Comparative Analysis of Laboratory and PXRF Methods for Gallinas Mountains Rock Samples

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Abstract

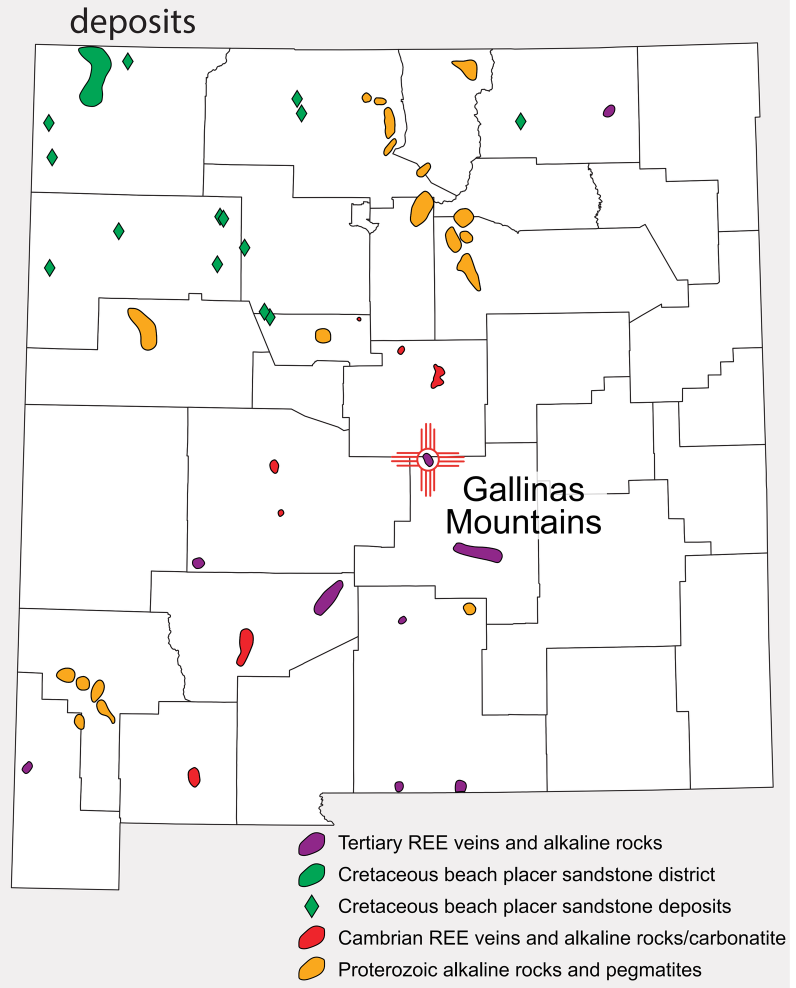
The Energy Act of 2020 defined critical minerals as those that are essential to the economic and national security of the United States and serve an essential function in the manufacturing of products such as computers, smartphones, abrasives, and a host of other technologic applications. Over the last decade, the New Mexico Bureau of Geology and Mineral Resources (NMBGMR) and the United States Geological Survey (USGS) have been reevaluating known mining districts in New Mexico to analyze the potential for critical minerals. The Gallinas Mountains are part of the North America Collerdean belt of alkaline igneous rocks located in the Lincoln County porphyry belt, is one such mining district known to contain critical minerals such as rare earth elements, fluorite, and barite hosted within hydrothermal veins and breccias.The primary REE mineral in the district is bastnäsite $Ce(CO_3)F$, the same ore mineral as significant global REE producers such as the Mountain Pass mine (California (USA) and Bayan Obo mine (Inner Mongolia, China).
The highest REE values in grab samples to date from the Gallinas Mountains reach up to around 8% total REE.
This study aims to assess the accuracy of portable X-ray fluorescence (PXRF) analysis to determine if it can be a reliable tool for exploration geology in search of critical minerals in the unusual rocks of the Gallinas Mountains. Samples of veins and altered host rocks from the Gallinas Mountains were previously sent to the laboratory for whole rock and trace element geochemical analysis. A comparison study will be conducted between the whole rock and trace element geochemical data and data collected with PXRF on the returned powdered samples. Initial results show that the PXRF can be reliable for measuring some critical minerals, however, it does not detect elements lighter than phosphorus. The PXRF analyzer used in this study does not distinguish between the REE and does not detect barium, making it of limited value in exploring for critical minerals in the Gallinas Mountains at this time.

Figure 1. Gallinas peak (2,633 m asl) located in central New Mexico. View facing north.

Background

- New Mexico contains a variety of rare earth element deposits (Fig. 2)
- Gallinas Mountains are located in central New Mexico in the Lincoln porphyry belt in between Torrence and Lincoln counties.
- The Gallinas mountains were explored first in 1870 for Gold and silver
- The district contains (REE)-bearing fluorite veins and breccias
- Veins and breccia formed during the emplacment of trachyte/syenite sills, dikes, and magmatic hydrothermal breccia between 28-30 Ma
- The Gallinas Mountains contain rocks of Proterozoic through Quaternary age
- Base metals (Cu, Pb, Zn), fluorite, barite,and bastnäsite are predominately found in this district.

Figure 2. map of New Mexico's rare earth deposits



McLemore et.al. (2021) Geology and mineral resouces of the Gallinas Mountains, Lincoln Torrance Counties, New Mexico: NMBGMR, OFR 617, 164 p.

Purpose

- The Gallinas Mountains were selected for this study due to the presence of critical minerals (REE, barite, fluorite) as well as an existing geochemical dataset

1. Pros

- PXRF is a portable and fast way to generate qualitative to semi-quantiative elemental data making it a useful screening tool for exploration geology
- If PXRF can be proven effective and reliable against lab data then it can be used a prelimenary way to find critical minerals

2. Cons

- Many PXRF analyzers can not detect elements lighter than phosphorus (P)
- The PXRF analyzer used in this study was not able to identify fluorine, barium, and most REE
- PXRF performs better with powdered/homogenized samples
- PXRF analysis of slabbed hand samples is not necessarily representative due to small area (~1 cm^2)

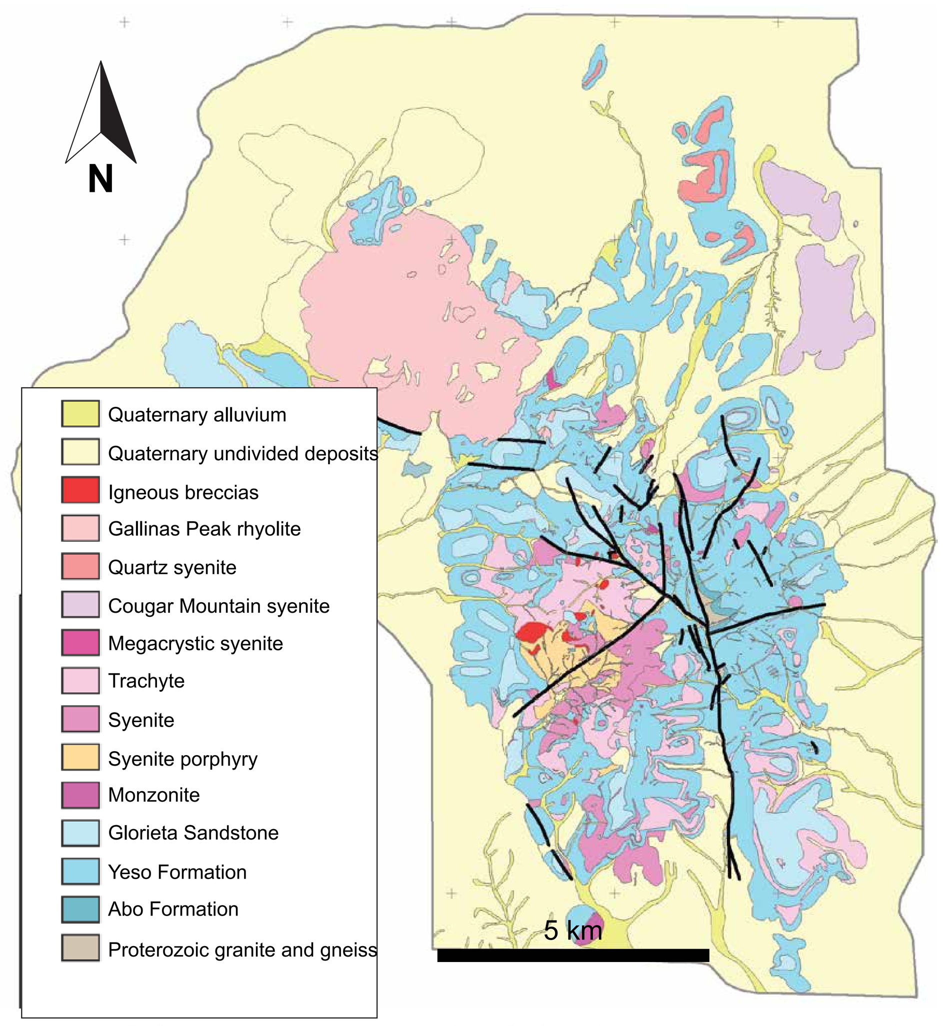


Figure 3. Generalized geologic map of the Gallinas Mountains based on the updated geologic map by the NMBGMR as well as historic geologic maps (modified from McLemore et al., 2021)

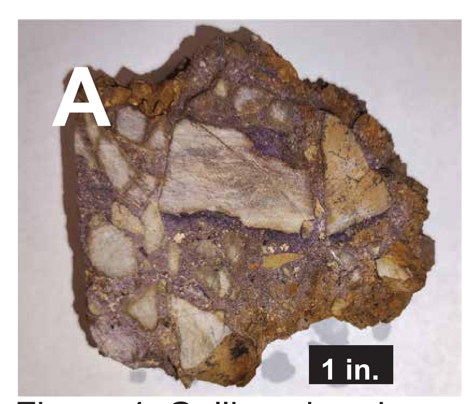


Figure 4. Gallinas hand sample fluorite breccia

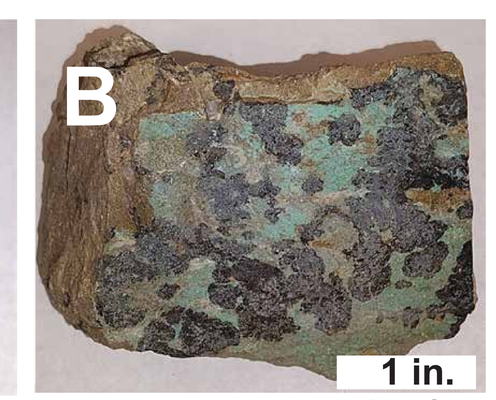


Figure 5. Hand sample of breccia with copper mineralization

Methods

- Lab geochemical analysis of pulverized hand samples for elemental composition
- Returned pulverized sampled portioned into pulps
- Powdered sample were slected based on high levels of critial mineral or indicator minerals
- Pulps scanned using PXRF
- Both analysis methods were compared using bivariate plots with X (Lab) and Y (PXRF)
- Lab data measured some metals in their oxide form so PXRF Fe, Ca, K, Ti, and Mn data was converted into weight percent oxide
- Composition expressed in weight percent oxide

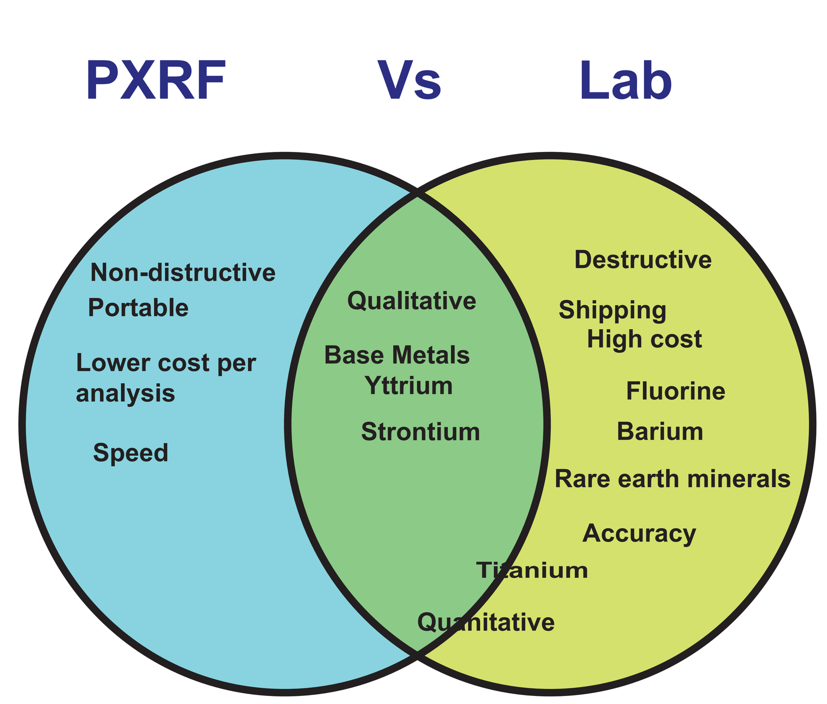
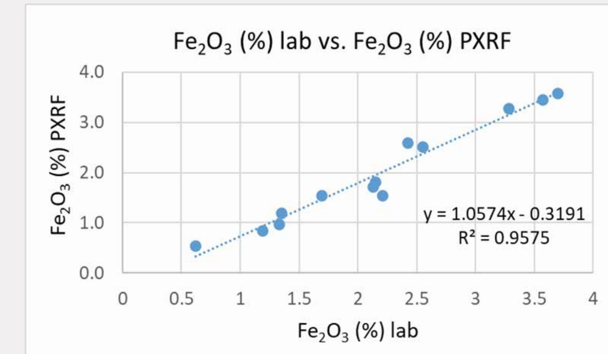
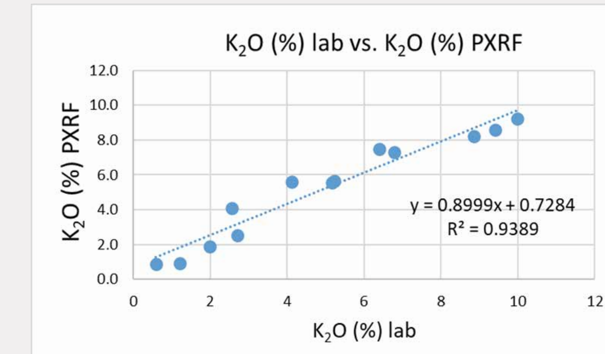
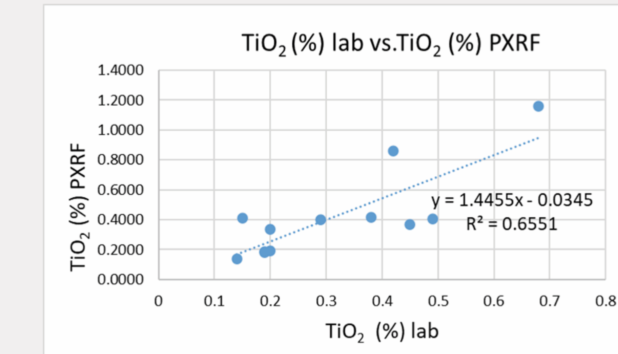


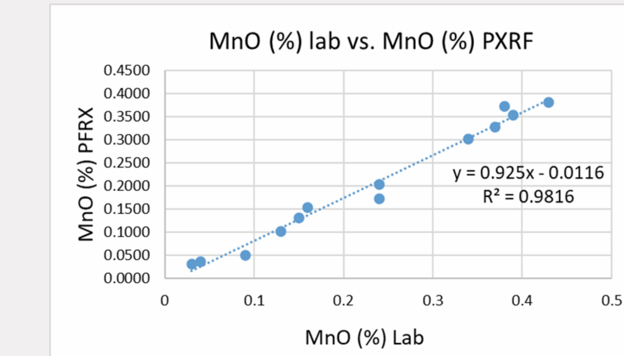
Figure.6 Venn Diagram of pros and cons of PXRF

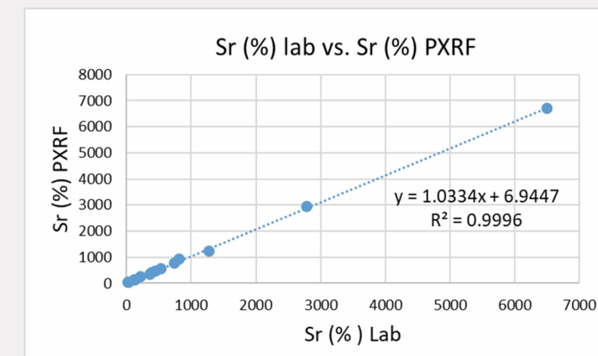
Graphical Results of Lab vs. PXRF Comparison

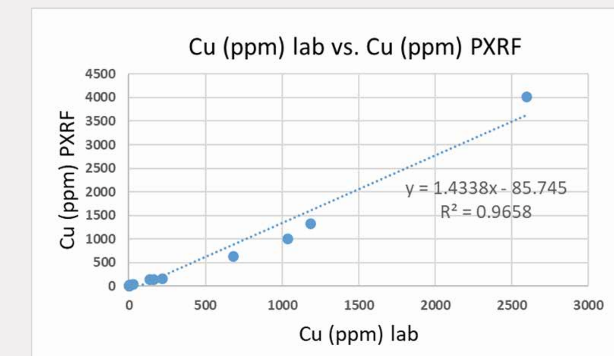


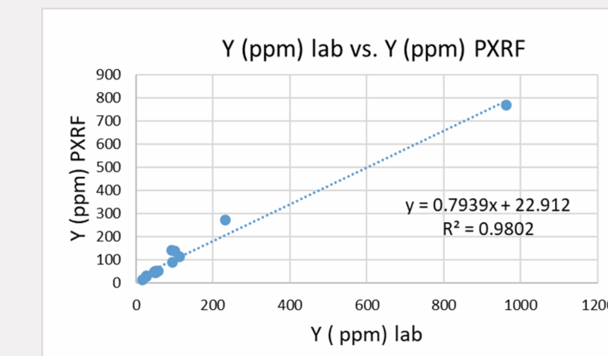


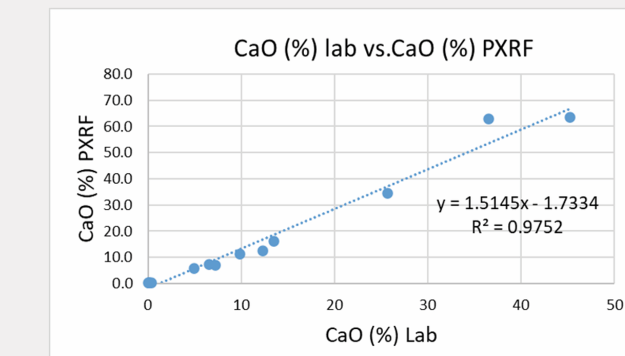


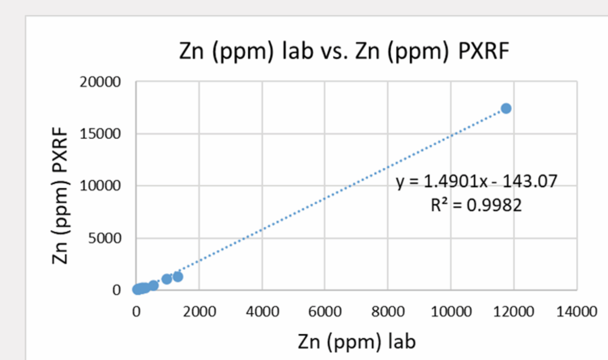


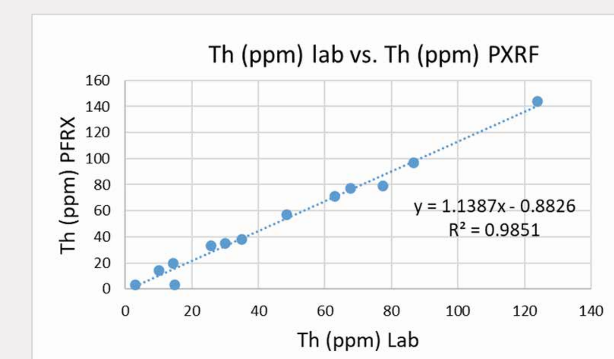


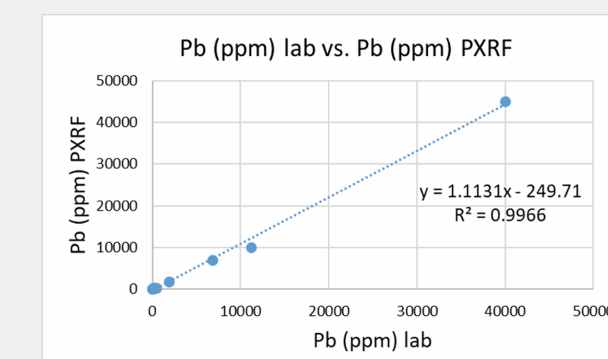












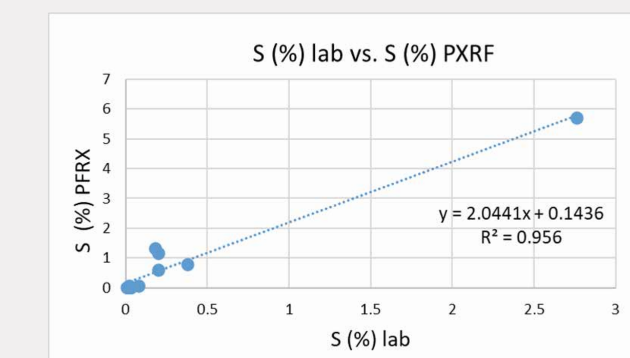


Figure 7. Pulps (pulverized rock samples) from the Gallinas Mountains district in sample cups ready to be analyzed with PXRF

Discussion

- A slope of 1 (y=x) means that PXRF concentrations match that of lab analysis for a given analyte
- R^2 value indicates how well the data fits a linear relationship, with R^2=1 indicating a perfect fit
- For some analytes, PXRF significantly overreported (S, Ca, Ti, and Zn) or underreported (Y and K) analytes
- TiO_2 likely yielded poor results due to peak overlap between characteristic Ti and Ba X-rays
- Sr was most accurately measured by the PXRF of any analyte (slope closest to 1, highest R^2)

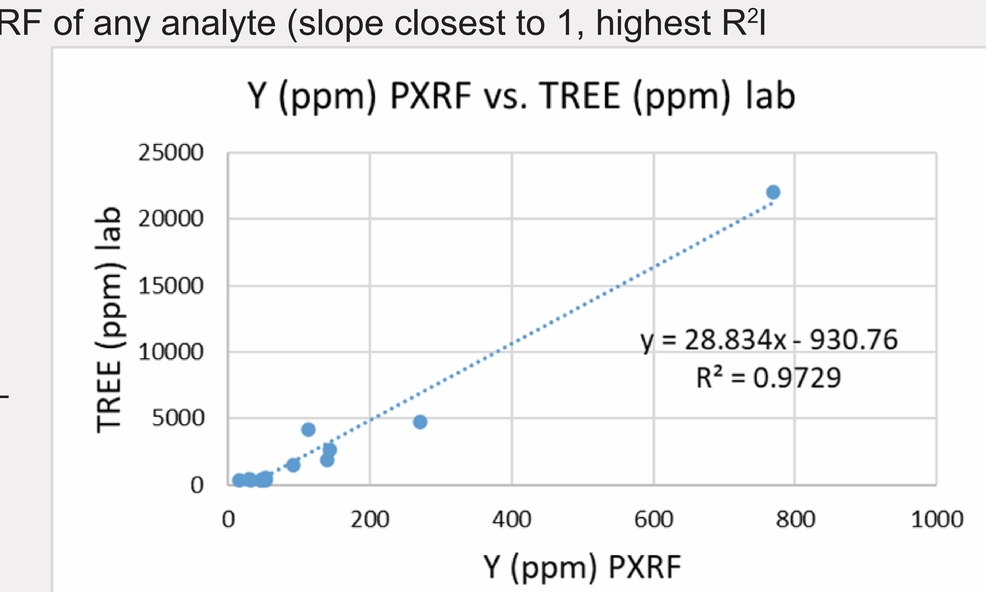


Figure 9. In this graph Y was plotted against total rare earth lab analysis showing a positive correlation between the two and demonstating that Y can be an indictator for the rare group of elements.

Figure 8. PXRF analysis allows for qualitative to semi-quantitative elemental analysis in both field and laboratory settings. Here, the use of a PXRF analyzer is demonstrated in the field.

Conclusion

- PFRX was capable of positive correlation with base metal , S and Y
- The analyzer's inablity to detect F, Ba, REE, and elements above K makes its use very limited in the Gallinas district
- Lab data is still more accurate and favorable to PFRX, however the device can be a viable sceening tool by using the elements it can detect as an anolog
- Y was plotted against total REE in the sample data set
- A positive correlation between Y and total REE
- Further studies comparing whole rock analysis are needed to determine PXRF accuracy without homogenized sample
- More resreach with the whole Gallinas geochemical data set needs to be conducted in order to more accurately plot the PXRF efficincy
- Future studies are required with different types or updated PXRF devices for conparison

References

Owen, E. J. (2024). Mineral paragenesis and geochemistry of hydrothermal REE-F bearing veins and breccias in the gallinas mountains, new mexico (Order No. 30996469). Available from ProQuest Dissertations & Theses Global. (3047982766). Retrieved from https://nmt.idm.oclc.org/login?url=https://www.proquest.com/dissertations-theses/mineral-paragenesis-geochemistry-hydrothermal-ree/docview/3047982766/se-2

Open-file Report - 617. (n.d.). New Mexico Bureau of Geology & Mineral Resources. Retrieved July 24, 2024, from https://geoinfo.nmt.edu/publications/openfile/details.cfml?Volume=617

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