

DOE NETL

7/22/2015

**Coal and Coal Byproducts with  
Elevated Rare Concentrations**

**Background Information and  
Useful Places to Look**

# Coal Basin REE Assessments

- **Source: Bryan, .C., D. Richers, H.T. Anderson, and T. Gray, “Assessment of Rare Earth Elemental Contents in Select United States Coal Basins”, Tetra Tech Report to Leonardo Technologies, Inc., DE-FE004002, 2015.**
- **<https://edx.netl.doe.gov/dataset/netl-ree-technical-reports>**

# Background Information and Useful Places to Look

- Coal Basin REE Assessments
- Whole Seam REE Contents
- Stratigraphic REE Distributions from Public Domain Publications
- Float Sink Data
- Possible REE Indications from Well Logs
- Additional Useful References

# Assessment of Rare Earth Elemental Contents in Select United States Coal Basins

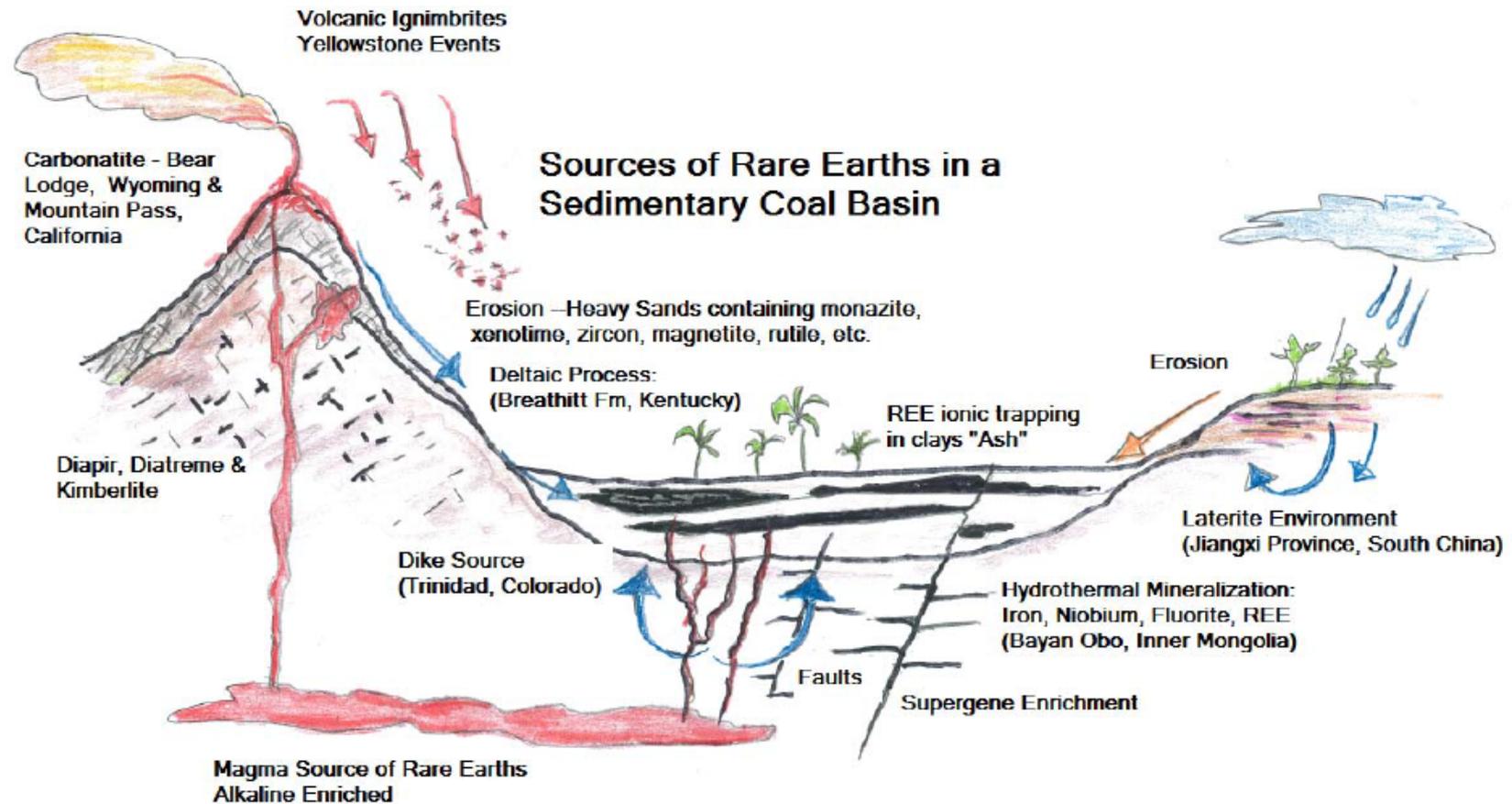
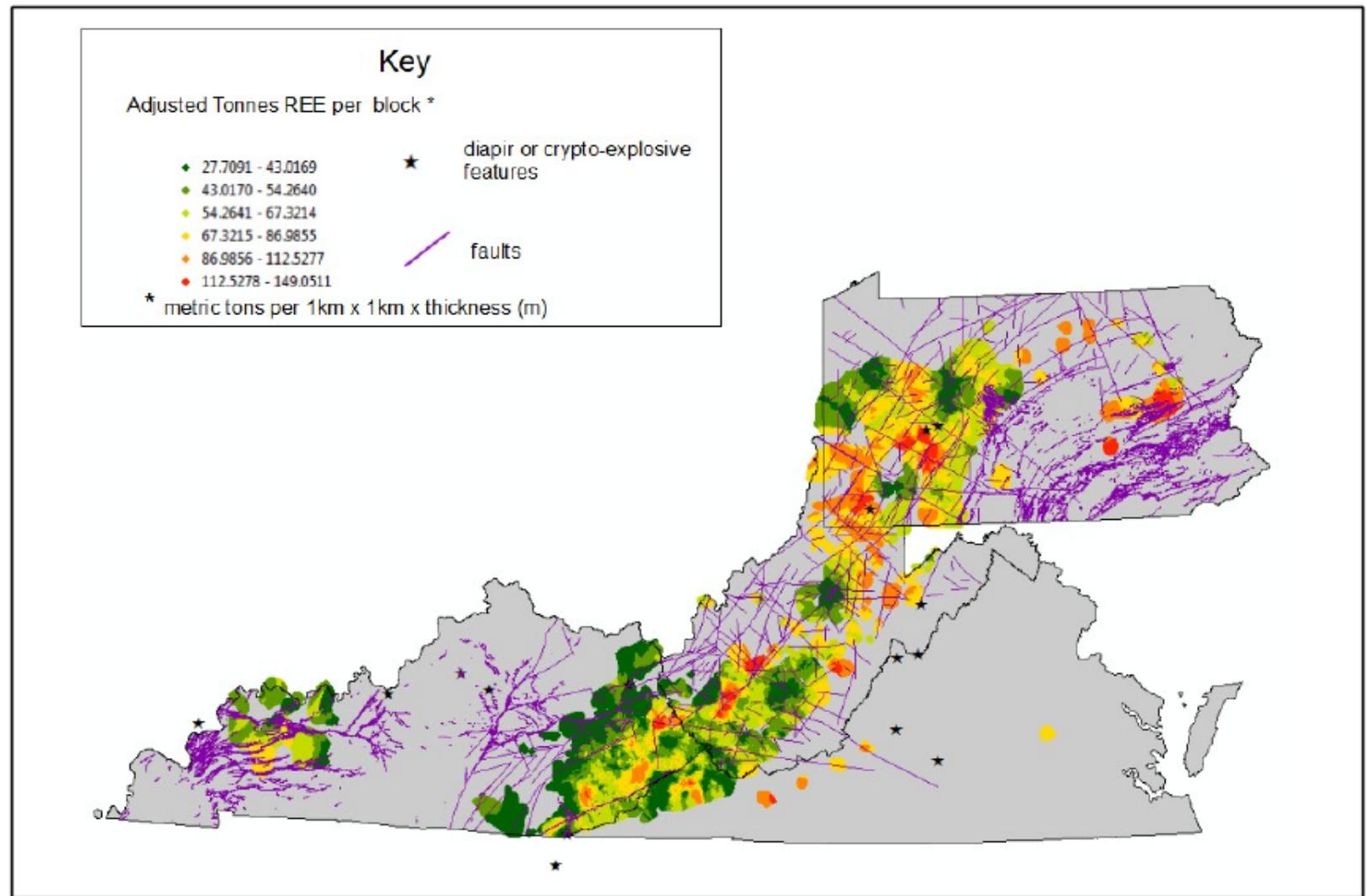
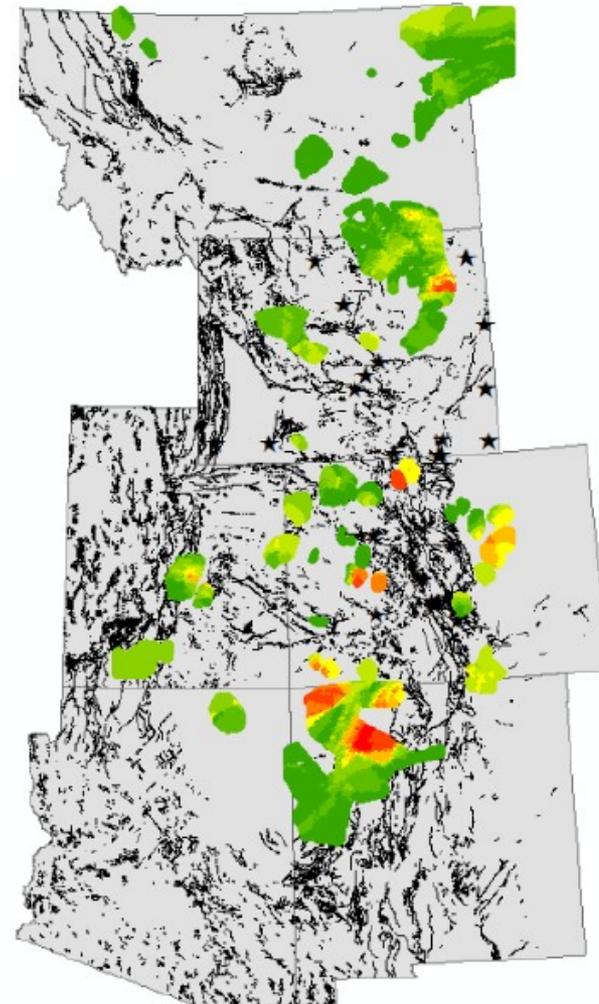
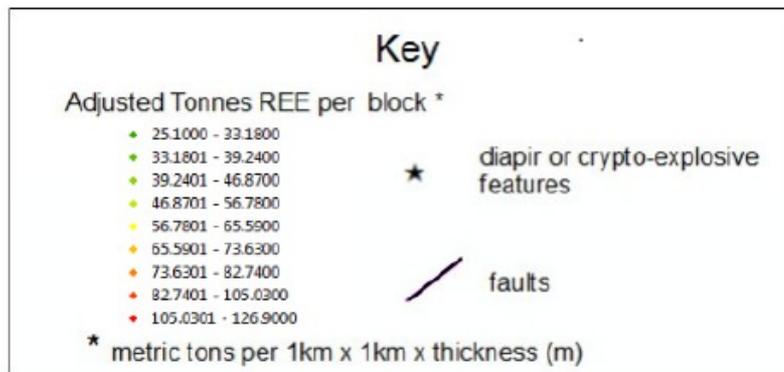


Figure 1.2 Possible Source Mechanisms for Introducing REEs into Coal Basins

# Assessment of Rare Earth Elemental Contents in Select United States Coal Basins



# Assessment of Rare Earth Elemental Contents in Select United States Coal Basins



# Whole Seam REE Contents

- USGS CoalQual Database
- <http://energy.er.usgs.gov/products/databases/CoalQual/intro.htm>
- By State
- By County
- By Formation
- By Bed

# USGS CoalQual Database

- 5200+ Trace Elements Analyses (Including REE's)
- Channel, Drill Core, Weathered Channel

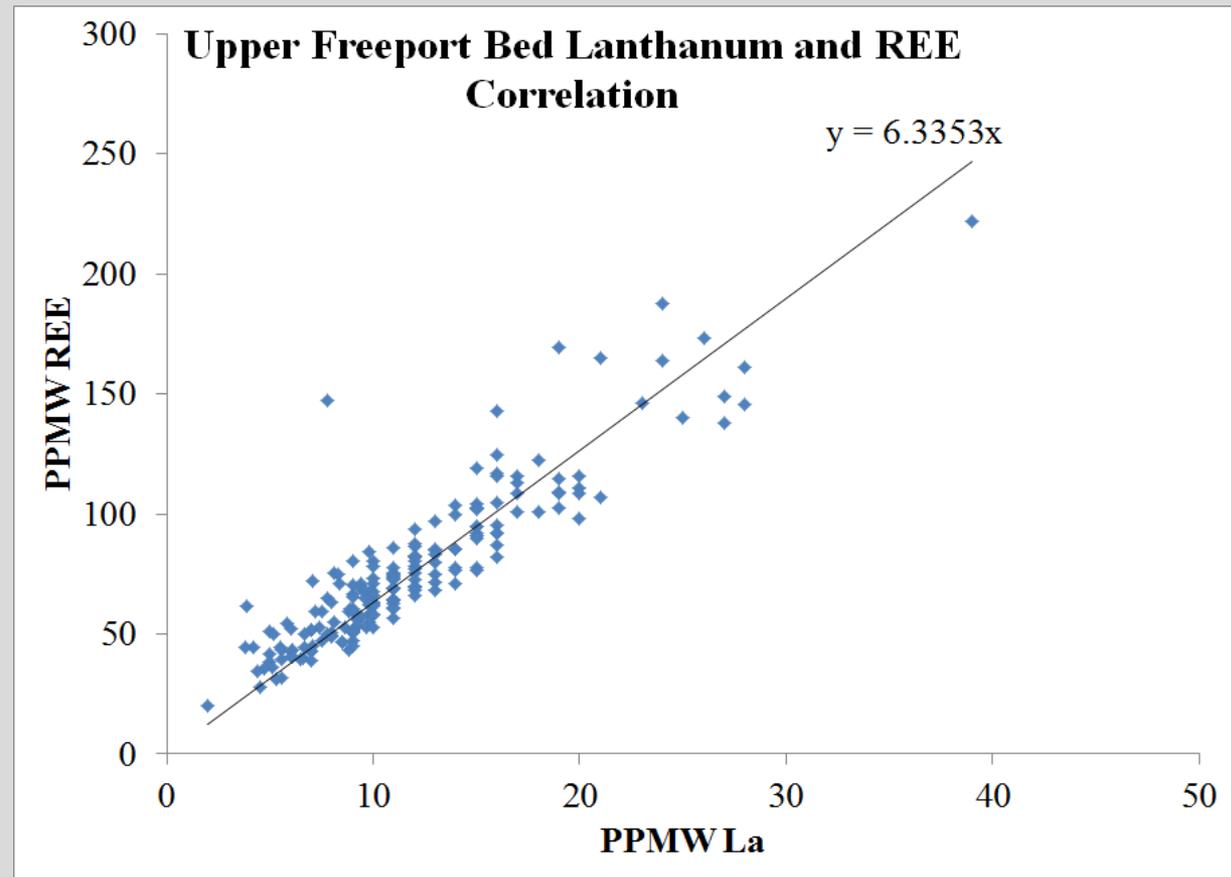
	A	B	C	N	Y	EI
1	CSample	Statecd	Cnty	Cbed	Esrnk	REE+Y
2	W23399	AL	Walker	Gillespy	Bituminous	429.1
3	W20790	AL	Fayette	Gillespy	Bituminous	360.9
4	W24101	PA	Elk	Upper Mercer	Bituminous	351.99
5	W22956	KY	Ohio	Unnamed	Bituminous	342.9
5	W19184	KY	Leslie	Fire Clay	Bituminous	325.03

# Stratigraphic REE Distributions from Public Domain Publications

- Zubovic, P., T. Stadnichenko, and N.B. Sheffey, “Geochemistry of Minor Elements in Coals of the Northern Great Plains Province”, United States Geological Survey Bulletin 1117-A, 1961.
- Zubovic, P., T. Stadnichenko, and N.B. Sheffey, “Distribution of Minor Elements in Coal Beds of the Eastern Interior Region”, United States Geological Survey Bulletin 1117-B, 1964.
- Zubovic, P., T. Stadnichenko, and N.B. Sheffey, “Distribution of Minor Elements in Coals of the Appalachian Region”, United States Geological Survey Bulletin 1117-C, 1966.
- Zubovic, P., T. Stadnichenko, and N.B. Sheffey, “Distribution of Minor Elements in Some Coals of the Western and Southwestern Regions of the Interior Coal Province”, United States Geological Survey Bulletin 1117-D, 1967.
- Gluskoter, H.J., R.R. Ruch, W.G. Miller, R.A. Cahill, G.B. Dreher, and J.K. Kuhn, “Trace Elements in Coal: Occurrence and Distribution”, Illinois State Geological Survey Circular 499, 1977.

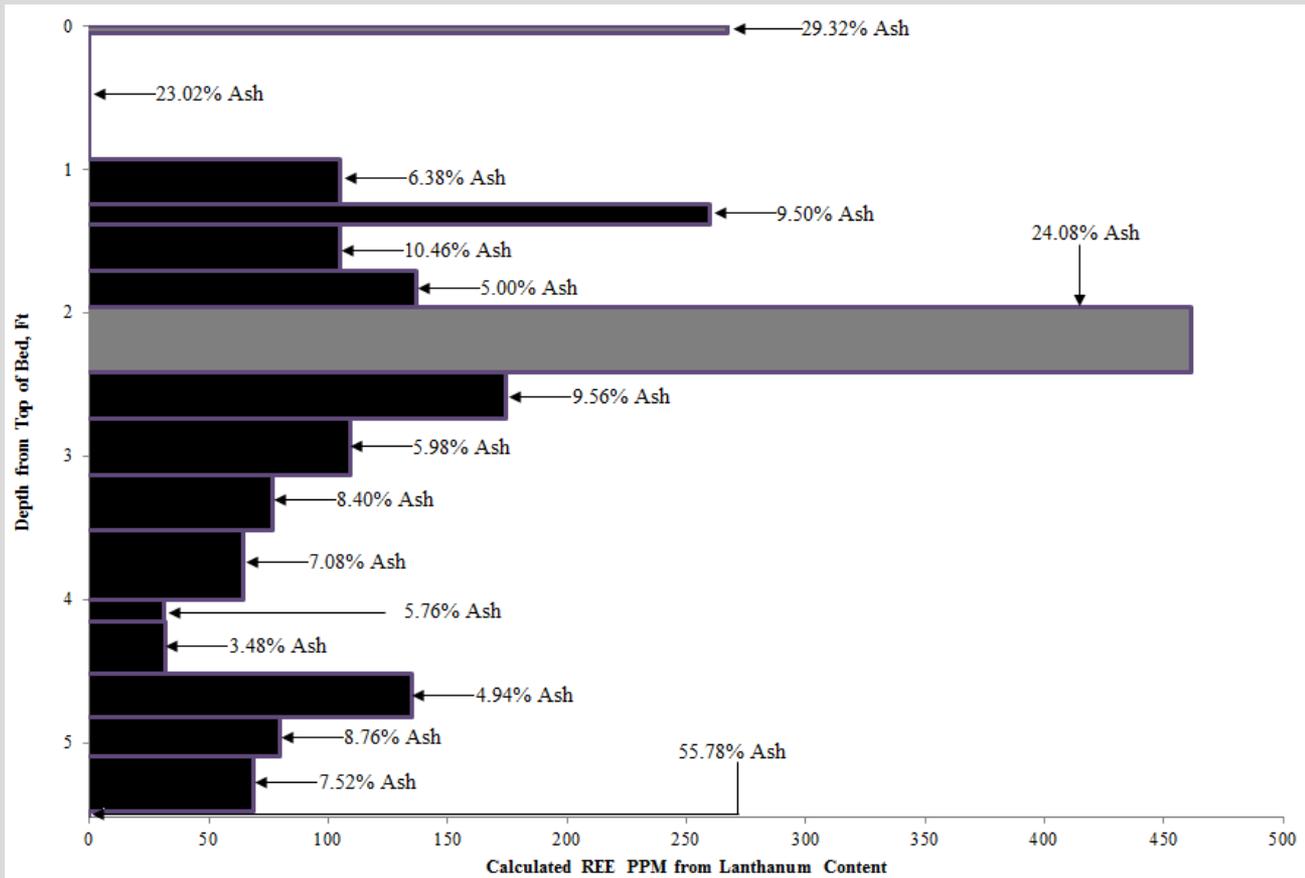
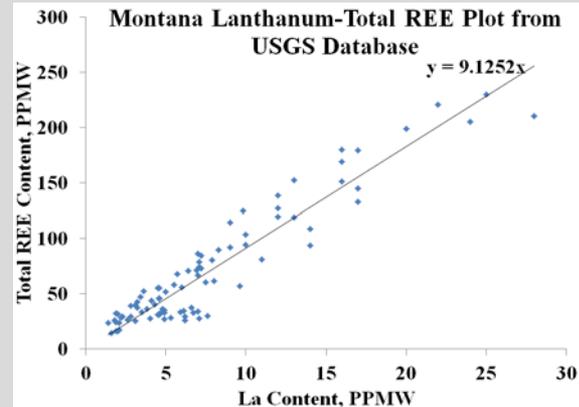
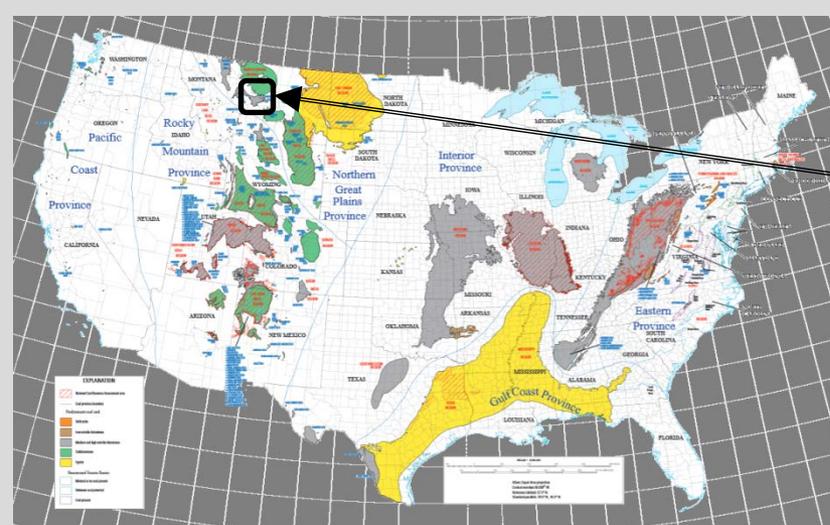
# Stratigraphic REE Distributions from Public Domain Publications

- May not Report all REE's for a Stratigraphic Interval.
- Crossplots can Be Generated from USGS Database (Example: La. Vs Total REE):



# Uncle Sam (Deep Mine) Fergus County, Montana Morrison Formation, Unnamed Bed

X-Axis Scale: 0-500 ppm ■ <20% Ash ■ >20% Ash

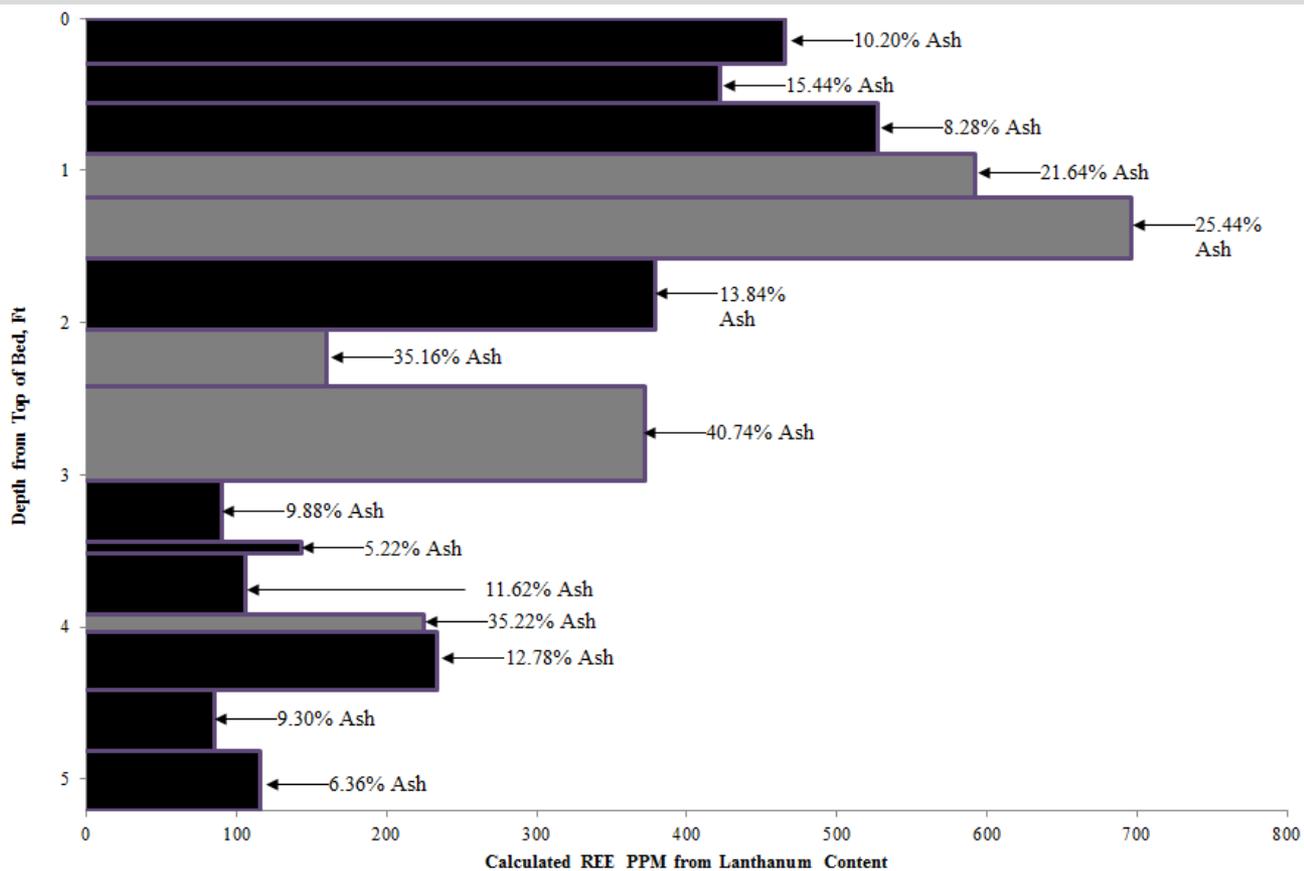
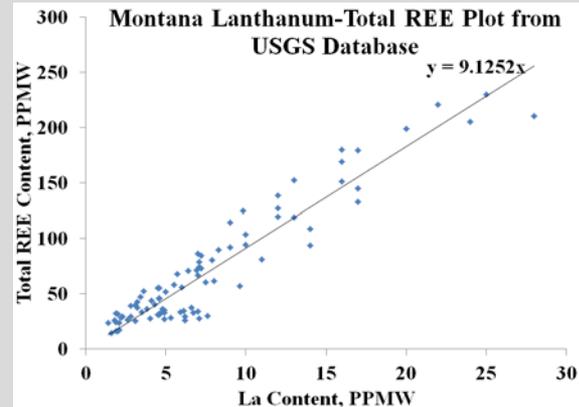
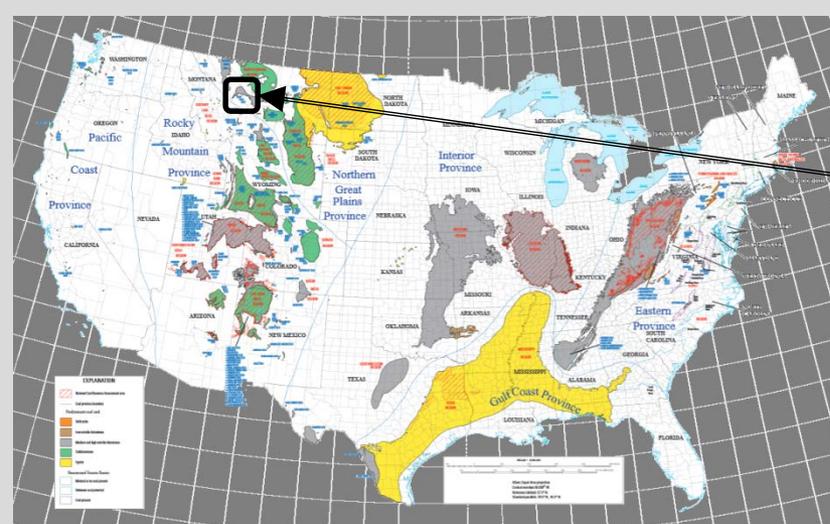


Data from Zubovic, P., T. Stadnichenko, and N.B. Sheffey, "Geochemistry of Minor Elements in Coals of the Northern Great Plains Province", USGS Bulletin 1117-A, 1961

# East Belt (Deep Mine) Cascade County, Montana Morrison Formation, Unnamed Bed

X-Axis Scale: 0-800 ppm

<20% Ash
  >20% Ash

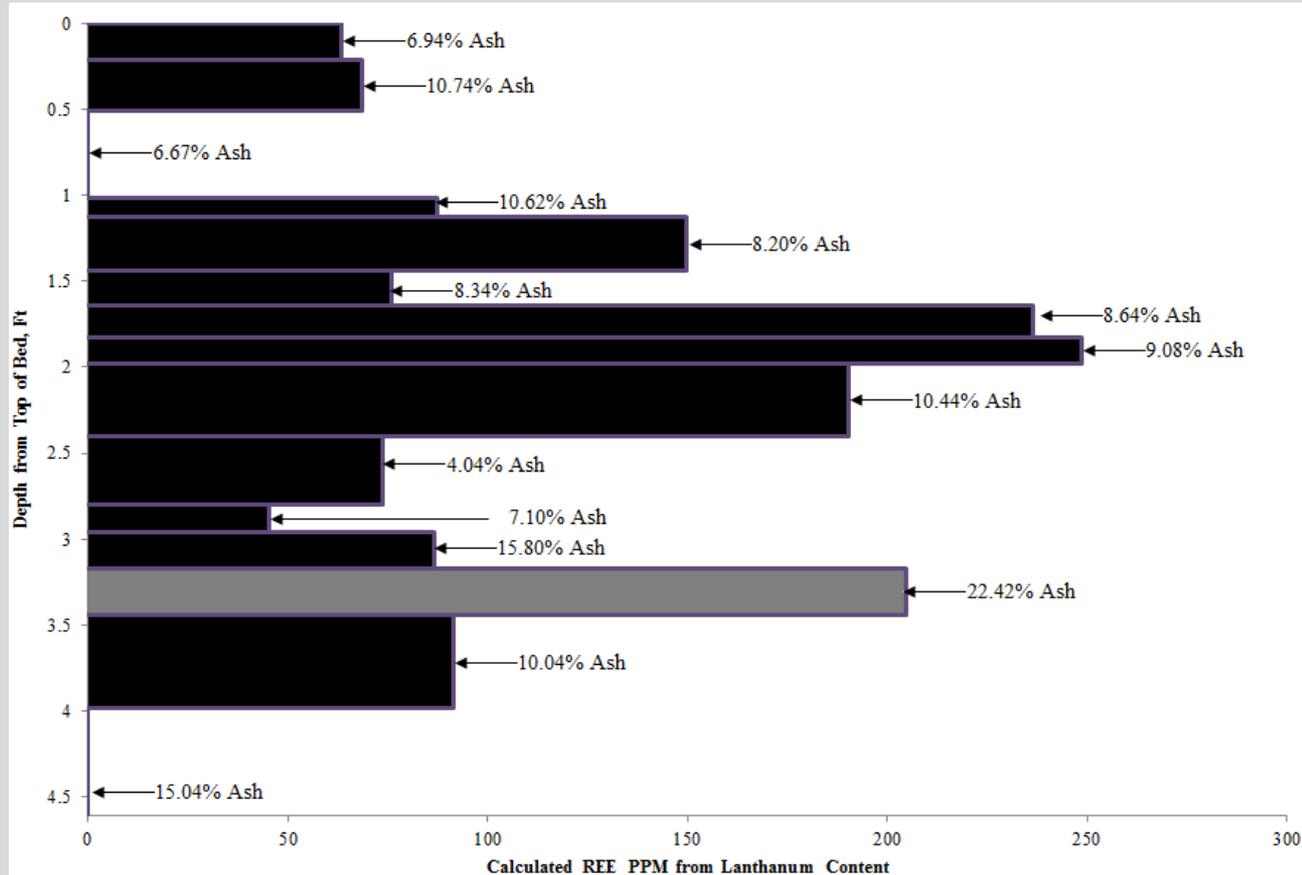
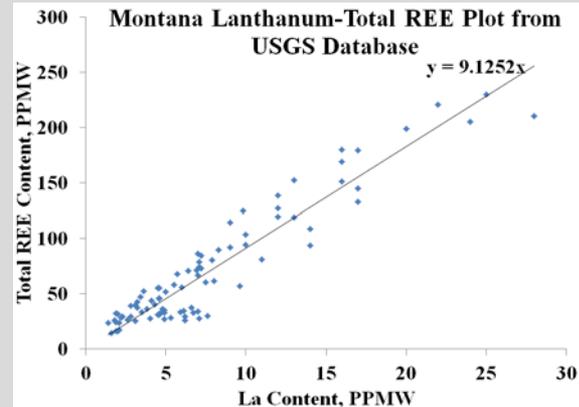
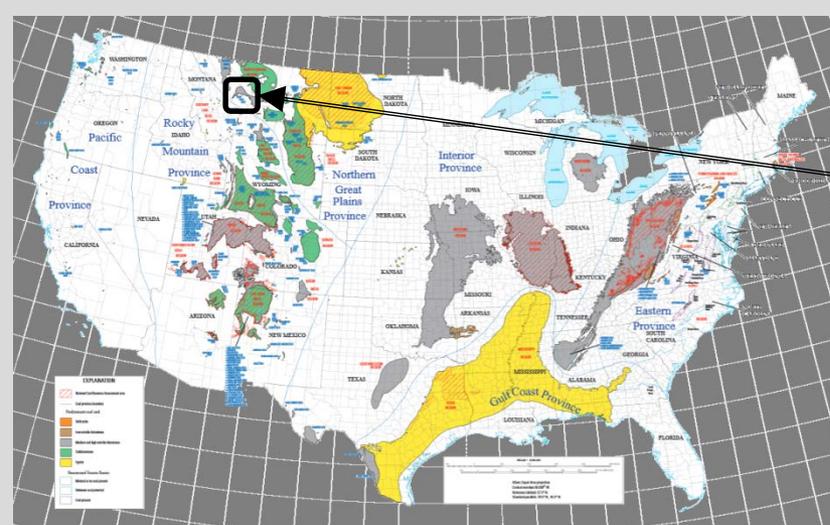


Data from Zubovic, P., T. Stadnichenko, and N.B. Sheffey, "Geochemistry of Minor Elements in Coals of the Northern Great Plains Province", USGS Bulletin 1117-A, 1961

# Cyril Tuss (Deep Mine) Fergus County, Montana Morrison Formation, Unnamed Bed

X-Axis Scale: 0-300 ppm

■ <20% Ash    ■ >20% Ash

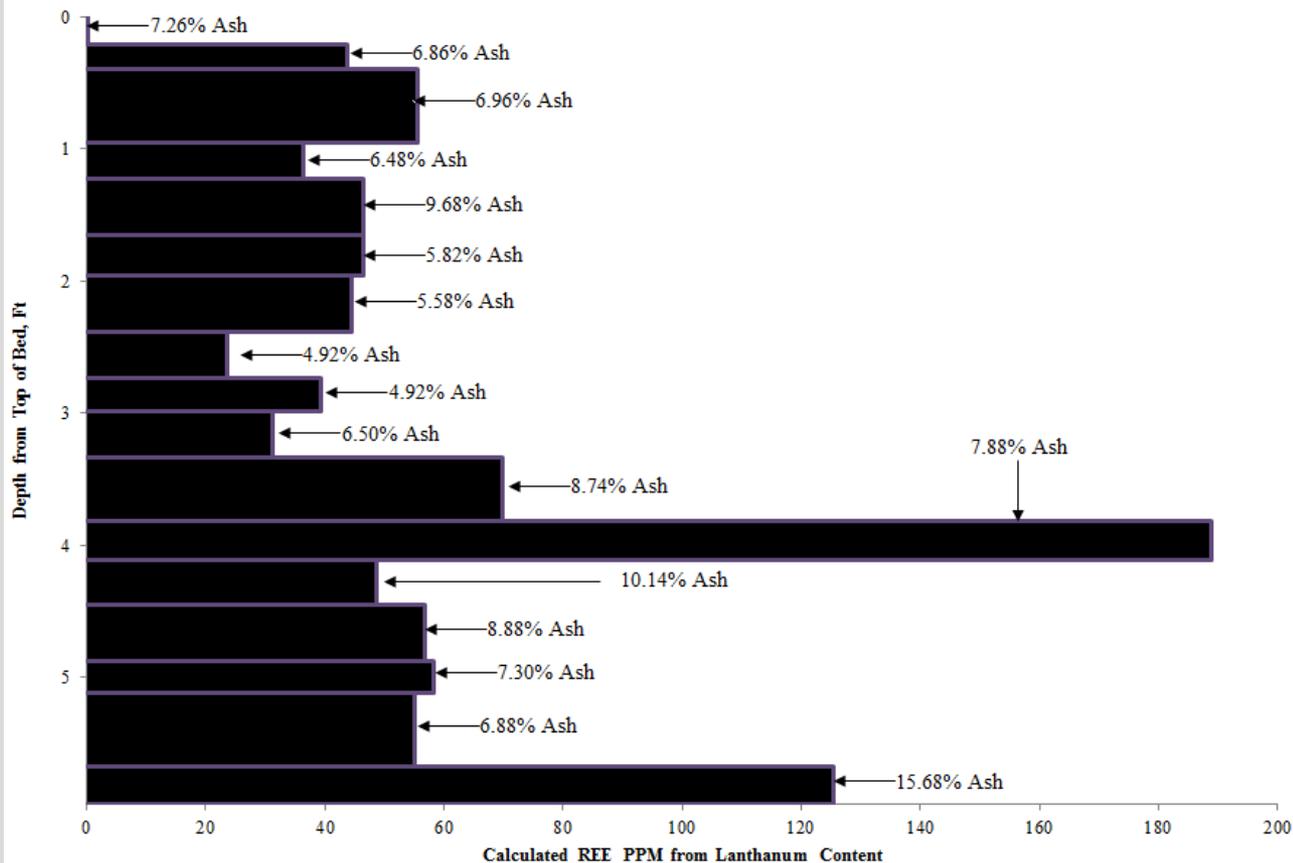
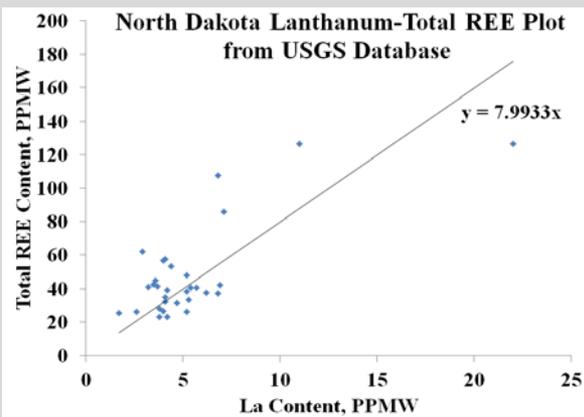
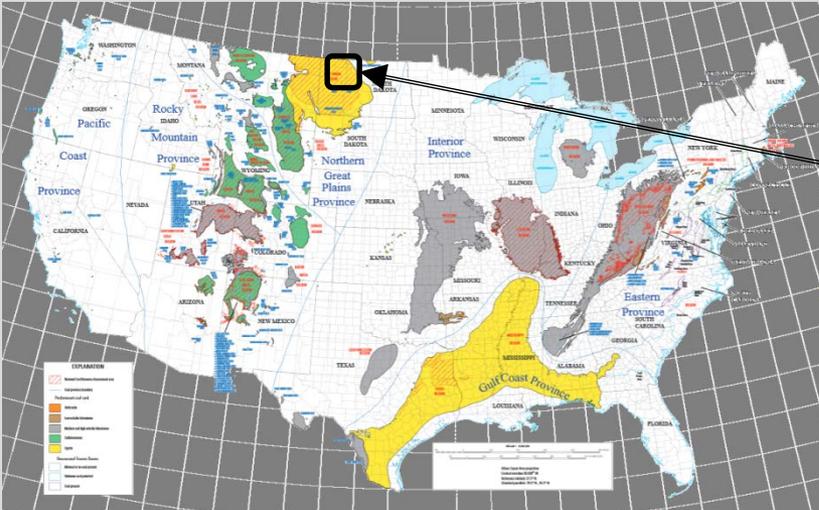


Data from Zubovic, P., T. Stadnichenko, and N.B. Sheffey, "Geochemistry of Minor Elements in Coals of the Northern Great Plains Province", USGS Bulletin 1117-A, 1961

# Baukol Noonan (Strip Mine) Divide County, North Dakota Fort Union Formation, Noonan Bed

X-Axis Scale: 0-200 ppm

<20% Ash
  >20% Ash

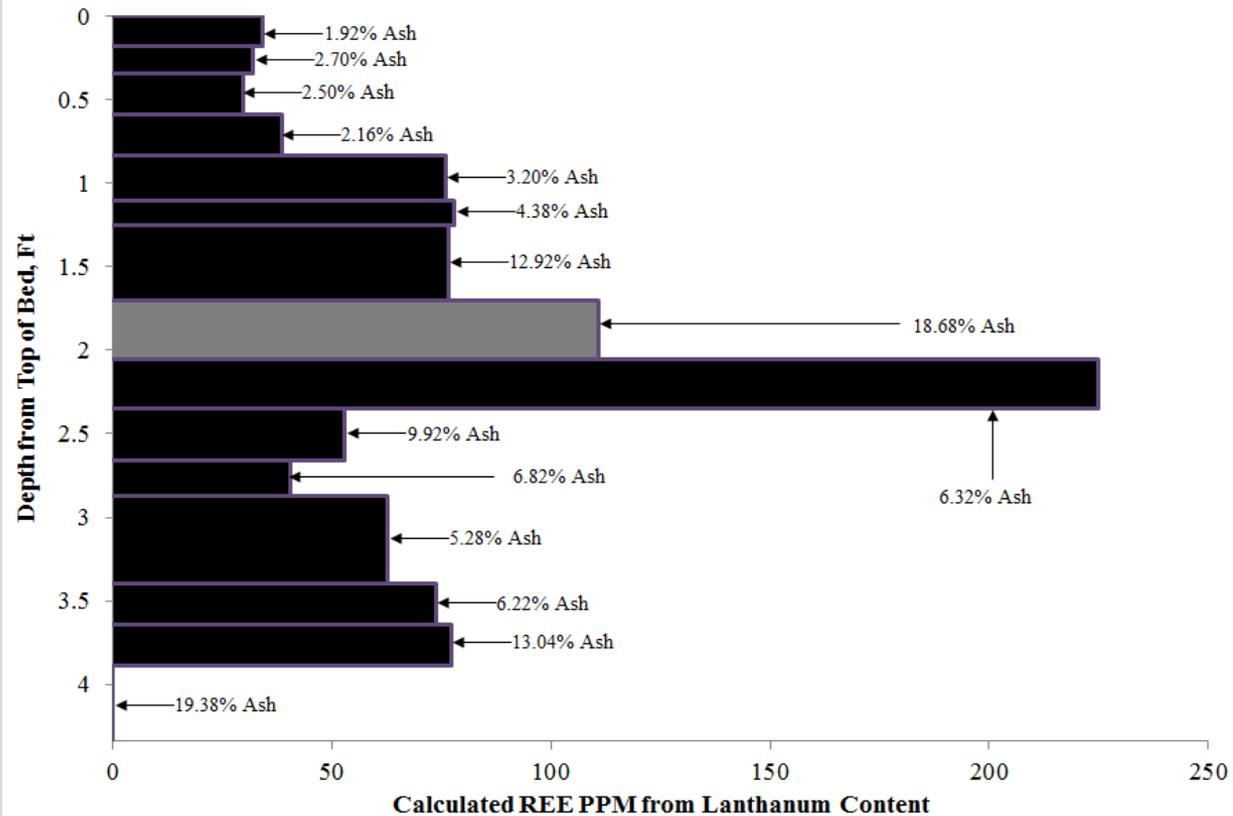
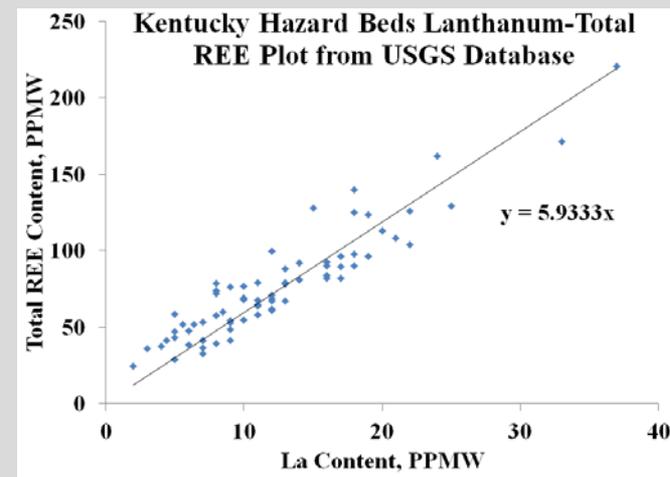
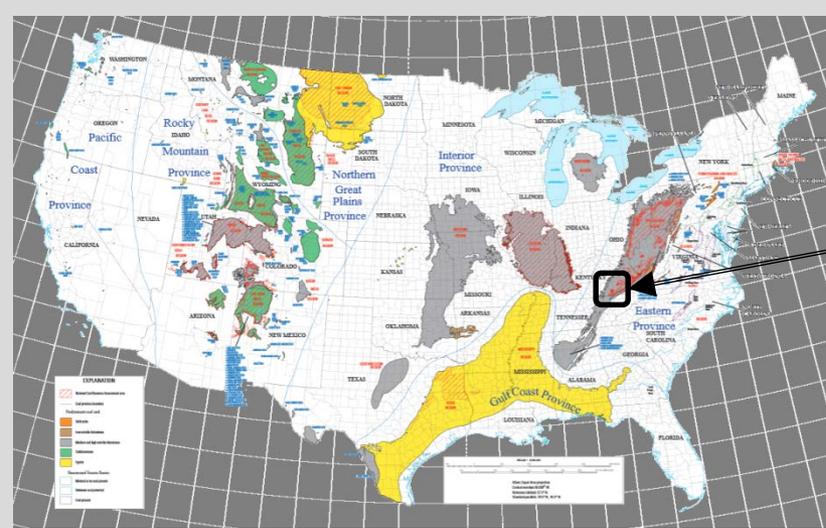


Data from Zubovic, P., T. Stadnichenko, and N.B. Sheffey, "Geochemistry of Minor Elements in Coals of the Northern Great Plains Province", USGS Bulletin 1117-A, 1961

# Deep Mine Perry County, Kentucky Breathitt Formation, Hazard #9 Bed

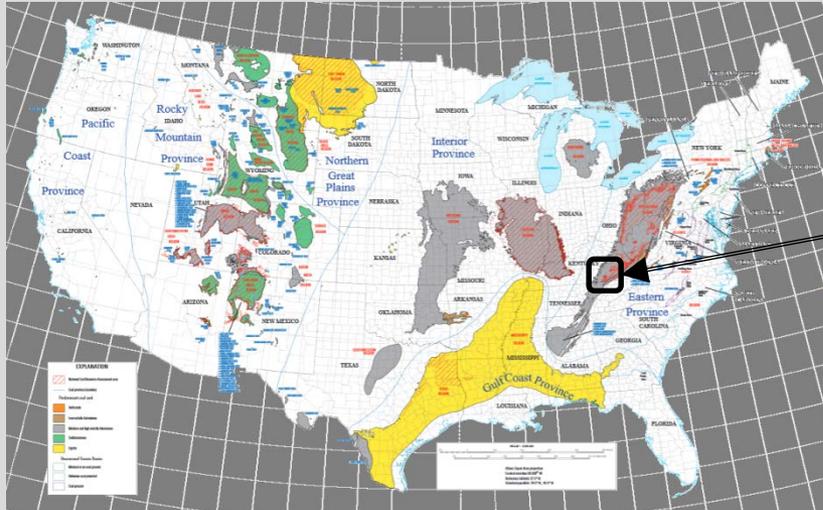
X-Axis Scale: 0-250 ppm

<20% Ash
  >20% Ash



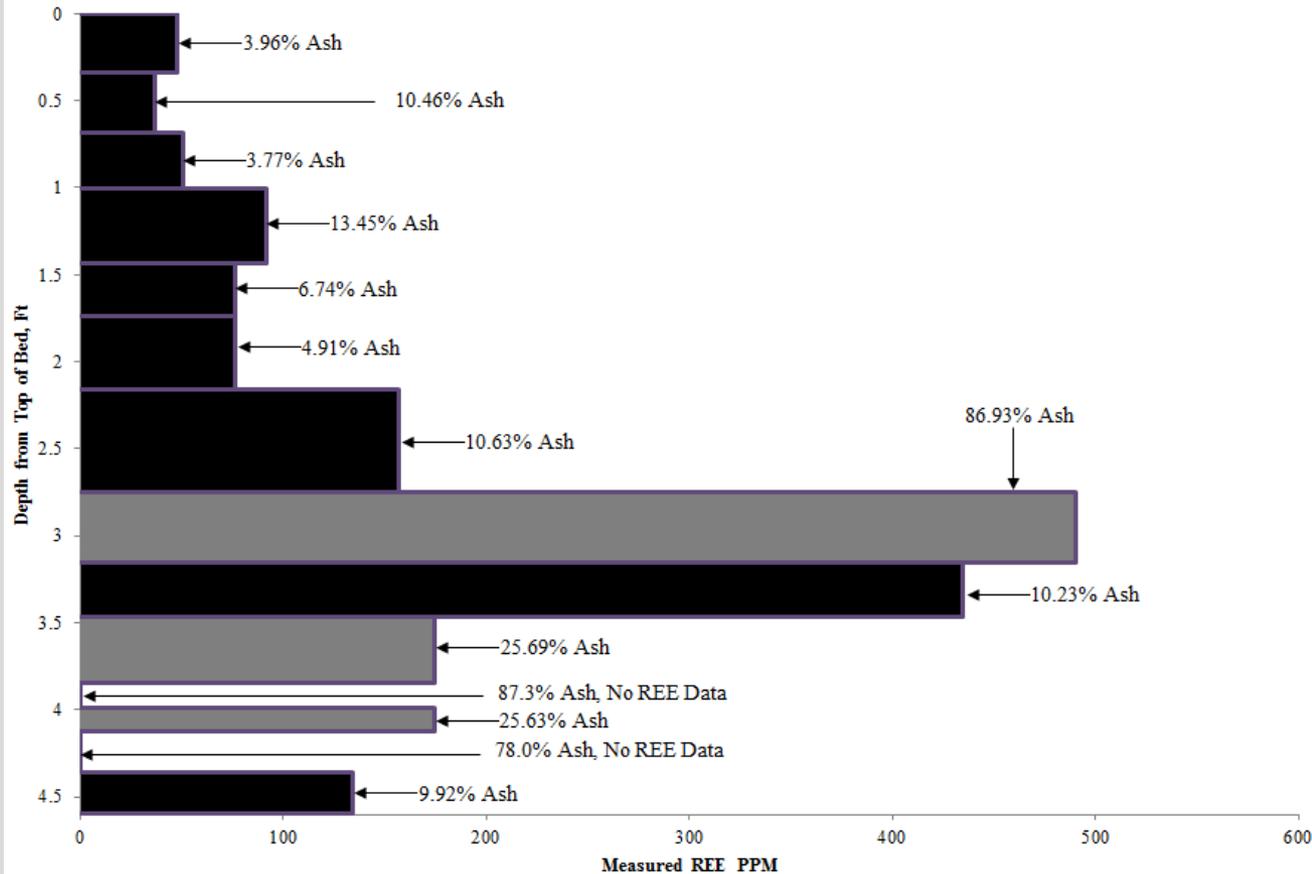
Data from Zubovic, P., T. Stadnichenko, and N.B. Sheffey, "Distribution of Minor Elements in Coals of the Appalachian Region", USGS Bulletin 1117-C, 1966

# Hyden East Leslie County, Kentucky Fire Clay Bed



X-Axis Scale: 0-600 ppm

■ <20% Ash    ■ >20% Ash

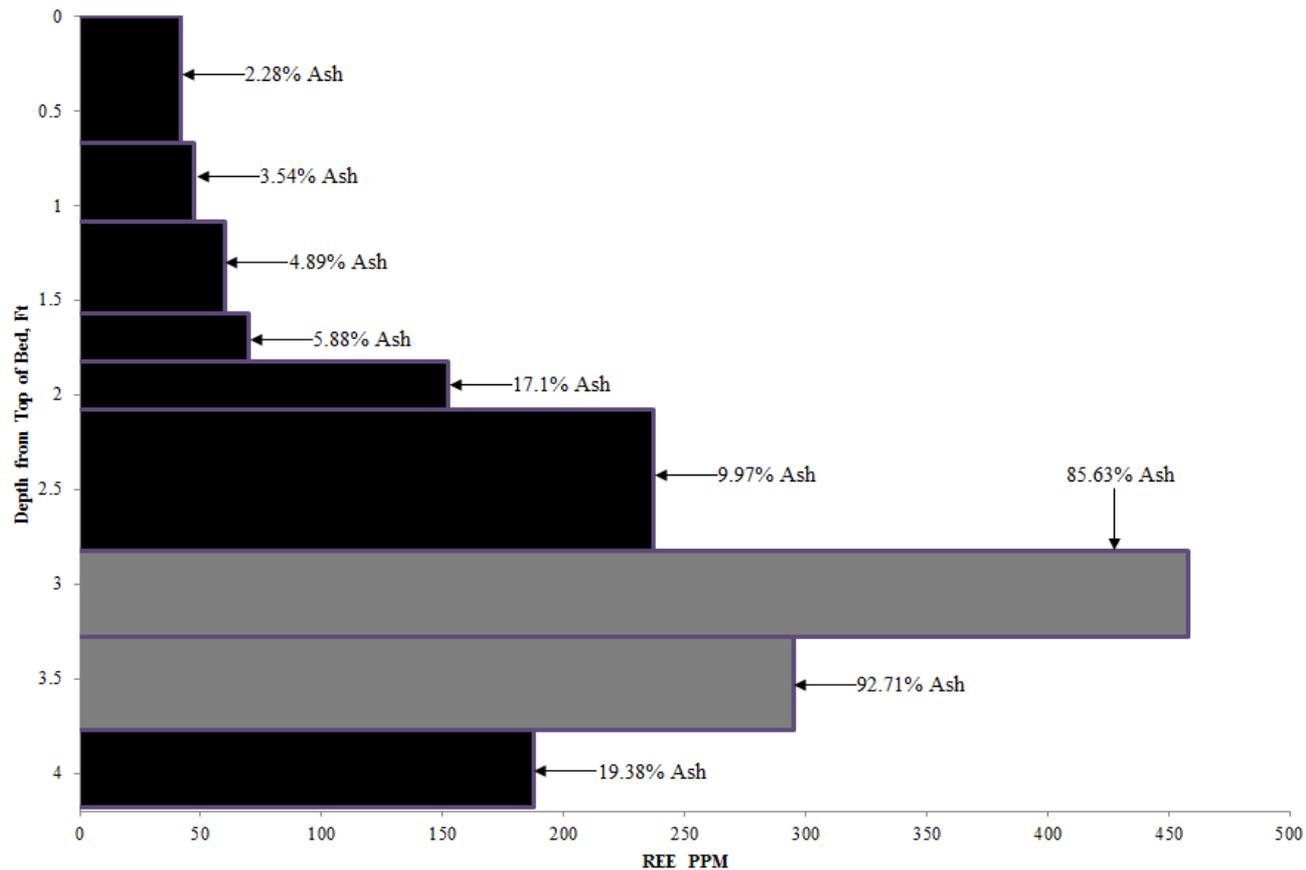


Data from Hower, J.C., L.F. Ruppert, and C.F. Eble, "Lanthanide, Yttrium, and Zirconium Anomalies in the Fire Clay Coal Bed, Eastern Kentucky, Int. J. Coal Geol., 39, 1999, 141-153.

# Tilford Letcher County, Kentucky Fire Clay Bed

X-Axis Scale: 0-500 ppm

<20% Ash
  >20% Ash

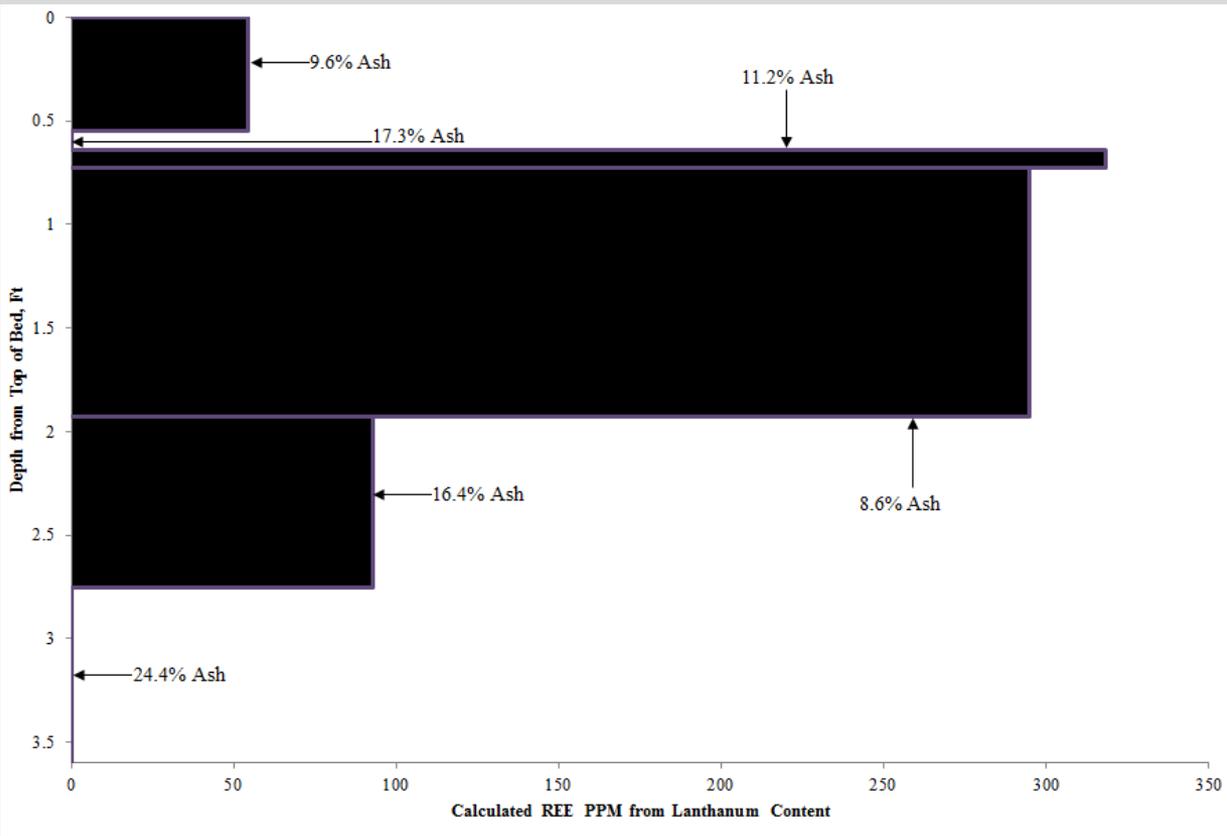
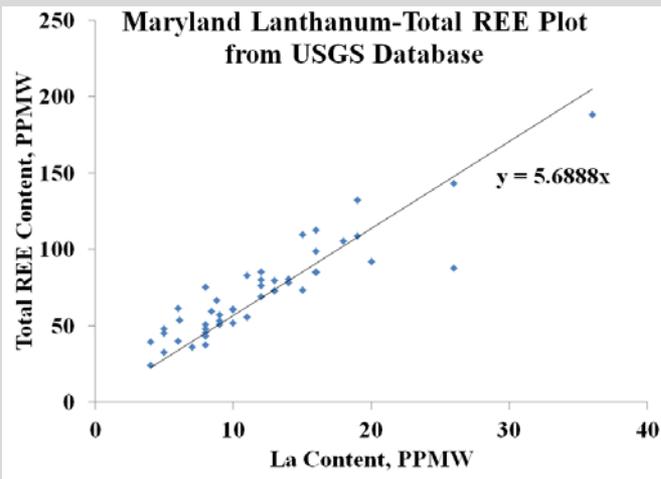
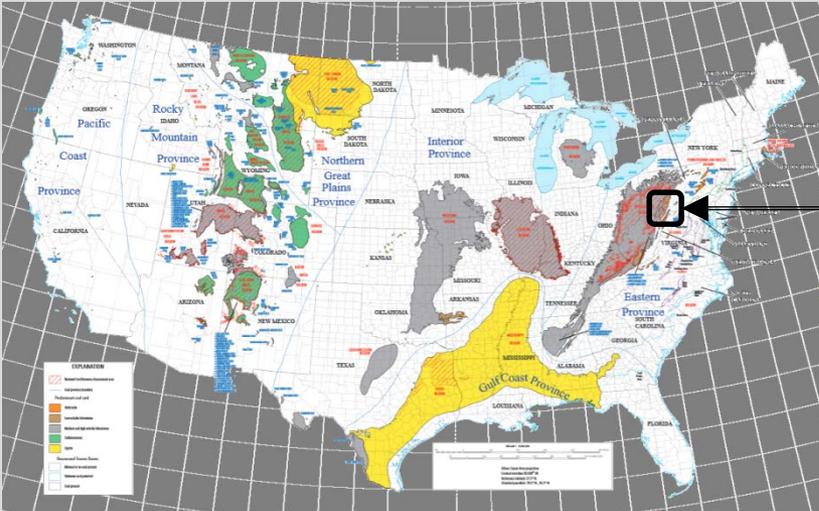


Data from Hower, J.C., L.F. Ruppert, and C.F. Eble, "Lanthanide, Yttrium, and Zirconium Anomalies in the Fire Clay Coal Bed, Eastern Kentucky, *Int. J. Coal Geol.*, 39, 1999, 141-153.

# Deep Mine Garrett County, Maryland Allegheny Formation, Lower Kittanning Bed

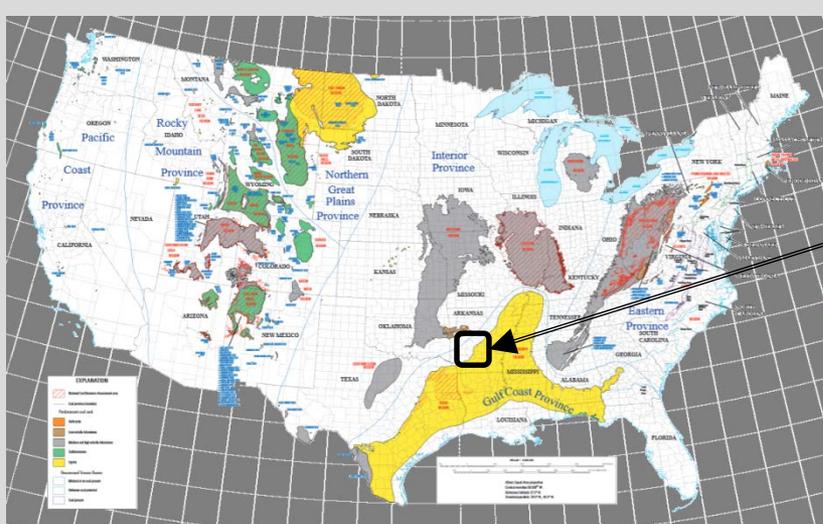
X-Axis Scale: 0-250 ppm

<20% Ash
  >20% Ash

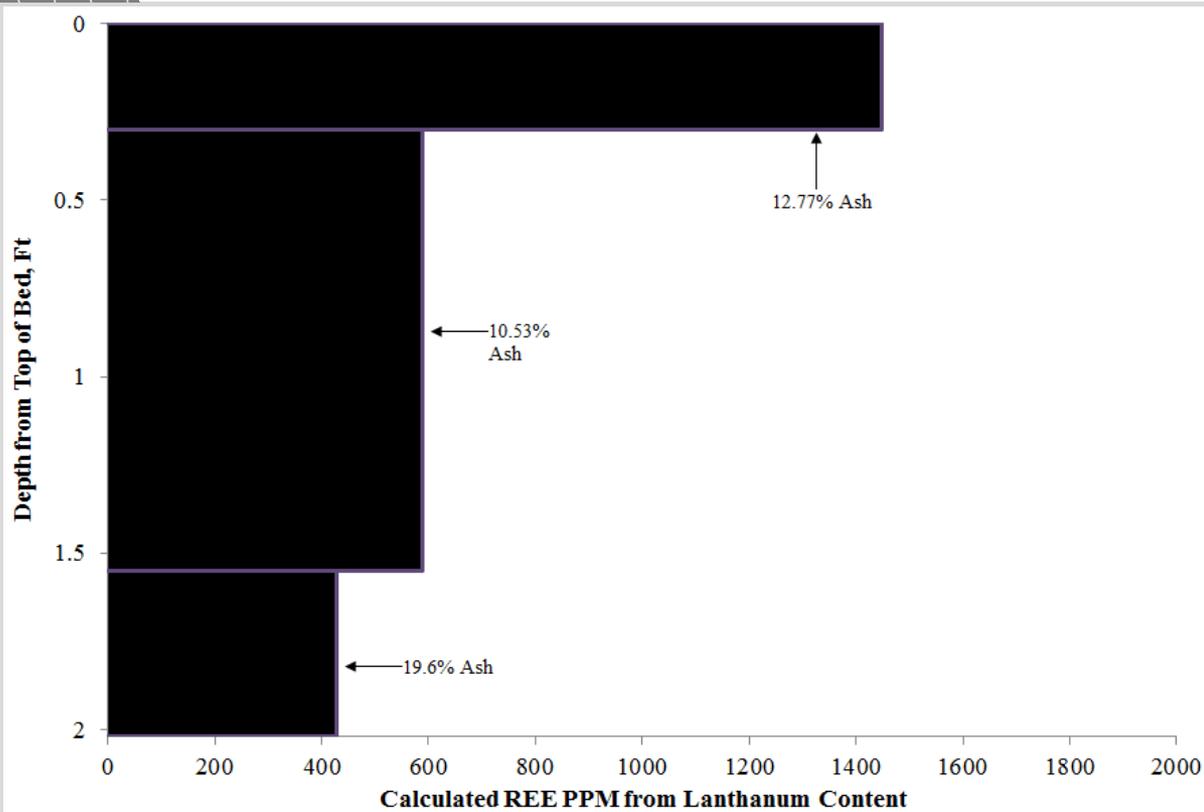
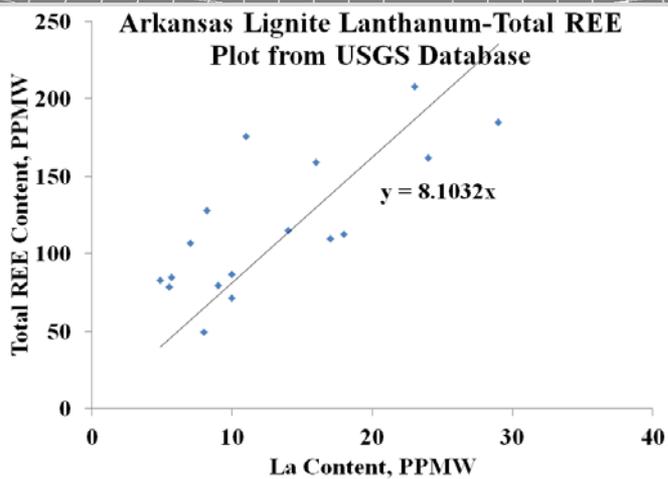


Data from Zubovic, P., T. Stadnichenko, and N.B. Sheffey, "Distribution of Minor Elements in Coals of the Appalachian Region", USGS Bulletin 1117-C, 1966

# Clay Pit (Strip Mine) Hot Spring County, Arkansas Wilcox Formation, Unnamed Bed



X-Axis Scale: 0-2000 ppm ■ <20% Ash ■ >20% Ash



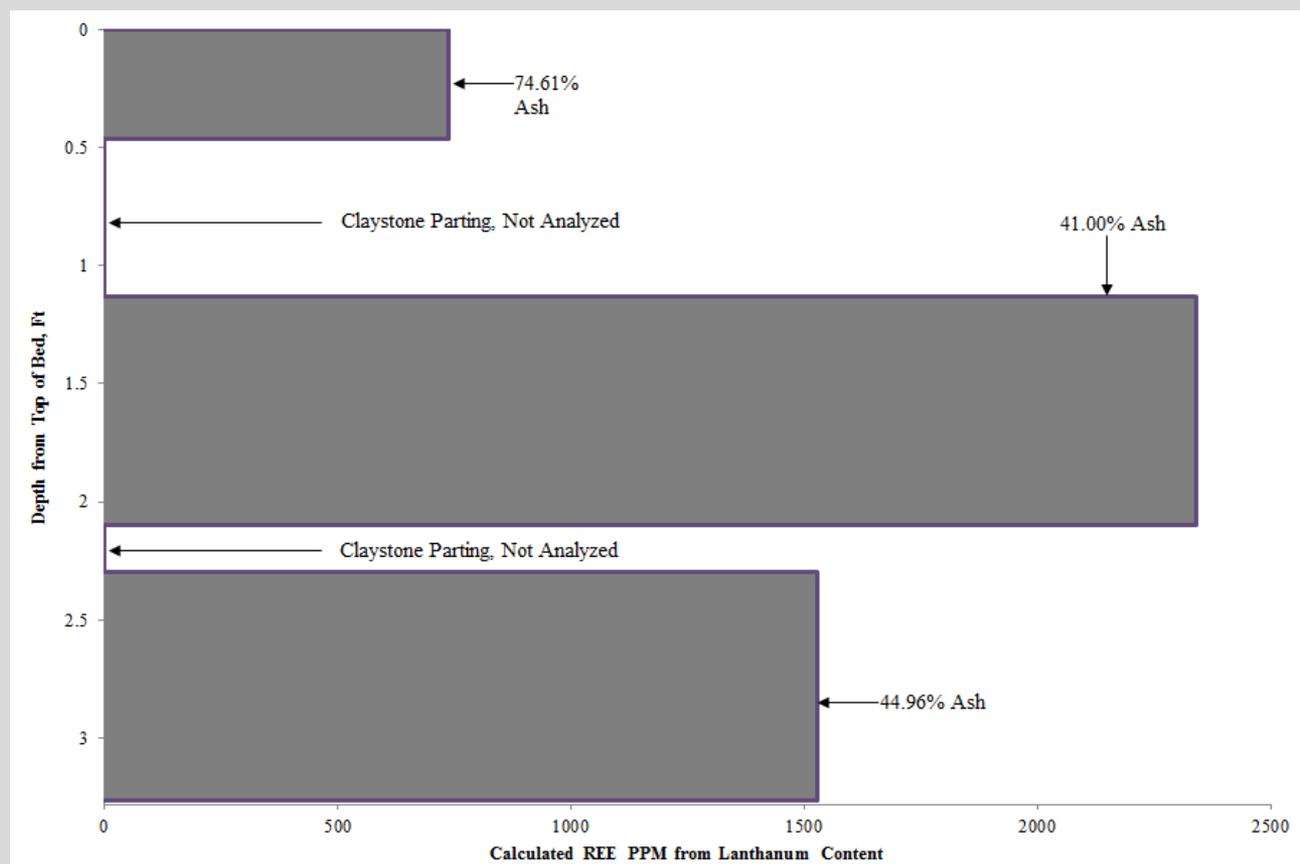
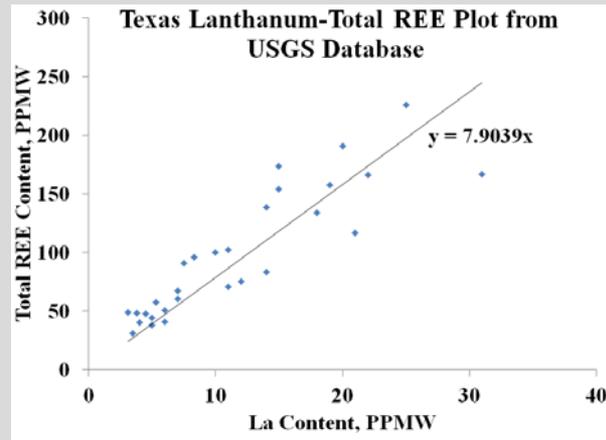
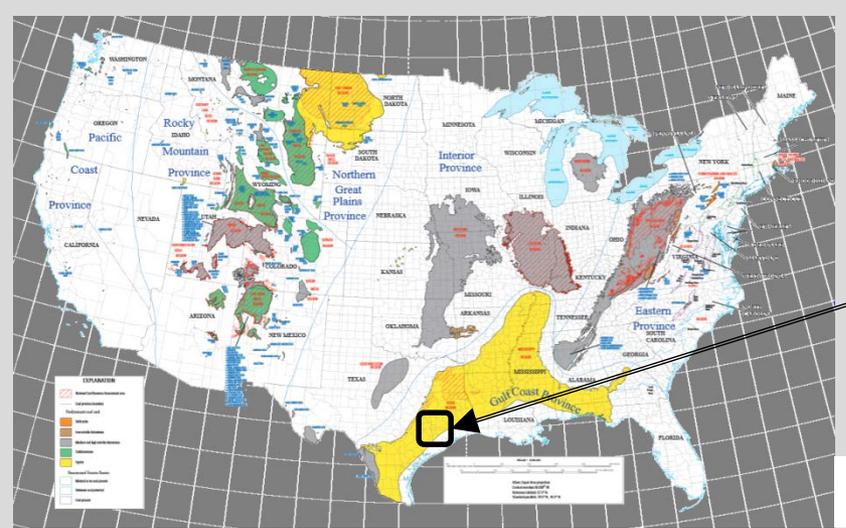
Data from Zubovic, N. B. Sheffey, and P. T. Stadnichenko, "Distribution of Minor Elements in Some Coals in the Western and Southwestern Regions of Interior Coal Province", USGS Bulletin 1117-D, 1967

# Gibbons Mine

## Grimes County, Texas

### Claiborne Group, 4500 Bed

X-Axis Scale: 0-2500 ppm  <20% Ash  >20% Ash



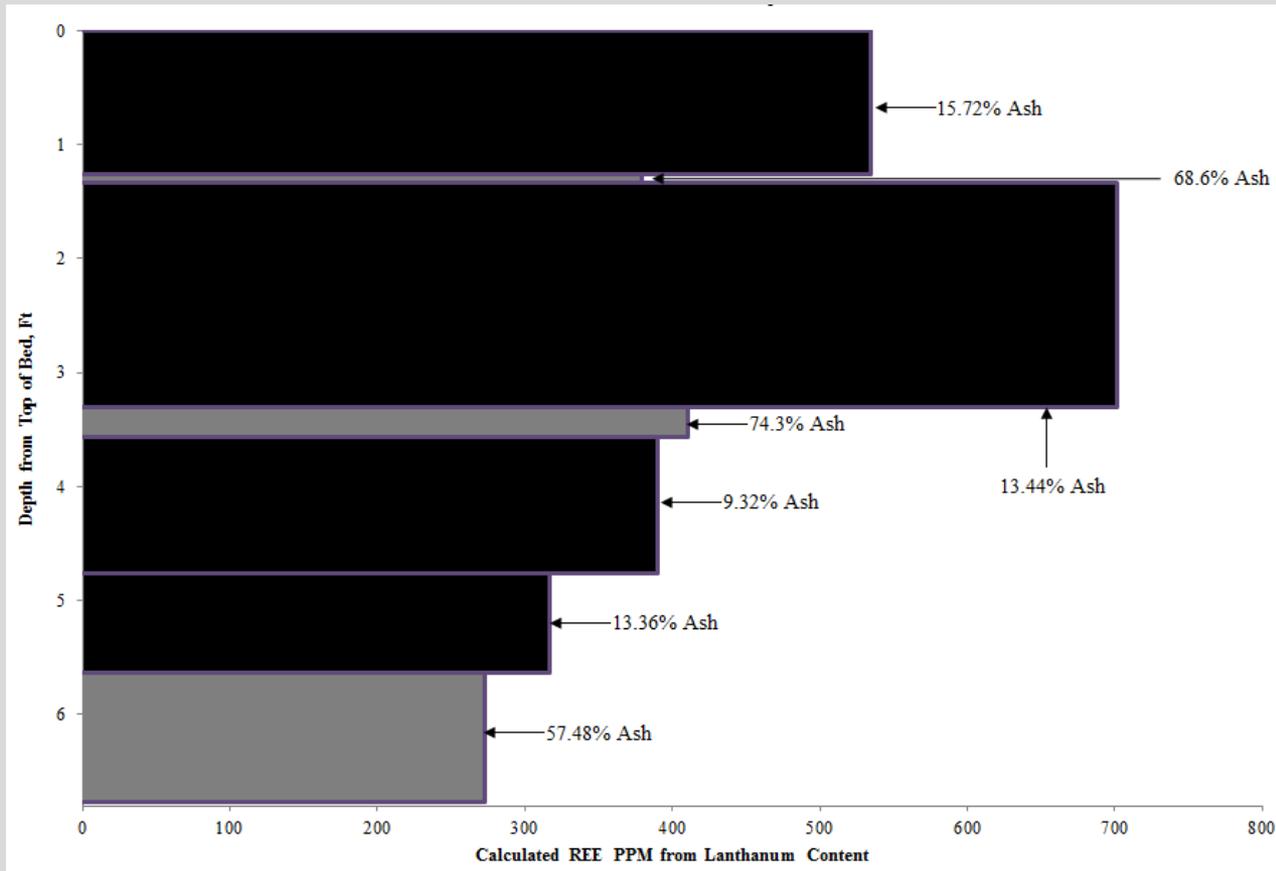
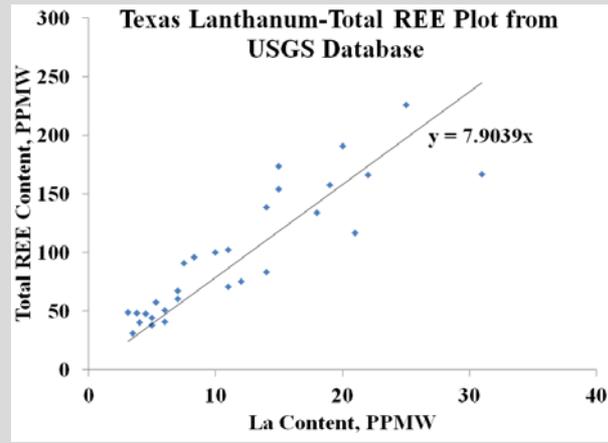
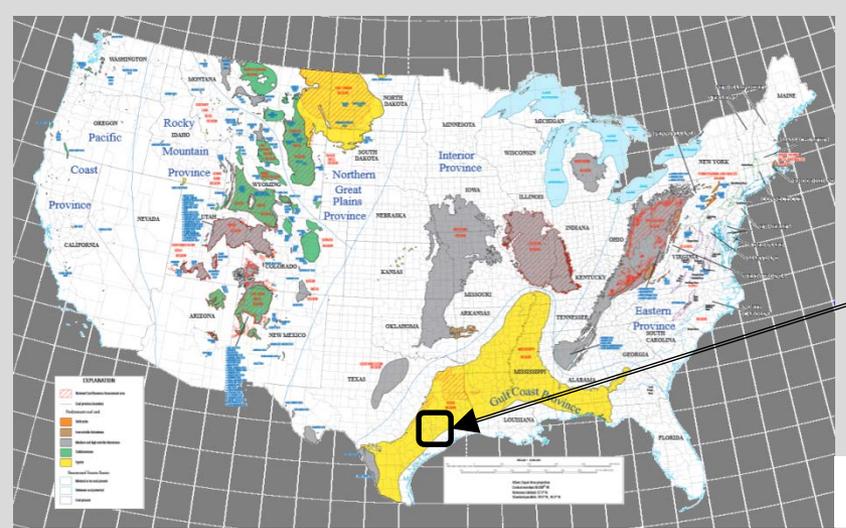
Data from Zwarwick, P.D., S. S. Crowley, L. F. Ruppert, and J. Pontolillo, "Petrography and Geochemistry of Selected Lignite reek Mine (Manning Formation, Jackson Group, Paleocene) of East Central Texas", Int. J. Coal Geol., 1997, 307-326.

# Gibbons Mine

## Grimes County, Texas

### Claiborne Group, 3500 Bed

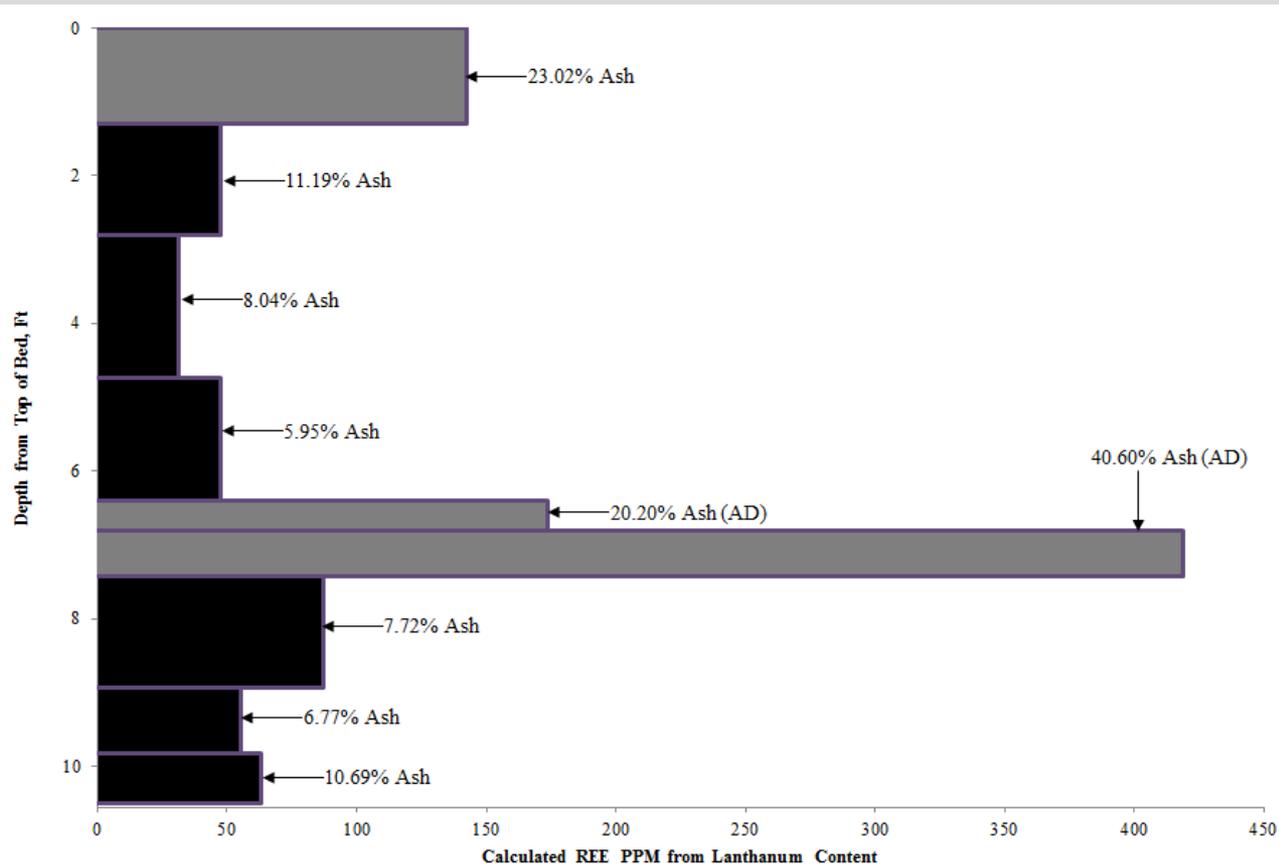
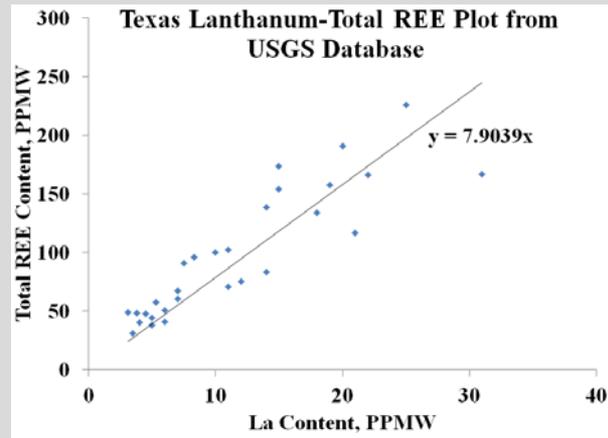
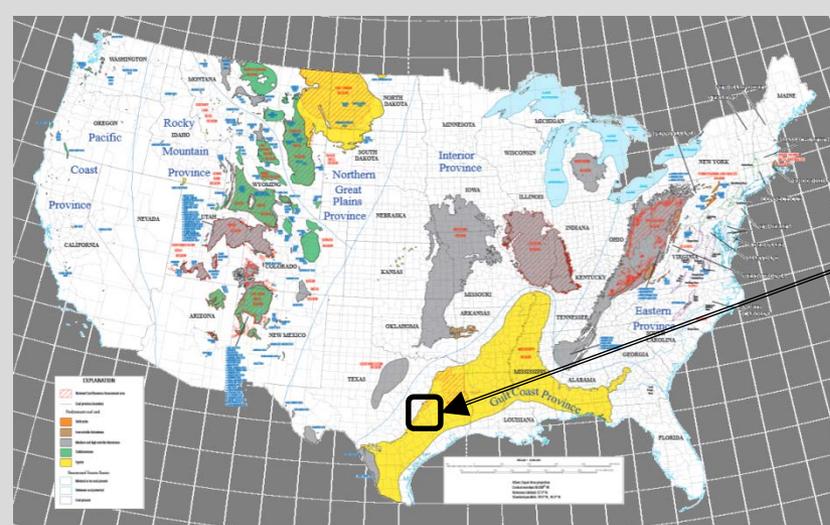
X-Axis Scale: 0-800 ppm  <20% Ash  >20% Ash



Data from Zwarwick, P.D., S. S. Crowley, L. F. Ruppert, and J. Pontolillo, "Petrography and Geochemistry of Selected Lignite reek Mine (Manning Formation, Jackson Group, Paleocene) of East Central Texas", Int. J. Coal Geol., 1997, 307-326.

# Calvert Mine Robertson County, Texas Wilcox Group, A1 Bed

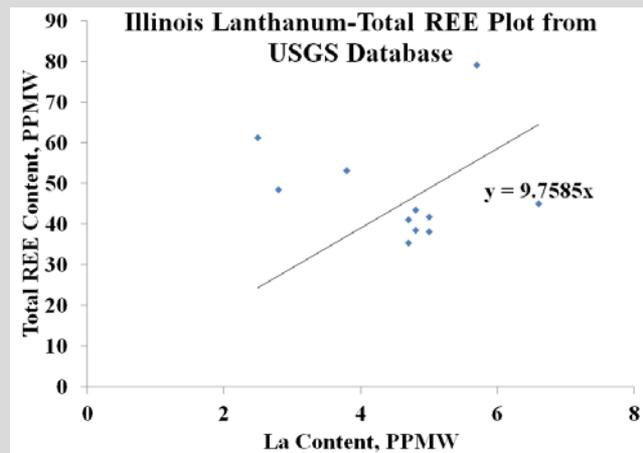
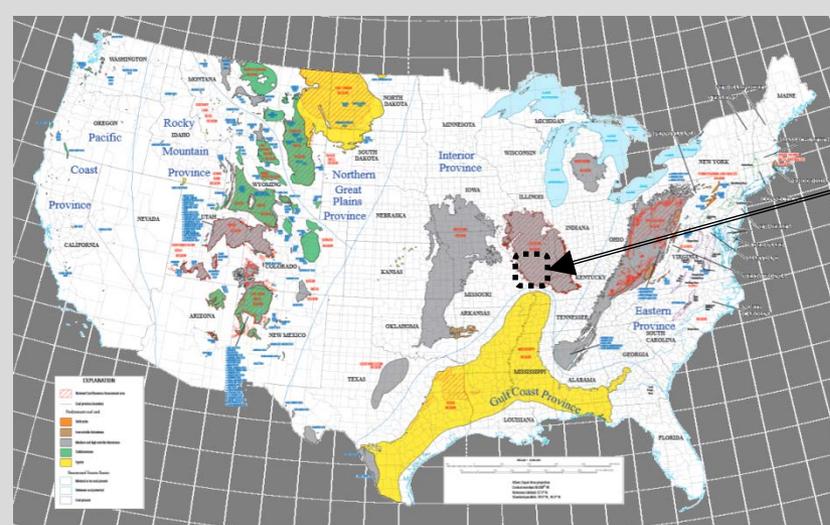
X-Axis Scale: 0-450 ppm  <20% Ash  >20% Ash



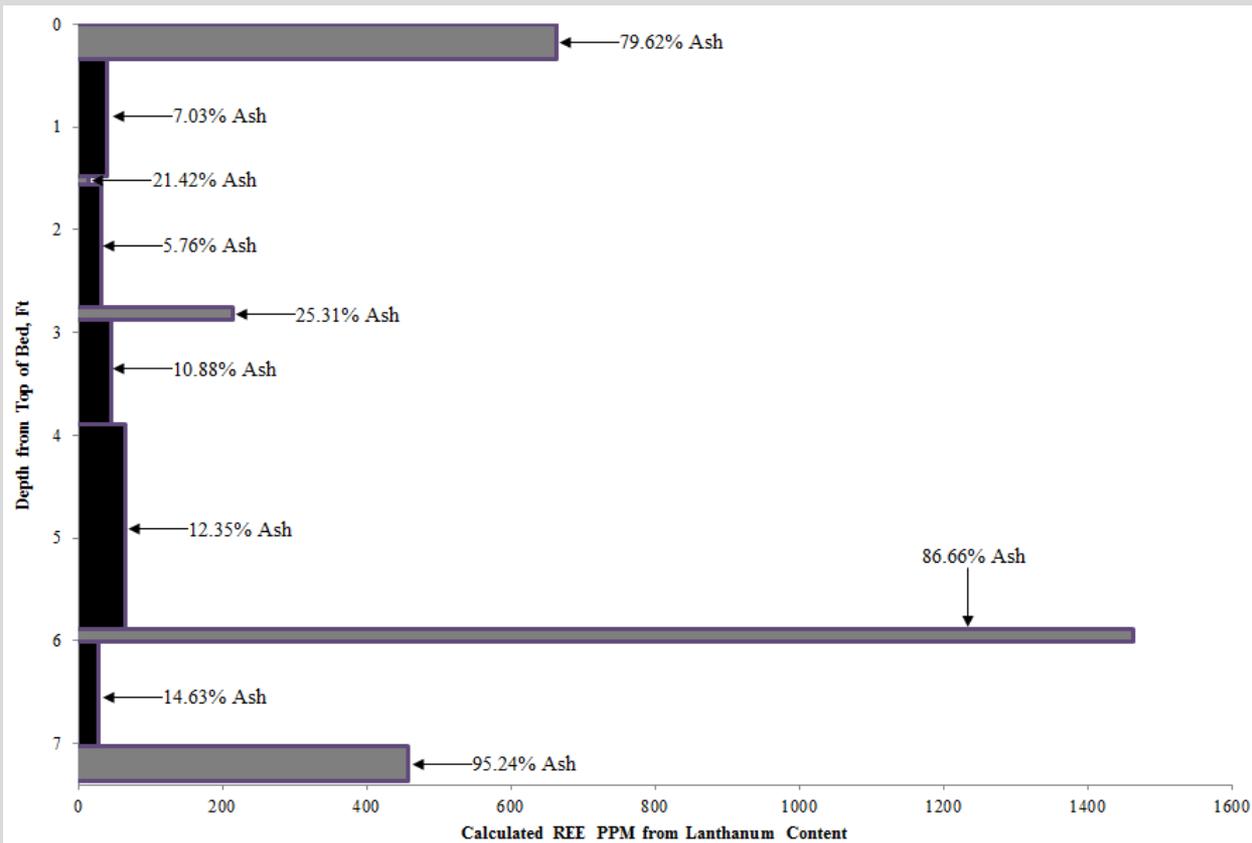
Data from Crowley, S.S., P.D. Warwick, L.F. Ruppert, and J. Pontilillo, "The Origin and Distribution of HAP's Elements in Relation to Maceral Composition of the A1 Lignite Bed (Paleocene, Calvert Bluff Formation, Wilcox Group), Calvert Mine Area, East Central Texas, Int. J. Coal Geol., Volume 34, 327-343.

# Unspecified County, Illinois #6 Bed

X-Axis Scale: 0-1600 ppm  <20% Ash  >20% Ash



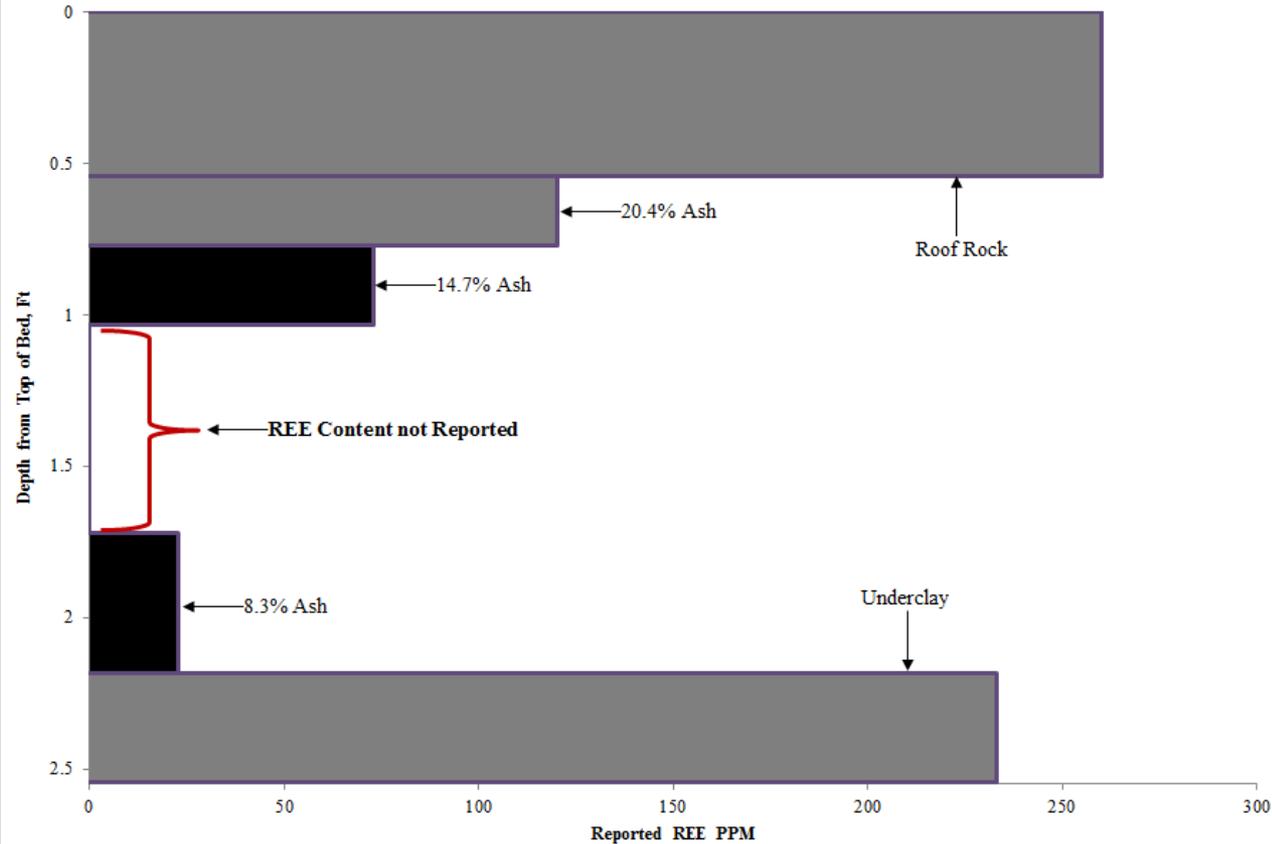
Data from Gluskoter et al., EPA-600/7-77-064, 1977



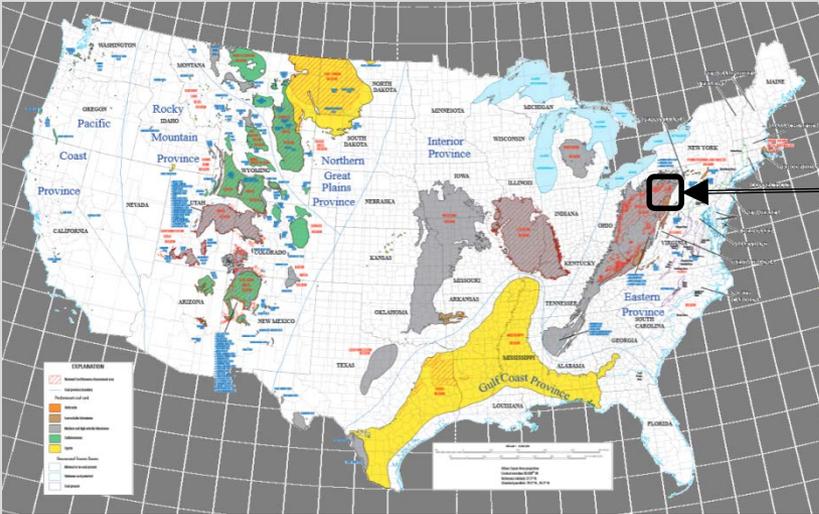
# Strip Mine Clearfield County, Pennsylvania Lower Kittanning Bed

X-Axis Scale: 0-300 ppm

<20% Ash
  >20% Ash



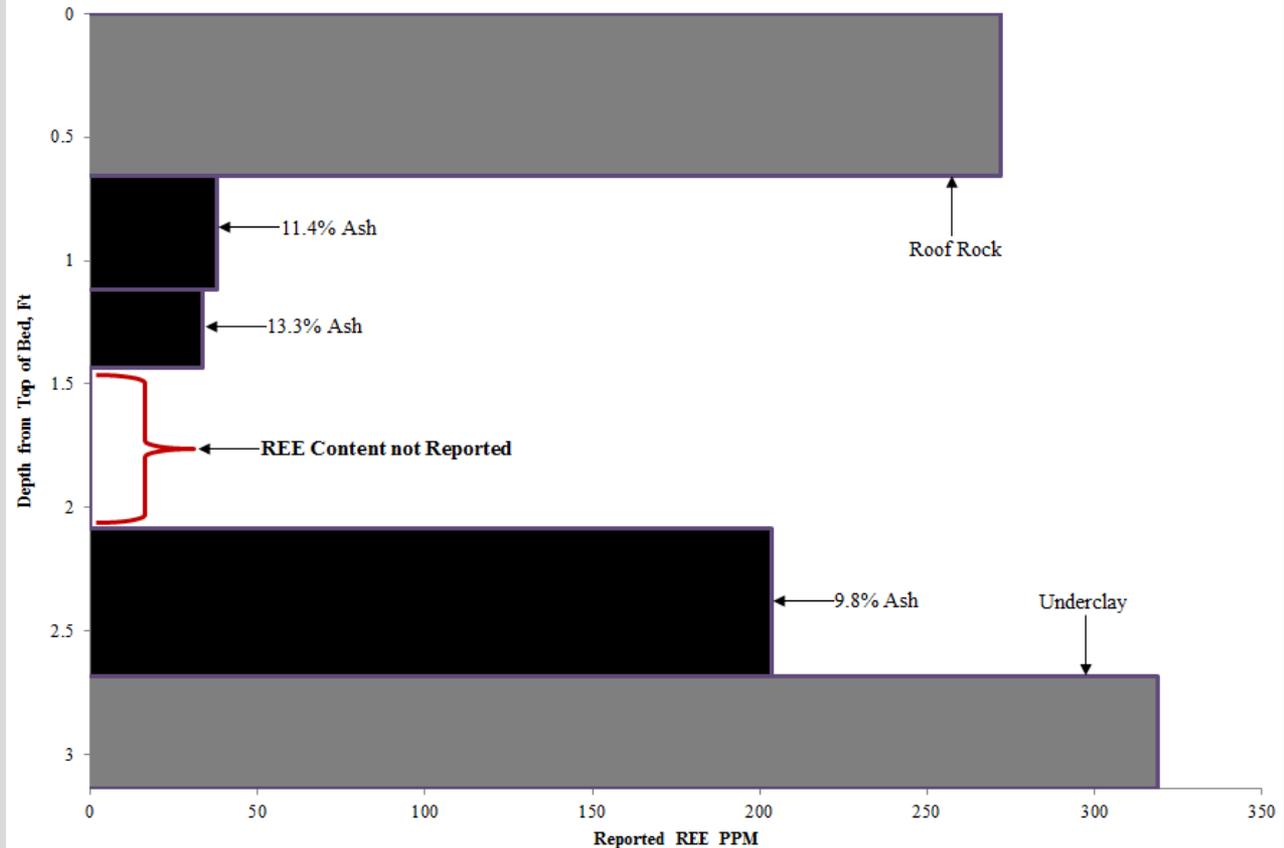
Data from Schatzel, S. J., and B. W. Stewart, Rare earth element sources and modification in the Lower Kittanning Bed, Pennsylvania: implications for the origin of mineral matter and rare earth element exposure in underground mines”, International Journal of Coal Geology, 54 (2003), 223-251



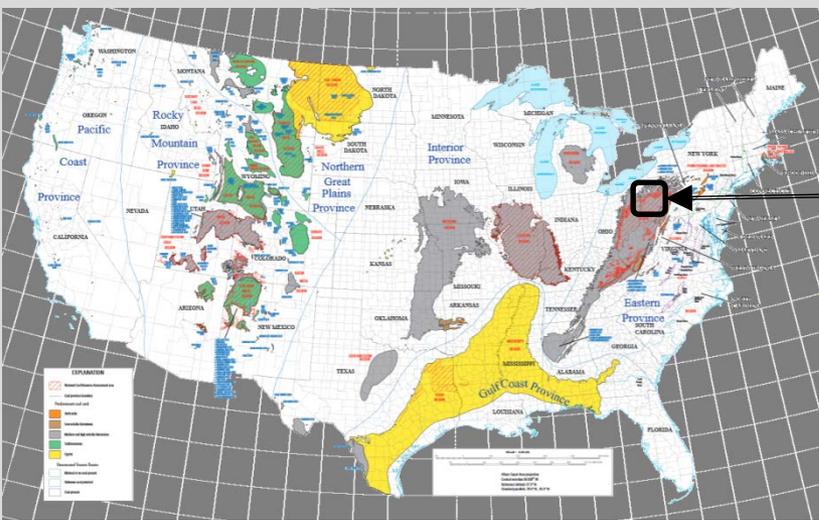
# Strip Mine Lawrence County, Pennsylvania Lower Kittanning Bed

X-Axis Scale: 0-350 ppm

<20% Ash
  >20% Ash



Data from Schatzel, S. J., and B. W. Stewart, Rare earth element sources and modification in the Lower Kittanning Bed, Pennsylvania: implications for the origin of mineral matter and rare earth element exposure in underground mines”, International Journal of Coal Geology, 54 (2003), 223-251



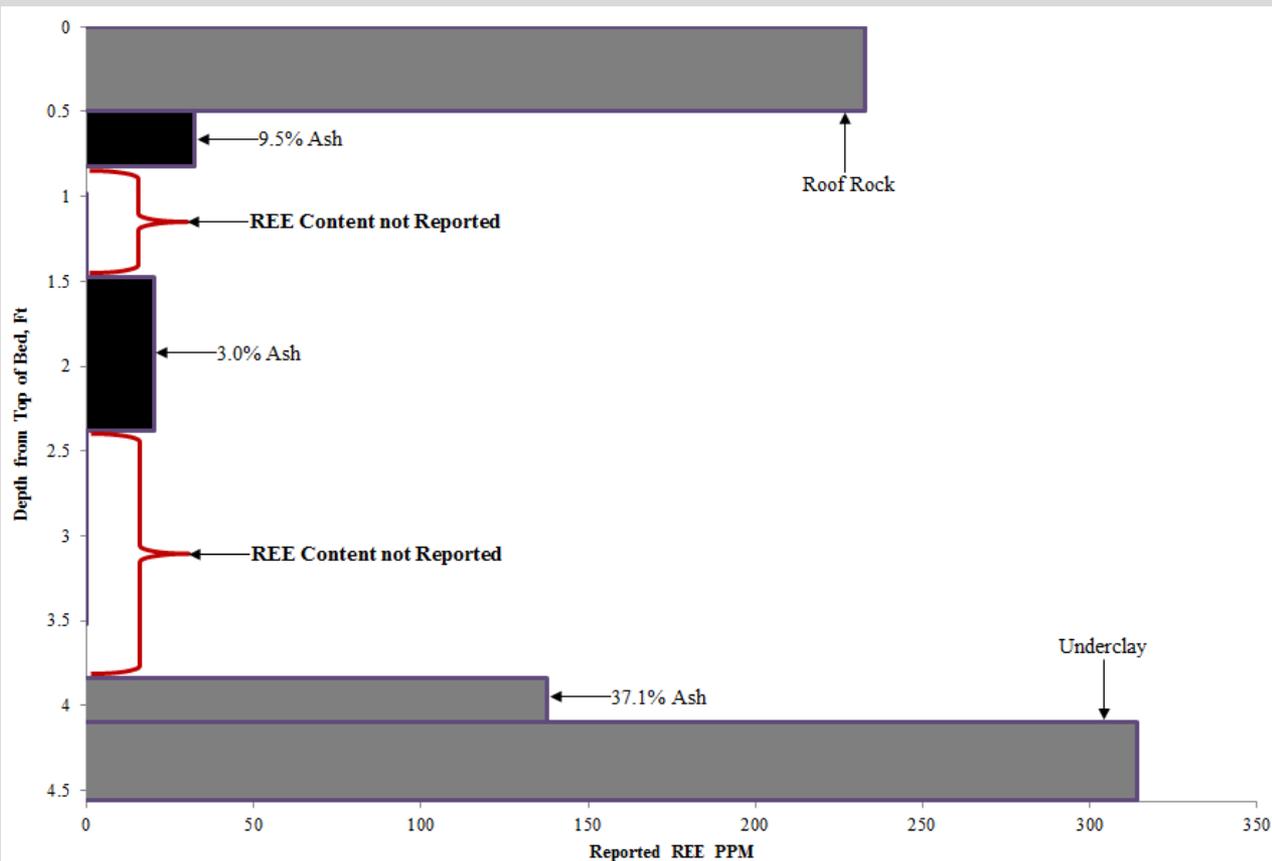
# Strip Mine

## Somerset County, Pennsylvania

### Lower Kittanning Bed

X-Axis Scale: 0-350 ppm

<20% Ash
  >20% Ash



Data from Schatzel, S. J., and B. W. Stewart, Rare earth element sources and modification in the Lower Kittanning Bed, Pennsylvania: implications for the origin of mineral matter and rare earth element exposure in underground mines”, International Journal of Coal Geology, 54 (2003), 223-251

# Strip Mine Clarion County, Pennsylvania Lower Kittanning Bed

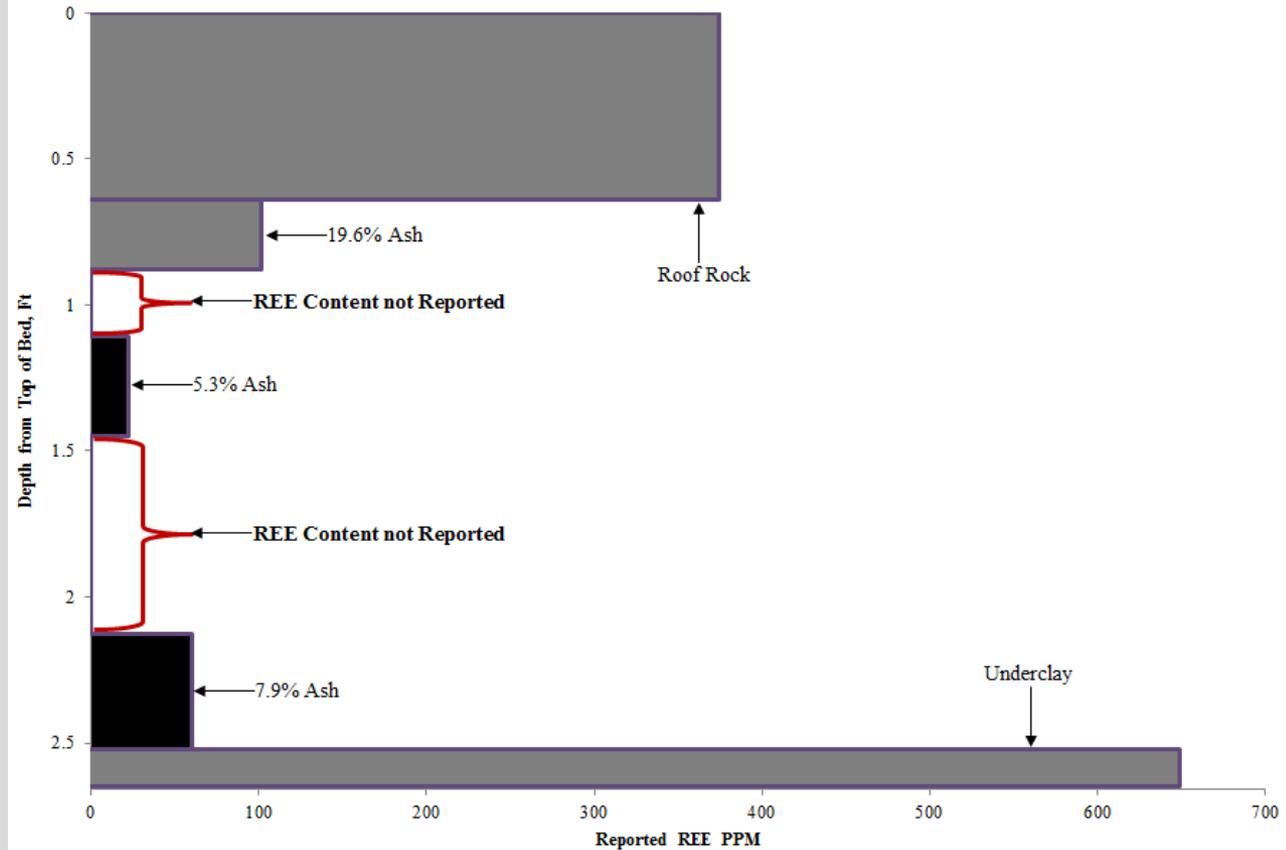
X-Axis Scale: 0-700 ppm



<20% Ash



>20% Ash



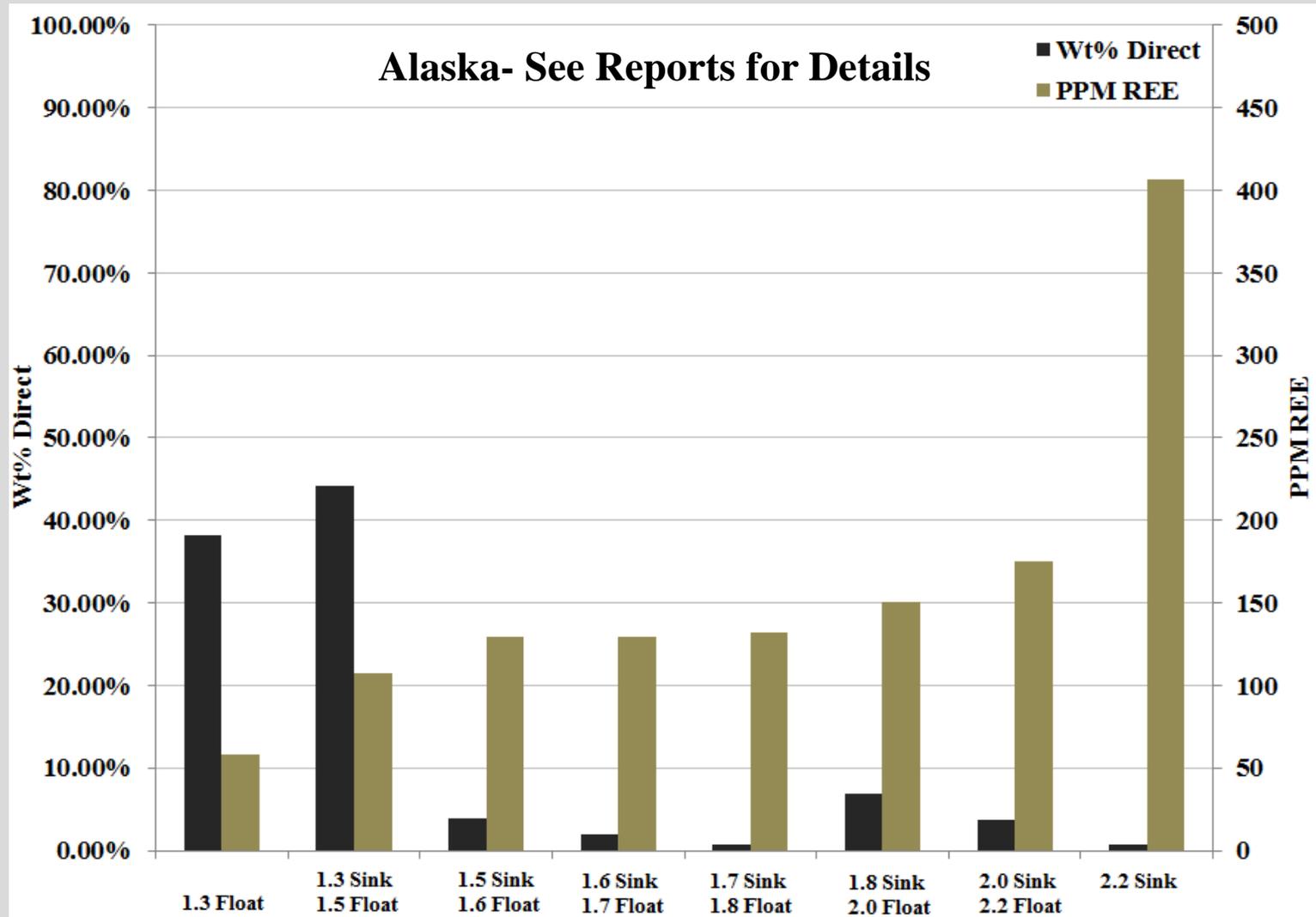
Data from Schatzel, S. J., and B. W. Stewart, Rare earth element sources and modification in the Lower Kittanning Bed, Pennsylvania: implications for the origin of mineral matter and rare earth element exposure in underground mines”, International Journal of Coal Geology, 54 (2003), 223-251

# Float Sink Data

- **Numerous Float Sink Tests Run in FY 2014**
- **<https://edx.netl.doe.gov/dataset/netl-ree-technical-reports>**
- **Additional Float Sink Data for Lanthanum:**
  - **EPA-600/7-78-028a**
  - **Gluskoter et al, “Trace Elements in Coal, Occurrence and Distribution”, Illinois State Geological Survey Circular 499, 1977**
  - **Need Crossplot Data to Convert to TREE**

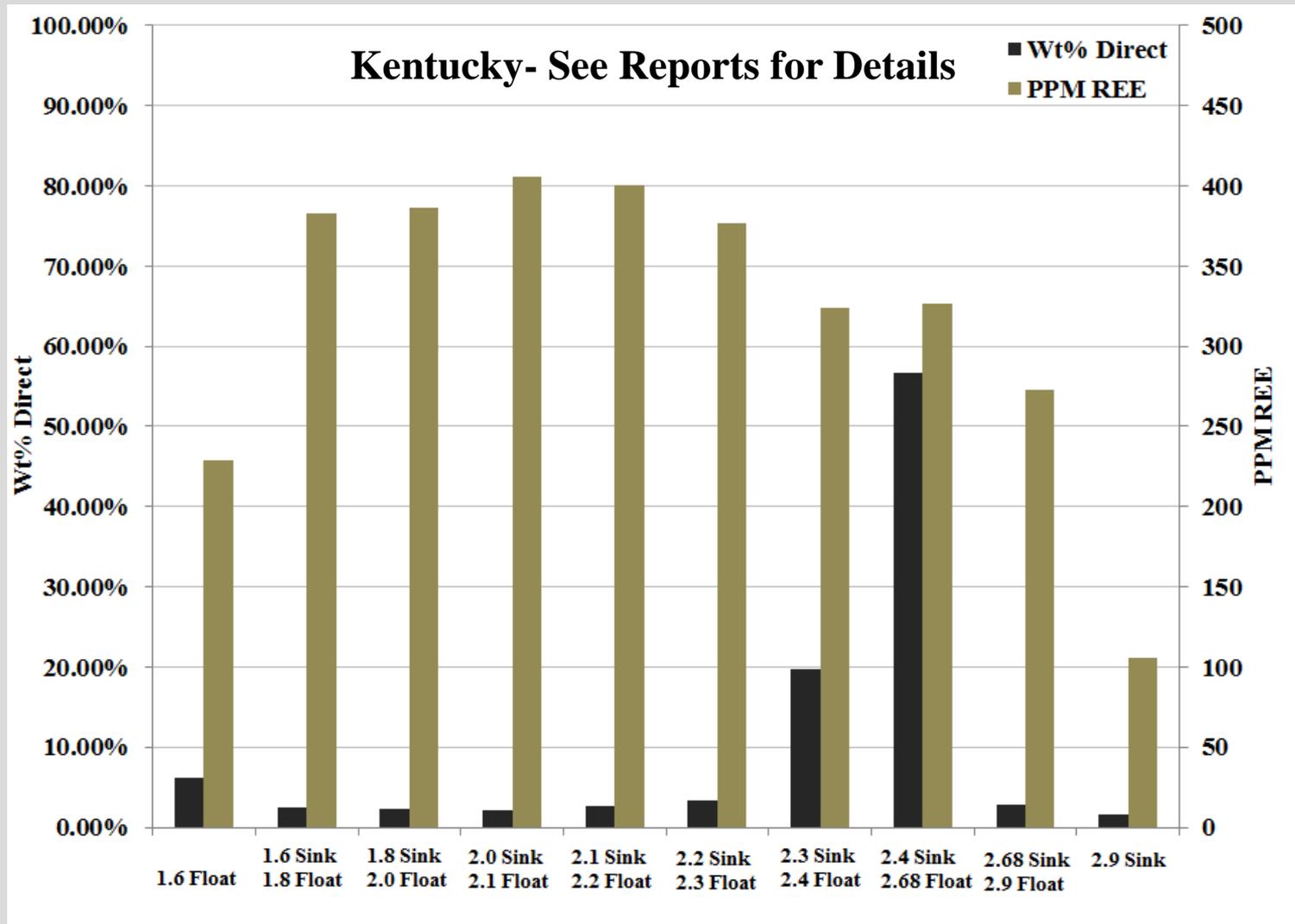
# Example Float Sink Data from

<https://edx.netl.doe.gov/dataset/netl-ree-technical-reports>



# Example Float Sink Data from

<https://edx.netl.doe.gov/dataset/netl-ree-technical-reports>

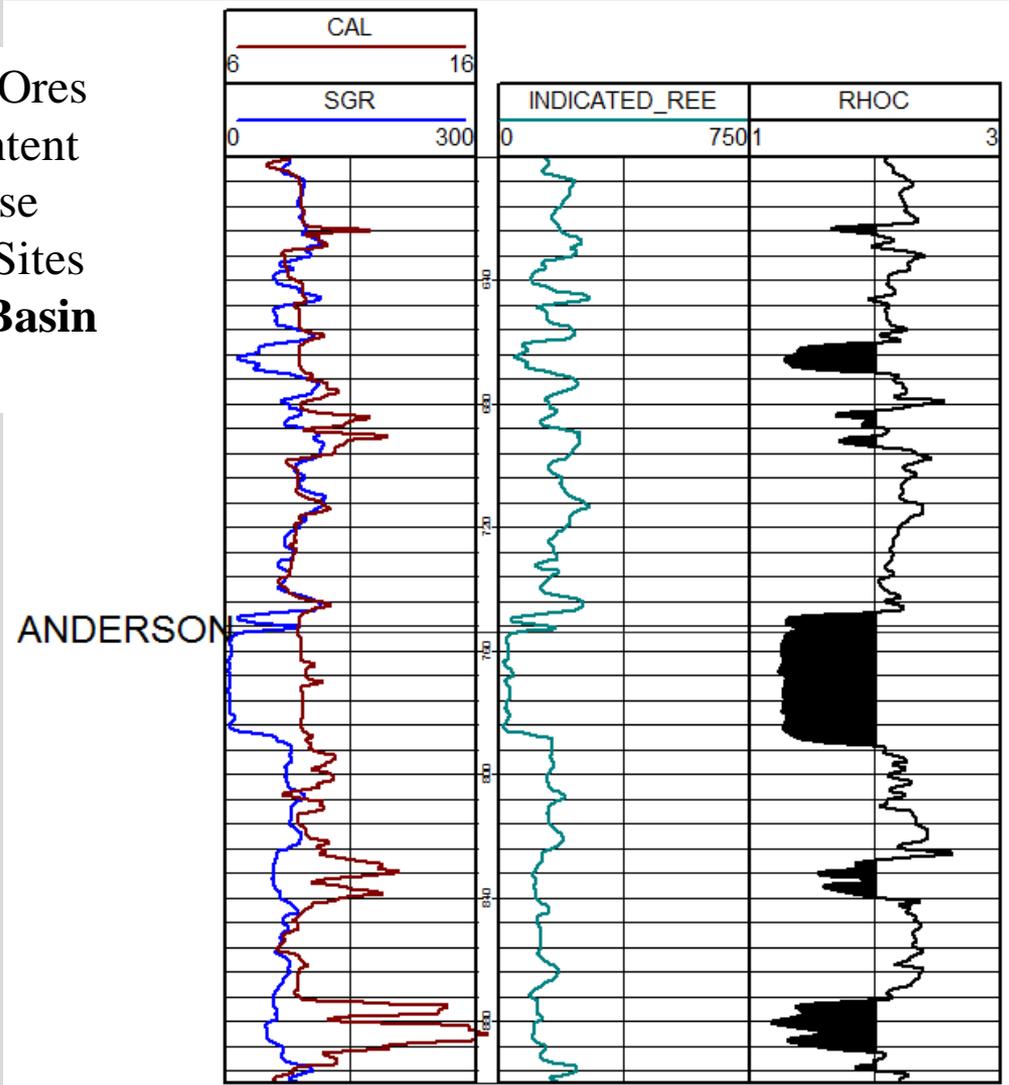
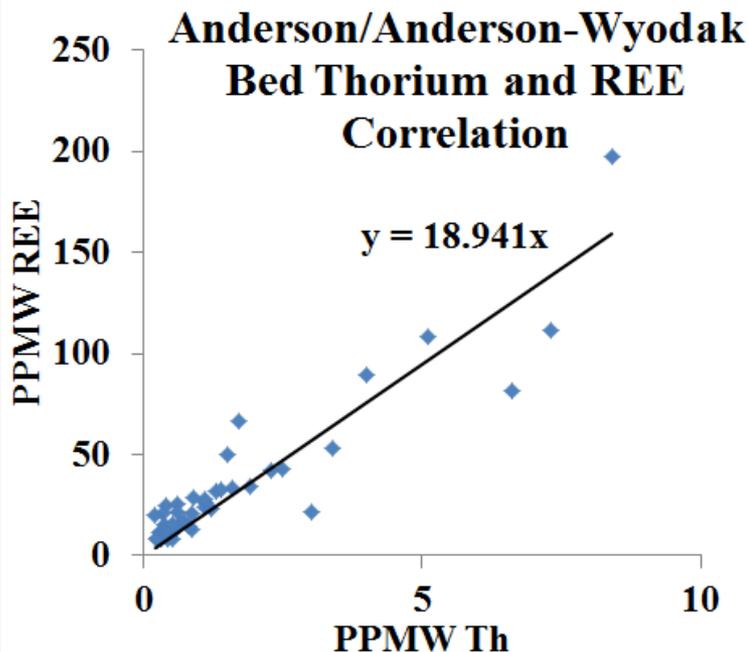


# Possible REE Indications from Well Logs

- Plenty of Log Data Available
- Thorium Spectral Gamma Ray Data can Indicate the Presence of an REE-Rich Zone
- Formation Tops or Coal Zones from Completion Reports
- Thorium to REE Conversions from Th/REE Crossplots Using USGS Database

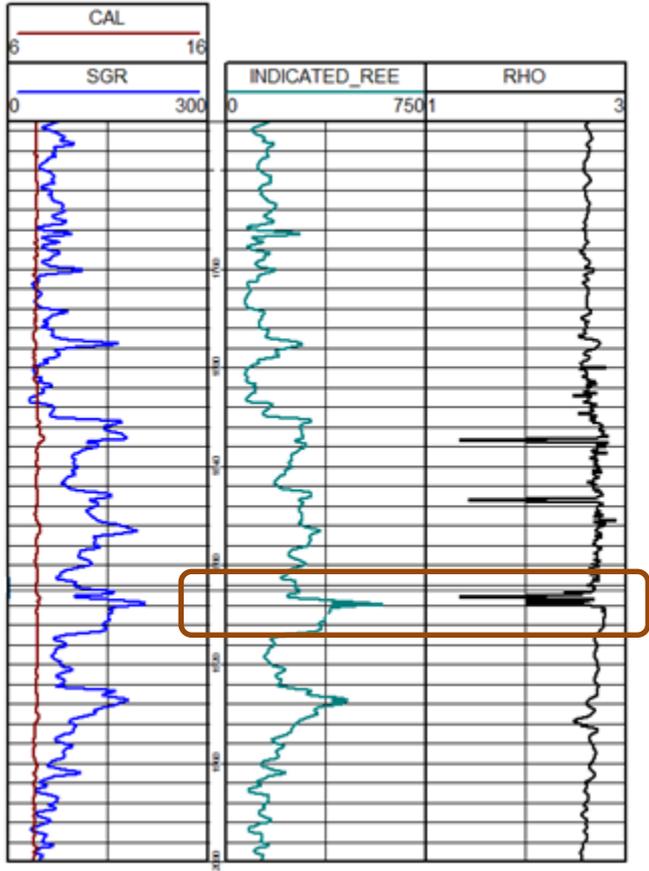
# Using Well Logs to Look for Rare Earths

- Thorium Associates with Some REE Ores
- Spectralog Th Converted to REE Content Using Crossplots from USGS Database
- LAS and TIFF Files from State Web Sites
- **Example here from Powder River Basin (Wyoming)**

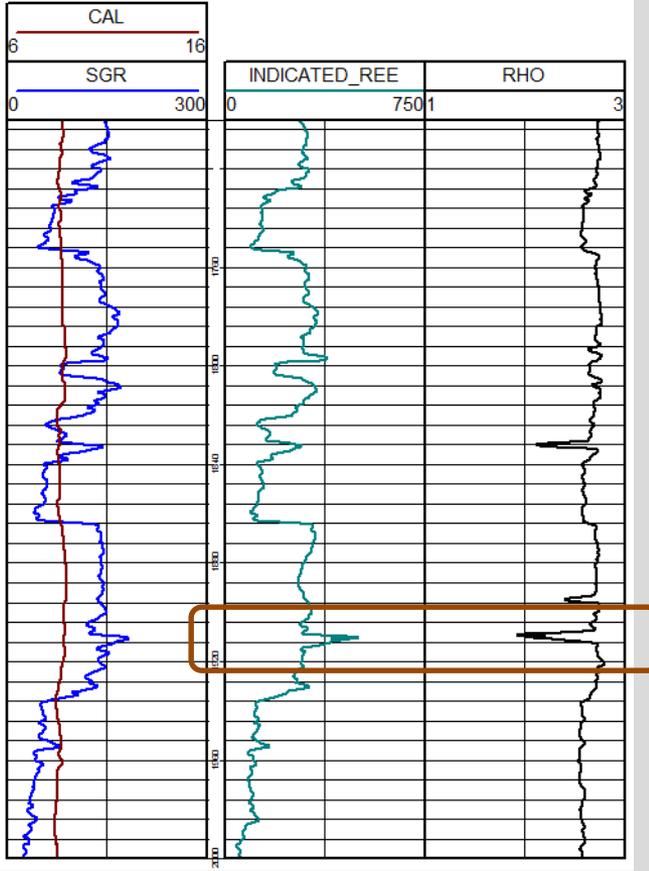


# Example Prospects from Well Logs

## Russell County, Va



## Letcher County, Ky



# **Supplemental Information- Useful References**

- **Hower, J.C., L.F. Ruppert, and C.F. Eble, “Lanthanide, Yttrium, and Zirconium Anomalies in the Fire Clay Coal Bed, Eastern Kentucky”, *International Journal of Coal Geology*, 39, 1999, 141-153.**
- **Warwick, P.D., S. S. Crowley, L. F. Ruppert, and J. Pontolillo, “Petrography and Geochemistry of Selected Lignite Beds in the Gibbons Creek Mine (Manning Formation, Jackson Group, Paleocene) of East Central Texas”, *International Journal of Coal Geology*, 34, 1997, 307-326.**
- **Crowley, S.S., P.D. Warwick, L.F. Ruppert, and J. Pontolillo, “The Origin and Distribution of HAP’s Elements in Relation to Maceral Composition of the A1 Lignite Bed (Paleocene, Calvert Bluff Formation, Wilcox Group), Calvert Mine Area, East Central Texas”, *International Journal of Coal Geology*, 34, 1997,, 327-343.**

# **Supplemental Information- Useful References**

- **Cecil, C.B., R.W. Stanton, and F.T. Dulong, “Geology of Contaminants in Coal: Phase I Report of Investigations”, United States Geological Survey Open File Report 81-953-A, 1981.**
- **Cecil, C.B., R.W. Stanton, and F.T. Dulong, “Appendices of Geology of Contaminants in Coal: Phase I Report of Investigations”, United States Geological Survey Open File Report 81-953-B, 1981.**
- **Schatzel, S.J., and B.W. Stewart, “Rare Element Sources and Modification in the Lower Kittanning Coal Bad, Pennsylvania: Implications for the Origin of Coal Mineral Matter and Rare Earth Element Exposure in Underground Mines”, International Journal of Coal Geology, 54, 2003, 223-251.**

# **Supplemental Information- Useful References**

- **Finkleman, R.B., “Modes of Occurrence of Trace Elements in Coal”, Ph.D. Thesis, University of Maryland, 1980.**
- **Finkleman, R.B., “The Inorganic Chemistry of Coal”, Scanning Electron Microscopy, 2, 1, 1988, 97-105.**
- **Finkleman, R.B., “Determination of Trace Element Sites in the Waynesburg Coal by SEM Analysis of Accessory Minerals”, Scanning Electron Microscopy, 1, 1978, 143-148.**

# **Supplemental Information- Useful References**

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