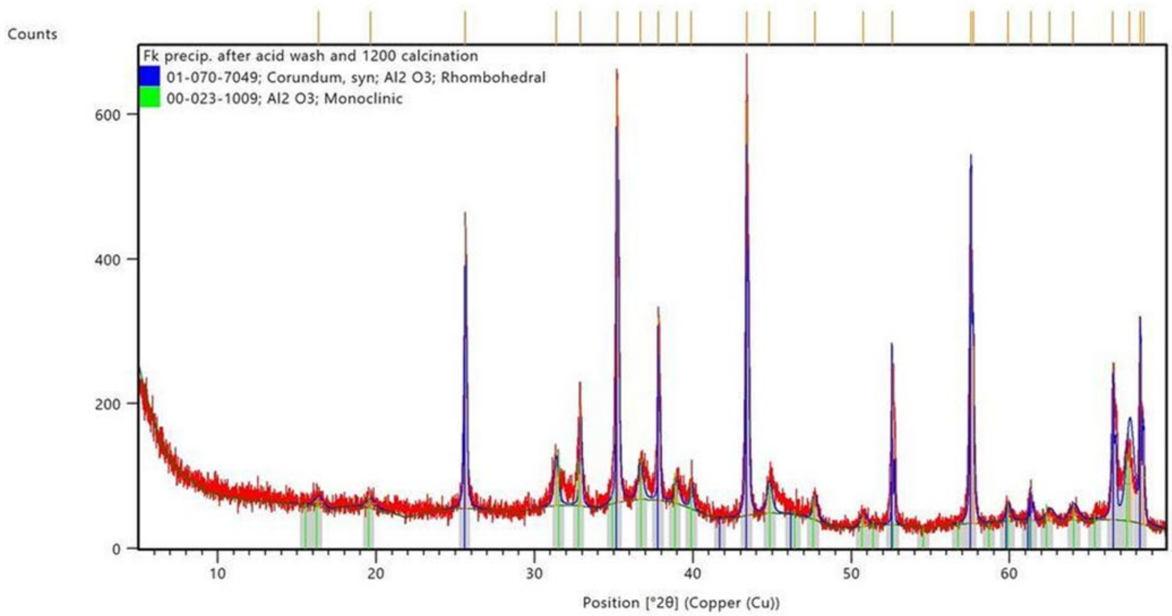
The goal of this research is to identify a procedure suitable for extraction of aluminum oxide, (Al_2O_3) from abundant New Mexico resources. In the interest of economic and environmental viability, the resources of interest include those from prospective, existing or abandoned mines sites.



XRD pattern for product extracted from kaolinite (FK) with acid wash, overlayed with published patterns for corundum (alumina).

The method used for this is a variation of the Seailles-Dyckeroff process (also known as the lime-sinter-process), which is more versatile than the Bayer process used commercially as it can remove alumina from any aluminum containing source, whereas the Bayer Process can only extract alumina from low-silica bauxites. [1] The lime-sinter process can extract alumina from feldspars, clay, shale, coal clinkers, coal, and waste products from other processes (such as the Red Mud left behind in the Bayer Process). The reason for this versatility stems from the lime-sinter step of the process where, after the ore is crushed, it is combined with lime ($CaCO_3$) and pressed into pellets. The pellets are then baked at 1360°C for an hour before cooling overnight in the furnace. This causes a phase change and disintegration into a fine powder. Aluminate ions ($^{-}Al(OH)_4$) are then leached using soda ash (Na_2CO_3). The aqueous slurry is filtered to remove calcium silicates, leaving behind a solution of sodium aluminate ($NaAl(OH)_4$) which is then pumped with CO_2 gas to reduce the sodium aluminate and transform it into gibbsite ($Al(OH)_3$) and sodium oxide (NaO). [2] The gibbsite precipitates out of the solution and is filtered out once the pH lowers from pH 14 to pH 7.5. [3] The precipitate is then dried washed with glacial acetic acid (CH_3COOH) before being heated to 1200°C in order to convert to aluminum oxide. Preliminary research has been carried out on food-grade kaolinite (a fairly abundant mineral with high aluminum content) with promising results. Early experiments without the acid wash step produced beta-alumina upon 1200°C calcination. Later experiments after the addition of the acid wash step resulted in products shown to be α-alumina with corundum crystal structure. The next stages of this research will be optimization of the process for coal, coal clinkers and clay from samples gathered around New Mexico, but it seems like a good replacement procedure has been found.

References:

[1] E.P. Flint, W.F. Clarke, E.S. Newman, L. Shartsis, D.L. Bishop, and L.S. Wells, Extraction of alumina from clays and high.silica bauxites. Part of the Journal of Research of the National Bureau of Standards, 36(RP1691):68–106, 1946.
[2] J.C. Seailles and W.R.G. Dyckerhoff, 1941. RECOVERY OF ALUMINA
[3] N.-K. Park, H.-Y. Choi, D.-H. Kim, T.J. Lee, M. Kang, W.G. Lee, and J.W. Park, Purification of al(oh)3 synthesized by bayer process for preparation of high purity alumina as sapphire raw material. Journal of Crystal Growth, 373:88–91, 2013.

Keywords:

Alumina, aluminum oxide, Al_2O_3, extraction, extractive metallurgy, New Mexico, mine, mine site, alumina extraction from clay, feldspar, kaolin, kaolinite, clinkers, feldspar, aluminum rich coal and shale, El Deeb, Seailles-Dyckeroff, lime sinter method

POST-WILDFIRE DEBRIS FLOW RISK ASSESSMENT MAPPING FOR INTERBASIN WATER TRANSFERS IN THE SOUTHERN AND CENTRAL ROCKY MOUNTAINS.

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Forested headwaters are crucial for surface water supplies in the Southwestern US, and interbasin water transfers – small and large-scale engineering projects that divert water from remote watersheds across drainage divides – move more than 700,000 acre-feet annually to municipalities and irrigators in the Southern and Central Rocky Mountains. Forest fires are well known to impact the quality of water in a watershed from hillside erosion, and post wildfire debris flows threaten to compromise water supply infrastructure entirely. Our project maps the post-wildfire debris flow annual risk probability for Interbasin Water Transfers. We use readily available remote sensing data to estimate the probabilistic contribution of wildfire severity, precipitation intensity, and take advantage of a database of recorded debris flows to estimate the influence of average basin slope on debris flow generation. To properly quantify the risk of post-wildfire debris flows compromising public water supply it is necessary to incorporate the risk of a disruption of water transferred from outside the basin. Our research aims to produce a regional risk map and, in the future, a detailed assessment of the San Juan-Chama Project, providing actionable insights for water resource management, forest management, and infrastructure planning. Preliminary results indicate headwaters in the Southern Rockies and the San Juan Mountains are at higher risk than transfer projects serving the Front Range of Colorado. By filling this research gap on interbasin transfers, this study has the potential to affect public water supply decision-making in New Mexico and the Rocky Mountain Region.

References:

Collar, N.M., and Earles, T.A., 2023, Unique challenges posed by fire disturbance to water supply management and transfer agreements in a headwaters region: Journal of Environmental Management, v. 339, p. 117956, doi:10.1016/j.jenvman.2023.117956.

Siddik, M.A.B., Dickson, K., Rising, J., Ruddell, B., and Marston, L., 2023, Interbasin water transfers in the United States and Canada: Scientific Data, v. 10, doi:10.1038/s41597-023-01935-4.

Staley, D.M., Kean, J.W., and Rengers, F.K., 2020, Data supporting an analysis of the recurrence interval of post-fire debris-flow generating rainfall in the southwestern United States:, doi:10.5066/P9CHY45I.

Keywords:

Interbasin water transfer, wildfire, debris flow, risk mapping, post-wildfire debris flow, headwaters, San Juan Chama Project

STRATIGRAPHIC ANALYSIS FOR CORRELATIVITY OF GEOPHYSICAL AND GEOCHEMICAL PROPERTIES WITH LITHOLOGY: RARE EARTH ELEMENT OCCURRENCE IN THE LATE CRETACEOUS FRUITLAND FORMATION

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The San Juan Basin of northwest New Mexico hosts economically significant organic energy resources that have been developed and studied since the early 1900’s (Shomaker. et. al., 1971; Alamito Coal Company, 1980; Beaumont and Speer, 1981; Reddy, 1981; Hoffman, 2017), including coal from the late-Cretaceous Fruitland Formation - a sequence of mostly siliciclastic sedimentary rocks laid down along a shifting shoreline as the shallow epicontinental sea finally regressed from North America (Shomaker, et. al., 1971; Beaumont and Speer, 1981). The lithostratigraphic subunits of the Fruitland Formation exhibit significant variability in their occurrence, thickness, and arrangement. This variability is directly attributable to complex interplay between the erosive capacity of the sedimentological processes in this marginal-marine depositional system. Fruitland coals are mostly of subbituminous A rank, have low sulfur content, and are highly weatherable (Beaumont, 1981; Hoffman, 2017). These coals were laid down intermittently with a sequence of sandstones, siltstones, shales, claystones and other sediments across a spatially dynamic shoreline. The well-established geometry of the Fruitland Formation along the Chaco Slope provides a solid basis to analyze diagenetic processes (and their respective energetic capacities) controls on the occurrence and distribution of rare earth elements within the associated depositional sequences. Our primary research focus is to quantify these relationships, between the lithological, geochemical, and geophysical character of the coal-bearing Fruitland Formation and to determine the critical minerals potential.

The NM Bureau of Geology has obtained core samples from many drillholes intersecting into the Fruitland Formation in the San Juan Basin. To date, geochemical samples collected as a function of depth were taken from only one Fruitland drillhole (E-61) situated a few miles basinward to the north of the Chaco Slope where the formation is buried more deeply. Though E-61 was sampled in detail across its entire cored interval, challenges arise due to the absence of corresponding geophysical well-log data for this BLM-funded drillhole. Correlation of the lithologic units with their geochemical and geophysical properties requires new samples to be sent for geochemical analyses from drillholes with both core and the accompanying well-preserved, high-resolution wireline geophysical surveys. This poster presents detailed analysis of the Fruitland Formation’s geometry and stratigraphy using this sample selection process.

Acknowledgement: Our research benefited immensely from the stewardship of Amy Trivett and Annabelle Lopez, who manage the records and physical samples at the subsurface library. Their efforts have been crucial to our investigation, providing access to invaluable resources that continue to underpin our work.

References:

Alamito Coal Company, 1980, Gallo Wash Mine, Surface Mine Permit Application and Mine Plan: submitted to the Mining and Minerals Division, State of New Mexico, Santa Fe, New Mexico. *no doi*

Beaumont, E., and Speer, W., 1981, Coal Resources of the San Juan Basin, supplement to Chaco Energy Company's Gallo Wash Mine Surface Mine Permit Application and Mine Plan: submitted to the Mining and Minerals Division, State of New Mexico, Santa Fe, New Mexico. *no doi*

Hoffman, G.K., 2017, Coal Resources, in McLemore V.T., Timmons, S., and Wilks, M., eds., Energy and Mineral Resources of New Mexico: New Mexico Bureau of Geology and Mineral Resources, Memoir 50B, and New Mexico Geological Society, Special Publication 13B. 80 p. ISBN: 978-1-883905-38-5, https://doi.org/10.58799/M-50B

Reddy, M. R., 1981, in Carbon Coal Company: Strip Coal Resources Report of the PRLA Region, San Juan Basin KCRCA, New Mexico * no doi*

Shomaker, J.W.; Beaumont, E.C; and Kottlowski, F.E., 1971, Strippable Low-Sulfur Coal Resources of the San Juan Basin in New Mexico and Colorado in New Mexico Bureau of Mines & Mineral Resources Memoir 25. https://doi.org/10.58799/M-25

Keywords:

Fruitland, Coal, REEs, Sequence Stratigraphy, Wireline Geophysics, Downhole Geochemistry, depositional mechanics, core interperetation

RAPIDLY PROSPECTING FOR ADVANCED, ENHANCED, AND CAGED GEOTHERMAL POWER GENERATION

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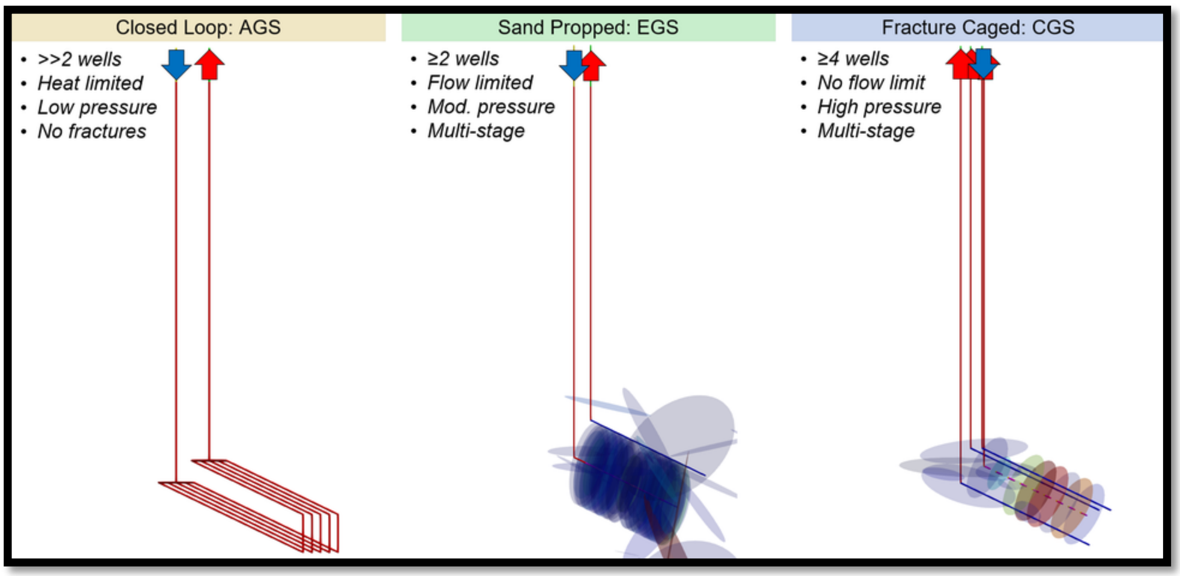
We evaluate unconventional hot dry rock resource potential as a function of development methodology. Methods include closed-loop, sand propped, and fracture caged geothermal systems.



As we seek to expand geothermal development, unconventional resources that lack natural convection are becoming increasingly appealing. However, the viability of developing unconventional hot dry rock resources is directly dependent on both the properties of the resource and the design of the system that will be used to extract its heat. In this presentation, we will explore the prospectivity of undeveloped "greenfield" geothermal resources in parallel with different options for development. More specifically, we will consider closed-loop advanced geothermal systems (AGS), hydraulic fractured and propped enhanced geothermal systems (EGS), and multi-well fracture caged geothermal systems (CGS). In addition, we will consider subsurface uncertainty, fault density, reservoir depth, thermal gradient, and faulting regime. Our cross-comparison of results is founded on economic potential that includes factors such as drilling cost, pumping cost, earthquake risk, and other factors. Ultimately, we find that all three systems offer promise for economic generation of power and heat at previously undeveloped locations in and around New Mexico.

Keywords:

caging, Enhanced Geothermal Systems, EGS, CGS, economics

Preliminary Geochronological Results From the Fra Cristobal Range of South-Central New Mexico – Revision of Cretaceous-Age Units to Santa Fe Group

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The Fra Cristobal range of south-central New Mexico is a north-south striking horst block bounded by the Engle basin to the west and the Jornada del Muerto basin to the east. Phanerozoic units in the range are generally southeast-dipping, exposing Proterozoic-age basement in the northern section of the range. Previous work in the northern section of the range revealed: i) a possible Laramide-age thick-skinned thrust fault, ii) a widespread geothermal system that altered basement rock and Phanerozoic cover, and iii) a previously known but unmapped volcanic tuff. We hypothesize that Precambrian basement rocks overthrust Paleozoic limestones during the Laramide orogeny (~75 Ma; Seager et al., 1997; Amato et al., 2017). After cessation of thrust faulting, the volcanic tuff was emplaced, followed by deposition of trough cross-bedded sandstones previously interpreted as syn-Laramide McRae Formation stratigraphically above the tuff (Nelson, 1986). The tuff's source and timing of emplacement is anomalous in the current understanding of the regional geologic history because the tuff's petrographic properties (for example, relatively large phenocryst size) implies a local caldera source. However, the closest known possible source is the Copper Flat complex, 10's of km away from the range. We therefore sampled the trough cross-bedded sandstone unit and the underlying tuff for $^{40}Ar/^{39}Ar$ dating to clarify the timing of tuff emplacement and subsequent sandstone deposition. Detrital sanidine samples from the sandstone yield a maximum preliminary age of ~24-35 Ma, rather than Cretaceous-age syn-Laramide sedimentation as previously hypothesized. Sedimentation is likely associated with early Rio Grande rift deposition, analogous to the Popotosa Fm. to the north of the range. This observation is an important addition to our understanding of the tectonic evolution of the Fra Cristobal range and will assist in ongoing structural evaluations of its geologic history. Ongoing research will integrate geochronological and thermochronological techniques with sequentially balanced and restored cross-section analysis to further constrain the range's structural evolution from the Laramide to Rio Grande rift tectonic regimes.

References:

Amato, J.M., Mack, G.H., Jonell, T.N., Seager, W.R., and Upchurch, G.R., 2017, Onset of the Laramide orogeny and associated magmatism in southern New Mexico based on U-Pb geochronology: Geological Society of America Bulletin, p. B31629.1, doi:10.1130/B31629.1.

Nelson, E.P., 1986, Geology of the Fra Cristobal Range, south-central New Mexico,*in*Truth or Consequences Region, New Mexico Geological Society, p. 83–91, doi:10.56577/FFC-37.83.

Seager, W.R., Mack, G.H., and Lawton, T.F., 1997, Structural kinematics and depositional history of a Laramide uplift-basin pair in southern New Mexico: Implications for development of intraforeland basins: Geological Society of America Bulletin.

Nitrogen, Sulfur, and Carbon-Cycling Capabilities of Microbial Communities From Desert Cave Systems

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https://doi.org/10.56577/SM-2024.3008

Dry desert caves contain unique microbial communities that survive in energy starved subterranean environments. These caves often contain slow-growing chemolithotrophic microorganisms that may utilize the chemical energy from inorganic sulfur, nitrogen, or metals in minerals and trace gases, and in the process might modify cave walls by slow carbonate dissolution or secondary mineral formation. In this study, we are using metagenomics to determine the identity and genomic potential of novel S and N cycling microorganisms from the walls of two arid cave systems, and explore their roles in the cave ecosystems. The first site, Lehman Caves, Nevada, is an ancient hypogene cave that might have experienced sulfuric acid corrosion more than 10 million years ago. The second, Lechuguilla Cave, is an ancient sulfuric acid cave that formed around 4-6 million years ago. We don't expect these caves to have active sulfide oxidizing microbial populations, and instead hypothesize that, based on previous rRNA gene surveys, inorganic N compounds like ammonia and other trace gases are the primary source of energy for life in these oligotrophic settings. We initially generated two small preliminary metagenomes: one from a recent sample from Lehman Caves that generated 44 total megabase pairs (Mbp) of DNA sequence following quality filtering and trimming, and one collected more than 20 years ago from Lechuguilla Cave, which generated 219 Mbp of sequence. These metagenomes contained genes for carbon dioxide fixation, dissimilatory nitrogen oxidation, and manganese oxidation. Classification of conserved marker genes shows that they contain populations of previously undescribed microorganisms; however, they did not have sufficient depth of coverage to recover metagenome-assembled genomes (MAGs). We therefore generated a larger metagenome from a second sample from Lehman Cave, and were able to recover several high-quality MAGs. We will describe the genomic potential of these novel organisms, and discuss implications for energy resources and biogeochemistry of desert caves.

Geomorphology of the Southernmost West Mesa Escarpment, Petroglyph National Monument, Albuquerque, New Mexico

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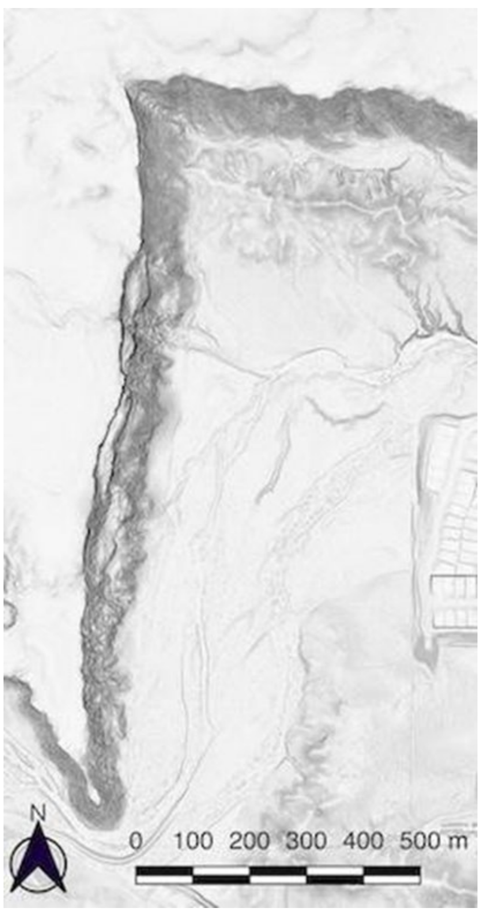
https://doi.org/10.56577/SM-2024.2967

The geomorphology of the southernmost West Mesa escarpment (SWME), which is aligned with a known down-to-the-east middle to late Quaternary normal fault inferred from borehole and aeromagnetic information, is significantly different than that of the rest of the 25-km long escarpment. In addition to having an unusually straight and nearly north-south trace, the SWME includes a 1-km long zone of previously undocumented basalt capped Toreva-block-like rotational landslides characterized by arcuate scarps and concave headwalls, tilted strata, bulked convex toes, and slope profiles suggesting at least one and perhaps two episodes of retrogressive movement. The SWME is the only portion of the escarpment with significant landslides. Geomorphometric maps derived from publicly available airborne lidar digital elevation models additionally show the SWME is rougher and has more highly disrupted drainage than portions of the escarpment that are not coincident with the fault. The absolute ages of the landslides are unknown; however, the relative ages of the Albuquerque volcanoes basalt flows and the fault preclude the possibility that the SWME is a simple down-to-the-east normal fault scarp degraded by landslides. A more plausible explanation is that flowing basalt was blocked by a north-south obsequent fault-line scarp with landslides occurring after topographic inversion in which footwall sediments of the Pliocene Ceja Formation were removed by erosion along an ancestral Mirehaven Arroyo, creating the relief necessary for the landslides to occur, perhaps in response to Pleistocene downcutting along the Rio Grande. Once the relief was developed, seismic acceleration and/or water delivered from a large footwall catchment during wet periods may have contributed to slope instability. The landslides do not appear to be currently active.



Slopeshade image produced from a 2018 0.61-m lidar digital elevation model showing landslides developed along the southernmost West Mesa escarpment. Data source: Mid-Region Council of Governments.

Keywords: rotational landslide, slope stability, digital terrain modeling, Albuquerque basin, Santa Fe Group

STRATIGRAPHY AND PROVENANCE OF THE BACA FORMATION IN THE BACA AND CARTHAGE-LA JOYA BASINS, CENTRAL NEW MEXICO

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https://doi.org/10.56577/SM-2024.2969

The Eocene fluvial-lacustrine Baca Formation is critical to understanding late Laramide sediment transport in central New Mexico. Here, we present new data to evaluate conflicting hypotheses about the connection between the Baca and Carthage-La Joya basins (e.g. Cather, 2009; Lucas and Williamson, 1993), as well as their connection to other Laramide basins. This study combines sedimentologic field techniques (e.g., measured section, imbrication/paleoflow measurements) with sandstone petrographic analysis and U-Pb detrital zircon (DZ) geochronology. Geochronologic analysis compares published data from the San Juan and Tornillo Basins to published data from the Baca and Carthage-La Joya basins. Our data suggests that the Baca and Carthage-La Joya Basins preserve two distinct fluvial systems.

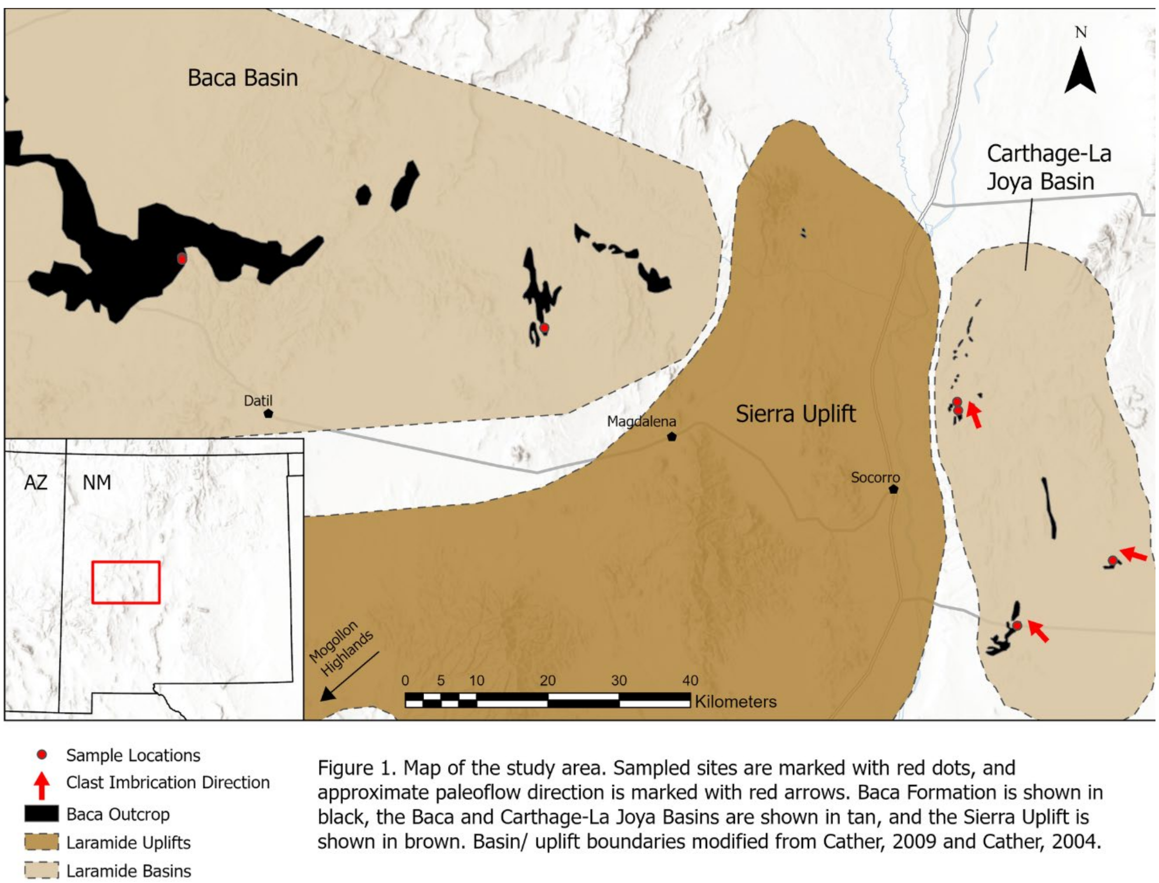

Figure 1. Map of the study area. Sampled sites are marked with red dots, and approximate paleoflow direction is marked with red arrows. Baca Formation is shown in black, the Baca and Carthage-La Joya Basins are shown in tan, and the Sierra Uplift is shown in brown. Basin/ uplift boundaries modified from Cather, 2009 and Cather, 2004.

The lithologies of strata mapped as Baca Formation differ substantially between the Baca basin in western New Mexico and the Carthage-La Joya basin in central New Mexico. Baca Basin strata comprise siltstones to medium-grained sandstones, whereas Carthage-La Joya strata are dominated by pebble to boulder conglomerates and minor fine- to coarse-grained sandstones. Published paleocurrent measurements from the Carthage-La Joya basin suggest southeastward paleoflow, whereas new data indicate northwestward paleoflow. This northwest paleoflow found throughout the Carthage- La Joya Basin suggests that the Baca Basin did not drain southeast through the Carthage-La Joya Basin (fig. 1). Limited published U-Pb DZ geochronologic data suggests similar sedimentary provenance in both basins; however, there is not yet enough data in the Baca and Carthage-La Joya Basins to draw meaningful conclusions.

References:

Cather, S. M., 2004, Laramide orogeny in central and northern New Mexico and southern Colorado: New Mexico Geological Society Special Publication 11, 203–248.

Cather, S. M., 2009, Stratigraphy and structure of the Laramide Carthage–La Joya Basin, central New Mexico: New Mexico Geological Society Guidebook 60, 227–234.

Lucas, S. G. & Williamson, T. E., 1993, Eocene vertebrates and late Laramide stratigraphy of New Mexico: New Mexico Museum of Natural History and Science Bulletin 2 145–158.

Keywords:

Baca Formation, provenance, Baca Basin, Carthage-La Joya Basin, Laramide

THE RIO GRANDE RIFT, MINING, AND GEOTHERMAL ENERGY

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The Rio Grande Rift Zone is a growing ~30 MY extensional structural split in the SW North American plate running from near Leadville, Colorado, south to northern Mexico. Many mineral deposits, including a new Mo/Cu/Au porphyry prospect in the San Luis Valley, occur along the rift co-located with high heat flow capable of heating geothermal waters. A previous owner of the Climax Mine, AMAX Exploration, did extensive geothermal exploration of the northern rift near the Mt. Princeton Hot Springs area in the Arkansas Valley, Chaffee CO, Colorado, in the mid 1970's. The goal was to find cheaper energy for the Climax mining operation. AMAX sought a steam-based resource typical of the time and was unsuccessful. Mt. Princeton Geothermal LLC began more recent exploration for geothermal energy in the Arkansas Valley in 2008, aided by data from the Colorado School of Mines, the Colorado Geological Survey, and AMAX. Several drill ready or prospective targets near the Mt Princeton Hot Spring Resort area have been developed utilizing a *new* exploration approach based on structural geology, seismology, magneto-tellurics, airborne magnetics, and remote sensing. This exploration model may apply to several other similar basins in Colorado and south along the rift zone into New Mexico. At present, the current primary target awaits funding for reservoir confirmation drilling. Delays in drilling have been caused by the recent addition of new local and state regulations, industry reluctance to invest in "over regulated and too environmental" Chaffee County / Colorado, and bouts of Nimbyism. The eventual success of this first hydrothermal geothermal energy 10+MW plant in Colorado should lead to additional discoveries south in Chaffee County, the San Luis Valley and into New Mexico along the Rio Grande rift zone.

LITHIUM CLAY DEPOSITS IN THE MCDERMITT CALDERA, NEVADA - OREGON: CHARACTERISTICS AND CONTRIBUTIONS FROM CLOSED-HYDROLOGIC SYSTEM DIAGENESIS (CHSD) AND POSSIBLE HYDROTHERMAL ACTIVITY

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Magmatism around the McDermitt caldera, an early igneous center of the Yellowstone hotspot, began shortly after 17 Ma with emplacement of Steens Basalt, the oldest part of the Columbia River Basalt. Precaldera volcanic rocks became progressively more silicic through time and included both peralkaline and biotite-bearing rhyolites, which are now exposed in the caldera wall. Collapse of the ~40 x 25 km caldera resulted from 16.4 Ma eruption of ~1000 km^3 of the McDermitt Tuff, which is zoned from aphyric, high-SiO_2, peralkaline rhyolite to abundantly porphyritic, metaluminous icelandite (Fe-rich, tholeiitic dacite-andesite). A resurgent dome formed shortly after collapse probably related to residual icelandite magma. Minor icelandite volcanism continued to 16.1 Ma, when volcanism ceased.

Rhyolitic tuffaceous sediments accumulated in an irregular moat/lake around the resurgent dome between 16.4 and 15.7-15.6 Ma, mostly post-doming. Composition and phenocryst assemblage of dated tephra and age and K/Ca of their feldpars demonstrate that most tephra are from regional, non-McDermitt sources. The intracaldera sediments host possibly the world's largest Li clay deposits. Li smectite deposits with maximum grades of ~4000 ppm occur throughout the caldera. Li illite deposits with maximum grades of ~9000 ppm are only known in the southern, Thacker Pass part of the caldera. The origin of the Li clay deposits, particularly the contribution of low-T diagenetic vs high-T hydrothermal processes, and the total source of Li remain uncertain and controversial. The tuffaceous sediments underwent closed-hydrologic system diagenesis(CHSD), in which rhyolitic glass dissolved to generate high-TDS, alkaline water that, enriched by closed-basin evaporation, precipitated smectite, zeolites, authigenic Kfeldspar and albite, and possibly illite. Similar Li smectite deposits are present elsewhere in Nevada in extensional basins containing diagenetically altered, rhyolitic tuffaceous sediments. The similarity of Li smectite deposits in the McDermitt caldera basin and extensional basins is strong evidence that both formed through diagenesis. Questions about McDermitt deposits are (1) origin of the high grade, illite part, which is absent or sparse elsewhere in Nevada, and (2) the total source of Li (dissolution of glass ± contributions of hydrothermal solutions). My very rough mass balance indicates solution of glass in the McDermitt intracaldera sediments alone is insufficient to account for all the Li in the caldera clay deposits.

The strongest evidence for a hydrothermal component is that the McDermitt caldera, unlike other early Yellowstone hotspot calderas, has many hydrothermal systems related to caldera magmatism, including Hg, U-Zr, U non-Zr, and Au. However, the hydrothermal deposits mostly occur along the caldera ring-fracture zone or occupy compact, subcircular areas, whereas the Li clay deposits are continuous throughout the intracaldera sediments. One Hg deposit and one U-non Zr deposit partly overlap spatially with Li mineralization in the northern part of the caldera, but no definite hydrothermal deposits are present in Thacker Pass. Elements enriched in Li deposits (Mg, K, Rb, F, Mo, As, Sb) partly overlap with those in hydrothermal deposits:

Hg: As, Sb, Mo, ±Zr, U, F, Tl;

U-Zr: Y, Yb, As, Sb, F, Mo, Tl ±Hg, Au, Th, Te;

U: As, Mo, Sb, F, Hg;

Au: As, Sb, Ag, Cu ±Hg, W, Bi.

Overlapping elements are those enriched by either hydrothermal systems or low-T redox reactions. No known hydrothermal deposit is enriched in Li. All hydrothermal deposits formed shortly post-collapse based on adularia $^{40}Ar/^{39}Ar$ dates (16.35±0.03 Ma, Moonlight U-Zr; 16.67±0.14 Ma, McDermitt Hg) or restriction to McDermitt Tuff or basal intracaldera sediments. Hydrothermal activity driven by magmatism is reasonable. Late icelandite magmatism is spatially unrelated to any mineralization. Li mineralization is undated other than post-15.7 Ma, the youngest mineralized sediments, and 14.87±0.05 Ma on authigenic Kspar in the illite zone at Thacker Pass. A heat source to drive hydrothermal activity at this late, post-magmatic time is unknown. $^{40}Ar/^{39}Ar$ dating of the Li illite to provide a definitive time of high-grade mineralization is being investigated.

A possible Li source in addition to CHSD solution of glass is shortly post-collapse degassing of residual magma or high-T devitrification of McDermitt Tuff to release U, Zr, Y, Yb, etc as well as Li. The less mobile elements fixed in deposits, for example as U-rich zircon at the Moonlight Mine. More mobile elements (Li, K, Rb) and especially elements soluble in oxidizing water (As, Mo) entered the intracaldera lake-groundwater system ultimately to precipitate as Li smectite and illite at relatively low T. The absence of U, another redox-controlled element, in the Li deposits is one of many unresolved questions about the origin of the Li-clay deposits.

Keywords:

Lithium, McDermitt caldera, age, geochemistry, origin

Learn, Connect, Protect: The National Cave and Karst Research Institute's 2024 Education and Outreach Program

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The key to protecting sensitive resources is to see its value and to understand our interdependence with it. The goal of the National Cave and Karst Research Institute (NCKRI) education and outreach program is to provide interdisciplinary resources that illuminate these seldom seen, interconnected landforms while providing easily accessible information. Due to the multidisciplinary nature of cave and karst, outreach events range from online based initiatives such as Cave Week to local (karst) waterway cleanups to family functions teaching K-12 science standards while learning cave survey techniques.

Our audience is divided into people living with caves and karst, those furthering the understanding of these environments and those entering cave environments. We try to reach these audiences by creating resources for formal and informal education using images that imbue connection and interpretive materials that scales down jargon rich subject matter. Technical cave resource protection procedures are created based on audience needs, with visual examples and additional learner-centered content. One such example was the building of a gear decontamination station with additional interpretive materials that were used at the National Speleological Society's annual convention. This interagency initiative's goal was to instruct participants in cave conservation practices while making a White-nose Syndrome decontamination procedure that could easily be reproducible at other events or even a person's home.

In another initiative, NCKRI has been supporting student research opportunities in cave and karst science at NMT through an undergraduate fellowship program that so far has included students in the Earth Science, Biology, and Mechanical Engineering departments. Recently, we expanded this program to support two undergraduates to participate in a scientific expedition to explore new caves in the Tongass National Forest, Alaska. In this presentation, we will discuss these and other initiatives, as well as ongoing and future plans to develop curriculum pieces that use caves as a classroom, providing support to our public land partners in creating educational materials, and expanding the interpretive displays at NCKRI's headquarters.

Normal Faults in the San Juan Basin: Preliminary Report on Their Prevalence and Significance

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Many geologic mapping efforts in the San Juan Basin (SJB), northwest New Mexico, reveal short (<10 km), often high-angle (dip angle >75°) normal faults. These faults generally are too small to be captured on statewide or basinwide geologic compilation maps, but are revealed in many areas within the basin by most field mapping efforts at the 1:100,000 scale or larger. Though the tectonic significance of basin-interior normal faults is almost certainly of lesser importance than the larger-scale compressional and/or transpressional tectonics more plainly manifest in San Juan basin deformation structures, it nonetheless deserves consideration. At present, however, it remains largely unaddressed.

Recent STATEMAP mapping on the Chaco Canyon 30'x60' Quadrangle (Hobbs and Pearthree, 2021) and the Coyote Canyon 15' Quadrangle (Hobbs and Krupnick, in preparation 2024), and geologic mapping related to hazards analysis on the southern Jicarilla Apache Nation (Hobbs and Pearthree, 2023) presented opportunities for detailed documentation of several San Juan basin-interior high-angle normal faults. In each of these locations throughout the central and southern SJB, normal faults are found in Cretaceous and Paleogene siliciclastic sedimentary units. Where fault planes can be measured, their dips range from 56° to 88°. Fault offset is up to 18 m and approaches 0 at fault tips, where faults merge into joints traceable for up to hundreds of m. Most observed fault planes do not preserve reliable kinematic indicators, but where striations are observed, they indicate dip-slip motion. Timing of fault motion is constrained only by cross-cutting relations, with maximum ages of deformation provided by the age of Late Cretaceous, Paleocene, or Eocene sedimentary rocks cut by faults, and minimum ages provided by undeformed Pleistocene or Holocene surficial sediments that overlie faults. SJB normal faults often are isolated; where they occur in proximity to one another, the sense of motion on each sub-parallel fault is the same (i.e., all faults in an area are down-to-the-south), suggesting a distributed fault zone as opposed to a series of grabens and horsts. Within individual quadrangles or similarly-sized areas of study, the faults reported here sometimes have systematic orientations, especially near the eastern and western basin margins. In general, however, the wide range of fault orientations does not indicate a basin-wide uniform stress orientation leading to SJB normal faulting.

Further work with more mapping and basinwide documentation and analysis is needed to understand more fully the causes, timing, and tectonic and/or basin evolution significance of the faults reported here. As SJB siliciclastic sedimentary units are further exploited as reservoirs for oil and gas, as aquifers, as repositories for produced water, and as targets for carbon sequestration, small-offset faults like these potentially serve as traps, leaks, or zones of increased permeability due to fault-zone fracturing, yet are unlikely to be recognized or documented in the subsurface. Characterization of these faults through geologic mapping is a first step to increasing understanding of the prevalence and significance, and can shed light on why there are widespread (though small) extensional features throughout the otherwise compressional SJB.

References:

Hobbs, K.M., and Krupnick, J.M., in preparation 2024, Geologic Map of the Coyote Canyon 15' Quadrangle, Navajo Nation and McKinley County, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-file Geologic Map 314, scale 1:100,000, 1 sheet, 80 p. report, doi.org/10.58799/OF-GM-292.

Hobbs, K.M., and Pearthree, K.S., 2021, Geologic Map of the Chaco Canyon 30'x60' Quadrangle, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-file Geologic Map 292, scale 1:100,000, 1 sheet, 24 p. report, doi.org/10.58799/OF-GM-292.

Hobbs, K.M., and Pearthree, K.S., 2023, Geologic Map of the Cañon Largo Watershed on the Jicarilla Apache Nation, Rio Arriba and Sandoval Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-file Report 620A, scale 1:50,000, 1 sheet, 56 p. report, doi.org/10.58799/OFR-620A.

Keywords:

San Juan Basin, faulting

ELIMINATING HUMAN ERROR DURING DRILLING: THE FIRST STEP TOWARD AUTOMATING OPTIMIZED GEOTHERMAL DRILLING

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Rate of penetration (ROP) optimization during drilling reduces costs during geothermal exploration and development of geothermal fields. One of the major bottlenecks for ROP optimization is bad zeroing, which depends on hookload and weight on bit (WOB). WOB is a calculated parameter that depends on the weight of the drill string and the hook load. Because the string weight is manually measured after a new stand has been added and before the drill bit is on hole bottom, it is subject to human error and can cause the WOB to deviate from the correct calculation by up to 100\%. The primary purpose of this study is to help drillers avoid bad zero thus preparing the dataset for ROP optimization. We used the 2020 Utah FORGE drilling dataset from well 16A(78)-32 1Hz data to identify when a new stand is added to the drill string and calculated the change of string weight in the dataset once the new stand has been added. This identifies the instances where string weight was incorrectly updated. We demonstrate how our algorithm helps eliminate human error by identifying the window in which the hook load can be updated or by automatically correcting the string weight. This leads to a correct WOB calculation thus effectively optimizing ROP.

Keywords:

geothermal, drilling optimization

Reconnaissance Survey of Volcanic Caves and Cave Microbial Communities at Capulin Volcano National Monument, NM

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Volcanic landscapes on Earth are valuable planetary analogs for the moon and Mars, and the lava tubes and other caves associated with these terrains are targets in the search for extraterrestrial life. Volcanic caves provide shelter from harsh surface environments and contain nutrients and energy resources such as iron (Fe) that could support microbial growth. Capulin Volcano National Monument (CAVO) is a well-preserved cinder cone in northeastern New Mexico, with trachybasalt lava flows and volcanic caves. The goal of this project was twofold: to begin to create a cave and microbial inventory for conservation purposes, and to evaluate CAVO as a Mars analog site. We described several small primary and secondary volcanic caves within the Monument, and mapped two primary caves that are likely tumulus or blister features. While we did not find extensive lava tubes within Monument boundaries, there are secondary caves and possibly substantial subsurface habitat within the lava flows. To perform a reconnaissance geobiology survey, we combined culture independent and dependent analyses to describe microbial communities in CAVO caves and evaluate if microorganisms from this site could live on reduced compounds in basalt. High-throughput 16S rRNA gene sequencing from small primary and secondary caves showed that the most abundant taxa on the walls were members of the Actinobacteria and Alphaproteobacteria, and that many samples include abundant phototrophs and some potential iron- and sulfur-oxidizing taxa. Multivariate analyses show that different caves have distinct communities, and that CAVO microbial communities are different from those in well-studied lava tubes. Several isolates were obtained on low nutrient organoheterotrophic media, including strains of Bacillus, Arthrobacter, Pontibacter, Curtobacterium, and Dietzia. Long-term enrichments on olivine showed growth over time, including ammonia oxidizers and nitrate reducers in secondary enrichments, although we did not find evidence that microbes were having an impact on olivine dissolution rates. Ongoing analyses will continue to explore whether microorganisms from these communities can obtain energy from olivine and other Fe-bearing minerals in basalt, and evaluate microbial communities and activity in situ with additional rRNA gene and transcript libraries.

Keywords:

Volcanic Caves, Cave Survey, geobiology

3D Seismic Imaging and Fault Detection at the Lightning Dock Geothermal Field

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New wells are often needed to improve energy production in geothermal power plants. Integrating 3D seismic imaging and fault detection with geological and geochemical information can help site new geothermal injection wells to reduce drilling risk and ensure the sustainability of geothermal power production. Lightning Dock Geothermal (LDG) LLC conducted a 3D active-source surface seismic survey in 2011 using accelerated weight drop sources for subsurface characterization. We use an open-source data analysis package called Madagascar to process the raw seismic data, update the velocity model in the shallow region using first-arrival travel-time tomography, improve the entire 3D surface velocity model using full-waveform inversion, and produce a 3D subsurface image of the Lightning Dock geothermal field using reverse-time migration. We then detect faults on the 3D seismic image using a machine learning algorithm based on nested residual U-Net. Our 3D seismic imaging and fault detection results provide valuable information for siting new geothermal wells at the Lightning Dock geothermal field.

GEOCHEMICAL EVOLUTION AND $^{40}Ar/^{39}Ar$ GEOCHRONOLOGY OF THE UVAS BASALTIC ANDESITE: INSIGHTS INTO THE EARLY RIO GRANDE RIFT

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The Uvas Basaltic Andesite (UBA) is a series of lava flows, cinder cones, and dikes emplaced between the post-Laramide volcanism of the Mogollon-Datil volcanic field and the early stages of magmatism in the Rio Grande rift. The timing of volcanism has been poorly constrained with only some bracketing ages and unpublished K-Ar dates. In addition, the source of volcanism is still unknown; both asthenospheric vs. lithospheric mantle sources have been postulated. This study employs high-resolution $^{40}Ar/^{39}Ar$ geochronology (n = 9) to constrain the eruptive age of lava flows from five localities, showing that volcanism lasted from as early as 29.13±0.19 Ma to 27.39±0.03 Ma. This timeframe includes an eruptive sequence that comprises the interlayered Bell Top Formation Tuff 7, previously dated at 28.57±0.03 Ma, and the Thurman Formation, previously constrained by a single crystal 40Ar/39Ar sanidine maximum deposition age of 27.4 Ma.

Most of the UBA lava flows have higher LILE/HFSE ratios, higher LREE/HREE ratios, and negative Nb-Ta anomalies. Furthermore, the low ε_{Nd} values (-4.3 to -3.8) for these samples mirror those of other basaltic rocks associated with post-Laramide volcanism (e.g., Southern Cordillera Basaltic Andesites suite) suggesting that the source region was an enriched sub-continental lithospheric mantle.

In contrast, the geochemical signatures of the two youngest UBA samples, collected from Rincon Hills and located directly above potential early rift-related sediments of the Thurman Formation, suggest the incorporation of material from a more depleted and likely asthenospheric mantle source, in line with rift-related magmatism. These samples exhibit a lower LILE/HFSE ratio, reduced LREE/HREE ratios, the absence of a negative Nb-Ta anomaly, and a higher εNd value (+2.5). This transition to a geochemical signature characteristic of a rift-related depleted mantle melt source, occurring alongside the initial stages of rifting in the southern Rio Grande rift, is consistent with the mixing of asthenospheric mantle melts into the magmatic system, marking a temporal link between the geochemical evolution and the onset of rifting.

In summary, this study employs high-resolution $^{40}Ar/^{39}Ar$ geochronology to constrain the eruptive period of the Uvas Basaltic Andesite, revealing a geochemical shift indicative of a source transition from an enriched lithospheric mantle source to a more depleted and likely asthenospheric mantle source in conjunction with the initial stages of rifting within the southern Rio Grande rift.

Keywords:

Rio Grande rift, Geochemistry, Early continental extension, Isotope Geochemistry, $^{40}Ar/^{39}Ar$ geochronology, altered basalts, SCORBA, Southern Cordillera Basaltic Andesites Suite

Exploration for Critical Minerals Resources in the Zuni Mountains, NM

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Exploration geochemistry is important for locating critical minerals resources that are crucial to meeting the demand placed by a variety of industries, and stream sediment sampling is often the first step towards achieving this goal. This exploration technique has been shown to be a reliable way of locating deposits in the early stages of exploration over large areas. In the past, the Zuni Mountains have been mined for their deposits of copper, fluorite, and barite, although obsidian, turquoise, azurite, malachite, and copper have been (and continue to be) mined by the Zuni people and later prospectors. The Zuni Mountains are a small mountain range located in northwest New Mexico, near Grants. These mountains were formed during the Laramide orogeny and lie along the Jemez Lineament. While much of the lithology of the Zuni Mountains is sedimentary, there are units of Precambrian basement rock, some of which have been metamorphosed. With the demand for critical minerals increasing, the NMBGMR has been contracted by the USGS to evaluate the critical minerals potential of the Zuni Mountains through stream sediment sampling and chip sampling. From the data that were received from USGS (all stream sediment and chip sample data from the August 2023 field trips), there are some key differences between the initial NURE (National Uranium Resource Evaluation) data and the Zuni Mountains project data.

Though the Zuni Mountains project is mainly focused on sampling new locations and evaluating the critical minerals potential of the district, there are some key details that are different between the original NURE data taken in 1970s and the newly generated data. The first key difference between the two projects is the mesh size of stream sediment samples. The original NURE sampling project used a 150-micron mesh, while this project used a 2 mm mesh to sample stream sediments. This creates differences in the data due to the properties of different critical minerals. For example, the original NURE data had higher concentrations of vanadium when compared to Fe_2O_3 than the new data collected in late 2023. This is due to vanadium having the tendency to be absorbed into clay structures or iron oxide coatings, and the original NURE sampling procedures collected clay-sized stream sediments. Another key difference is what elements the two projects analyzed. The original NURE program did not analyze for elements such as Cd, Cs, Rb, Sb, and Y, all current critical minerals. This is possibly due to what the laboratory could analyze for at that time. Given the two key differences, the current data can now be evaluated based on what was not evaluated in the previous NURE data. New geochemical data may help gain a better understanding of critical minerals behavior in coarser size fractions. When looking at the current data from the Zuni Mountains district on a chondrite normalized graph (McDonough and Sun, 1995), both show an enrichment in REEs, and the datasets correlate similarly even though some REEs weren’t analyzed for in the NURE data. Anomalies of REEs are above 150 ppm and are found within the granitic gneisses, the Paleoproterozoic rhyolite and felsic volcanic units, along faults in the southeast portion of the district, and few along the shear zone. Anomalies of Cu (>22 ppm) were found along the shear zone and in the granitic gneisses and red sandstones. Sb anomalies (>3.8 ppm) were found mainly along a fault in the northwest part of the district and only two were located in the granitic gneiss unit. Ba (>850 ppm) anomalies were found along faults, the shear zone, granitic gneisses, and the Paleoproterozoic rhyolite and felsic volcanic units. Zn anomalies (>16 ppm) were found in the Paleoproterozoic rhyolite and felsic volcanic units, granitic gneisses, along the shear zone, with some found along the faults in the southeast area of the district.

USING NEW MEXICO'S UNIQUE GEOLOGY, HYDROLOGY, AND TOPOGRAPHY TO DEVELOP PUMPED-STORAGE HYDROELECTRIC (PSH) FACILITIES IN SUPPORT OF RENEWABLE ENERGY GENERATION, STORAGE, AND DISTRIBUTION

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New Mexico is moving toward a "mostly-electric" future as abundant renewable, carbon-free electric energy is produced in-state, with a substantial portion exported to meet out-of-state demand. Ideally, this energy should be provided on a 24/7, as-needed, base-load resource. The 2019 New Mexico Energy Transition Act (NMETA) requires utilities to generate and distribute 50% of their electric power using renewable sources (primarily solar, wind, and geothermal) by 2030 and 100% by 2045. Fortunately, New Mexico has the nation's largest combined solar/wind/geothermal energy potential. Because the sun and wind can't shine or blow 24/7, neither solar nor wind power can generate electricity full-time or on an as-needed basis--two features necessary for a successful energy transition. The solution to this problem is developing utility-scale energy storage technologies such as pumped-storage hydroelectric power (PSH).

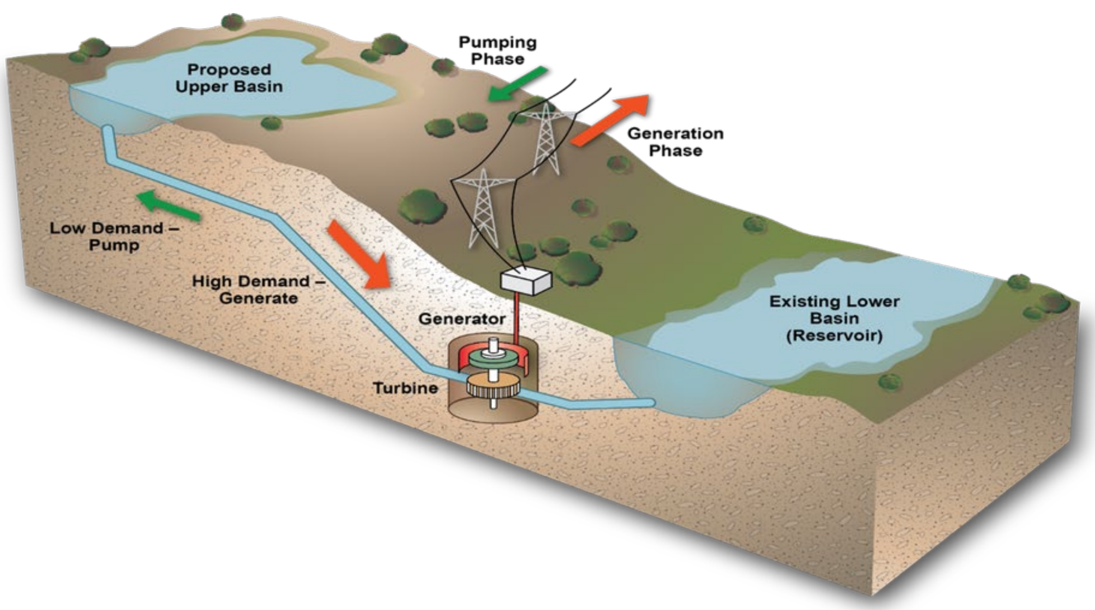

Figure 1: Hypothetical Closed-loop Pumped Storage Hydroelectric (PSH) Facility

Numerous large-scale electric energy storage schemes have been proposed, but most have one or more shortcomings at utility-scale. These shortcomings include inadequate capacity (lithium-ion batteries can store only around 4-6 hours of energy at mega-watt levels); environmental impacts (lead-acid batteries produce massive amounts of toxic waste and have limited lifespans); physical limitations (compressed-air storage requires monumental facilities, whether manmade structures or air-tight, impermeable geologic formations); or are economically impractical (a forest of gravity-powered counterweight towers cost billions of dollars). According to DOE's National Renewable Energy Laboratory, the most dependable, economical, and environmentally-friendly grid-scale electric storage technology available today is proven, centuries-old pumped-storage hydroelectric (PSH).

Employing PSH requires a special combination of physical and geotechnical characteristics, conditions that are seldom present at most locations. However, New Mexico's existing natural features (especially its geology, hydrology, and topography) provide ideal circumstances for creating PSH facilities at multiple sites around the state. Developing PSH involves construction of a closed-loop water cycling system, which can be powered by New Mexico's abundant daytime supply of low-cost (~2 cents/kwh) solar and wind energy to pump water through penstocks from an existing lower reservoir to an upper reservoir located at least 500 feet above, thereby creating a substantial "hydrologic head" that can later be used to drive electricity-generating turbines. During periods of high-demand for electric power in late afternoon and evening, the process is reversed: water from the upper reservoir is released downward through the same penstocks under high pressure and into the combined turbine/pump equipment to generate high-value, carbon-free electricity. The combined mechanical-electrical efficiency of such systems is typically 85-90%, so that power generated during peak-demand periods can then be sold for ~10-12 cents/kwh, yielding a gross return of 500-600%. A portion of this return-on-investment will be used to offset the significant capital construction costs of building a PSH facility, but is compensated by low operational costs--thus providing substantial profit to the facility owner (utilities and/or investors). The ideal PSH facility will provide at least 100 hours of renewable energy storage at 500-1000 MW power capacity—true utility-scale storage. See Figure 1 for example of a hypothetical PSH facility.

But PSH cannot successfully be developed unless certain key geologic, hydrologic, and topographic features are concurrently present at sites under consideration. The essential site characteristics of a successful PSH facility in New Mexico are: (1) an existing primary/lower reservoir holding at least 100,000 acre-feet of water, with a minimum 1000 acres surface-area; (2) year-round water availability (no new water-rights need be acquired since PSH does not "consume/use" water while being cycled through its closed-loop system; water is merely "borrowed" or leased from the existing water-rights owner); (3) topography suitable for constructing an storage/upper reservoir with at least 1000 acre-foot capacity, ideally within a dry canyon or large off-stream arroyo to minimize excavation/construction costs and environmental impacts; (4) suitable geology and soil conditions (i.e., underlying geologic impermeability) to construct a leak-resistant earth-fill storage dam and buttresses using local geomaterial; (5) at least a 500-foot elevation difference between the upper storage reservoir and existing lower reservoir to create sufficient hydrologic head within the penstocks driving electricity generating turbines located in the lower-reservoir-level powerhouse; (6) sufficient non-turbid water available from the primary reservoir to fill the upper/storage reservoir without creating problematic daily drawdown or environmental effects at the surface of the lower reservoir; (7) at least 1000 acres of land available for purchase or long-term lease at the facility site, preferably for acquisition from a willing public agency or landowner; (8) proximity to nearby existing electric transmission lines for importation of low-cost renewable electricity to power the pumps and for exportation of higher-valued power generated by the turbines back into the grid during peak-demand periods; (9) access to existing surface roads for construction and maintenance of the PSH facility; (10) absence of any "fatal flaw" conditions that might delay or prevent development of the facility (e.g., unsuitable geotechnical conditions for construction/operation, presence of T&E species or sensitive archeological/cultural features at the site, unwillingness of the existing reservoir owner or operator to allow use/cycling of its water for the PSH facility).

All of these conditions/features are present at a minimum of eleven sites within the state of New Mexico. These sites are also located in proximity to existing or planned utility-scale wind, solar, and geothermal generation facilities. The identified sites and their respective owners/operators are: Navajo Reservoir (USBOR), Heron Reservoir (USBOR), El Vado Reservoir (USBR/MRGCD), Abiquiu Reservoir (USACOE), Cochiti Reservoir (USACOE), Elephant Butte Reservoir (USBOR), Caballo Reservoir (USBOR), Bluewater Reservoir (USBOR), Conchas Reservoir (USACOE), Santa Rosa Reservoir (USACOE), and Eagle Nest Reservoir (NMISC/NMPD). To fulfill the NMETA's mandates, New Mexico's three investor-owned utilities, seven public-agency electric utilities, two co-op generators, and the more than a dozen merchant power generators--as well as state agencies such as the NMPRC, NMEMNRD, and the Legislature—need to recognize that it will be difficult to achieve NMETA's lofty goals of achieving a carbon-free, reliable and renewable energy future unless they develop facilities for utility-scale, long-term, high-capacity, dispatchable, and demand-responsive storage of electric power created by the state's abundant renewable solar, wind, and geothermal energy resources.

Keywords:

pumped-storage hydropower, renewable energy storage, utility-scale electric power storage

Petrographic and Paragenetic Analysis of Arsenide Five-Element Vein Mineralization in the Black Hawk District, Grant County, New Mexico

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Arsenide five-element vein deposits are high grade silver veins (1000's g/ton of silver) with significant cobalt, nickel, bismuth, and arsenic along with other elements such as U, Cu, Pb, Zn, Sb, and Hg; many of these elements are critical minerals important for the economic and national security of the United States. These deposits are distinctive due to the unusual combination of elements with varying chemical properties not commonly found together. Arsenide five-element veins typically host Ag, Bi, and As as native elements, while Co and Ni occur as arsenides and/or sulfides. The Black Hawk district in the Burro Mountains, Grant County, New Mexico contains arsenide five-element vein deposits and historically, has been a significant producer of silver, with approximately 1,286,000 million ounces extracted between 1881 and 1960, along with other metals such as Cu, Pb, Au, tungsten, and fluorite.

This study presents analysis of petrographic descriptions, mineralogy, and paragenesis of samples collected from the Black Hawk district using petrography, geochemistry results and microprobe analysis. Samples were obtained from drill core and hand samples from underground at the Black Hawk mine and include fresh and altered host rocks and mineralized veins and breccia. A total of 48 samples were prepared into polished sections and thin sections for detailed petrographic and mineral analysis, with a subset of three thin sections selected for Electron Microprobe Analysis (EPMA). Gangue minerals predominantly comprise calcite, dolomite, and quartz, with quartz displaying early and late occurrences. Ore minerals, including native metals (Ag) and arsenides, exhibit complex paragenetic relationships, suggesting a sequential deposition pattern. Gangue minerals quartz and carbonates dominate early and late-stage mineralization, hosting micro-inclusions of hematite. Late-stage minerals include native silver, base-metal sulfides, and sulfosalts. Electron Microscopy Analysis showed the chemical diversity of sulfarsenides and highlighted enrichment in U, particularly in niccolite nodules. Whole rock geochemical analyses provided insights into major, minor, and trace element compositions. Based on mineralogy and chemistry results Black Hawk district samples are elevated in critical minerals such as arsenic, cobalt, barium, copper, nickel, and zinc. The study enhances understanding of arsenide five-element vein deposits, shedding light on its complex textures and mineral assemblages of these potentially important sources of critical minerals.

Keywords:

Black Hawk mine, arsenide five-element vein deposits

THE BEHAVIOR OF ER IN HYDROTHERMAL FLUIDS AT SUPERCRITICAL CONDITIONS, VARYING PH AND SALINITY AND APPLICATIONS TO REE MINERALIZATION IN IOA DEPOSITS

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Rare earth elements (REE) are a rapidly expanding resource due to their growing use in advanced technologies, principally within the green energy sector [1]. In REE-bearing magmatic-hydrothermal systems, the mobility of these metals in hydrothermal fluids is controlled by the stability of REE phosphates, fluorocarbonates and zirconosilicates [2,3] and the aqueous species with which they complex. Current thermodynamic models often underpredict the solubility of these elements in high temperature hydrothermal fluids due to a lack of experimental and thermodynamic data at supercritical conditions [4]. This can result in predictions, which differ from experimentally measured REE solubilities by several orders of magnitude, greatly limiting our capabilities to accurately predict REE transport and fractionation in supercritical fluids. Here we use batch-type Inconel 625 Parr reactors to investigate synthetic $ErPO_4$ (xenotime) solubility between 350°C at P_{SAT} and 450°C and 500 bar, varying starting pH (2, 3, 4, 7, and 10), and salinities (0.01, 0.1, and 0.5 molal NaCl). Chloride and hydroxyl Er complexes are important in controlling REE mobility, specifically for iron oxide apatite (IOA) deposits. IOA deposits are a relatively untapped REE-bearing resource, which have recently garnered attention due to their elevated REE potential. One of the largest domestic IOA deposits is the Pea Ridge deposit in Missouri. Pea Ridge provides an excellent natural system application of REE mobility as a function of chloride and hydroxyl speciation as REE within this system are believed to have been transported almost exclusively by chloride complexes [5].

At 350 and 400°C and 0.01m NaCl, Er demonstrates high solubility at acidic pH and decreased solubility at mildly acidic conditions. For alkaline experimental solutions (starting pH ~10) solubility is less than or equivalent to those at mildly acidic pH values. However, at 450°C, Er assumes a different trend where solubility is elevated at alkaline pH. The increased solubility of Er in acidic conditions is indicative of chloride speciation whereas the high solubility observed in alkaline conditions at 450°C likely results from hydroxyl complexation. Reduced solubility at mildly acidic conditions suggests a loss of chloride complex dominance, and, at 450°C, a transition to Er hydroxyl complex dominance. As a function of increasing salinity, Er becomes more soluble at low pH and the solubility minimum shifts towards alkaline pH as a result of expanded Er chloride complex stability. Theoretical predictions of Er solubility and speciation were performed using GEM-Selektor code package [6] and the MINES database [7]. Modeled speciation trends indicate $ErCl^{2+}$, $ErCl_2^+$, and $ErCl_{3(aq)}$ dominance at acidic conditions for 350, 400, and 450°C respectively and $Er(OH)_4^-$ at alkaline conditions. However, 350 and 400°C experimental solubility trends do not follow predicted speciation in alkaline conditions, rather they more closely mirror the behavior of $ErOH_{3(aq)}$. Furthermore, these models incorrectly overpredict the total solubility of Er by up to two orders of magnitude. These results highlight a need for further high temperature experimental data. Such findings will serve in providing more accurate models of natural systems, specifically IOA deposits which are strongly dependent on chloride complexation.

References:

[1] Migdisov et al. (2016), Chem. Geol. 439, 13-42; https://doi.org/10.1016/j.chemgeo.2016.06.005

[2] Gysi et al. (2015), Chem. Geol. 401, 83-95; https://doi.org/10.1016/j.chemgeo.2015.02.023

[3] Gysi et al. (2018), Geochim. Cosmochim. Acta. 242, 143-164; https://doi.org/10.1016/j.gca.2018.08.038

[4] Haas et al. (1995), Cosmochim. Acta 59, 4329-4350; https://doi.org/10.1016/0016-7037(95)00314-P

[5] Harlov et al. (2016), Econ. Geol. 111, 1963-1984; https://doi.org/10.2113/econgeo.111.8.1963

[6] Kulik et al. (2013), Comput. Geosci. 17, 1-24; https://doi.org/10.1007/s10596-012-9310-6

[7] Gysi et al. (2023); https://doi.org/10.58799/mines-tdb

Keywords:

REE, Rare Earth Elements, Hydrothermal, Speciation, IOA

MAPPING GEOTHERMAL RESOURCES USING AI/ML

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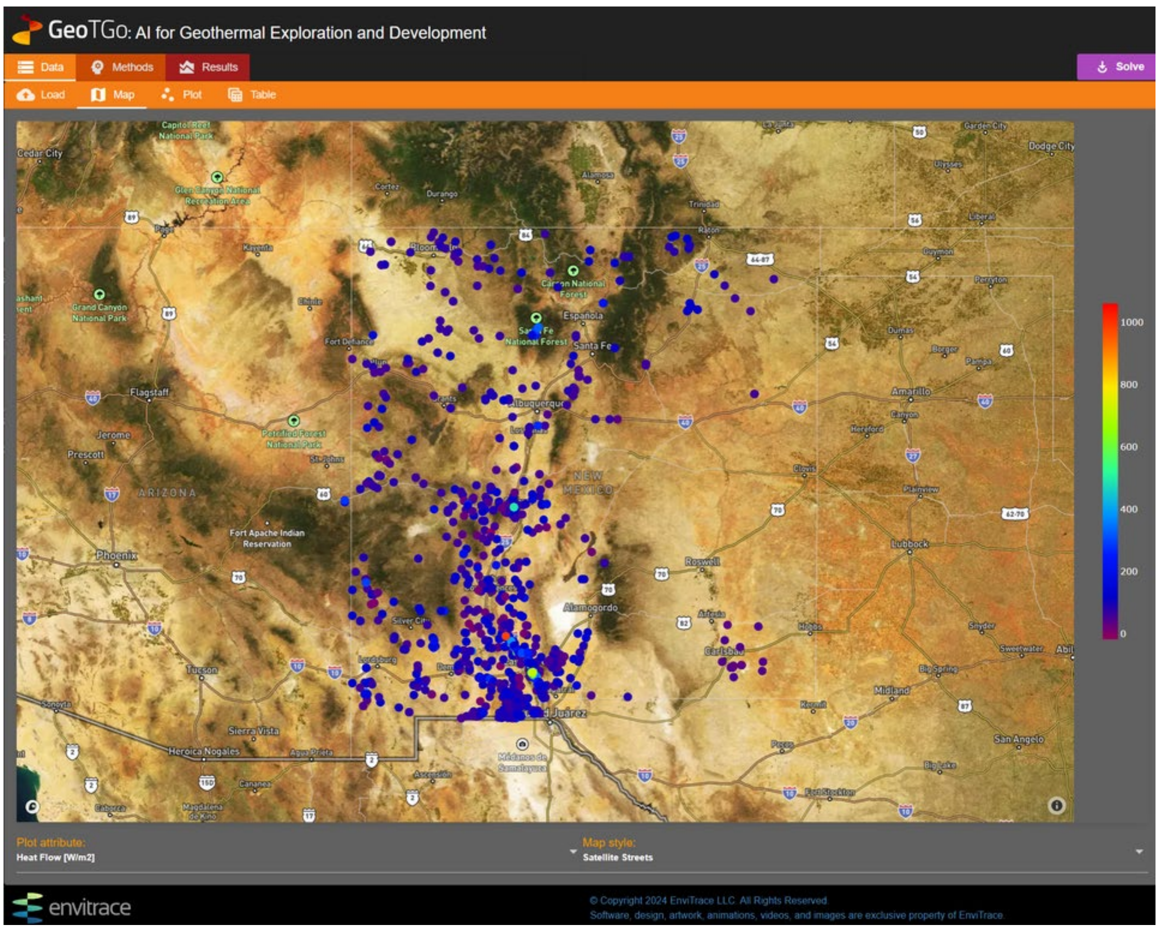
Geothermal energy is a vital renewable resource. However, exploring and producing geothermal resources can be challenging, expensive, and risky. One key factor contributing to these challenges is the need for accurate characterization and mapping of geothermal resources. Without a comprehensive understanding of the location, extent, and properties of geothermal reservoirs, it is difficult to plan and execute successful drilling operations.



GeoTGo dashboard for AI/ML analysis, mapping, interpretation, and prediction of geothermal resources.

Geothermal reservoirs are typically deep underground and hidden without explicit surface manifestation. Additionally, the geological formations associated with geothermal resources can be complex and spatially variable. To overcome these challenges, various geophysical and geological techniques are employed to characterize and map geothermal resources. These techniques include seismic surveys, gravity surveys, magnetotelluric surveys, and geochemical analyses. By combining data from multiple sources, we can create detailed models of geothermal reservoirs, which are essential for planning drilling operations and optimizing resource extraction.

We have developed cloud-based interactive software and a user-friendly interface for geothermal exploration and utilization. It is called GeoTGo (https://envitrace/geotgo). GeoTGo applies supervised, unsupervised (self-supervised), and physics-informed machine learning methods. The methods are designed to operate and solve real-world problems critical for our customers with minimal user input. GeotTGo allows for the joint processing of diverse datasets with different sizes, pedigrees (geological, geochemical, geophysical, etc.), attribute types (qualitative and quantitative), accuracy, and support scales. Large and complex datasets may require extensive use of cloud-computing resources. The software is designed to operate on alternative cloud computing services (Google Cloud, Microsoft Azure, AWS, etc.). Our company provides tiered licensing and commercial support. Machine learning and artificial intelligence methods in GeoTGo are based on our existing open-source algorithms (SmartTensors, https://github.com/SmartTensors, and MADS, https://github.com/madsjulia). However, the developed software is proprietary. It includes a frontend for data management, control, and visualization.

GeoTGo is preloaded with predeveloped ML models and datasets related to the Great Basin in the Southwestern U.S. It also includes New Mexico geothermal datasets. GeoTGo is designed to provide information for local communities in these regions to understand and develop their geothermal resources. Our work bridges the gap between technology advancements and community needs by facilitating interactions between the geothermal industry, regulators, stakeholders, and end-users. GeoTGo aims to provide equitable and sustainable solutions. GeoTGo will help accelerate the development of geothermal energy and contribute to the achievement of net-zero carbon emissions.

Keywords:

machine learning, data analyses, artificial intelligence, community-based geothermal development

Lake Socorro and the 7.4-7.0 Ma fluvial integration of the ancestral Rio Grande through the Socorro Basin, south-central New Mexico

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Detailed sed/strat study, geologic mapping, and new $^{40}Ar/^{39}Ar$ age data indicate the ancestral Rio Grande integrated through the previously endorheic (closed) Socorro Basin during 7.4–7.0 Ma, heralding the earliest known stage of southward axial river integration in southern New Mexico. An essential component of the geochronologic data is detrital sanidine (DS) analyses, providing maximum depositional ages (MDA) of deltaic and fluvial sand beds as well as provenance markers. Two stages are inferred for the playa-lake system occupying the Socorro Basin ("Lake Socorro") prior to Rio Grande integration. **First-stage lake sedimentation** is characterized by pinkish-reddish gray to reddish-brown to pastel-colored (including greenish) clays, minor interbedded sandstones, and local gypsum precipitation. These strata are interbedded with the 9.9 Ma basalt of Kelly Ranch. The sandstones are tabular, fine- to medium-grained, and lack cross stratification. Mud cracks and other dessication features are absent or very sparse, and no signs of microfauna were observed in exposures 5–10 km north of Socorro. There, playa-lake clays intertongue to the northwest with a fan-delta deposited by the ancestral Rio Salado, based on southeast-paleoflow indicators and DS provenance signature (i.e., lack of Jurassic ages and lack of 25.1-25.5 Ma DS from the Latir volcanic field). Paleogeographic reconstruction using the 8.5 Ma basalt of Broken Tank and clast counts indicate a large, southwest-sloping fan formed a basin-wide, paleotopographic high ground near present-day San Antonio. **Second-stage lake sediment** consists of reddish brown clays interbedded with sand bodies, the latter locally coarsening upwards and exhibiting intricate micro-lamination with clays (horizontal-planar and ripplemarked, with thicker cross-stratification to the north). Gypsum precipitation is notably sparser than in the first stage. Paleoflow indicators in the sands are generally to the south. The reddish brown clay has 0-3% scattered sand grains and desiccation features are not obvious. 25.1–25.5 Ma DS ages from the Latir volcanic field are absent or sparse (<0.5%). Deposition during the **closed-to-fluvially integrated basin transition** is characterized by floodplain and lake(?) clays being subordinate or subequal to sands, abundant clay rip-ups in the sands, >1% Latir sanidine grains in DS analyses, and channels back-filled by western-sourced sediment or floodplain clays. Clayey sediment commonly exhibits desiccation features (clay brecciation, calcium carbonate nodules, shrink-swell mixing and slickensides).

Two basalts (9.9 and 8.5 Ma) flowed into the playa and both lack pillow features or extensive palagonite that would be expected of deep water. These two lavas, the 7.0 Ma basaltic andesite of Sedillo Hill, plus a coarse ash sourced from the local Grefco rhyolite dome (7.95 Ma) provide age control that supplements fifteen new DS MDAs. Using this age control and the aforementioned sedimentologic observations, we infer: 1) **The first-stage playa-lake (>10.6 Ma to 8.0-8.5 Ma)** rarely dried up but yet the water levels were quite shallow; the lake water may have been fed by shallow-discharging, sulfate-rich groundwater whose salinity or pH levels were not amenable for aquatic life. 2) **The second stage (8.0-8.5 to 7.4 Ma)** had slightly(?) deeper water levels, deltaic sands extended southward across the basin, and was possibly less saline and more amenable to aquatic micro fauna -- perhaps due to a higher influx

of water from the Rio Grande and/or lake water draining southwards through permeable fan deposits. 3) The **closed-to-fluvially integrated basin transition** occurred between 7.4 to 7.0 Ma; the 7.0 minimum age is interpreted based on the lack of 6.9–7.0 Ma (Peralta Tuff) DS grains in the stratigraphically lowest fluvial sand tongues. The earlier paleotopographic high on the south end of the basin was progressively lowered by west-down faulting near San Antonio, accompanied by eastward basin-floor tilting, which was essential for allowing spillover of Lake Socorro. Higher inferred sediment and water discharges into the Socorro Basin by the Rio Grande during part of the transition, accompanying the observed post 7.4-Ma increase in 25.1–25.5 DS ages (from the Latir volcanic field), may also have facilitated this early Rio Grande integration.

Keywords:

Rio Grande, Socorro Basin, Rio Grande rift, axial river, integration, ancestral Rio Grande, Socorro Peak rhyolites, Lake Socorro

SURFACE WATER AND SNOWPACK MODELING WITH EMPHASIS ON POST-WILDFIRE HYDROLOGIC IMPACTS IN THE SANTA FE WATERSHED, NM

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This study intends to develop a coupled snowpack-surface water model for the Santa Fe Municipal Watershed. The Santa Fe Municipal Watershed is a source of drinking water and water storage for the City of Santa Fe and these water resources are believed to be at considerable risk from high severity wildfires. Surface water rainfall-runoff modeling will begin in HEC-HMS, while the SnowModel package will track seasonal snowpack evolution and provide meltwater inputs to HEC-HMS. It is believed that the coupling of these models will provide more reliable runoff and water yields estimates than with less complex snow modeling modules. Models will then be parameterized with different wildfire and forest management scenarios to provide insight into hydrologic vulnerability and resilience in the Santa Fe Municipal Watershed. Model input data will be showcased including vegetation distribution and meteorological data from watershed weather stations (SNOTEL, RAWS).

Rare earth elements and major constituents in surface water from Lee Ranch Mine

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Rare earth elements (REE) have been investigated in coals and coal byproducts in recent years. In this study, water from Lee Ranch Mine, a surface mine that produced 3.7 million tons of coal, was collected for analysis in the Analytical chemistry laboratory in the New Mexico Bureau of Geology and Mineral Resources. Equipment in the lab includes ion chromatography (for anions), inductively coupled plasma mass spectrometer, induced coupled plasma optical emission spectrometer (for cations), and an autotitrator. Surface water samples were collected from pits at Lee Ranch Mine, and analyzed for major and trace constituents, including REE. Compared to mine waste water from other sites in New Mexico, which include copper mines from the Steeple Rock and Hillsboro districts, REE and trace metal content in water from the Lee Ranch Mine is relatively low and has no significant value of either. REE data collected was barely above method detection limits, and a majority of trace metals were below reporting limits. Major cation and anion data indicate that the water from reclaimed and unreclaimed sites at Lee Ranch mine have different hydrochemical compositions, with reclaimed water having a sodium-chloride composition and unreclaimed water having more of calcium-chloride composition.

Hydrologic Response of the Gallinas River to the Spring Snowmelt Post-2022 Hermits Peak/Calf Canyon Fire; Y2

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Forest fires are well known to impact the quality of water in a watershed from hillside erosion and fire sedimentation as well as the quantity of water entering the system from decreased soil infiltration, lessened vegetation interception, and increased catchment evapotranspiration. The Gallinas Watershed in northern New Mexico was impacted by the 2022 Hermits Peak/Calf Canyon (HP/CC) Fire, the largest wildfire in New Mexico's history (>340,000 acres). Approximately 115,542 acres burned in the Headwaters Gallinas River Watershed, 21% of which were classified by the USFS Burned Area Emergency Response team as high burn severity. While much research focuses on the increased flooding from monsoonal rains after a forest fire, little data exists about wildfire impact on snowmelt runoff. We are monitoring the Gallinas River's discharge during the spring runoff (March through May) to test what if any impact the 2022 HP/CC forest fire has on streamflow. As of March 25, 2024, the snowpack depth at the NRCS Wesner Springs snow monitoring station at the Gallinas River's source (Elk Mountain; 11,151 feet) stands at 43.0 in. and snow water equivalent is 13.3 in., which are both higher than the 30-year median by 116% and 106% respectively. The above-average snowpack raises concerns for increased snowmelt in the watersheds, with heightened concern for earlier onset and higher levels of peak flows due to post-fire watershed conditions. We have been monitoring in near real-time the SWE, air temperature, and soil moisture at Wesner Springs and comparing these data to both historic and 2024 Gallinas River discharge data with emphasis on the period during the spring snowmelt (March through May) to test what if any impact the 2022 HP/CC forest fire is having on hydrologic conditions. Historically, the hydrographs for Gallinas Creek near Montezuma, NM (USGS 08380500) show generally broad and diffuse trends with step-wise increases in discharge from March to May from snow melt in contrast to the narrow, sharp, and marked increases in discharge from June to August from monsoon rains. The Spring 2023 Gallinas River hydrograph had a similar pattern to historic trends (step-wise increase in discharge with peak runoff (214 ft^3/sec) in mid-April. The Spring 2024 Gallinas River hydrograph (as of March 25th) shows a flashy response with the highest runoff to date of 32.9 ft^3/sec. The NRCS National Water and Climate Center has calculated a forecast volume (50% exceedance probability) of 101% of the 30-year median at Gallinas Creek near Montezuma. Historically, peak discharge on the Gallinas occurs around May 15th based on the 96-year record, but has been occurring earlier during the millennium drought. This year, with the above average snowpack, post-fire conditions, and departure of the hydrograph from historic trends, monitoring in near real-time is imperative to forecast flood stages, manage fire sedimentation, and protect water supplies.

Keywords:

Hermits Peak/Calf Canyon, discharge, Headwaters Gallinas Watershed, snow water equivalent, flood

Status of the RioSol Transmission Line Project

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SouthWestern Power Group (SWPG) is the developer of the SunZia Transmission Line Project which originally comprised two, high voltage transmission lines between central New Mexico and central Arizona. The RioSol Transmission Line Project is the second phase of the SunZia Transmission Line project. RioSol is an alternating current (AC) line that will interconnect with three to six utility systems in both states. The line will start in Torrance County, run across to Valencia County, down to Luna County, and terminate in Pinal County. The line will interconnect with 3-5 utilities along the route with opportunities for other interconnections for large scale projects. The project is expected to start construction in late 2026 and start commercial services in late 2028. This presentation will provide the current development status and interconnections plans for the RioSol Project.

Keywords:

transmission lines, renewable energy

DEVELOPING ACCESSIBLE VISUALIZATIONS OF GEOPHYSICAL AND GEOCHEMICAL PROCESSES FOR CAVE AND KARST EDUCATION.

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The National Cave and Karst Research Institute (NCKRI) is a research institute of New Mexico Institute of Mining and Technology that was created by the US Congress in 1998 in partnership with the National Park Service, the State of New Mexico, and the City of Carlsbad. Part of the mission of NCKRI is to promote public education by acting as a nexus for education and outreach projects between various entities, providing resources to educators and academic institutions, and having multiple ways in which to interact with the public. NCKRI's educational endeavors include social media posts, learning module systems and a website. Through these platforms, an ongoing project of NCKRI is the development of accessible visuals on cave and karst science. Visuals are an effective tool for delivering scientific information, and are used in a variety of different scientific contexts such as on research papers, poster and oral presentations, and textbooks. According to Mayer and Anderson (1991), students learn topics best when text or verbal information is presented along with a visual, as opposed to only text/verbal information or only visual information. As a result, visual information can be a powerful supplement in text or verbal communication and aids in the comprehension of complex or abstract ideas. Visuals can be any graphics such as diagrams, pictures or animations. For earth sciences, envisioning information in a variety of forms is beneficial. Animations are specifically helpful in explaining geophysical processes because of its ability to emphasize attributes and their dimensions, temporal changes and even spatial changes. Geophysical and geochemical processes such as how speleothems form, speleogenesis of caves, and development of karst landscapes can be shown through animated diagrams and videos. Using these principles, NCKRI is currently creating diagrams to explain geophysical and geochemical processes for cave and karst public education. These diagrams are converted into Graphics Interchange Format (GIF) that can be shared through the platform GIPHY, via text messages and stories on social media. They are also turned into one minute animations with verbal descriptive information to be shared as a Youtube Short and Instagram Reel. The purpose of this project is to promote cave and karst education by providing accurate and targeted information to a wider audience.

References:

David DiBiase , Alan M. MacEachren , John B. Krygier & Catherine Reeves (1992) Animation and the Role of Map Design in Scientific Visualization, Cartography and Geographic Information Systems, 19:4, 201-214

Mayer, Richard & Anderson, Richard. (1991). Animations Need Narrations: An Experimental Test of a Dual-Coding Hypothesis. Journal of Educational Psychology. 83. 484-490. 10.1037/0022-0663.83.4.484.

Multiyear Monitoring of an Experimental Watershed and Seismic Modeling of Bedload Transport in Gravel-Bed Alluvial Channel

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https://doi.org/10.56577/SM-2024.3021

We first present a comprehensive dataset of five-year monitoring of an experimental watershed at the Arroyo de los Pinos in the central New Mexico. We measured bedload flux directly by mechanical samplers, and seismic signals by seismometers located outside the channel. We then applied a physics-based model of Tsai et al. (2012) to estimate bedload flux to an ephemeral channel with gravel-bed alluvium active on the riverbed. Due to the discrepancy between model predictions and field observations, we further incorporated modifications to better estimate bedload flux in this environment. We altered the statistical distributions of bedload impact frequency, velocity, and angle to account for rolling and sliding and to account for inelastic bed impacts. The modified model decreased error relative to observations to less than one order of magnitude. Although we obtained a good agreement between model predictions and observations, further investigations are needed in other environmental contexts to demonstrate the robustness and broad applicability of the modified model.

References:

Tsai, V.C., Minchew, B., Lamb, M.P. and Ampuero, J.P., 2012. A physical model for seismic noise generation from sediment transport in rivers. *Geophysical Research Letters*, 39(2). https://doi.org/10.1029/2011GL050255

EVOLUTION OF HYDRAULIC FRACTURE PERMEABILITY IN EGS CONSIDERING NATURAL FRACTURE COMPRESSIBILITY AND STRENGTH OF THE SURROUNDING ROCK

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The long-term success of an Enhanced Geothermal System (EGS) project requires distributed fluid flow in created fractures, ideally each with uniform and moderate permeability to avoid early thermal breakthrough. Yet, thermal depletion causes fracture opening, increasing the likelihood of flow channeling in areas with high fracture permeability. Furthermore, the effective reservoir rock stiffness (including natural fracture compliance) has a first-order impact on thermally induced stress changes, and thus fracture permeability. The objective of this work is to explore the role of thermal depletion on hydraulic fracture permeability considering a non-linear elastoplastic geothermal reservoir response. We utilize three-dimensional numerical simulations based on effective medium theory of fractured rocks to implicitly account for natural fracture compressibility and strength. Results demonstrate that a portion of the thermal strain induced by cooling is absorbed by natural fracture compressibility, which reduces the overall stress change, and tends to attenuate hydraulic fracture opening. Critically stressed natural fractures can yield during operation and decrease the likelihood of flow channeling. Lastly, the modeling results indicate that linear elastic models tend to overpredict fracture opening compared to models that account for effective properties of fractured rock masses.

Keywords:

EGS, plasticity, modeling, effective medium

A STREAM-SEDIMENT GEOCHEMICAL SURVEY FOR CRITICAL MINERALS IN THE ZUNI MOUNTAINS, CIBOLA AND MCKINLEY COUNTIES, NEW MEXICO

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We are resampling geologic material, including stream sediments, mineralized rocks, mine wastes, and host rocks, in the Zuni Mountains, west of Grants in Cibola and McKinley Counties as part of a project with the U.S. Geological Survey's Earth MRI program. The purpose of this sampling is to assess the critical minerals potential of this area, as well as to train the next generation of geologists and engineers in modern exploration techniques.

Critical minerals are mineral commodities that are essential to the economic and national security of the U.S., and are from a supply chain that is vulnerable to global and national disruption. In the mining industry, minerals refer to any rock, mineral, or other naturally occurring material of economic value, including metals, industrial minerals, energy minerals, gemstones, aggregates, and synthetic materials sold as commodities, including critical minerals. In many cases, mineral deposits are available in the world for specific critical minerals, but the real challenge for the U.S. economy and security is potential supply disruptions of these essential commodities.

Re-examination of the Zuni Mountains for critical minerals is important because of the diverse geology in the area as well as the need for critical minerals in the U.S. Most of the exposed rocks in the Zuni Mountains consist of Proterozoic granites, pegmatites, and metavolcanic rocks. Permian sedimentary rocks consist primarily of the Abo Formation, Yeso Group, Glorieta Sandstone, and San Andres Formation. Quaternary basalt flows and cinders are found throughout the southern portion of the area. The major types of mineral deposits in the Zuni Mountains include 1) veins and replacements in Proterozoic rocks, 2) stratabound, sedimentary-copper deposits, 3) fluorite veins, 4) episyenites (REE-Th-U metasomatic bodies), 5) high-calcium limestone, 6) volcanic cinders (scoria), and 7) iron deposits. Potential deposits are cobalt-nickel-platinum group metals in ultramafic rocks and pegmatites. Base and precious metals were found in the Zuni Mountains mining district circa 1900 and at least one metal mill was built in the district. Total reported production from the district amounts to more than 30,000 lbs copper, 260 oz silver, and 2 oz gold from 1923 to 1965; additional copper, gold, and silver production probably occurred during the late 1800s.

In order to train the next generation of geologists and engineers, a graduate-level exploration geochemistry class was taught by the lead author during the fall semester of 2023. Sampling in the Zuni Mountains was conducted primarily by class members, which allowed 17 students with varying field experience to learn how to plan and execute a geochemical sampling program. The students were split into five groups to sample different areas within the Zuni Mountains. Approximately 90 samples have been collected in the Zuni Mountains. Unfortunately, the chemical analyses were not received in time for the class to interpret the data before the end of the semester, but a graduate student and some of the students will continue with the project.

The class learned valuable lessons in team work, field safety and the importance of good communication during this project. Some groups experienced muddy roads, even getting a truck stuck on one occasion. Satellite communicators were used to inform the instructor of the situation and retrieve everyone, including the truck, safely.

Preliminary results indicate that some areas near the stratabound, sedimentary-copper deposits have elevated heavy rare earth elements (REE), vanadium, cobalt, and arsenic. The northern Zuni Mountains also appear to have elevated REE, probably associated with the granitic rocks and pegmatties. Quartz Hill and Copper Hill areas in central Zuni Mountains have elevated arsenic anomalies surrounding those areas of known Cu-Ag veins and stratabound, sedimentary-copper deposits. Additional sampling in the Zuni Mountains is warranted as geochemical data are analyzed. Petrographic investigations also will be conducted on thin sections prepared from hand samples collected in the district using optical microscopy and electron microprobe analytical methods.

Keywords:

exploration geochemistry, critical minerals, stream sediments, Zuni Mountains

NEWLY DISCOVERED STROMATOLITES AND BIMODAL MAGMATISM AT ~1.23 GA IN THE BURRO MOUNTAINS OF NEW MEXICO: MESOPROTEROZOIC RIFTING FORMED A SHALLOW OCEAN BASIN IN SOUTHWESTERN LAURENTIA

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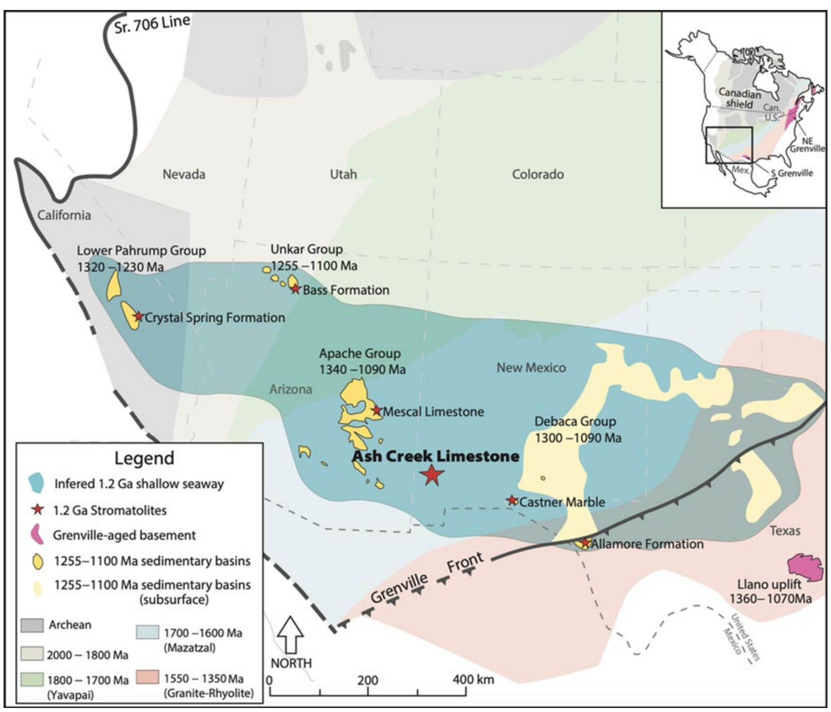
We interpret a newly discovered laminated limestone associated with Middle Proterozoic rocks in the Redrock and Brushy Mountain quadrangles of southwestern New Mexico as representing stromatolites, possibly *Conophyton*. This locality is geographically aligned with other outcrops of ~1.2 Ga stromatolites documented in the southwest U.S., such as those in the Bass Formation (Grand Canyon, AZ), the Mescal Limestone (Salt River Canyon, AZ), the Castner Marble (Franklin Mountains, TX), and the Allamoore Formation (Van Horn, TX). These stromatolites have similar morphologies to those found in Texas and represent the first instance of Proterozoic fossils identified within the state of New Mexico. The stromatolite-bearing unit, termed here the Ash Creek Limestone, is exposed along with a marble unit surrounded by the ~1225 Ma Redrock Granite (Williams, 2015). Mapping at 1:6,000 scale shows that the carbonates are also associated with a unit consisting of serpentinite interbedded with talc (forming a rock informally referred to as ricolite), meaning they share a similar depositional setting. The carbonates are only found surrounded by granite, whereas ricolite outcrops are typically in contact with a metabasalt. The metabasalt yielded a U-Pb zircon weighted mean $^{207}Pb/^{206}Pb$ age of 1229 ± 12 Ma (n= 35; MSWD= 0.8). This represents the first direct dating of ~1.2 Ga mafic volcanism in the area, and these racks are similar in age to anorthosite dated at 1223 ± 6 Ma and 1231 ± 4 Ma (Ramo et al., 2003). Together, the ~1.2 Ga bimodal magmatism and shallow marine limestone units indicate that the tectonic setting of southwest Laurentia at this time involved a NW-SE-trending Mesoproterozoic seaway that formed as a result of coeval regional extension during the early stages of the Grenville orogeny.



Map of the southwest United States highlighting localities where ~1.2 Ga stromatolites have been found in the past and in this study (Ash Creek, Redrock, NM). Locations of Mesoproterozoic sedimentary basins and a proposed shallow seaway also shown. Modified from Mudler et al. (2017).

References:

Mulder, J.A., Karlstrom, K.E., Fletcher, K., Heizler, M.T., Timmons, J.M., Crossey, L.J., Gehrels, G.E., Pecha, M., 2017, The syn-orogenic sedimentary record of the Grenville Orogeny in southwest Laurentia: Precambrian Res. v. 294, p. 33–52, https://doi.org/10.1016/j.precamres.2017.03.006.

Rämö O.T., McLemore, V.T., Hamilton, M.A., Kosunen, P.J., Heizler, M., and Haapala, I., 2003, Intermittent 1630-1220 Ma magmatism in central Mazatzal Province; new geochronologic piercing points and some tectonic implications: Geology, v. 31, p. 335–338, https://doi.org/10.1130/0091-7613(2003)031<0335:IMMICM>2.0.CO2.

Williams W.A., 2015, Proterozoic sedimentation and magmatism in the Redrock Area, Burro Mountains, southwest New Mexico [M.S. Thesis]: Las Cruces, New Mexico State University, 146 p.

Keywords:

Proterozoic, Grenville, New Mexico, stromatolite, bimodal, Laurentia

Evaluating chemical weathering in a small catchment in New Mexico's Black Range to explore implications for limestone dissolution and regional solution caves.

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Solution caves are formed in soluble rock such as limestone, dolomite, and gypsum. Acidic surface streams dissolve the soluble rock along small cracks, joints, faults, and bedding planes. While most limestone dissolution is driven by carbonic acid, certain circumstances can lead to corrosion by stronger acids such as sulfuric or nitric acid, which represent a net CO_2 source to the atmosphere. In New Mexico's Black Range, solution caves occur in Paleozoic carbonates that are stratigraphically associated with sulfur-rich black shales. We are therefore exploring the role of carbonic and sulfuric acid weathering of carbonate rock in the North Percha Creek Watershed. Using geographic information systems (GIS) software, we analyzed the bedrock composition and relative amounts of black shale and limestone in North Percha Creek to determine the primary method and dominant control on chemical weathering in that region. We then analyzed water samples using colorimetric techniques to evaluate shale and limestone weathering. Two preliminary water samples collected in August, 2023 were supersaturated with respect to calcite, and had relatively high conductivities of 587 and 731 µS/cm. Sulfate concentrations for these two waters were 127.5 and 75 mg/L, which could indicate that shale weathering is occurring and may be contributing to limestone dissolution. We will report results from ongoing analyses of a larger number of samples to evaluate if chemical changes in North Percha Creek reveal the primary method of chemical weathering of carbonate bedrock in the watershed.

Keywords:

New Mexico Black Range, Carbonic Acid, Sulfuric Acid, Solution Caves, Limestone Dissolution

Late Holocene Climate Change and the Expansion and Contraction of the Chihuahuan Desert Based on Soil, Geomorphic, Isotopic, and Macrobotanical Evidence at the Cañada Alamosa Archaeology Project, New Mexico

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The Cañada Alamosa Archaeology Project (CA) has documented a 4000-year cultural sequence near the current boundary of the Chihuahuan Desert that is dominated by C3 shrubs and surrounded by C4 grasslands. Given the topographical relief, erodible soils, ^{14}C-datable charcoal in sediments, stepped sequence of fan terraces, carbon isotopes in both soil organic matter and pedogenic carbonate, and macrobotanical remains in archaeological structures, we tested the hypothesis that the landscape at the CA contains a late Holocene climate change record with implications for making inferences about the expansion and contraction of the Chihuahuan Desert. The results indicate that (1) the greatest expansion was in the late Middle Holocene based on charcoal in “Alamosa I” sediments dating to 3695 cal BP and 3952 cal BP. (2) Following this greatest period of expansion was a period of greatest contraction when a 800 to 1000-year span of landscape stability allowed the formation of a well-developed soil on “Alamosa I” sediments. (3) The last major desert expansion based on charcoal in “Alamosa III” sediments was underway by 1358 cal BP when sedimentation continued for some 800 years throughout the Medieval Warm Period. (4) By 500 cal BP (CE 1450), now within the Little Ice Age period, a last retreat of the Chihuahuan Desert. Pueblo people abandoned the site during this period of time. (5) By the 1770s, before the introduction of domestic livestock, arroyo cutting and fan building were underway, and were soon exacerbated by overgrazing.

COMPARATIVE MINERALOGY OF THE 5-ELEMENT ARSENIDE VEIN SYSTEMS OF THE BLACK HAWK DISTRICT, GRANT COUNTY, NEW MEXICO

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Five-element style deposits are unusual hydrothermal systems that are typically characterized by a nickel-cobalt-arsenic-silver-bismuth metal assemblage. This mineralization is often represented by abundant native silver, arsenic, or bismuth, and followed by nickel, cobalt, and iron arsenides (skutterudite, safflorite, nickeline, rammelsbergite, and lollingite). The Black Hawk district in Grant County, New Mexico is one of the few examples of this mineralization style in the United States. Despite differences in formation temperature, depth of emplacement, and host rocks between five-element style deposits worldwide, there are commonalities in mineralogy, ore texture, and composition. A detailed exploration of the native metal and arsenide phases was performed to compare ore forming fluids between systems and the effects on styles of mineralization and paragenesis, as well as to aid in broader classification of the deposit style. Mineralogy and mineral relationships of the Black Hawk District and the Cobalt-Gowganda district, Canada, are characterized by reflected light petrography, scanning electron microscopy, X-ray diffraction, and electron microprobe analysis. Despite these two deposits having very similar genetic relationships, 5-element style mineralization occurring in relation to calc-alkaline bodies intruding into Proterozoic bedrock, there are notable differences in the abundances of cobalt, antimony, and uranium, as well as the ratio of metal to arsenic of the major arsenide phases. Mineralogical phase diagrams were generated to better understand the driving processes and evolution of these systems, and to use the relationships between nickel, cobalt, and iron to reflect the formation conditions through native metal and arsenide precipitation.

APPLICATIONS OF UAS MULTISPECTRAL IMAGERY IN THE EARTH AND ENVIRONMENTAL SCIENCES - GEOSPATIAL APPLICATIONS IN NATURAL SCIENCES LABORATORY

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The Geospatial Applications in Natural Sciences Laboratory (GAINS lab) is the geospatial technology resource center at New Mexico Highlands University (NMHU) that is managed by the Natural Resources Management Department. The lab supports instruction in geographic information science and technologies, along with research applications of geospatial technologies. The lab also provides technical assistance to individuals and groups seeking to incorporate geospatial information into their work. Recently, the GAINS lab was awarded a $162,500 grant from the National Science Foundation - Instrumentation and Facilities program to advance the programs' field surveying capabilities. Here, we report on new Uncrewed aerial system (UAS) applications and ongoing research projects utilizing the new airborne vehicles available at the GAINS laboratory. UAS surveying and mapping provide shape, size, spatial location, and properties of natural geographic features or human-made structures, infrastructure, and facilities on the Earth's surface and near surface. UAS data are often used in land use planning, land resources, geological exploration, water resource development, geologic mapping, conservancy, environmental monitoring, agriculture, transportation, and many other fields. We present a few recent UAS examples from NMHU students, staff, and faculty that include multispectral and RGB imagery of a historic cultural site, an eroded Pliocene volcano, riparian vegetations and fluvial deposits, site monitoring, and many other projects that demonstrate the depth and breadth of UAS imagery applied to Earth systems. The NMHU GAINS team deploys two drone types, both with RGB and multispectral capabilities. The WingtraOne survey-grade UAS is a fixed-wing, vertical take-off drone that provides high precision (<2 cm), RGB and multiple-spectral mapping of large areas using either a full-frame, RGB, 42 MP Sony RX1R II camera or a MicaSense RedEdge sensor that combines a panchromatic sensor with five narrow bands (B,G,R,Re,NIR). The DJI Mavic 3 Enterprise quadcopters provide similar mapping precision and multispectral imagery with the added benefit that their small size allows for high resolution surveys in flight-restricted areas not accessible by a fix-winged aircraft. The UAS are equipped with multi-frequency PPK GNSS receivers, on-board GNSS system, or located with RTK base station positioning control. The new equipment compliments the existing survey gear and supports the GIS technologies course offerings and research to enhance our students' learning environment; builds GIS proficiencies in the community; and makes geospatial data collection available to interested students, faculty, and community members.

Keywords:

uncrewed areal systems, multi spectral, remote sensing

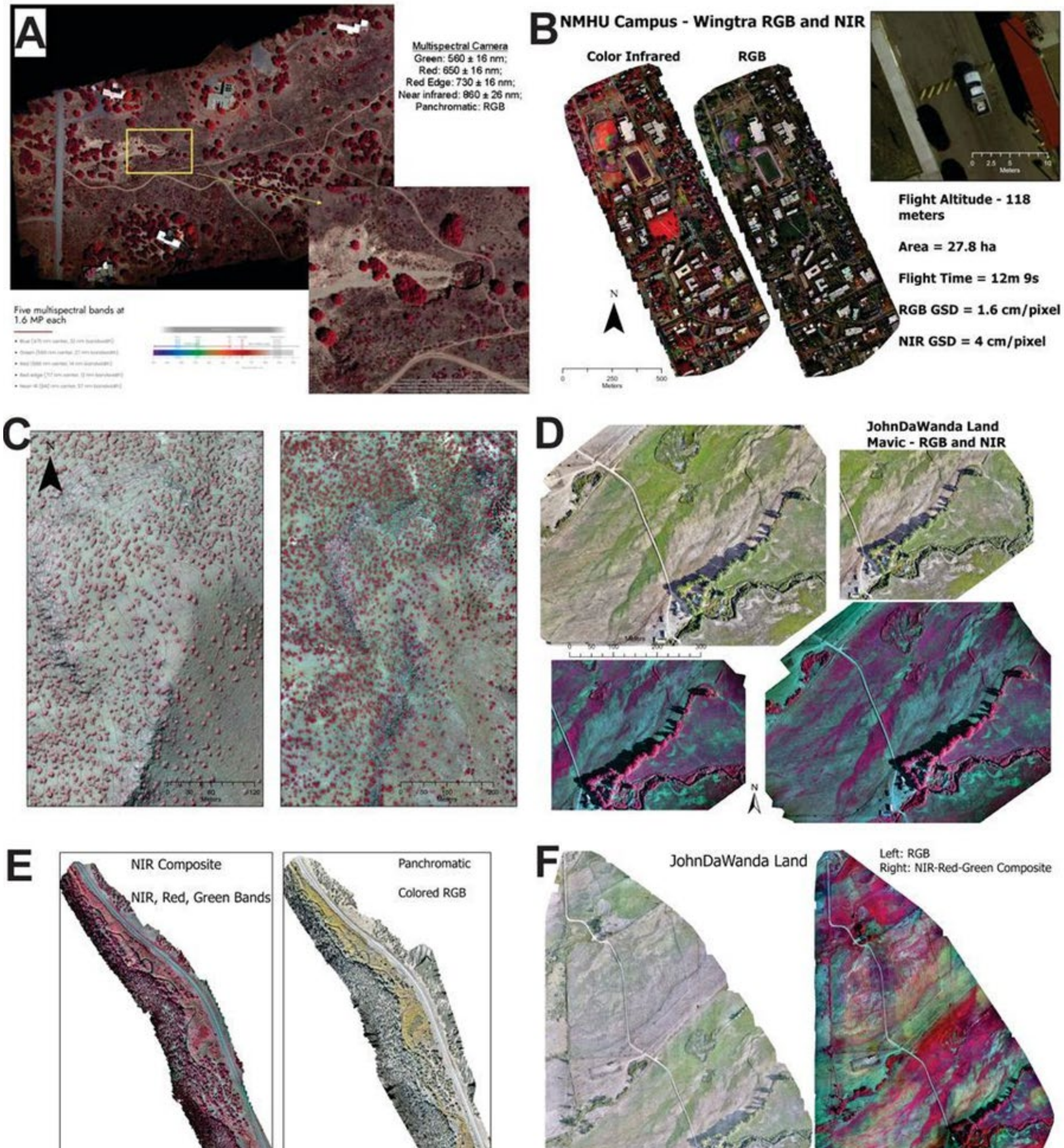

Figure 1. Representative results from recent NMHU student and faculty applications of UAS surveying using the Wingtra and Mavic 3. A) NIR composite image of fluvial knickpoint monitoring. B) NIR and RGB of NMHU campus. C) NIR overlain on UAS acquired digital surface model. D) Mavic 3 enterprise multispectral and RGB camera data. E) NIR and panchromatic images. F) Wingtra RGB and NIR images.

Evaluating Segmentation Behavior Along the Alamogordo Fault, central New Mexico, Using Neotectonic Mapping, Soil Chronosequences, and Geodynamic Modeling

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Earthquake magnitude scales with the length of the ruptured fault plane. Regional seismic hazard assessments therefore require an understanding of how individual fault segments may link together to produce large earthquakes. Though fault segmentation's impact on rupture has been explored along strike-slip faults, such as the San Andreas system in California, similar studies along normal faults are generally limited to the Wasatch fault in Utah (e.g. Duross 2016, Valentini et al., 2020). The Alamogordo fault is a segmented normal fault in the Tularosa Basin of south-central New Mexico with established seismogenic potential (Koning and Pazzaglia, 2002). A rupture along this fault would threaten critical infrastructure, such as the city of Alamogordo (population >30,000), White Sands Missile Range, and Holloman Air Force Base. Here we assess fault segmentation along the Alamogordo fault using a combination of remote sensing, field-based mapping, and geodynamic modeling techniques. Restricted access within the White Sands Missile Range has limited previous mapping efforts, but the release of new statewide lidar datasets allows us to conduct more detailed remote sensing-based neotectonic mapping. Our remote mapping efforts have increased the length of Quaternary rupture by >15 km at both ends of the fault. We have verified these remote mapping interpretations at three locations using high-resolution (1:5,000) neotectonic mapping at locations along the fault with differing geologic and geomorphic characteristics, including variations in basin depth, lithology, and fault geometry. We present one of those neotectonic maps here. These maps identify which Quaternary surfaces have been offset by the fault, allowing us to place an upper bracket on rupture timing. To assess different scenarios for segment linkage and long-term slip rates, we have integrated our updated fault geometries into the lithospheric dynamics code ASPECT. We compare these model results with slip rates derived from soil chronosequences that provide preliminary ages of offset surfaces. Future work will include the collection of cosmogenic nuclide geochronology datasets to validate soil chronosequence interpretations, allowing us to more precisely verify model results and the rupture history of the Alamogordo fault.

References:

DuRoss, C. B., S. F. Personius, A. J. Crone, S. S. Olig, M. D. Hylland, W. R. Lund, and D. P. Schwartz, 2016, Fault segmentation: New concepts from the Wasatch Fault Zone, Utah, USA, J. Geophys. Res. Solid Earth, 121, 1131–1157, doi:10.1002/ 2015JB012519.

Koning, D.J., and Pazzaglia, F. J., 2002, Paleoseismicity of the Alamogordo fault along the Sacramento Mountains, southern Rio Grande rift, New Mexico in: Lueth, V., Giles, K.A., Lucas, S.G., Kues, B.S., Myers, R.G., and Ulmer-Scholle, D., eds., New Mexico Geological Society 53rd Fall Field Conference Guidebook, Geology of White Sands, p. 107–119.

Valentini, A., C.B. DuRoss, E. H. Field, R. D. Gold, R. W. Briggs, F. Visini, and B. Pace, 2019, Relaxing segmentation on the Wasatch Fault Zone: Impact on seismic hazard, Bull. Seismol. Soc. Am. 110, 83-109, doi: 10.1785/0120190088

Keywords: segmentation, neotectonic mapping, soils, modeling, Alamogordo fault, Rio Grande rift

APATITE RARE EARTH ELEMENTS CHEMISTRY AND FLUID INCLUSION STUDY IN HYDROTHERMAL VEINS OF THE LEMITAR MOUNTAINS CARBONATITE, NEW MEXICO

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The Lemitar Mountains carbonatite (Fig. 1A) is a 515 Ma rare earth element (REE) mineral deposit in New Mexico comprising over one hundred carbonatite dikes intruded into Proterozoic igneous rocks [1, 2]. The carbonatite displays grades of up to 1.1 % total REE and showcases variable degrees of hydrothermal autometasomatism and overprinting of the surrounding host rocks through fenitization and veining [1-3]. In this study, we employ a combination of petrography, optical cold-cathode cathodoluminescence and scanning electron microscopy to delineate the mineral paragenesis of the carbonatites and the associated crosscutting hydrothermal veins (Fig. 1). The determination of trace element concentrations in apatite was achieved using LA-ICP-MS. Fluid inclusions were studied in thick sections using optical microscopy, microthermometry and a confocal Raman spectroscopy to assess their salinity, homogenization temperature, and chemical composition.

Magmatic minerals in carbonatite dikes are calcite, dolomite, phlogopite, magnetite, apatite, baddeleyite, and pyrochlore. Our study identifies three hydrothermal vein types (Fig. 1A, B): type I veins (albite-quartz) represent the earliest hydrothermal veins; type II veins (quartz-chlorite ±calcite) crosscut type I veins and are associated with REE-bearing minerals including parisite, zircon, and monazite; and type III veins composed of calcite, quartz, fluorite and barite ± hematite (±parisite). Alteration linked to type I veins includes silicification and sodic fenitization. Alteration associated to types II veins include silicification, chloritization, potassic fenitization, and hematization. Type III veins are characterized by silicification and/or Ca-F metasomatism.

Three different generations of apatite were distinguished based on textures and REE chemistry. Apatite 1 is present as rounded xenocrysts in the carbonatite matrix and exhibits a dull yellow fluorescence. Apatite 2 is commonly found in association with hydrothermally altered carbonatites, presenting as euhedral crystals with dull to bright yellow fluorescence. Apatite 3 occurs in the fenitized host rocks adjacent to the carbonatite dikes and is characterized by 100-500 µm long euhedral crystals with a distinct yellow to blue fluorescence. Apatite 1 contains, on average, ~0.2 wt% REE, apatite 2 contains up to 3.2 wt% REE, and apatite 3 contains ~0.4 wt% REE. The chondrite-normalized REE profiles of the three apatite generations exhibit distinct variations in light vs. heavy REE (Fig. 1C), with apatite 2 enriched in light REE and apatite 3 displaying a flat REE profile with a heavy REE enrichment.

Fluid inclusions (FI) hosted in apatite are complex, multi-phase, solid dominated inclusions. Quartz-hosted inclusions from type I veins are characterized by liquid (L) inclusions with up to 80 vol% vapor (V). Calcite and quartz-hosted FI in type II and calcite-, fluorite-, and quartz-hosted FI in type III veins are liquid dominated with up to 15 vol% V and some of them containing a halite daughter crystal coexisting with vapor dominated inclusions. Microthermometry in inclusions from type III veins indicate homogenization temperatures of ~180 °C with salinities ranging from ~2−15 wt% NaCl eq. The presence of H_2 and CH_4 gaseous species and SO_4^{2-}, CO_3^{2-} as well as dissolved CO_2 species were measured in type I veins in quartz-hosted FI. Type III veins containing fluorite hosted inclusions from the fenitized country rock are observed with H_2 and CH_4 gas, and fluorite hosted inclusions crosscutting the carbonatites is observed with SO_4^{2-}.

In summary, three distinct vein generations are identified, with types II and III containing REE minerals. Apatite 1 exhibits a clear magmatic REE signature, whereas apatite 2 and 3 display an enrichment in light and heavy REE, respectively. Fluid inclusions indicate decreasing temperature from type I to type III vein with reducing gases (i.e. H_2 and CH_4) present in the fenitized zone and an oxidizing sulfate-bearing fluid in the carbonatite, potentially serving as an important ligand for REE transport in this system.

References:

[1] McLemore V. (1987) Geology and Regional Implications of Carbonatites in the Lemitar Mountains, Central New Mexico. J. Geol. Volume 95.
[2] Haft E.B., McLemore V .T., Ramo O. T., Kaare-Rasmussen J. (2022) Geology of the Cambrian Lemitar carbonatites, Socorro County, New Mexico: Revisited, in: Socorro Region III. Presented at the 72nd Annual Fall Field Conference, New Mexico Geological Society, pp. 365–373.
[3] Perry E. P. (2019). Rare Earth Element Signatures in Hydrothermal Calcite: Insights From Numerical Modeling, Experimental Geochemistry, and Mineral Deposits in New Mexico. Ph.D. Dissertation, Colorado School of Mines.

Keywords:

Rare Earth Elements, Hydrothermal Mobility, Mineral Paragenesis, Mineral Chemistry

Developing Accessible Resources for Education and Training in Cave Science

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The National Caves and Karst Research Institute (NCKRI) is an institute headquartered in Carlsbad, NM, specializing in cave and karst research, education, and stewardship. It is a research institute of New Mexico Tech, and one of its major partners is the National Park Service. Public outreach and education is essential to NCKRI's stewardship and scientific goals. However, cave science is a particularly jargon-filled field and carries with it a lot of mainstream misconceptions, so it is vital to explore many different routes of public education. One of these methods is the cave and karst word of the week, which is a weekly social media effort to define a "jargon" cave science term. This is an effective tool in combating jargon in an easy and accessible way to a wide-reaching user base. NCKRI's education department is also spearheading another approach: the creation of learning modules for students and training prospective park rangers or tour guides. Through the use of an online learning module system, lessons can be compiled into easily digestible sections. These learning modules walk the user step-by-step through lessons that explain cave science topics with clarity and efficiency. Lessons include text that describes processes in accessible language, visual depictions (including images and narrated animations), and knowledge checks scattered throughout each lesson to ensure user comprehension. These knowledge checks include quizzes, sorting activities, and definition matching to reinforce understanding of complex processes in cave science. The learning modules can be taken at the user's own pace and are designed to logically string together concepts so that, by the end of a module, the user can feel confident in their understanding of cave processes. We are currently finalizing learning modules for volcanic caves and solution caves, with more planned for the future, including modules on speleothems and erosional caves. As these learning modules and other strategies in NCKRI educational outreach are realized, issues in public conception and productive communication of cave science can be addressed in ways that are both accessible and effective.

NEW ^{40}AR/^{39}AR DETRITAL SANIDINE GEOCHRONOLOGY FROM THE EOCENE SAN JOSE FORMATION, EASTERN SAN JUAN BASIN, NORTHWESTERN NEW MEXICO

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The San Juan basin (SJB) of northwest New Mexico has received a considerable amount of study focused on determining the timing of Laramide deformation, provenance, and basin-scale sediment dispersal trends from Jurassic-earliest Paleogene strata. However, little is known about the sources and driving mechanisms for deformation and erosion that resulted in the deposition of Eocene synorogenic strata of the San Jose Formation in the SJB. The San Jose Formation has been subdivided into four units that include: (1) the basal Cuba Mesa Member (sand- and gravel-dominated facies), (2) the overlying silt-dominated Regina Member, (3) the sand-dominated Llaves Member, and (4) the youngest (sand and silt dominated) Tapicitos Member. Presented here are N=8 new ^{40}Ar/^{39}Ar detrital sanidine samples from the San Jose Formation.

The basal Cuba Mesa Member of the San Jose Formation contains a variety of peaks ranging from 180-160 Ma and 80-63 Ma, a primary peak at 74 Ma, and a secondary peak at 81 Ma. The youngest grain obtained in the Cuba Mesa Member is at 61 Ma. The overlying Regina Member contains peak ages between 180-220 Ma, 78-82 Ma, and 74-76 Ma, with the youngest grain at 65 Ma. The Llaves Member has a peak between 260-280 Ma with the youngest grain at 130 Ma. The Tapicitos Member has a peak between 380-480 Ma with the youngest grain at 360 Ma. Both the Llaves and Tapicitos Members have a noticeable lack of late Mesozoic grains that are present in the two lower members. In addition to the peak ages, all four members also contain occurrences of ages that fall between 500-1000 Ma. The youngest grain in these members is in the Cuba Mesa Member, with an age of 61 Ma.

Detrital sanidine ages that are older than 300 Ma are likely other varieties of K-feldspar, such as microcline and orthoclase. Ages between 300-150 Ma overlap with the Sevier fold-and thrust belt. Ages between 150-90 Ma overlap with the Cordilleran arc. Ages that are younger than 90 Ma likely represent detritus from the Cordilleran arc and Laramide volcanism. The lack of grains from syn-depositional Eocene sources could be explained through numerous means: (1) paleoriver and climate patterns did not favor the deposition of sanidines into the basin; (2) there are a small amount of sanidines in the basin and a larger sample size is required; (3) basement K-feldspars overwhelm the sanidines in the samples; or (4) a combination thereof. Younger grains are also increasingly less common in the upper members of the San Jose Formation, and more common in the lower members. This could represent more regional sources in the Cuba Mesa and Regina Members (Cordilleran arc, Sevier fold-and-thrust belt) and more local sources in the Llaves and Tapicitos Members (microclines and orthoclases sourced from nearby basement Laramide uplifts). These data support a model where the overlying Llaves and Tapicitos Members were sourced increasingly from local Laramide uplifts.

Geologic mapping, structural analysis, and microprobe analysis of the Mazatzal Province in the Salinas Peak region, San Andres Mountains

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Geologic mapping, structural analysis, and microprobe analysis have been paired to improve our understanding of the origin and evolution of the Mazatzal Province in southern New Mexico. This study focuses on tackling the origin of various amphibolite units throughout the Salinas Peak region in the San Andres Mountains. The goal is to extrapolate the tectonic setting that was responsible for the development of the Mazatzal Province and how it evolved with the onset of the Mazatzal Orogeny.The diverse lithologies that make up the Mazatzal Province makes it difficult to propose a model that accounts for the generation of cogenetic and coterminal units. Many models have been proposed for the development of the Mazatzal Province, but there have been limited studies on the Mazatzal Province in southern New Mexico. Further studies throughout New Mexico can help identify tectonostratigraphic terranes that represent different tectonic settings of the Mazatzal Province. Preliminary mapping at a 1:12,000 was done to identify the variable lithologies that were previously unknown. Structural analysis is used to decipher sets of foliation trends that may be associated with different deformation events. Foliations plotted on a stereonet shows a SE hinge for folded foliations in the Salinas Peak area. SW and NE compression is responsible for the folding of these foliations. It is speculated that the foliations and their subsequent deformation took place during the Mazatzal or Picuris Orogeny. Petrography of some amphibolite shows evidence of prograde and retrograde metamorphism with poikiloblastic amphibole filled with quartz. Titanite in equilibrium with amphibole provides backing for future U-Pb titanite geochronology to date the age of metamorphic events. Microprobe analysis of amphibole and plagioclase from amphibolite was done to understand the composition of the protolith.

AGE CONSTRAINTS ON LATE CRETACEOUS DINOSAURS: GEOCHRONOLOGIC AND STRATIGRAPHIC ANALYSIS OF THE MCRAE FORMATION WITHIN THE LARAMIDE LOVE RANCH BASIN, NEW MEXICO

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The Upper Cretaceous McRae Group, situated in the Laramide foreland basin known as the Love Ranch Basin in south-central New Mexico between Engle and Truth or Consequences, consists of the José Creek (oldest), Hall Lake (middle), and Double Canyon (youngest) formations. However, there are limited geochronological data available for these units. The Hall Lake formation has several dinosaur fossils, including *Alamosaurus* and *Tyrannosaur bones previously identified at T. rex but later postulated by* Dalman et al. (2024) to be a new *Tyrannosaur* species (*T. mcraeensis*), predating the late Maastrichtian *T. rex*. We used laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS) to obtain U-Pb ages from detrital and igneous zircons from sandstone and tuffs within the McRae Group, below, at, and above the fossil locality. All ages are $^{238}U/^{206}Pb$ zircon ages with uncertainties reported at 2s. We seek to establish the likely age for the strata containing the fossils, evaluate when Laramide deformation ended, and determine whether the K-Pg boundary is exposed in this section.

The Hall Lake Formation is approximately 700 m thick (Lucas et al., 2019) and consists of primarily mudstone, sandstone, and a 73.1 ± 0.7 Ma tuff layer (U-Pb zircon; Amato et al., 2017) that is 10 meters above the base of the Hall Lake Formation. We redated this tuff and it has a weighted mean U-Pb zircon age of 74.1 ± 0.9 Ma (n=17, MSWD=1.4; Campanian). An *Alamosaurus* fossil is ~150 m above the base of the Hall Lake strata (Lucas et al., 2019). Detrital zircons from a sandstone at this fossil locality stratigraphic level yielded a maximum depositional age (MDA) of 69.8 ± 0.7 Ma (Maastrichtian).

The Double Canyon Formation consists of sandstone, conglomerate, shale, and two newly identified silicified tuff layers previously described as chert. These tuffs are approximately 80 m above the Hall Lake contact. The lower tuff is approximately 5 meters thick and contains phenocrysts in an ashy matrix. The upper tuff is 1-2 m above the lower tuff and lacks phenocrysts. Igneous zircons from two samples of the lower tuff in the Double Canyon Formation yielded a combined age of 60.6 ± 1.3 Ma (n=7, MSWD = 0.5). The two samples of the upper tuff yielded a combined age of 60.6 ± 1.2 (n=11, MSWD=1.1); both ages are Paleocene. Sandstone near the base of the McRae Forest section of the Double Canyon Formation has an MDA of 57.6 ± 0.5 Ma, and sandstone near the top of this section has an MDA of 56.0 ± 0.6 Ma (at the Paleocene/Eocene boundary).

The Double Canyon Formation now known to be partly Paleocene and likely extends into the Eocene. The *Alamosaurus* strata are no older than 70 Ma. This means the K-Pg boundary, if exposed in this area, is located either in the 80 m of section below the 61 Ma tuffs in the Double Canyon Formation or, more likely, in the 550 m of section above the *Alamosaurus* strata in the Hall Lake Formation. The stratigraphic location of this boundary is the focus of ongoing investigation, as is the MDA of the *Tyrannosaurus-bearing* strata which will bear on the hypothesis that *T. mcraeensis* is a predecessor of *T. rex*.

References:

Amato, J.M., Mack, G.H., Jonell, T.N., Seager, W.R., and Upchurch, G.R., 2017, Onset of the Laramide orogeny and associated magmatism in southern New Mexico based on U-Pb geochronology: Geological Society of America Bulletin, p. B31629.1, doi:10.1130/B31629.1.

Dalman, S.G., Loewen, M.A., Pyron, R.A., Jasinski, S.E., Malinzak, D.E., Lucas, S.G., Fiorillo, A.R., Currie, P.J., and Longrich, N.R., 2024, A giant tyrannosaur from the Campanian–Maastrichtian of southern North America and the evolution of tyrannosaurid gigantism: Scientific Reports, v. 13, p. 22124, doi:10.1038/s41598-023-47011-0.

Lucas, S.G., Nelson, W.J., Krainer, K., and Elrick, S.D., 2019, The Cretaceous System in central Sierra County, New Mexico: New Mexico Geology, v. 41, p. 3–39, doi:10.58799/NMG-v41n1.3.

ALTERATION AND GEOCHEMISTRY OF CLINKERS IN THE SAN JUAN BASIN, NEW MEXICO

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There are 24 coal fields in the San Juan Basin, northwestern New Mexico. Clinkers are found near the coal beds and are former sedimentary rocks that were baked by coal fires. When coal catches fire through various causes (wildfires, lightning strikes, spontaneous combustion through pyrite breakdown) it spreads underground and burns at high temperatures, heating up and baking the surrounding rock layers. These high temperatures cause organic materials to be removed from the sedimentary rocks that surround the coal layer. This causes the iron minerals in the sedimentary rocks to oxidize, changing the rock coloration to a deep orange-dull yellow. Clinkers can vary in durability and hardness depending on the mineral structure present in the original sedimentary rock, as well as the temperature they were exposed to during pyro-metamorphosis.

The purpose of looking at clinkers within the San Juan Basin is to examine them for critical minerals and rare earth elements as part of the DOE Core-CM project. Clinkers have not undergone drastic geochemical changes during the pyro-metamorphism process; however, some new mineral phases were formed as a result of the high temperatures. The highest detected REE concentrations are 323 ppm. However, some clinkers do contain high levels of Al_2O_3, up to 40% in some cases. While low in other critical minerals, clinkers may have potential as aluminum resources in the future.

Coal 28E, San Juan Basin clinker outcrop, Virginia T. McLemore photo

GEOCHRONOLOGY AND CRITICAL MINERAL POTENTIAL OF SELECTED LARAMIDE PORPHYRY AND RELATED DEPOSITS IN SOUTHWEST NEW MEXICO

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Southwest New Mexico is part of the larger southwestern North America Laramide porphyry belt, which stretches from Arizona into New Mexico and further south into Mexico. The primary products of these deposits are copper, molybdenum, and gold, but additional by- and co-products can be extracted from these deposits such as Platinum Group Elements, tellurium, indium, gallium, germanium, and others, of which many are classified as critical minerals. These deposits are largely Laramide (~80-45 Ma) in age, and are a result of hydrothermal interactions with calc-alkaline igneous plutons from the arc magmatism of subduction zones. In New Mexico, these deposits occur alongside younger mid-Tertiary (Eocene-Oligocene, ~40-30 Ma) deposits that are thought to be a result of transitional arc magmatism to extensional magmatism. A new geochronological study of southwest New Mexico was necessary in order to resolve the question of whether some deposits are Laramide or mid-Tertiary. New argon-argon geochronology, whole rock and trace element geochemistry, and electron microprobe analyses have resolved questions on whether some deposits are Laramide or mid-Tertiary in origin. Several districts were confirmed as either Laramide or mid-Tertiary, while others were determined to have both deposit styles present in the same district. The updated geochronology and characterization of these districts leads to the updating of the mineral-resource potential of these districts, as well as the different types of critical minerals that have the potential to occur with each deposit style.

Hydrothermal Rare Earth Elements (REE) Partitioning into Fluorite: A Fluid Inclusion Study from the Gallinas Mountains REE-bearing Fluorite Deposit, NM

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Rare earth elements (REE) are becoming increasingly important in modern society due to their numerous uses in manufacturing of components for green and high-tech energy industries. Studying the mechanisms of REE mineral formation in geologic systems is vital for understanding where and how these mineral deposits form. Previous studies of REE mineral deposits have shown that hydrothermal fluids can play a key role in the mobilization and enrichment of REE (Williams-Jones et al., 2000; Gysi et al., 2016; Vasyukova and Williams-Jones, 2018). Fluorite is ideal to study the behavior of REE because of their compatibility in its structure and it is a ubiquitous hydrothermal vein mineral found together with REE fluorocarbonates (i.e., bastnäsite and parisite). However, the controls on hydrothermal fluid-mineral REE partitioning in these deposits are not yet fully understood.

In this study, we present petrographic observations of fluorite veins and fluid inclusions from the Gallinas Mountains REE-bearing fluorite veins/breccia deposit in New Mexico (McLemore, 2010; Williams-Jones et al. 2000). The Gallinas Mountains deposit notably contains hydrothermal fluorite and bastnäsite, and is associated with ~30 Ma alkaline igneous rocks intruded into Permian sedimentary rocks (McLemore, 2010). The goal of this study is to better understand the cause of REE variations in fluorite as a function of temperature and salinity of the fluids, and to determine how the REE concentrations change in barren and mineralized veins. Optical microscopy and cold-cathode cathodoluminescence (CL) is used to distinguish different fluorite generations and fluid inclusion types. Scanning electron microscopy (SEM) is used to identify REE minerals, zonation in fluorite, and acquire elemental compositions of different vein minerals.

Fluorite samples collected in this study include sandstone-hosted (i-iv) and trachyte-hosted (v) veins/breccias that are classified into: i) bastnäsite-quartz-fluorite veins (GAL3015B); ii) barite-calcite veins crosscut by barren calcite-fluorite veins (GAL3018B); iii) barite-calcite veins crosscut by mineralized bastnäsite-(calcite)-fluorite veins (GAL3046); iv) barite-fluorite and bastnäsite-fluorite breccia and vein infills containing base metal sulfides (GAL3041A); v) bastnäsite-(calcite)-fluorite breccia (GAL3044A). Three different fluorite generations are distinguished based on CL with distinct fluid inclusion types. Fluorite 1 is euhedral and zoned, with generally bright blue to purple CL colors, and is found in bastnäsite-(calcite)-fluorite veins and breccias (samples GAL3046 and GAL3044A) as brecciated fluorite clasts and cubes with bastnäsite rimming or replacement textures in a calcite matrix. In samples GAL3015B and GAL3041A, fluorite 1 is present in bastnäsite-quartz-fluorite and barite-fluorite veins/breccias with later crosscutting finer grained fluorite ± bastnäsite infills. The later fluorite is classified as fluorite 2, which shows a green to dark blue/purple CL color. Fluorite 3 displays a bright green to lavender luminescence and forms euhedral cubes with complex growth zoning and occurs in sample GAL3018B. Another very fine-grained fluorite was distinguished in the matrix of some veins and breccias found in GAL3015B and GAL3041A, being pronounced in the vicinity of sandstone and possibly being a replacement of some of the quartz clasts, similarly observed by Williams-Jones et al. (2000).

Several types of fluorite-hosted fluid inclusions (FI) were identified including vapor (V) rich inclusions, liquid (L)+V inclusions, and L+V+solid inclusions. The L+V can be classified into two populations: high temperature inclusions with high vapor proportions between ~30-40 vol% and low temperature inclusions with smaller vapor proportions ranging between ~5-15 vol%. The next step in this study is to relate the FI petrography to the different fluorite generations, and to conduct microthermometry heating/freezing experiments to determine their salinities and homogenization temperatures.

In conclusion, the studied fluorite can be classified into different vein types depending on the presence or absence of barite, bastnäsite, calcite, and quartz. Three main different fluorite generations were distinguished but more CL work is needed to identify some of the more complex fluorite intergrowth textures and relationships. The FI petrography indicates a potential to link the fluorite types with different FI types based on their varying L+V ratios. The latter are indicative of entrapment temperatures, with inclusions with larger vapor proportions reflecting a higher fluid entrapment temperature.

References:

Gysi, A. P., Williams-Jones, A. E., and Collins, P. (2016) Lithogeochemical vectors for hydrothermal processes in the Strange Lake peralkaline granitic REE-Zr-Nb deposit. Economic Geology 111, 1241–1276. https://doi.org/10.2113/econgeo.111.5.1241

McLemore, V. T. (2010) Geology and mineral deposits of the Gallinas Mountains, Lincoln andTorrance counties, New Mexico: Preliminary report. New Mexico Bureau of Geology andMineral Resources, Open-file Report OF-532, 92 p. https://doi.org/10.58799/OFR-532

Vasyukova, O. V., Williams-Jones, A. E. (2018) Direct measurement of metal concentrations in fluidinclusions, a tale of hydrothermal alteration and REE ore formation from Strange Lake, Canada.Chemical Geology 483, 385–396. https://doi.org/10.1016/j.chemgeo.2018.03.003

Williams-Jones, A. E., Samson, I. M., and Olivo, G. R. (2000) The genesis of hydrothermal fluorite-REE deposits in the Gallinas Mountains, New Mexico. Economic Geology 95, 327–341. https://doi.org/10.2113/gsecongeo.95.2.327

Rural Geothermal Potential: A Case Study for Presidio County Texas

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The geothermal resource of Presidio County could supply many times the county's electrical and direct-use needs if developed. Geothermal power would also increase resiliency and incentivize businesses to settle and expand in the county. Presidio County clearly has substantial, undeveloped geothermal resources. These resources could prove economically viable for development in a wide range of scenarios for electricity production, industrial/agricultural, and heating/cooling use. The economics of geothermal development are varied and (without considering any tax/credit/loan incentives, which can be substantial) range from poor to good.

The best quality resource (the Border region) is a strip approximately 16km (10 mi) wide along the border with Mexico running from Redford to the NW corner of the county. The thermal gradients in the zone are quite high (on the order of 200-300°C/km), meaning the required drilling depths to reach a given temperature are relatively shallow (which in turn means lower project cost). This zone corresponds to a large percentage of the relatively low population and thus energy demand of all types.

The bulk of the county (about 2/3) is in the Interior Region. Despite the name, this area is still an excellent resource, with temperatures above average worldwide. Although drilling depths needed to reach a given temperature are deeper than the Border Region, they are still within the range of present technology, are potentially economic, and could easily support the main population center of Marfa.

The county's southeast corner, the Big Bend Region, is a relative unknown. There is a severe lack of data other than surface geologic mapping; thus, not much can be said about the potential here, though it is likely to fall within the bounds of the Border and Interior regions and therefore have significant potential. Drilling new wells in this region would be needed to improve the assessment of this zone.

Further research is proposed that would “buy down” risk to all parties.

Reservoir Characterization and Management of the Radium Springs Geothermal System for Heating a Large Geothermal Greenhouse at Masson Radium Springs Farm

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The Masson Radium Springs Farm is the largest geothermally-heated greenhouse in the United States with 30 acres (121,1406 m^2 or 12 hectares) of enclosed crop growing space. Three large diameter production wells supply up to 3,000 gpm (189 L/s) of 190 to 200 °F (87.8 to 93.3 °C) fluid to plate-and-frame heat exchangers that transfer heat to a massive closed-loop fresh water heating system of bare pipe heat and radiant floor heat. Three large diameter injection wells gravity feed cooled geothermal fluids piped from the surface plate-and-frame heat exchangers back to the natural geothermal flow regime. In 1986, the initial 4 acres (16,187 m^2 or 1.6 hectares) of greenhouse were supplied by two shallow productions wells completed in a highly-fractured and a shallow-angle, north-dipping Oligocene rhyolite dike. After heat exchange, the cooled fluids were returned to the fractured rhyolite via injection wells completed at distances between 300 and 800 ft (91.4 and 243.8 m) from the production wells. After several years, the production wells began to show cooling with thermal break- through from closely-located injection wells as the greenhouse grew in acreage and geothermal well production volume. In 2000, a large diameter production well was drilled across the fractured rhyolite and the confining Eocene andesitic volcanoclastic lahar unit of Palm Park Formation into the Permian Hueco Formation consisting of fractured limestone with solution permeability. The structural geometry provided a solution to the problem of thermal breakthrough as the Palm Park Formation provided a local barrier between hot upwelling fluid in the rhyolite and Hueco Formation. Upflow in the rhyolite is supplied by the Hueco Formation in the subsurface at an estimated distance of >3,500 ft (>2,750 m) north of the greenhouse. All geothermal production was transferred to the deep parent confined Hueco Formation reservoir and the injection was applied to the rhyolite to complete the short circuit of the natural flow path by tapping the deep reservoir for production. Drawdown provides hydraulic conductivity information for the deep confined carbonate reservoir. The production wells in the fractured limestone show an average transmissivity of 28,000 ft^2/d. A nearby down-to-the-west Pleistocene fault forms a western boundary of the rhyolite and Hueco Limestone reservoirs and the fault proximity no doubt influences reservoir properties as a no-flow western boundary due to stratigraphic juxtaposition of aquitards (Palm Park Fm) and aquifers (rhyolite dike) and an enhancement of footwall fracture permeability. Recognition of the reservoir and flow components of geothermal hydrogeologic windows has important utility in reservoir characterization and management.

Keywords:

geothermal, direct-use, Radium Springs, greenhouse, hydrogeologic window

Determining Key Factors in Well Selection Criteria for Navajo Technical University-New Mexico Tech-Navajo Nation Water Purification Project (N^{4}WPP)

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Access to clean and safe water is a fundamental human right. Yet, many indigenous communities, including the Navajo Nation, face persistent challenges in securing potable water sources due to pollution and inadequate infrastructure. The Navajo Reservation, spanning portions of Arizona, New Mexico, and Utah, faces multifaceted water contamination issues from natural and anthropogenic sources. These challenges include arsenic and uranium contamination from geological formations, mining activities, and inadequate wastewater treatment facilities. Consequently, residents face heightened risks of waterborne illnesses and long-term health effects.

In response to these challenges, N^{4}WPP aims to install filtration units on the Navajo Reservation in conjunction with Navajo Technical University and New Mexico Tech. The project proposes establishing comprehensive selection criteria to guide the prioritization and implementation of water purification initiatives on the Navajo Reservation. The selection criteria encompass a multidimensional approach, considering technical feasibility, environmental sustainability, cultural appropriateness, and community engagement.

Technical feasibility factors include assessing available water sources, water quality parameters, and the suitability of purification technologies for addressing specific contaminants prevalent in the region. Environmental sustainability considerations encompass the ecological impacts of purification methods, energy requirements, and the potential for long-term maintenance and scalability.

Cultural appropriateness criteria recognize the importance of indigenous perspectives and traditional knowledge in water management practices. This involves engaging with Navajo communities to incorporate culturally relevant approaches, respect sacred water sites, and uphold tribal sovereignty in decision-making processes.

Historical water quality records from the Navajo Nation Environmental Protection Agency and Navajo Nation Water Resources Department guide the search for suitable wells. Wells with high levels of total dissolved solids (TDS) are the initial target for the filtration unit.

Another criterion considered was access; the location must be close enough to Navajo Technical University or New Mexico Tech, Alamo Chapter. The reasoning was that students would train on the unit, and students and other team members would teach community members how to run and maintain the units.

The last criterion evaluated was the conditions of the well. There had to be a place to attach the unit that would not hinder the operation of the tank. The location had to be easily accessible and navigable so that a trailer-mounted filtration unit could be easily installed.

Evaluation of existing data has identified wells that meet all criteria: Lake Valley (15T-584) and Baca-Prewitt (10T-241A). Well 15T-584 was chosen due to the proximity to Navajo Technical University and high TDS levels. Well 10T-241A was selected because of its proximity to Navajo Technical University, the amount of water produced, and the high levels of TDS and uranium.

Keywords:

Navajo Nation, Hydrology

Geologic Mapping in New Mexico: An Update on the New Mexico STATEMAP Program

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The New Mexico STATEMAP Program is the preeminent geologic mapping program in the state. Here, we present an update on the 31-year history of the program, with emphasis on current mapping priorities and derivative research. During the history of the program, ~$7.3 million dollars have been secured through competitive STATEMAP grants. These federal funds are matched 1-to-1, bringing the grand total to ~$14.6 million dollars to support mapping in New Mexico—the most of any state in the country as of 2023. With guidance from the NM STATEMAP Advisory Committee, three topics have been identified for focused, long-term geologic mapping. First, the administration and management of water is the most important issue in the state. As aridification of the American Southwest shows no signs of slowing, access to abundant and clean water remains the top priority. Characterization of aquifers and watersheds via geologic mapping is necessary to protect our limited water resources. Second, New Mexico's active geology generates an array of related hazards. Nine of the 14 natural hazards recognized by the state's Department of Homeland Security involve geologic processes. Geologic mapping provides critical information to characterize, and sometimes mitigate, the impact from our geologic hazards. Third, much of New Mexico's economy is linked to the abundant energy and mineral resources in the state. The same formations that host our rich hydrocarbon reservoirs are now being considered for storage of atmospheric carbon dioxide, helping to mitigate climate change impacts felt far outside the state. Geologic mapping is required to identify and safely use our resources as well as to select prime targets for carbon sequestration. The Advisory Committee has also selected three regions of the state as long-term mapping priorities. These areas are the Rio Grande watershed, the Pecos River watershed, and the San Juan basin. These regions are home to the majority of the state's population and critical economic sectors. Prior work in these regions largely focused on 1:24,000-scale geologic mapping within or adjacent to major metropolitan corridors. New efforts are mostly centered on sparsely populated areas of equal importance, but have not yet been the focus of dedicated, detailed mapping. Of the 121,598 square miles of New Mexico, approximately 33% of the state has been mapped at 1:24,000-scale via the STATEMAP Program. Recently, the New Mexico STATEMAP Program has reorganized priorities to align with the goals of the U.S. Geoframework Initiative, a USGS Program that seeks to produce a seamless 2D and 3D map of the country. Much of our mapping is now focused on laying the groundwork for 1:100,000-scale compilations of large regions of the state to support this effort. The creation of 3D subsurface models, data synthesis projects, and updating published maps to modern standards further supports developing a multi-resolution seamless geoframework of the nation. Our geologic maps can be accessed from our website (geoinfo.nmt.edu/publications/maps/home.html) or from our interactive webmap application (maps.nmt.edu).

Keywords:

Geologic Mapping, STATEMAP, Hazards, 3D Subsurface Model, Geochronology