Alteration and Geochemistry of Clinkers in the San Juan Basin, New Mexico

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Purpose of the study

- To determine the mineralogy and chemistry of clinkers
- To examine clinkers for potentially recoverable critical minerals

What is Clinker? How is it made? Where is it from?

- Clinkers (red) are pyrometamorphosed sedimentary rocks baked by fires
- Coal seam fires can start from multiple causes at the surface
  - Wildfires
  - Lightning strikes
  - Spontaneous combustion by the oxidation of pyrite
- Coal seam fires can spread extensively underground
- Temperatures can reach 1000°F, baking surrounding rocks
- Clinkers can be indicators of coal resources that aren't exposed
  - Resistant to erosion

Coal 11C,
Credit to Virginia T. McLemore

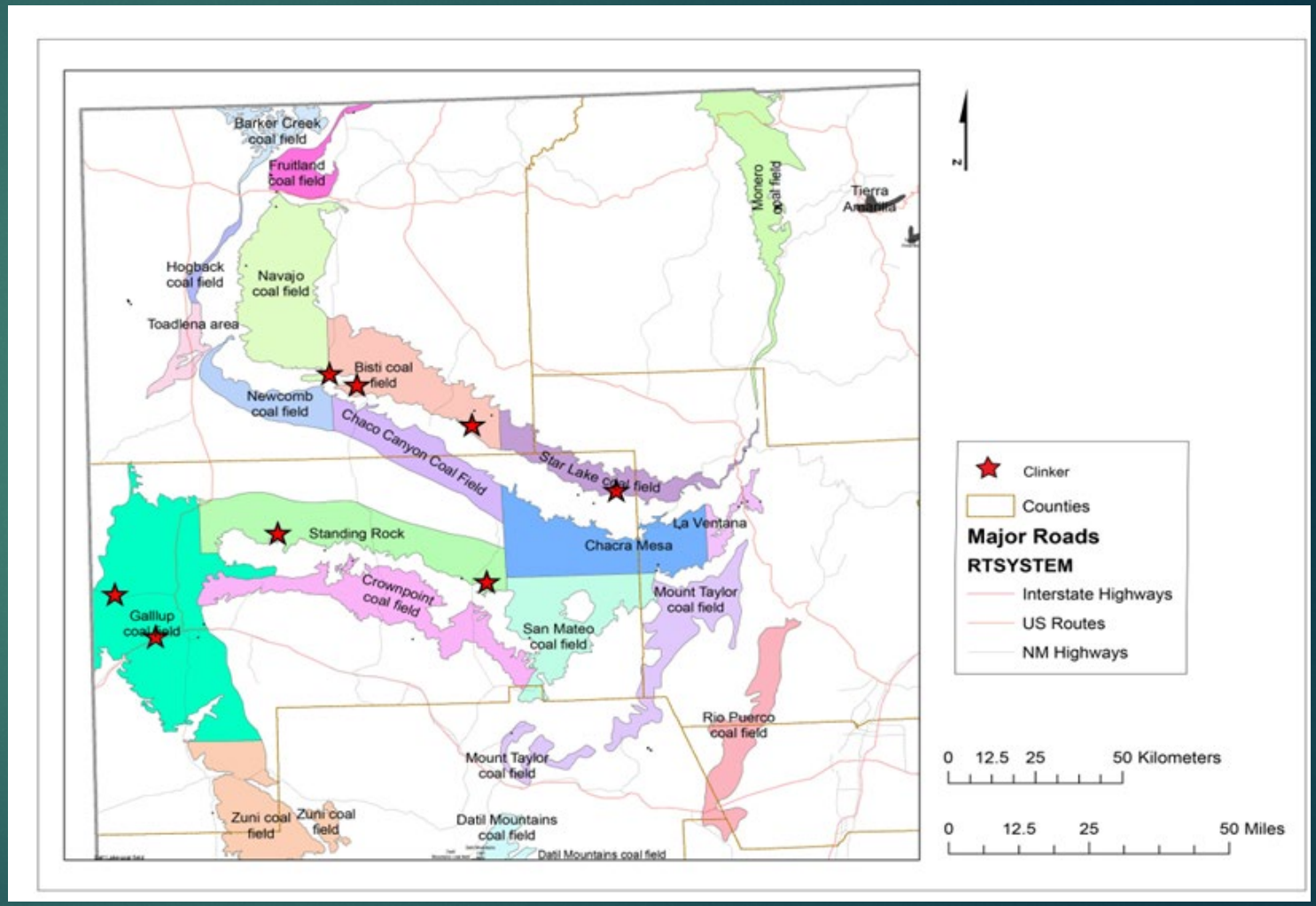
Clinkers industrial uses

- Clinker is broken down to gravel size pieces for aggregate
- Clinker is a cheap and readily available resource makes it ideal for construction as an aggregate
- Some forms of clinker can be used in metal working and glass manufacture after refinement down to fine powders

Top: Coal 28e. Bottom: Red Dog Clinker piles, El Segundo Mine.

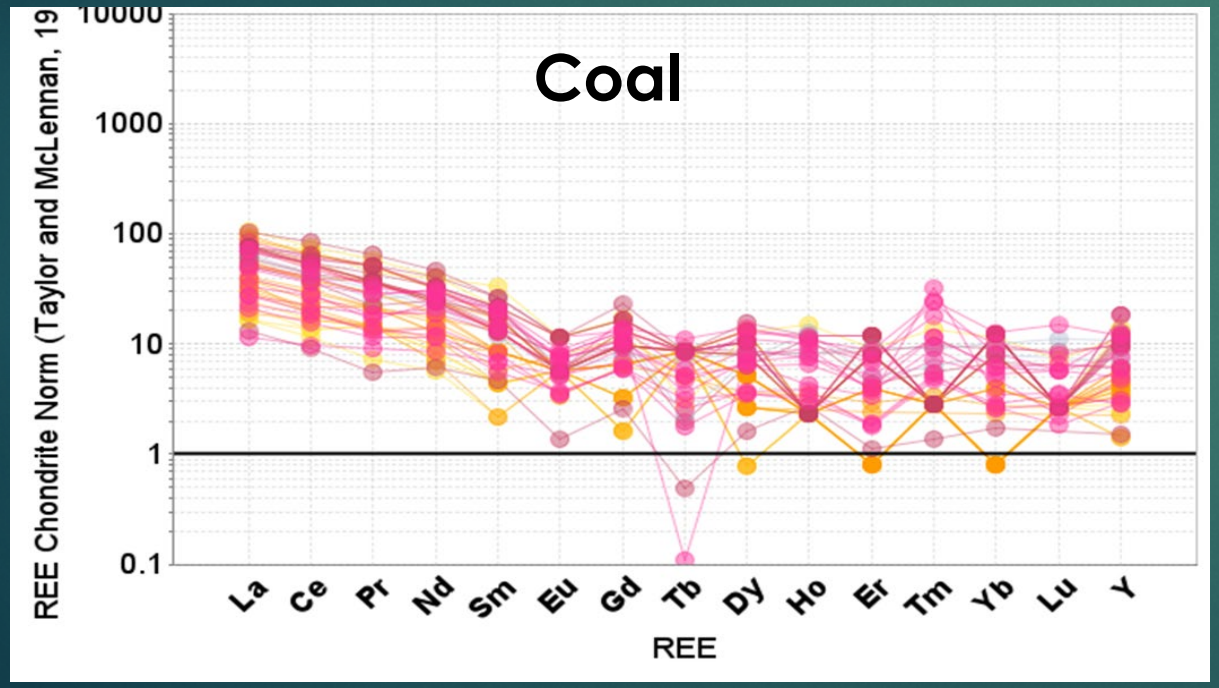
Methods of Study

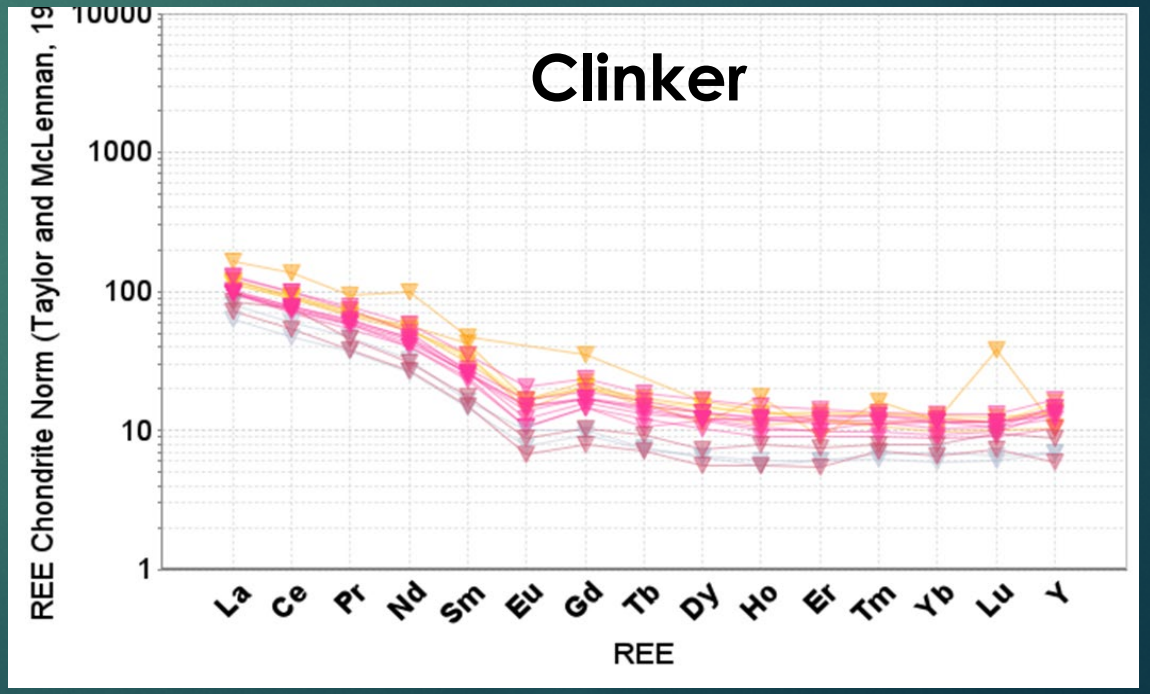
- Sample collection
- Rock chemistry
- Petrography
- Microprobe
- X-Ray Diffraction (XRD)



Clinker vs Coal

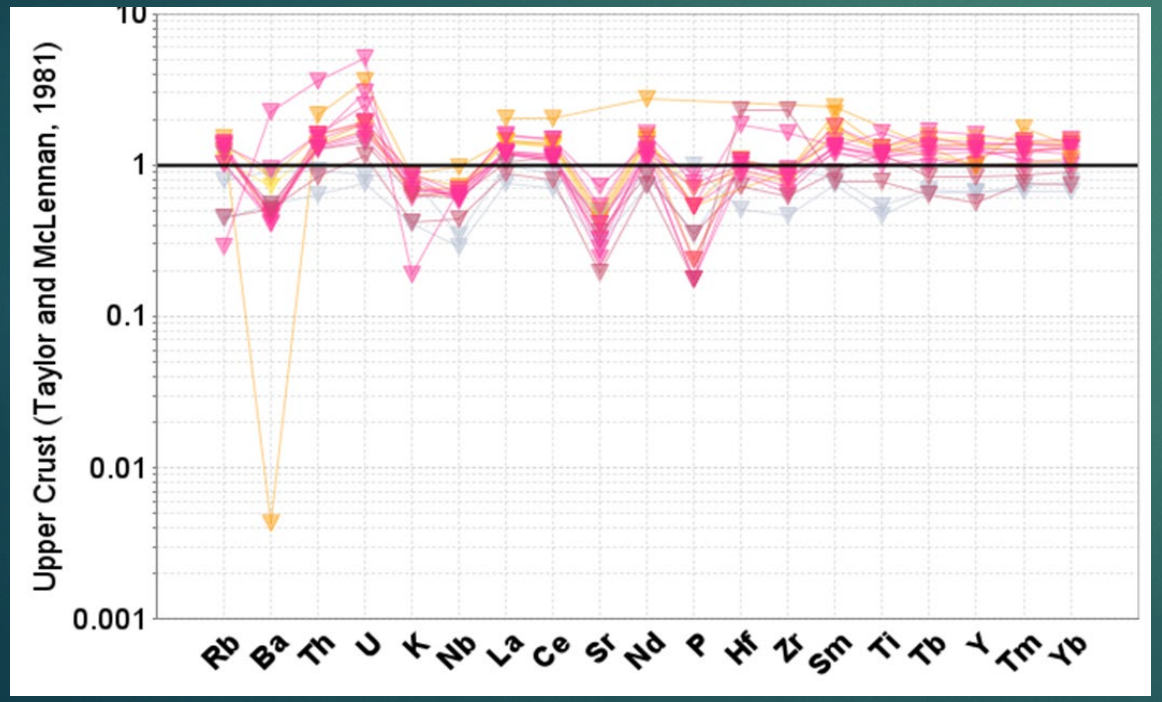
- Clinkers are very similar in chemistry compared to coals
- Both coal and clinker are slightly enriched in LREE compared to chondrite

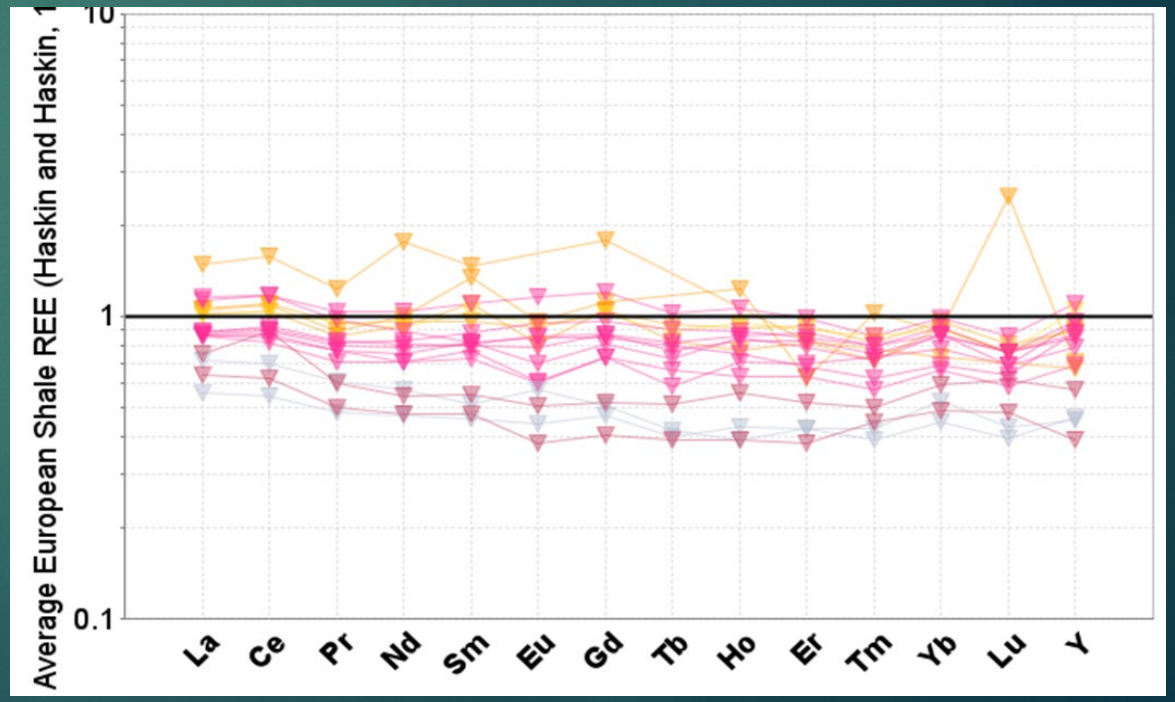




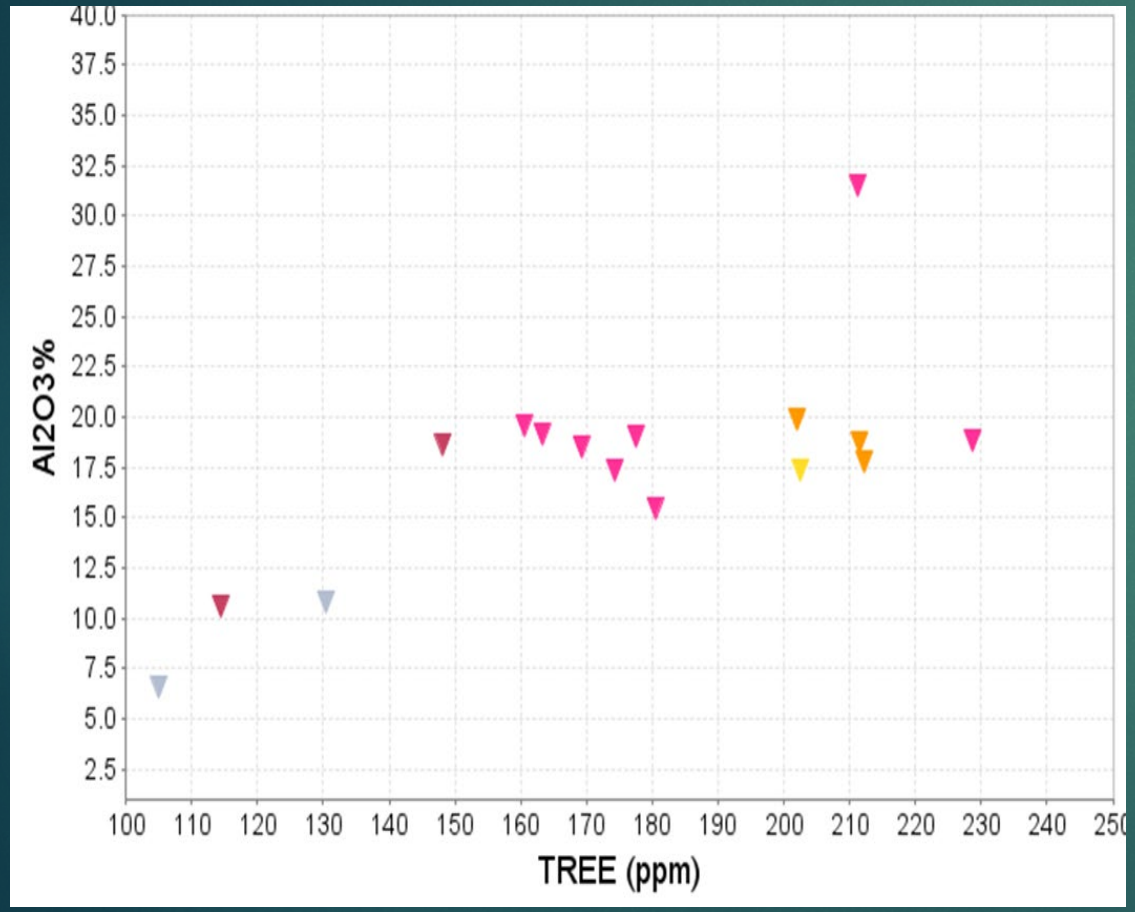
Clinker Comparisons

- Left: No significant enrichment in elements compared to Average Upper Crust sediments
- Right: REE concentrations similar or slightly depleted compared to Average European Shale
- Pyrometamorphism does not appear to affect REE concentrations

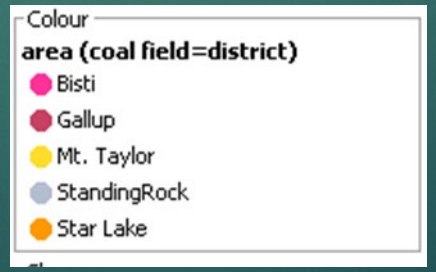




Clinker Chemistry

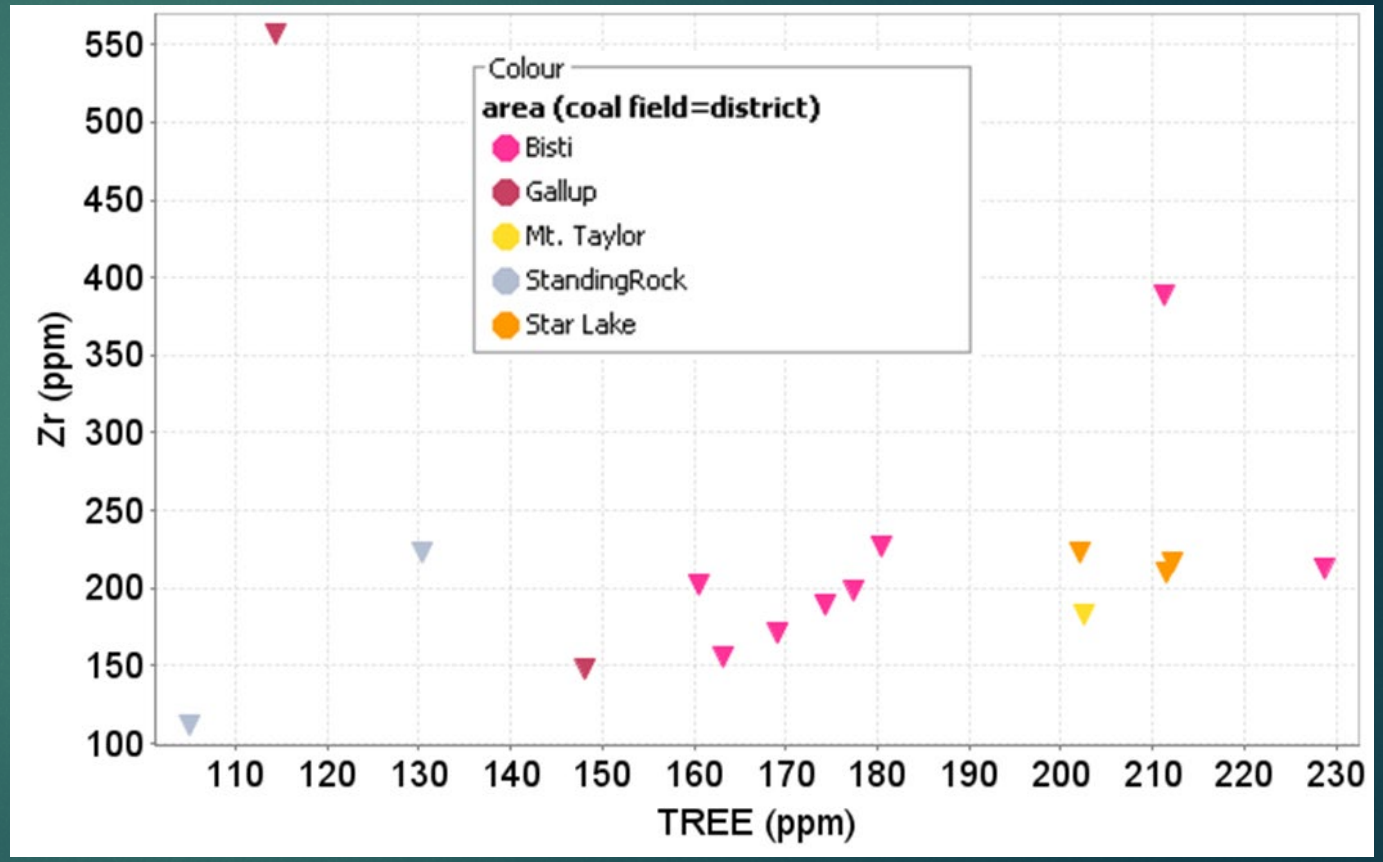


Slight positive correlation between Al_2O_3 and TREE, suggesting the REE may be found related to clay minerals

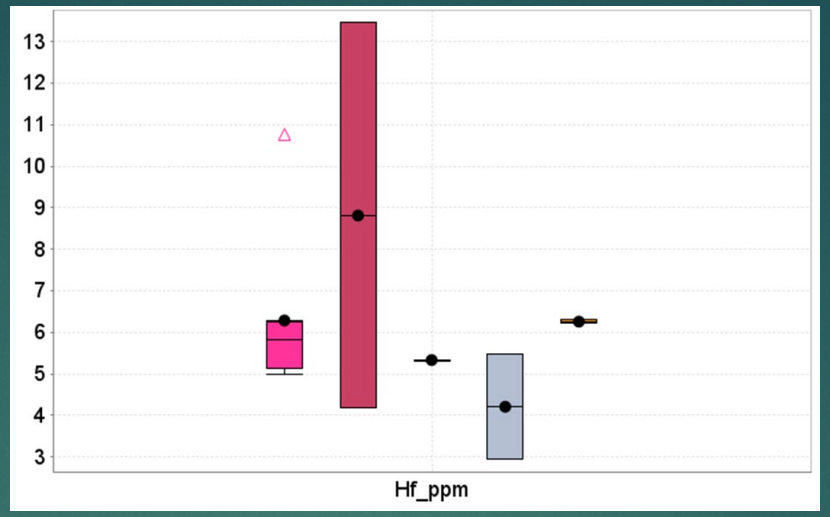


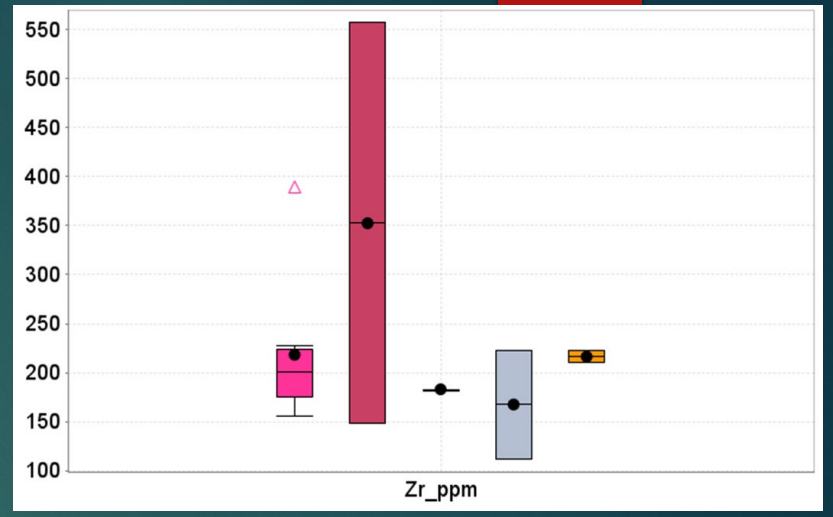
Clinker Chemistry

- Slight positive correlation between Zr and TREE
  - REE substitution in zircon
  - Other REE minerals (i.e. monazite) deposited with zircon in sediments

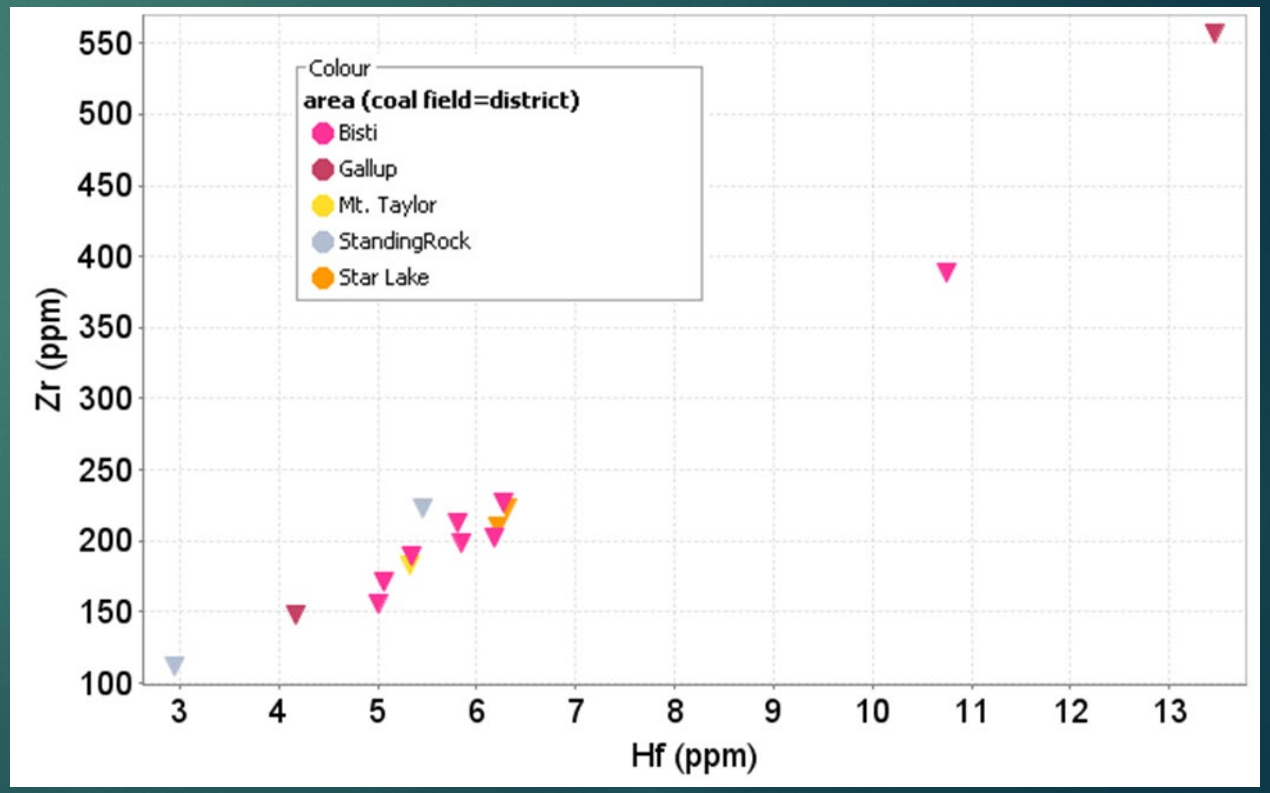


Clinker: Hafnium-Zircon



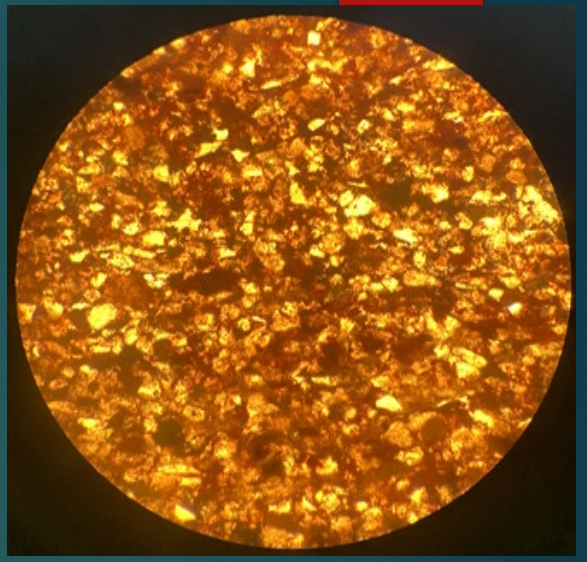


- Hafnium strongly correlates with zirconium
  - Hf substitution in zircon

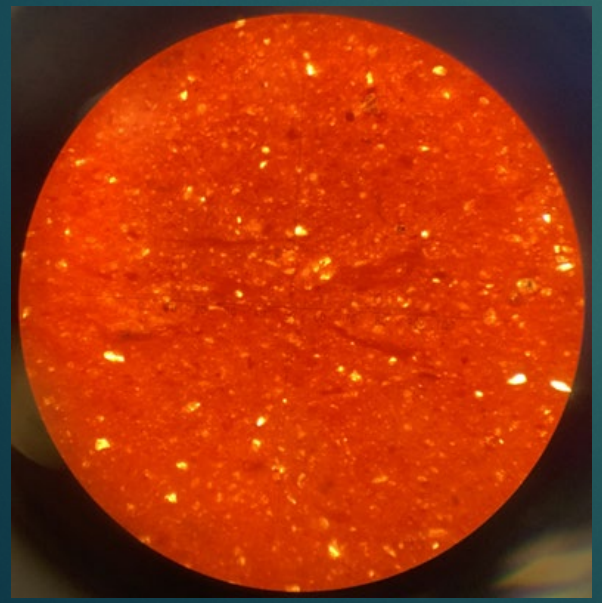


Petrography

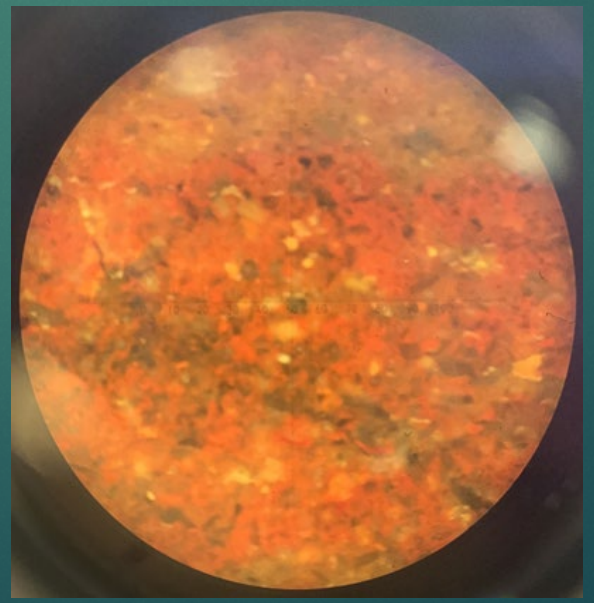
- Several samples have been examined with transmitted light microscopy
  - Coals 9, 28, and 36
  - Dominant minerals through all 3 samples are
    1. Quartz (SiO_2)
    2. Clay minerals (generally high in Al_2O_3)
    3. Hematite (more prevalent in some samples)



Coal 9.
A pyrometamorphosed mudstone with tight clusters of silicates



Coal 28. Baked clay, with strong iron oxide staining and very fine grains



Coal 36. Fine grain quartz arenite sandstone rich in iron oxide,12.09 Fe_2O_3T%. Even in microscope the bedding layers are visible

Future plans

- Plans going forward are to continue to collect samples of clinker from within the San Juan coal basin area to increase the range of samples overall. Further chemical analysis and petrography are also planned for the future.

Coals 9d, 9f, and 28c respectively.

Preliminary conclusions

As of now the data gathered shows us that:

- The pyrometamorphosis that formed clinker has not caused any significant variation in the concentrations of REE
- Clinkers do not show potential for REE, as concentrations are not high enough, barely reaching up to 100 ppm for some REE
- The REE are possibly hosted by clay minerals or very fine grained REE minerals (monazite)

Acknowledgements

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Questions?

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