SLATT UNDERGRADUATE RESEARCH FELLOWSHIP
FINAL REPORT

SCHOLAR NAME:	Caitlyn Cano
FACULTY ADVISOR:	Dr. Peter C. Burns
PROJECT PERIOD:	January-October 2021
PROJECT TITLE:	40-Potassium Analysis of Natural Samples from Pueblo of Laguna
CONNECTION TO ONE OR MORE ENERGY-RELATED RESEARCH AREAS (CHECK ALL THAT APPLY):	**( ) Energy Conversion and Efficiency** **(X) Sustainable and Secure Nuclear** **( ) Smart Storage and Distribution** **( ) Transformation Solar** **( ) Sustainable Bio/Fossil Fuels** **( ) Transformative Wind**

MAJOR GOALS AND ACCOMPLISHMENTS

Summarize your research goals and provide a brief statement of your accomplishments (no more than 1-2 sentences). Indicate whether you were able to accomplish your goals by estimating the percentage completed for each one. Use the next page for your written report.

RESEARCH GOALS	ACTUAL PERFORMANCE AND ACCOMPLISHMENTS	% OF GOAL COMPLETED
Quantify Radium Levels in Natural Samples using Gamma Spectroscopy	The long-term goal of the project was to quantify 226-radium in natural samples. We learned the technique of radiometric analysis using a gamma spectrometer (GS) and employed it for 40-potassium as a first step for understanding radium contamination. Analysis was further employed for radium quantification outside the scope of this project.	50
Quantify Potassium Levels in Natural Samples using Gamma Spectroscopy	Potassium detection was successful and we yielded reliable data on nearly all samples. There is room for further cross-verification to test the methods against IAEA reference materials, which showed significant agreement in preliminary study.	95
Confirm Sample Homogeneity using X-Ray Fluorescence	The samples yielded consistent and accurate data. The XRF method adequately confirmed that we could reasonably test any part of a sample to receive similar results.	100
Synthesize/Compile Data as a Poster	The poster was completed in September 2022 and presented in October of 2022 (attached).	100

RESEARCH OUTPUT

Please provide any output that may have resulted from your research project. You may leave any and all categories blank or check with your faculty advisor if you are unsure how to respond.

CATEGORY	INFORMATION
EXTERNAL PROPOSALS SUBMITTED	
EXTERNAL AWARDS RECEIVED	
JOURNAL ARTICLES IN PROCESS OR PUBLISHED	226Ra and 238U Occurrence in Sediments of the Jackpile Member of the Morrison Formation and Surrounding Areas in Pueblo of Laguna, New Mexico, Rodriguez, V. G., Majumdar, A., Meza, I., Corcoran, L. Cano, C., Gagnon, K., Tan, W., Aprahamian, A., Cerrato, J. M., Burns, P. C. Under Preparation.
BOOKS AND CHAPTERS RELATED TO YOUR RESEARCH	
PUBLIC PRESENTATIONS YOU MADE ABOUT YOUR RESEARCH	GSA Connects 2022; “Understanding Radioactive 40-Potassium at the Jackpile Mine and Surrounding Areas with Gamma Spectroscopy,” October 2022; Denver, CO
AWARDS OR RECOGNITIONS YOU RECEIVED FOR YOUR RESEARCH PROJECT	
INTERNAL COLLABORATIONS FOSTERED	Virginia Rodriguez; ND CEEES/Energy Frontier Research Center; Graduate Student Mentorship; Met weekly or more for guidance/support on project
EXTERNAL COLLABORATIONS FOSTERED	

WEBSITE(S) FEATURING RESEARCH PROJECT	
OTHER PRODUCTS AND SERVICES (e.g., media reports, databases, software, models, curricula, instruments, education programs, outreach for ND Energy and other groups)	

RESEARCH EXPERIENCE

Please let us know what you thought of your research experience: Did this experience meet your expectations? Were lab personnel helpful and responsive to your needs? What else could have been done to improve your experience or achieve additional results?

Overall I was very satisfied with my research experience. I got to work on a small piece of a long-term socially impactful project, which was especially gratifying. Our lab time/independent work structure adapted as the project progressed, and logistically the project went very smoothly. My conference experience was especially meaningful and encouraged me to synthesize what I'd learn and share it with others.

FINAL WRITTEN REPORT

(Please use the space below to describe your research project and objectives, any findings and results you can share, and graphs, charts, and other visuals to help us understand what you achieved as a result of this research experience.)

An important part of my project was compiling a poster to present at the GSA Connects 2022 Conference, which sums up the work I did and where the project stands going forward. The poster is attached.

Understanding Radioactive ^{40}K at the Jackpile Mine and Surrounding Areas with Gamma Spectroscopy

Caitlyn Cano[1], Virginia Rodriguez[1], Ashabari Majumdar[2], Isabel Meza[3], Wanpeng Tan[2], Ani Aprahamian[2], José M. Cerrato[3], and Peter C. Burns[1,4]

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BACKGROUND

The Jackpile Uranium Mine located in western New Mexico was once the world's largest open-pit mine. Today we aim to understand the behavior of radionuclides in the surrounding area of the mine. In collaboration with researchers at the University of New Mexico and the Pueblo of Laguna, we collected sediment samples upstream, downstream, and at the mine site to investigate the natural abundance of the radioactive elements with gamma spectroscopy. The method of quantifying 40–potassium (^{40}K) in natural samples using gamma spectroscopy is found in the environmental scientific literature using measurements using the 1460 keV spectral line.[1,2,3] This study will use the Jackpile mine site to understanding the region's natural radioactivity. The method used for ^{40}K can be applied to other radioactive isotopes that pose an environmental concern and lays the groundwork for further method development.

ACKNOWLEDGMENTS

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METHODS AND MATERIALS

Sediments were collected from throughout the mine site and surrounding areas (Figure C) and were analyzed in their existing physical state (using limited powdering and freeze drying where needed to ensure purity). The samples were analyzed in the lab for ^{40}K levels with the 1460.8 keV spectral line using gamma spectroscopy.[1,2,3]

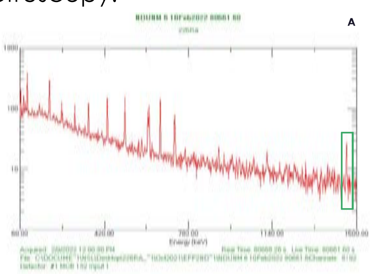

Figure A. Gamma Spectra for Mine 6 Sample. GS Data was collected using an HPGe detector inside a 10cm thick lead cage. The 1460 keV peak (boxed) was used to count ^{40}K activity.

Sample homogeneity was confirmed by X-ray fluorescence.[4] Our methods for the quantification of ^{40}K with gamma spectroscopy were confirmed against International Atomic Energy Agency (IAEA) reference materials IAEA-385 and IAEA-465 (samples of naturally occurring oceanic sediment with confirmed ^{40}K levels).

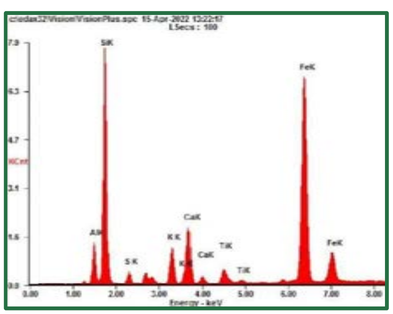

Figure B. XRF Spectra for Wetland 5 Sample.

RESULTS AND DISCUSSION

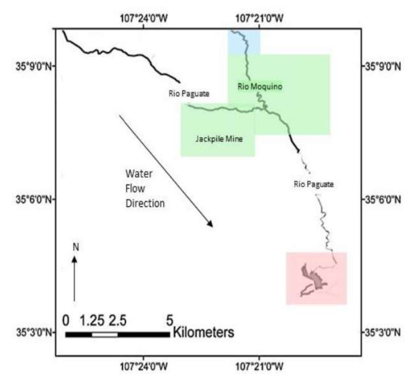

Figure C. Map of Sample Collection Sites. Additional samples were collected from upstream of the Rio Paguate (off-map).

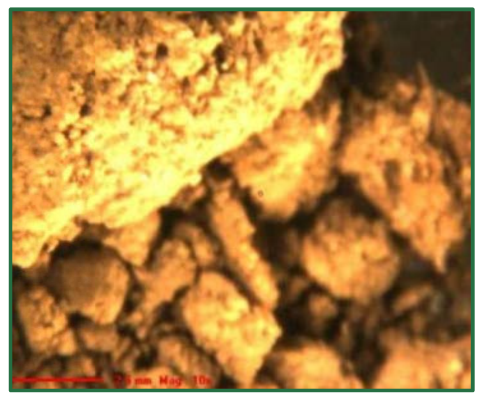

Figure D. Magnified image of sediment sample 5 from Wetland area.

Using the gamma spectroscopy method, we found average ^{40}K levels of 1275 Bq/kg in the upstream Rio Moquino (blue), 467 Bq/kg in the upstream Rio Paguate (yellow), 1890 Bq/kg at the mine site (green), including the Rio Paguate, and 683 Bq/kg in the downstream wetlands area (pink).

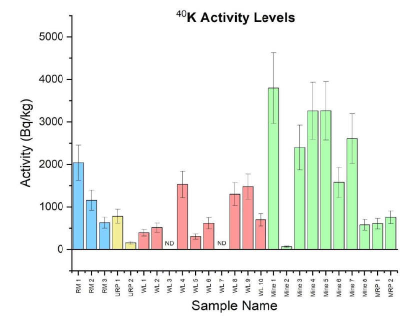

Figure E. ^{40}K Activity Levels organized and color-coded by location.

The X-ray fluorescence data confirmed that the tested samples were homogenous and approximated a natural or near-natural K content for the region (with levels of ^{40}K ranging from 2.62 - 8.13% by weight). The data collected provides a baseline for natural radioactivity in the region, which exists within the average range of ^{40}K levels for undisturbed soils.[1,5,6]

REFERENCES

[1] Santos Júnior, José Araújo dos, et al. "Analysis of the 40K levels in soil using gamma spectrometry." Brazilian Archives of Biology and technology 48 (2005): 221-228.
[2] Singh, Surinder, Asha Rani, and Rakesh Kumar Mahajan. "226Ra, 232Th and 40K analysis in soil samples from some areas of Punjab and Himachal Pradesh, India using gamma ray spectrometry." Radiation measurements 39.4 (2005): 431-439.
[3] Alnour, I. A., et al. "New approach for calibration the efficiency of HpGe detectors." AIP conference proceedings. Vol. 1584. No. 1. American Institute of Physics, 2014.
[4] Liritzis, I., et al. "Potassium determinations using SEM, FAAS and XRF: some experimental notes." Mediterranean Archaeology and Archaeometry 11.2 (2011): 169-179.
[5] Menshikova, Elena, et al. "Concentrations of natural radionuclides (40K, 226Ra, 232Th) at the potash salts deposit." Journal of Ecological Engineering 22.3 (2021).
[6] Shahbazi-Gahrouei, Daryoush, Mehrdad Gholami, and Samaneh Setayandeh. "A review on natural background radiation." Advanced biomedical research 2 (2013).

FUTURE WORK

Using these findings, we provide a greater understanding of radioactive elements in the region. The method used for ^{40}K can be applied to other radioactive isotopes that pose an environmental concern and lays the groundwork for further method development. Given that ^{40}K is typically where natural radioactivity dose comes from absorbed by humans, ^{40}K levels presented here can be compared against other naturally occurring radionuclides to understand radioactivity.