Preliminary Evaluation of Legacy Chemistry of Coal Deposits in New Mexico

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INTRODUCTON

As part of the USGS national coal resource assessment program, chemical data were obtained from the USGS and other sources for the Colorado Plateau (Fig. 1), which includes Colorado, Utah, New Mexico, and Arizona. Details of sample collection and analyses are in Affolter (2009). There are more than 40 coal fields in the Colorado Plateau, but the USGS reported chemical data for only 19 coal fields that were considered high priority (Fig. 2). Both the Durango and Trinidad coal fields are in Colorado, adjacent to the New Mexico-Colorado state line and included in this report. Additional data were compiled from other references.

The purpose of this report is to provide a preliminary interpretation of the chemistry of coal deposits in New Mexico to aid in sampling and characterization of future sampling endeavors of coals in New Mexico.

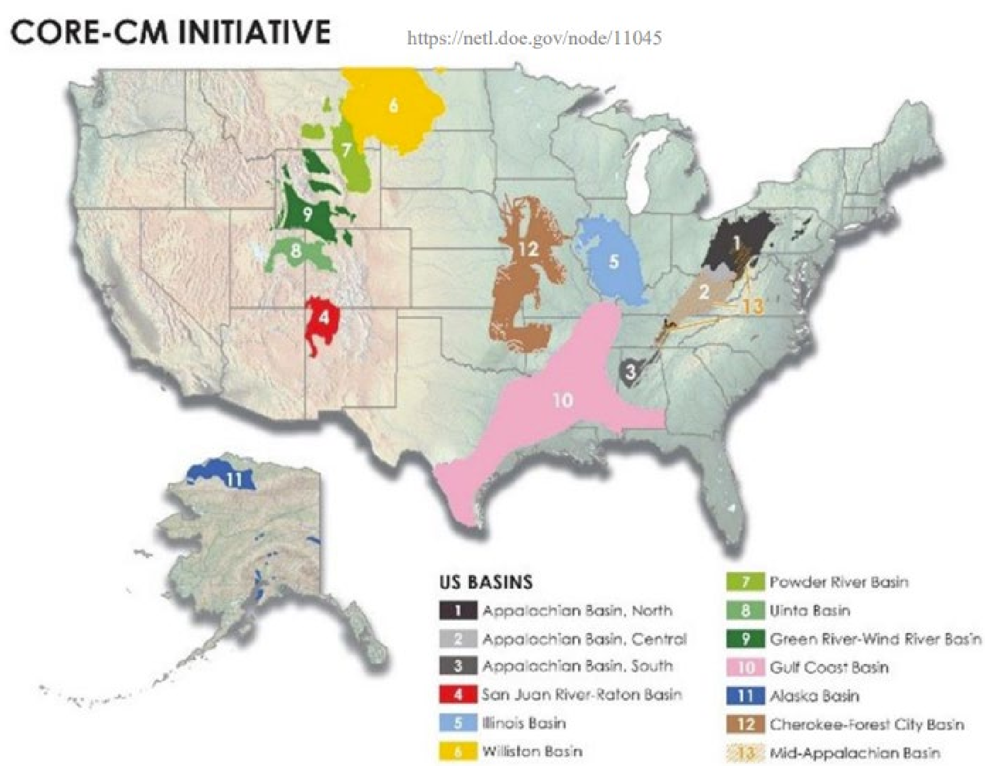


FIGURE 1. Location of the major areas of coal fields in the U.S., including the San Juan-Raton Basins (red).

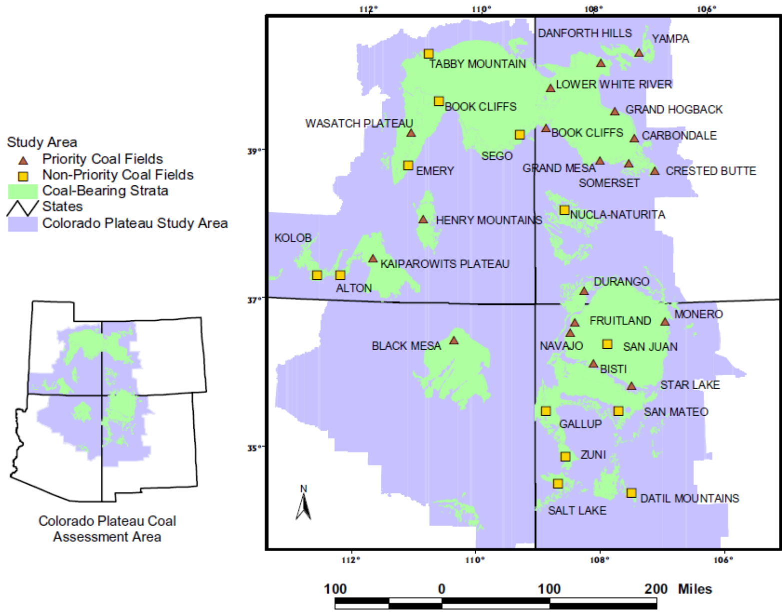


FIGURE 2. Location of high-priority and low-priority coal fields in the Colorado Plateau (from Affolter, 2009). The Trinidad and Raton coal fields are in northeastern New Mexico and southeastern Colorado and not shown in this figure.

METHODS AND RESULTS

I downloaded the USGS dataset and eliminated some analyses because they were incomplete or had inconsistent rare earth element (REE) analyses. The critical minerals are shown in Figure 3. Then I created a chondrite-normalize plot of the REE (Fig. 4) and various histograms of the critical minerals (Fig. 5-16). Scatter plots of the TREE (total REE) and various critical minerals are included (Fig. 17).

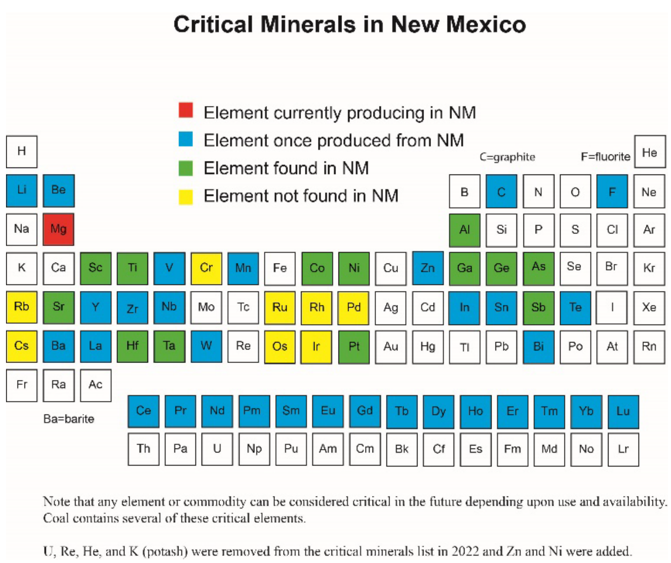


FIGURE 3. Periodic chart showing critical minerals found in New Mexico.

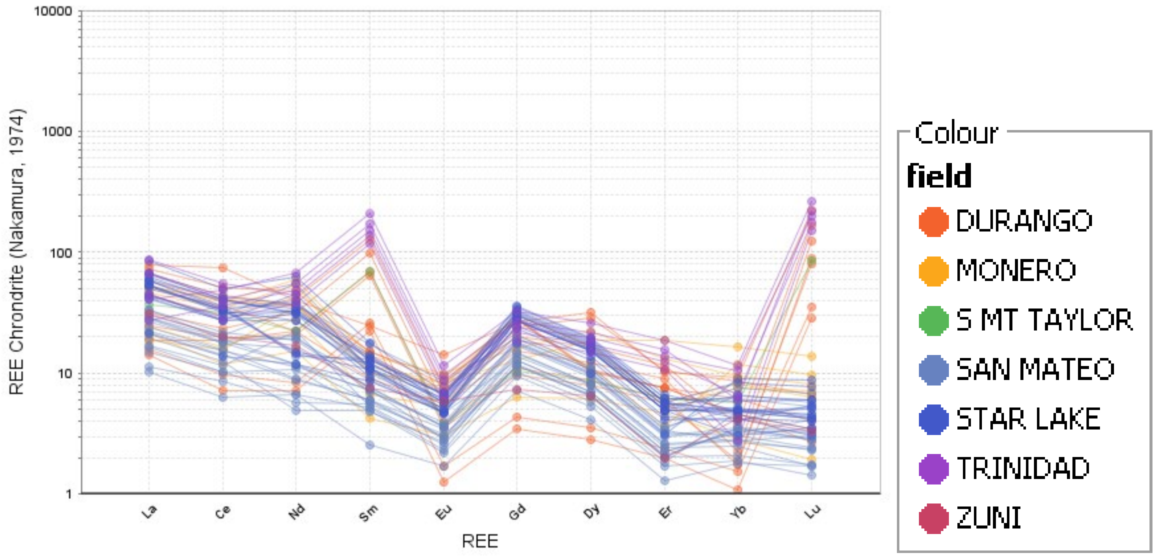


FIGURE 4. Chondrite-normalized plot of REE (data from Affolter, 2009). The elevated Sm and Lu requires further investigation to see if these anomalies are real or are an artifact of the chemical analyses.

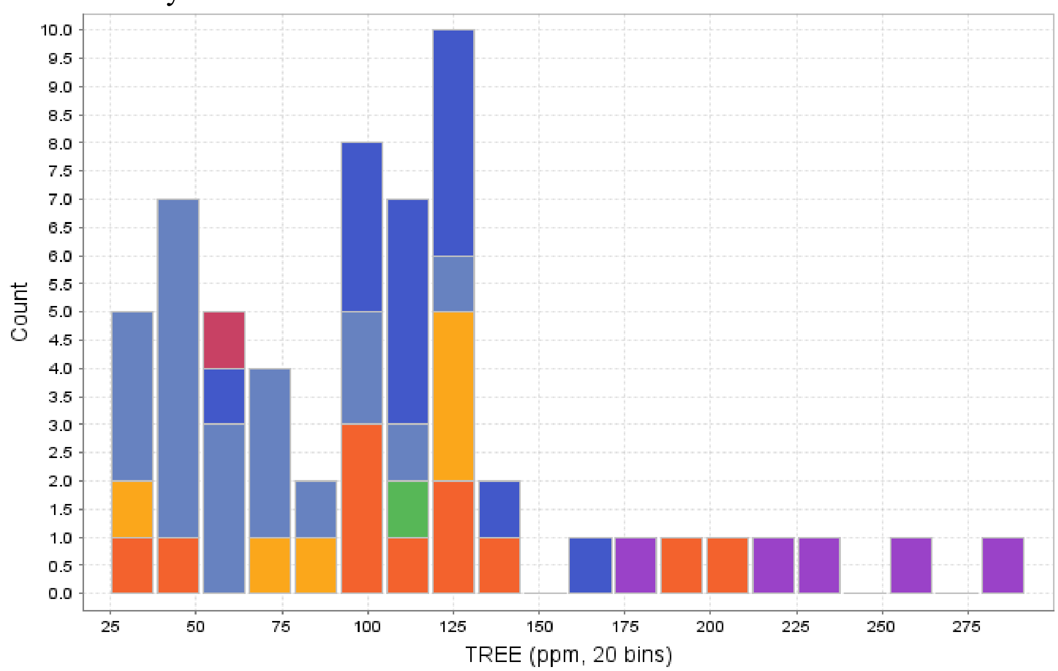


FIGURE 5. Histogram of total REE in ppm for coal fields in Colorado Plateau (data from Affolter, 2009). Legend is in Figure 4.

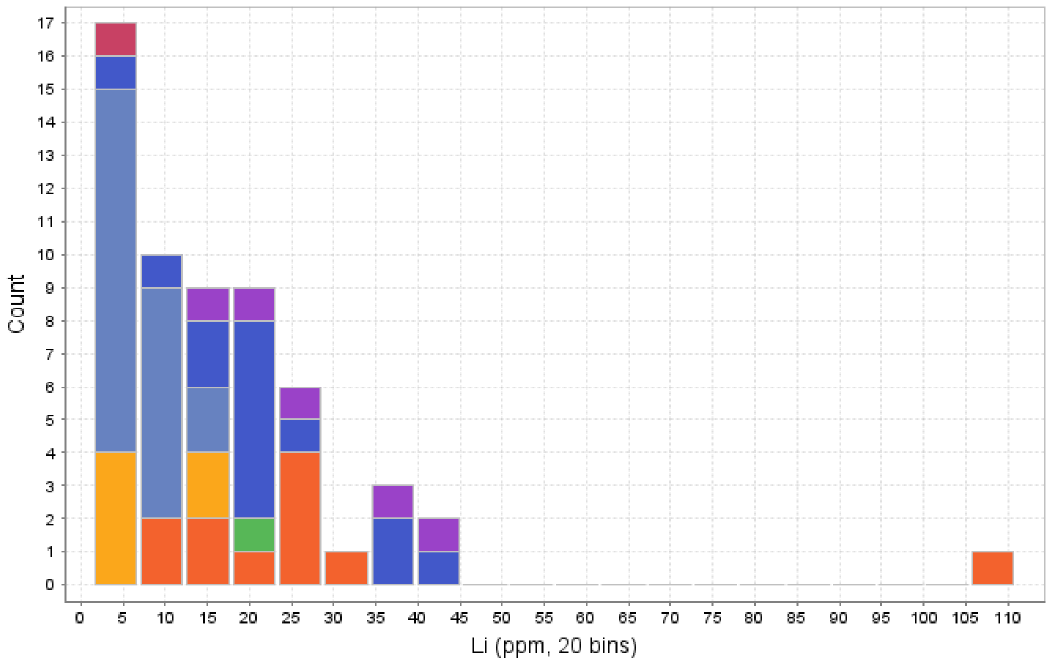


FIGURE 6. Histogram of Li in ppm for coal fields in Colorado Plateau (data from Affolter, 2009). Legend is in Figure 4.

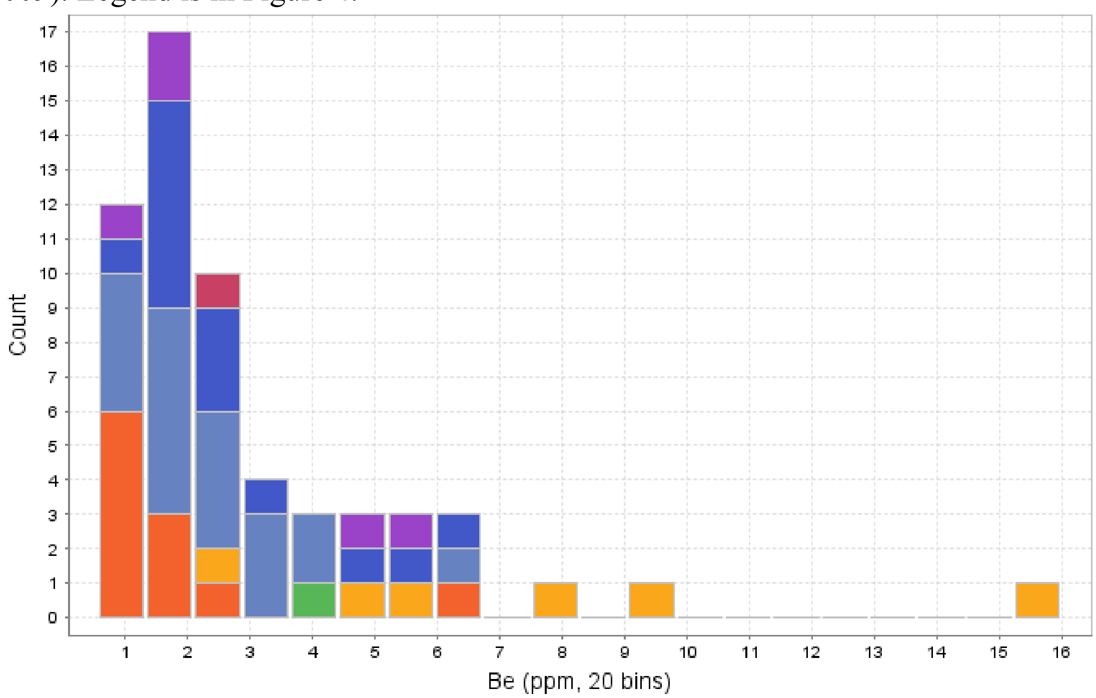


FIGURE 7. Histogram of Be in ppm for coal fields in Colorado Plateau (data from Affolter, 2009). Legend is in Figure 4.

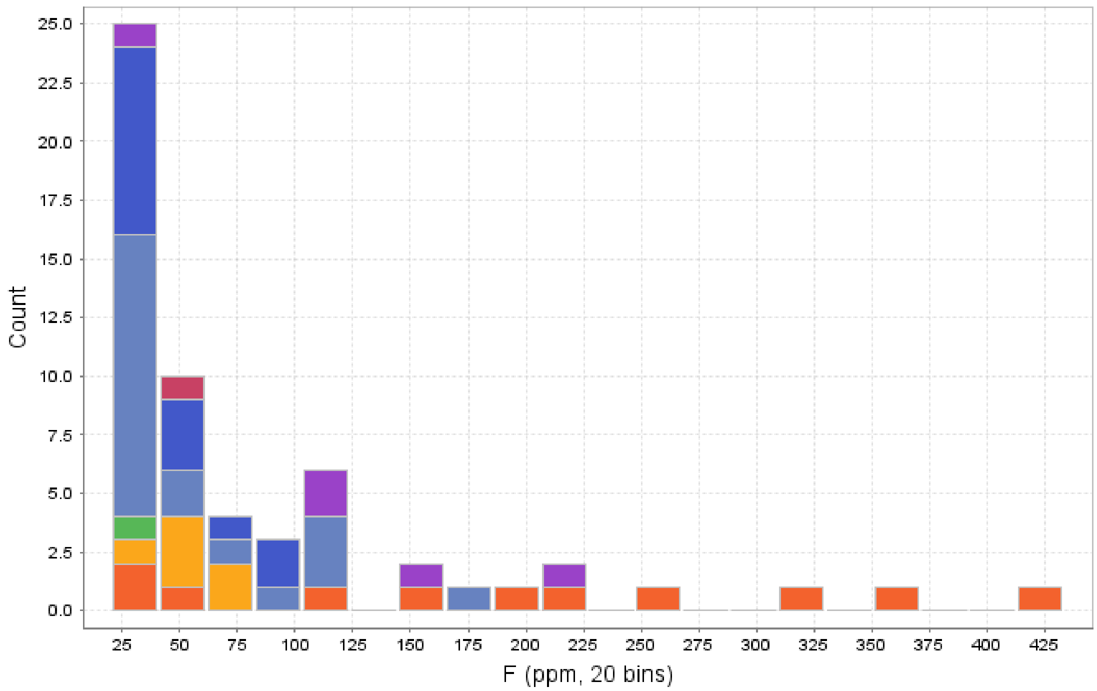


FIGURE 8. Histogram of F in ppm for coal fields in Colorado Plateau (data from Affolter, 2009). Legend is in Figure 4.

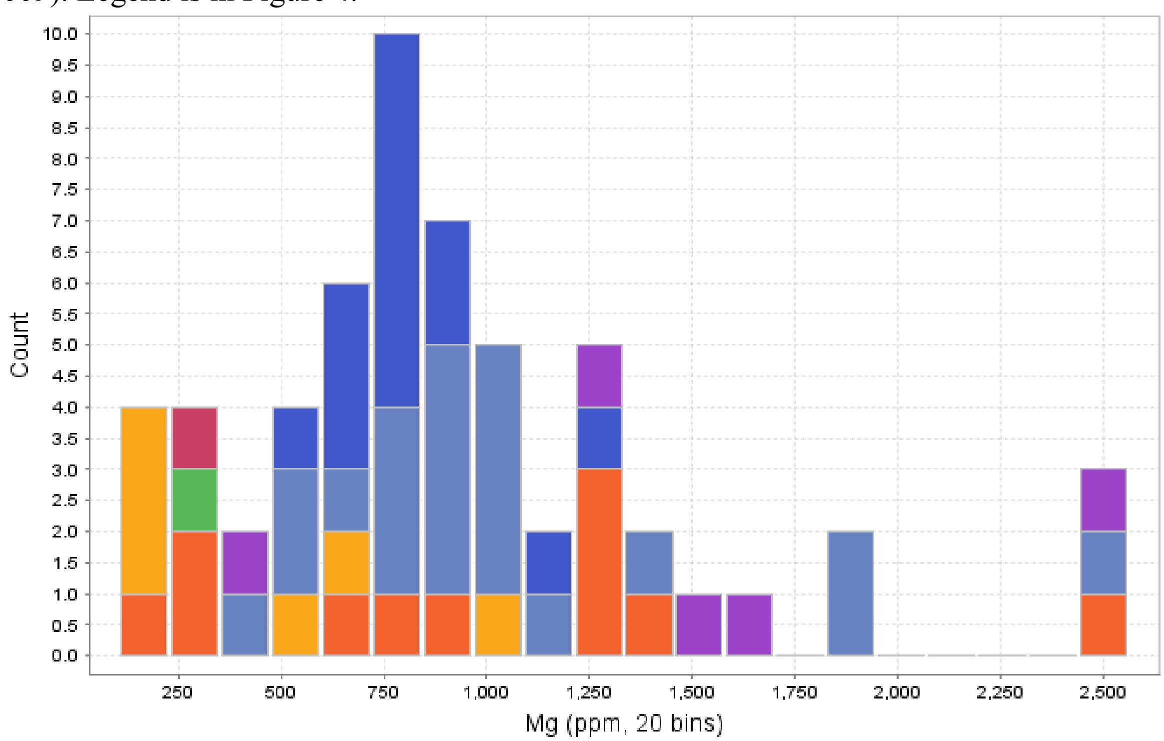


FIGURE 9. Histogram of Mg in ppm for coal fields in Colorado Plateau (data from Affolter, 2009). Legend is in Figure 4.

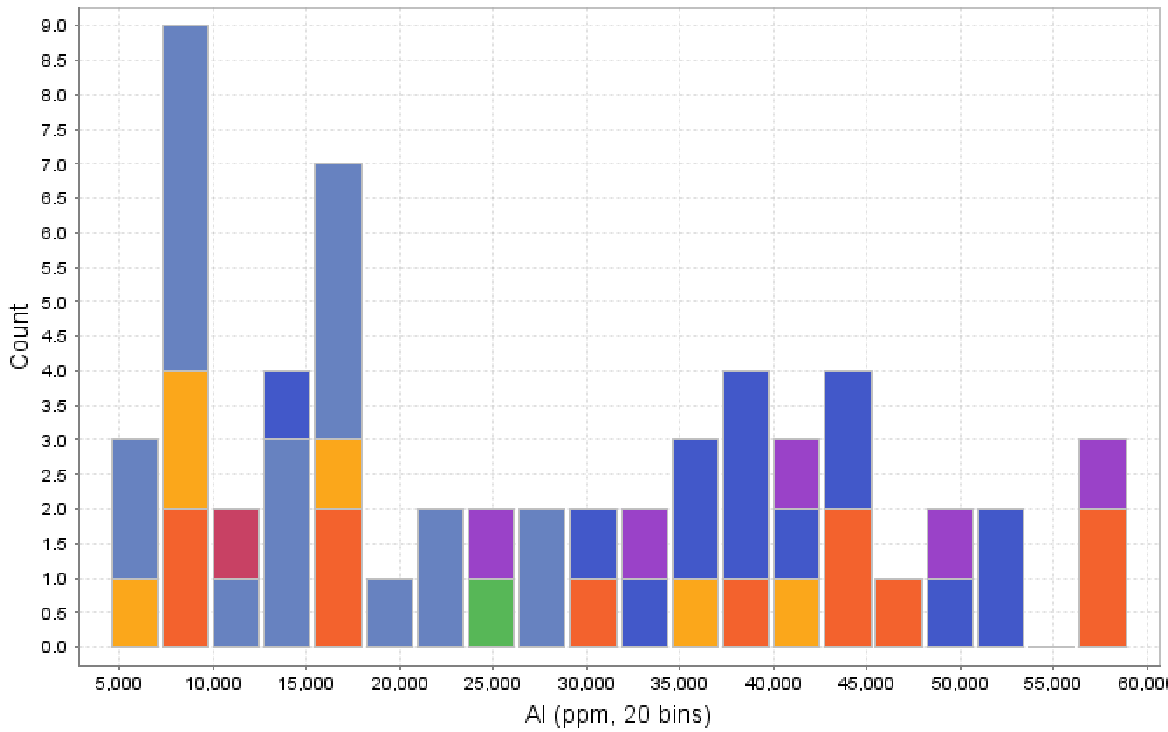


FIGURE 10. Histogram of Al in ppm for coal fields in Colorado Plateau (data from Affolter, 2009). Legend is in Figure 4.

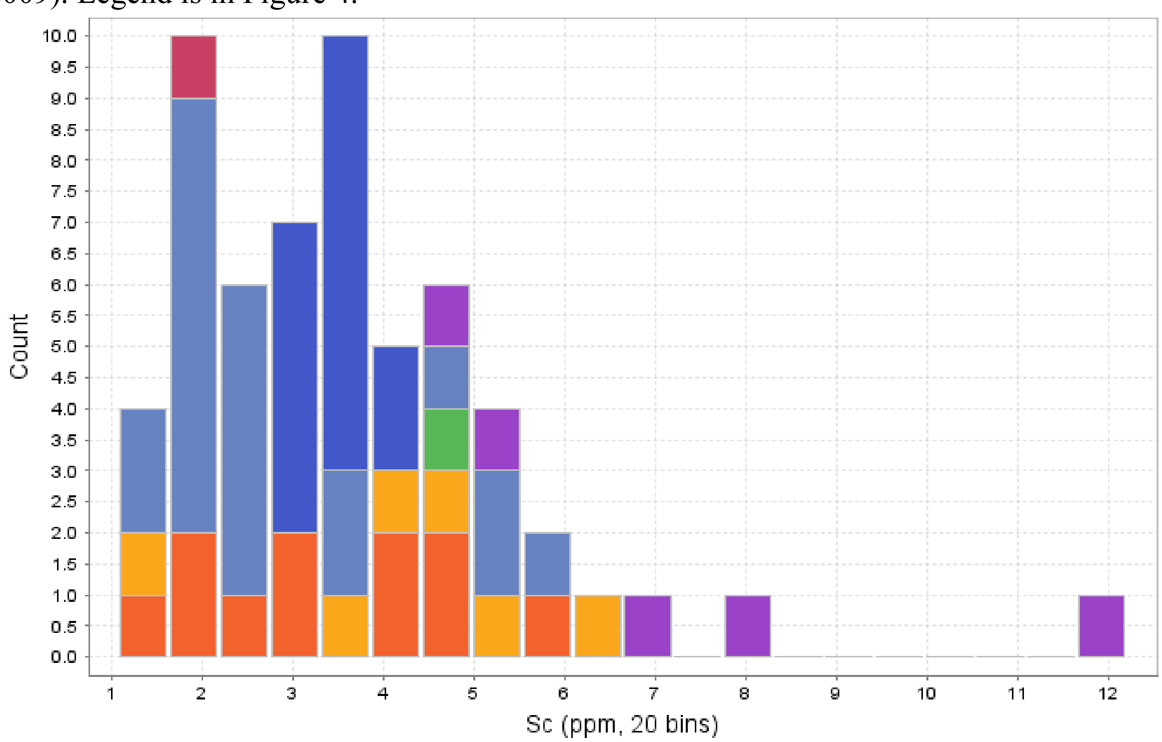


FIGURE 11. Histogram of Sc in ppm for coal fields in Colorado Plateau (data from Affolter, 2009). Legend is in Figure 4.

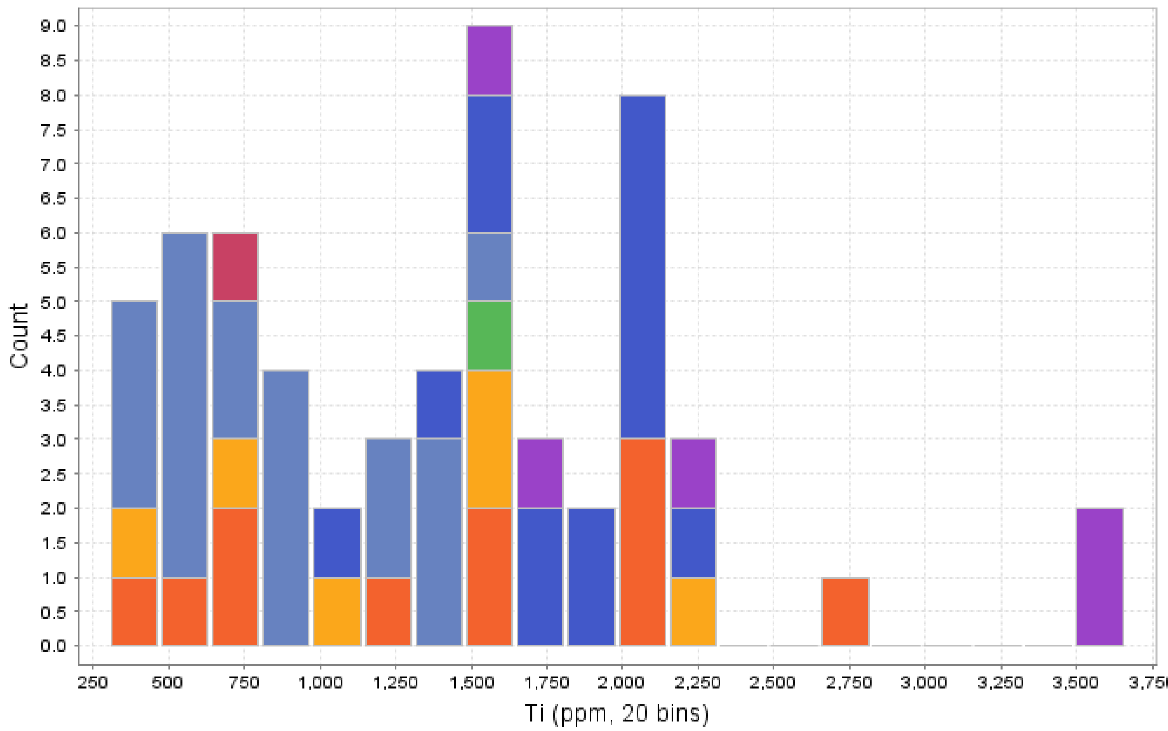


FIGURE 12. Histogram of Ti in ppm for coal fields in Colorado Plateau (data from Affolter, 2009). Legend is in Figure 4.

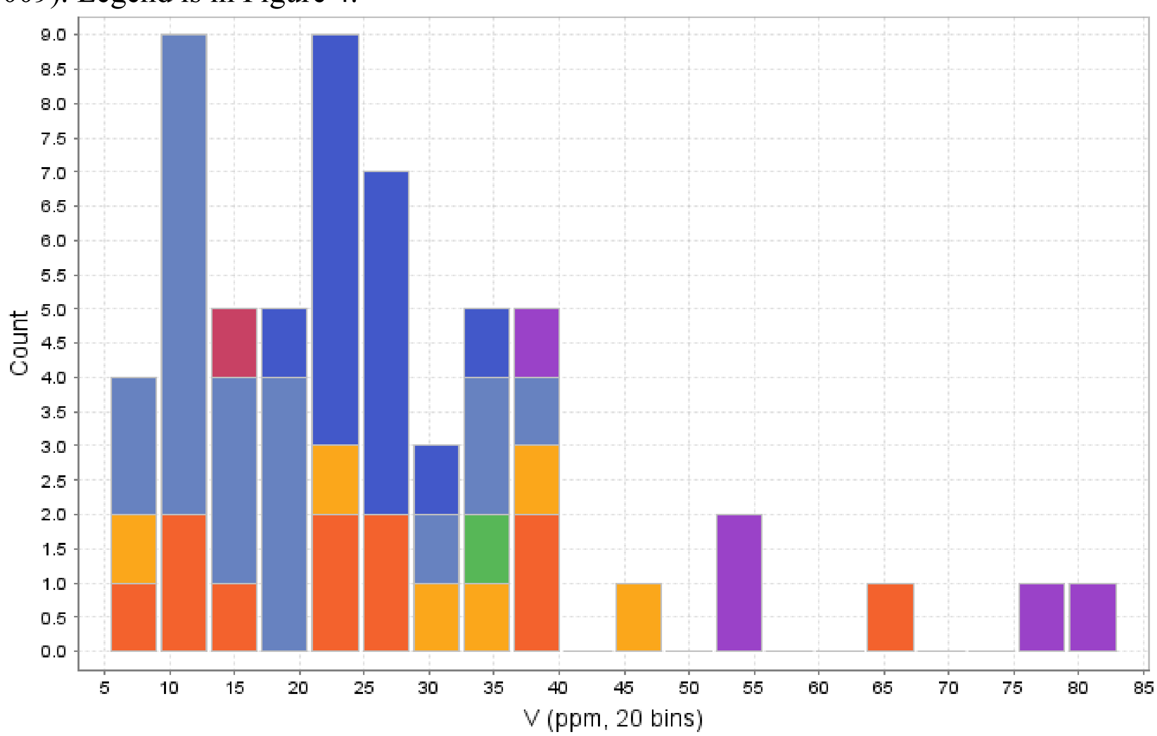


FIGURE 13. Histogram of V in ppm for coal fields in Colorado Plateau (data from Affolter, 2009). Legend is in Figure 4.

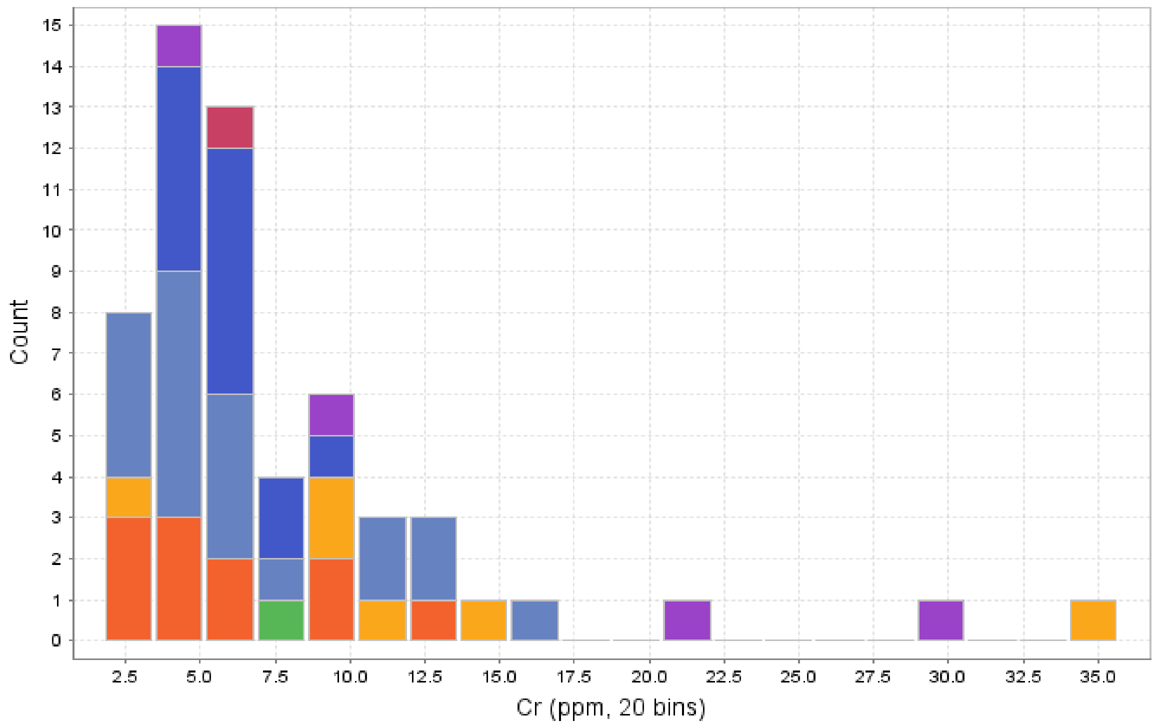


FIGURE 14. Histogram of Cr in ppm for coal fields in Colorado Plateau (data from Affolter, 2009). Legend is in Figure 4.

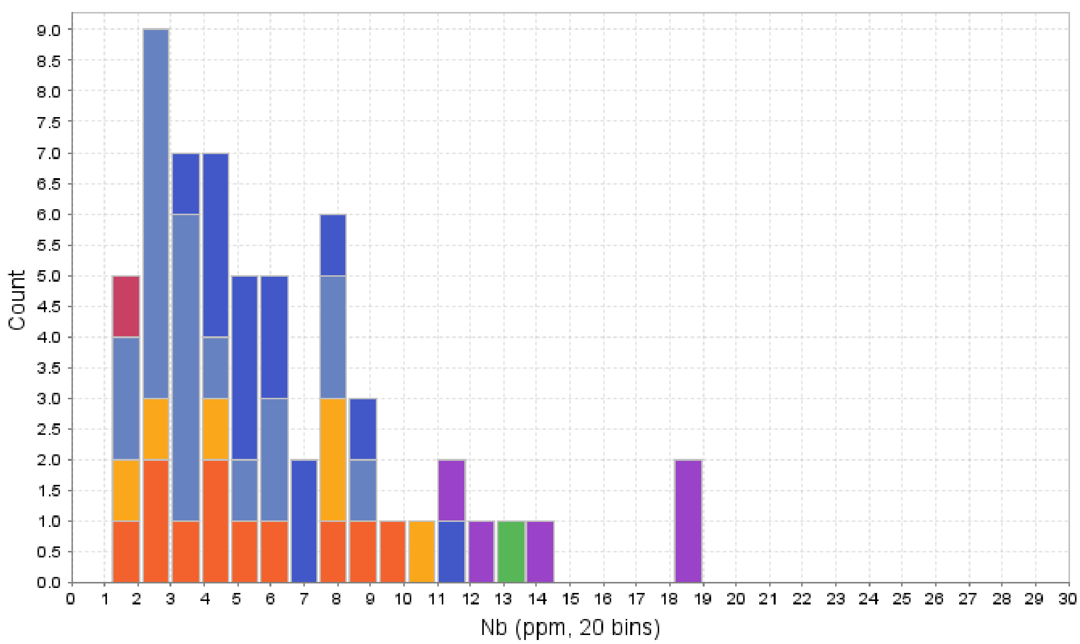


FIGURE 15. Histogram of Nb in ppm for coal fields in Colorado Plateau (data from Affolter, 2009). Legend is in Figure 4.

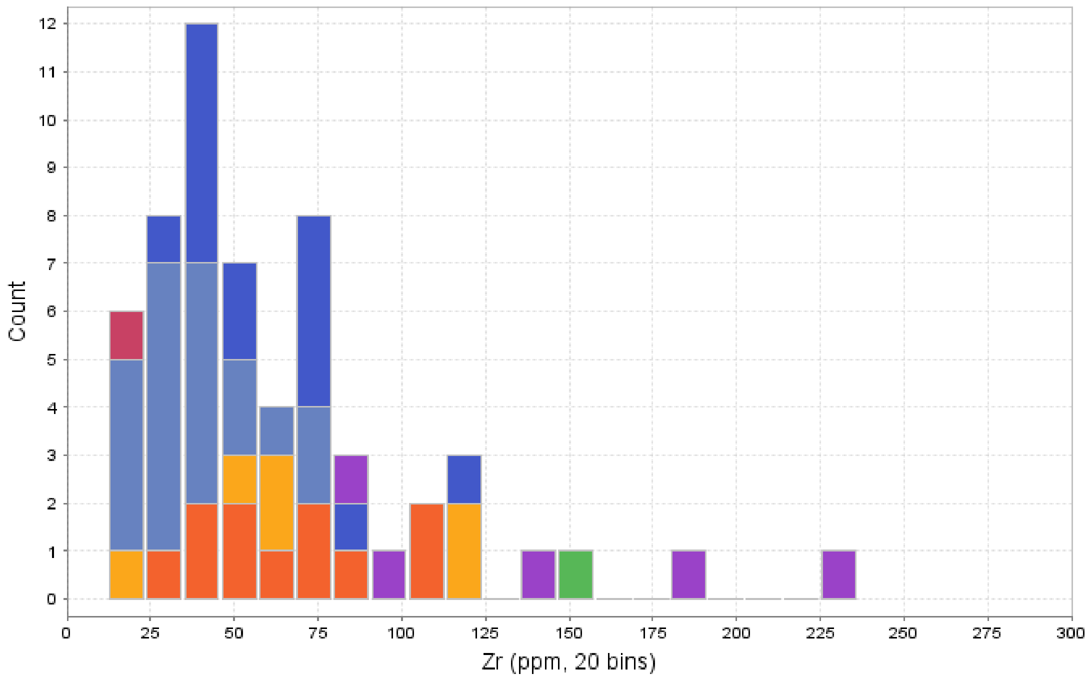
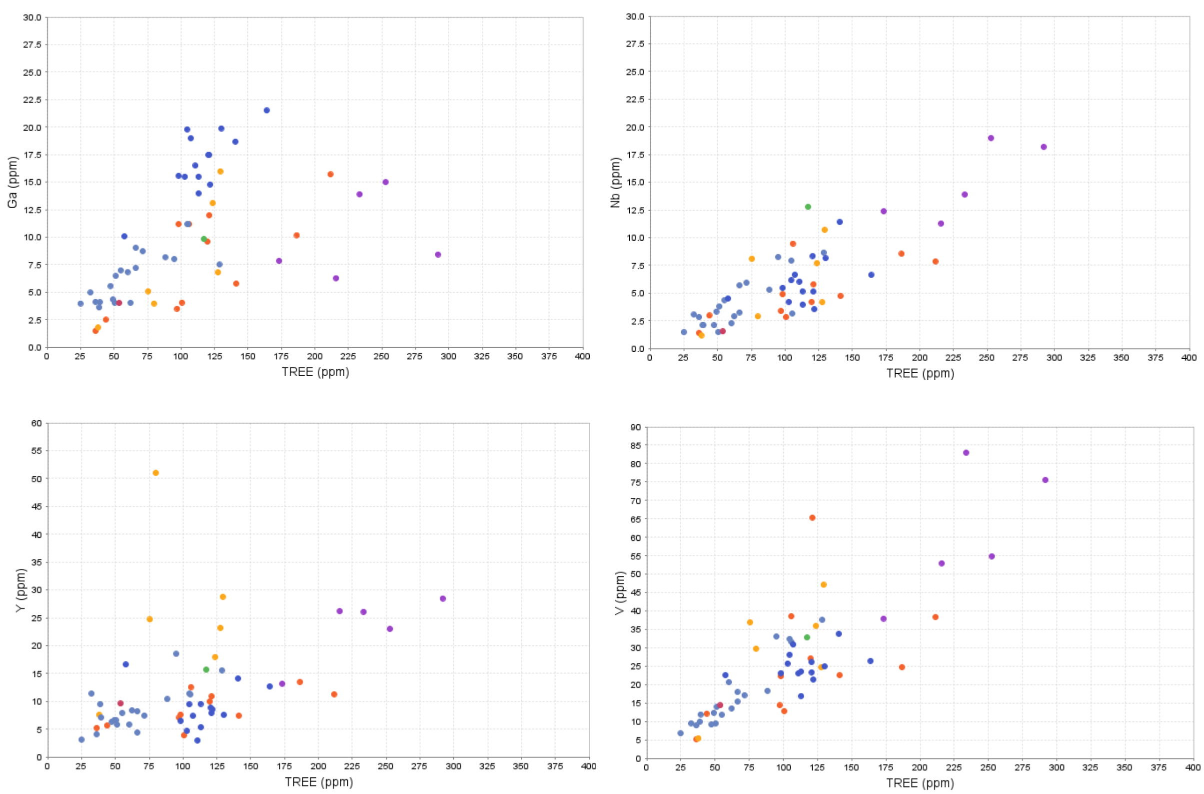


FIGURE 16. Histogram of Zr in ppm for coal fields in Colorado Plateau (data from Affolter, 2009). Legend is in Figure 4.



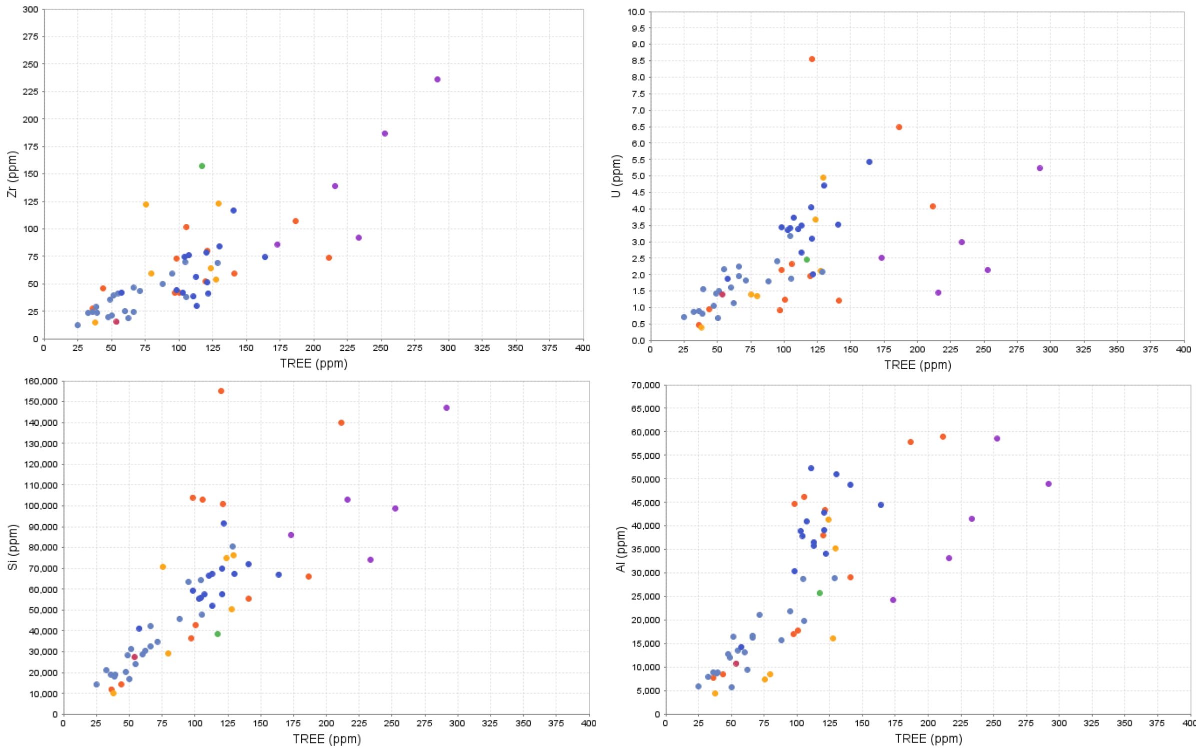


FIGURE 17. Scatter plots showing correlation between TREE, Si, and other critical minerals (data from Affolter, 2009). Legend is in Figure 4. A strong correlation may suggest the elements are within similar mineral phases that contain TREE and critical minerals, but more work is needed.

RELATIONSHIP TO BEACH-PLACER SANDSTONE DEPOSITS

Beach-placer sandstone deposits are accumulations of heavy, resistant minerals (i.e. high specific gravity) that form on upper regions of beaches or in long-shore bars in a marginal-marine environment (Fig. 18). They form by mechanical concentration (i.e. settling) of heavy minerals by the action of waves, currents, and winds. Specifically, beach-placer sandstones form in the upper part of the high-tide swash (wave) zone, in the foreshore zone, and in the sand dunes where they are remobilized by winds and waves, especially after storm surges (van Gosen et al., 2014). Coal deposits form in the swamps further inland from the beach (Fig. 18). Detrital heavy minerals comprise approximately 50-60% of the sandstones and typically consist of titanite, zircon, magnetite, ilmenite, monazite, apatite, rutile, xenotime, garnet, and allanite, among other minerals. Most of these minerals have a high specific gravity exceeding 4.

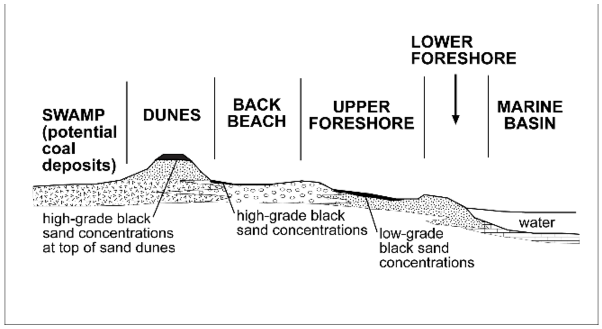


FIGURE 18. Idealized cross-section of formation of beach-placer sandstone deposits and the relationship to coal deposits (modified from Houston and Murphy, 1970, 1977).

Beach-placer sandstone deposits are found in coal fields in New Mexico (Fig. 19). Coal deposits overlie beach-placer sandstone deposits at Apache Mesa, New Mexico (McLemore et al., 2016) and in the Fox Hills Sandstone in Colorado (O'Keeffe et al., 2020).

Chemical analyses of selected beach-placer deposits are in McLemore et al. (2016). The REE plots exhibit light-REE chondrite-normalized enriched patterns, typically with negative Eu anomalies, similar to the coal deposits (Fig. 20). Ti, Fe, Cr, Nb, Th, U, Zr, Sc, and REE are found in high concentrations in these deposits. Pierson correlation coefficients indicate strong correlations between TiO_2, Cr, Nb, Th, Y, Zr, and REE (Fig. 3), which is consistent with the known mineralogy of the deposits, predominantly reflecting ilmenite, monazite, zircon, and other heavy minerals.

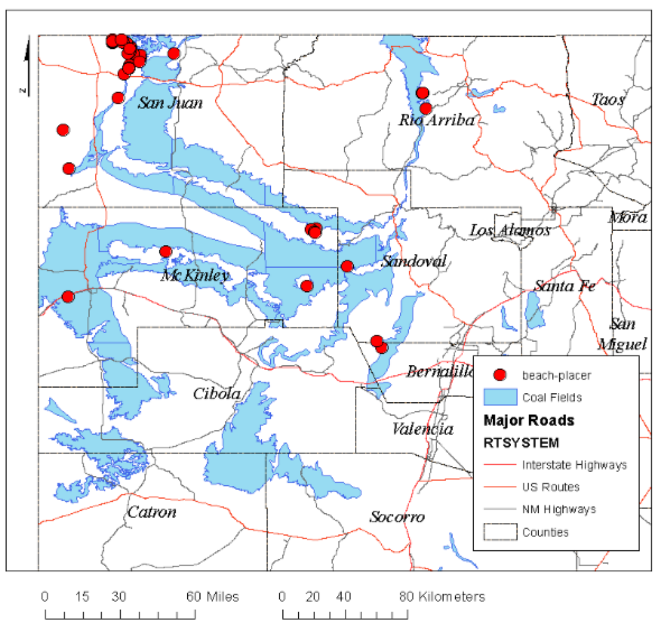


FIGURE 19. Location of Late Cretaceous heavy mineral, beach-placer sandstone deposits (red) and coal fields (blue) in the San Juan Basin, northwestern New Mexico. Some of the beach-placer deposits are described in McLemore (2010) and McLemore et al. (2016).

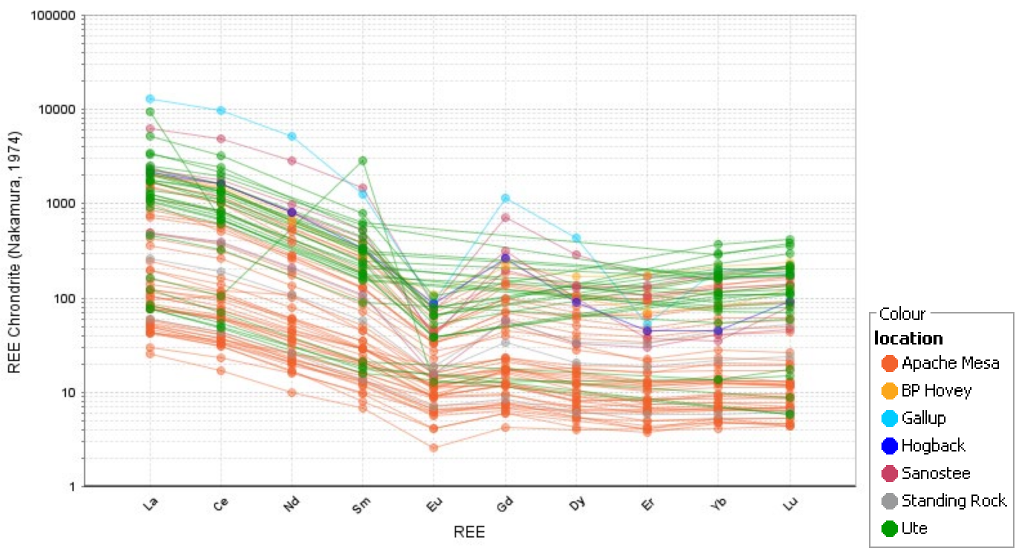


FIGURE 20. Chondrite-normalized REE plot (Nakamura, 1974) of selected heavy mineral, beach-placer deposits. Chemical analyses are in McLemore et al. (2016). Note that the upper scale of the REE chondrite in this figure is 100,000, whereas the upper scale in Figure 4 is only 10,000.

The importance of beach-placer sandstone deposits is 1) they are enriched in some critical minerals, such as REE (Fig. 20), 2) they could be a source of REE and critical minerals to coal deposits, and 3) they could aid in identifying the primary sediment source of the REE and critical minerals.

PRELIMINARY CONCLUSIONS

- Most of the critical minerals are relatively low in concentration in the coal samples as compared to economic deposits. However, the large tonnage of coal produced may allow for some of these to become economic to extract from coal produced for other uses. Additional sample collecting and analyses is underway.
- The coals exhibit light-REE chondrite normalized REE patterns, similar to many coal deposits.
- The coal samples show good correlation between TREE and Si and other critical elements. A strong correlation may suggest the elements are within similar mineral phases that contain TREE and critical minerals, but more work is needed. These correlations appear to be typical of similar correlations of TREE and other elements in sedimentary rocks, especially beach placer sandstone deposits.
- Beach-placer sandstone deposits are found in coal fields in New Mexico and also exhibit light-REE chondrite normalized REE patterns, but are more enriched in REE than the coal deposits.
- The importance of beach-placer sandstone deposits is 1) they are enriched in some critical minerals, such as REE, 2) they could be a source of REE and critical minerals to coal deposits, and 3) they could aid in identifying the primary sediment source of the REE and critical minerals.

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