Contractor Final Report for the Period October 1, 2016 through April 30, 2018

Project/Contract Title: REE Identification and Characterization of Coal and Coal Byproducts Containing High Rare Earth Element Concentrations

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Robert Uhrin

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## I: Executive Summary

Rare earth elements (REEs) have become strategically important due to their use in many applications, such as consumer electronics, optical applications, and national defense to mention just a few. This importance is increased by the lack of a stable US supply and market control by foreign entities. Thus, the present project is important for identifying potential sites of high rare earth element (REE) concentrations, particularly those that might contain a higher ratio of heavy rare earth elements (HREEs; Eu-Lu and Y) to light rare earth elements (LREEs; La-Gd, and Sc). There is an abundance of data obtained from coal by-products, but it's impractical to just incinerate the coal to obtain the REEs. Nevertheless, the REE concentration in coal samples can provide a direct indication of the REE concentrations in strata lying just above and just below the coal seam in question. Consequently, the roof rock, floor rock, and underclay are even more important potential sources of REEs.

Sampling of coal resources was conducted during the period October 1, 2016 through April 30, 2018. The objective was to locate potential sources of coal and coal-related materials containing >300 parts per million (ppm) of rare earth elements (REEs). The survey focused upon a wide geographical area within the Northern Appalachian Coal Basin, including both the bituminous and anthracite regions. However, the study was extended to the Southern Appalachian Coal Basin and to eastern Ohio. In order to accomplish this project samples from locations in western PA, eastern PA, eastern Ohio, and central Alabama were selected for analysis of REE content. Sampling sites included a selection of anthracite coal producers in the eastern portion of Pennsylvania encompassing Luzerne, Schuylkill, and Columbia Counties, as well as bituminous producers located in western Pennsylvania that included Blair, Cambria, Fayette, Indiana, Clearfield, Carbon, Centre, Armstrong, Somerset, and Westmoreland Counties. Harrison County in Ohio and Shelby County in Alabama were also sampled. Sample types included core samples, coal samples, coal -associated samples from surface mines, refuse samples, coal cleaning samples, sludge samples, and clay samples.

A handheld x-ray fluorescence (XRF) unit was chosen as a tool for scanning field samples. The unit was modified to have the capability of detecting LREEs that included lanthanum (La), cerium (Ce), praseodymium (Pr), and neodymium (Nd). It was also hoped that the unit could serve as a characterization tool for use in the laboratory. While it was determined that the detection sensitivity for the LREEs was not satisfactory for either application, it was with the total rare earth element (REE) concentration. This concept is discussed later in the report demonstrated that this unit could be used to detect a tracer element as a means of associating the tracer concentration

The complete collection included 231 samples of the previously mentioned types. This collection included 78 samples that were viewed as possibly containing a sufficient concentration of REEs and these were submitted to ICP-MS analysis. Of those samples, 11 samples contained concentrations of >300 ppm REEs. The two highest REE concentrations (491 ppm and 492 ppm) were detected in fire clay samples from western PA. The sample characteristics are displayed in attachments at the end of the report.

## II: Sampling

(A) Sources

The geographic accessibility of sampling sites within Pennsylvania was a major factor in choosing various locations for sampling. This was aided by the opening of new mining activities that increased the number of potential sites. Relationships developed with numerous operators during the sampling period improved cooperation that was mutually beneficial to the project and the operators. Sampling sources included inactive refuse sites, exploratory mining cores, active and inactive surface mining sites, coal preparation sites, and sludge retention sites. Coal ash was specifically excluded from sampling.

(B) Rationale

The origin of REEs is primarily volcanic, so these elements show up in sedimentary, igneous, and metamorphic rocks. Prior to the formation of coal deposits, what is now the eastern United States was covered by an ocean. Offshore volcanism moved steadily westward as ash and magma were simultaneously deposited and settled. Plate tectonics subsequently created the Appalachian Mountains which eroded into the Appalachian Basin, leading to the formation of bogs and the subsequent creation of coal deposits. The Appalachian Mountains run northeast to southwest, so western and north central Pennsylvania are choice locations for finding REEs in coal-associated strata.

The sedimentary quality of anthracite fields to the east is favored by weathering of the mineral species (igneous and metamorphic) known to contain the REEs. Coincidentally, igneous and metamorphic rocks are found nearer to the surface in eastern Pennsylvania and particularly south-eastern Pennsylvania as compared to western Pennsylvania.[(1)] Consequently, the strata above and below the anthracite seams are postulated to contain, as a result of weathering, higher REE concentrations that are nearer to the surface and, therefore, more accessible than western Pennsylvania seams.

The geology of western Pennsylvania is dominated by kaolinite, mica, and ion-exchangeable clays (including fire clays). Those species are notorious for containing REEs, which presents a good opportunity for sampling. The dominant minerals in shale from the anthracite region are illite, kaolinite, Fe-rich chlorite, pyrophyllite, and quartz-associated minerals. These are also prime sources of REEs, which offers an exceptional opportunity. Additionally, the anthracite region was susceptible to and contains many thrust faults known to be a major source of REEs.

(C) Sample Types

i. Core Samples:

During the course of mining exploration, cores are usually taken to identify the methane content of the desired coals as well as the presence and location of various seams. Less often entire cores from surface to the coal seam are obtained, but more often the core section containing the coal seam and strata just above and below are retained.  A selection of core samples from potential mining locations was made, and these were characterized at the Mount Pleasant facility.  Figure 1 illustrates a boxed section of retained cores.

Figure 1.  Section of a typical 2-inch diameter exploratory core.

Numerous cores were examined, primarily in the vicinity of the specific coal seam that had been extracted.  Interesting core features, when present, were also examined.  Eight different locations were surveyed using the XRF device, but only interesting samples were characterized using ICP-MS.

ii. Refuse Piles:

During the mining process the rejected material was discarded in a convenient location. This sample type offered the opportunity to examine both inactive and active spoil pile sites from which numerous samples were selected.  A large amount of accessible material was available in those locations, of which a typical spoil pile is shown in Figure 2.  A grab sample weighing approximately one kilo was collected at each site.  These sites also contain coal residue mixed with waste products, primarily rock.

Figure 2.  Typical appearance of inactive spoil pile sites that were surveyed.

iii. Coal Cleaning Sites:

In ongoing mining operations, the extracted coal is transported to a single site that contains a breaker unit for crushing the coal lumps and downsizing the pieces into uniform sizes, depending upon the application. These sites are located at a central location in the case of multiple mining sites or at the current mining sites. At those locations the bulk material is floated to separate the coal from waste products and washed to remove fine particulate matter. Consequently, such locations provide an opportunity to collect samples of coal, rock, coal tailings, and sludge from settlement ponds. One sampling location that contained all the above products is shown in Figure 3.

Figure 3. Typical coal cleaning site with breaker, wash plant, and cleaned coal.

iv. Open Pit:

Numerous above ground mining sites were surveyed. These included both active mining sites and inactive mining sites with substantial coal reserves. Typical samples included run-of-mine coal, rock samples from outcrops, top and bottom rocks, underclay, interburden between adjacent seams and splits, and waste products. The spoil from breaker units is usually transported back to active mining sites for storage. Grab samples included at least one kilo of material comprised of coal, individual rocks typical of the site, and samples removed from outcrops, top-of-coal strata and bottom rock, where available. Sludge from settling ponds was often available.

The geologies of western and eastern Pennsylvania are substantially different. In the western and north-central portion of the state the strata lie roughly parallel to the ground, Numerous above ground mining sites were surveyed. These included both active mining sites and inactive mining sites with substantial coal reserves. Typical samples included run-of-mine coal, rock samples from outcrops, top and bottom rocks, underclay, interburden between adjacent seams and splits, and waste products. The spoil from breaker units is usually transported

whereas in the anthracite region the strata are severely buckled and lie nearly vertical in most cases. In one area of eastern Pennsylvania an entire valley can be composed of a syncline with another area characterized by an anticline. The former is represented as a concave feature as viewed head-on, while the latter forms a convex or domed shape. An example is provided in Figure 4.

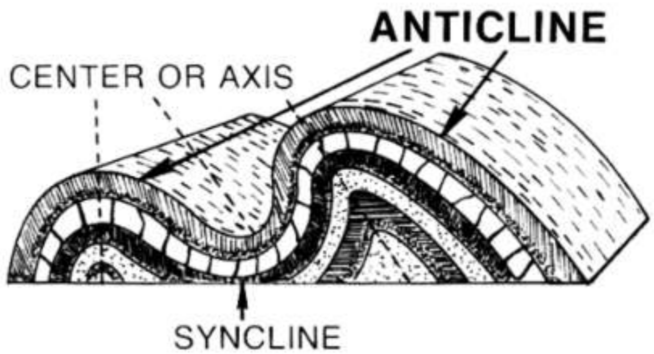



Figure 4. Example of the geological features referred to as syncline and anticline.

Features of the terrain and strata encountered in western and eastern Pennsylvania are provided in Figures 5-10.

Figure 5. Typical terrain for above ground mines in western Pennsylvania.

Figure 6. Western Pennsylvania mine site showing rock outcrop, overburden, and coal strata.

(a) (b)

Figure 7. Example of anticline (a) and syncline (b) features encountered in eastern PA.

Figure 8. Typical rock deposits sampled for containing REEs.

v. Clay Deposits:

Erosion of the igneous materials formed during volcanic activity led to the sedimentation process whereby individual mineral particles and clays were deposited. The strata lying just below a coal seam starts as a clay that hardens during the metamorphism. Conditions in western Pennsylvania led to pliable clay formation directly below the coal seam. This clay is usually referred to as underclay. Clays and micaceous materials are notorious for containing REEs as a result of direct substitution or by way of ion-exchange. All clays do not contain REEs, however, since this is dependent upon the erosion source. In particular, fire clay offers an excellent source of REEs, because the physical structure can incorporate large ions such as REE-ions. Figure 9 displays a site in western Pennsylvania where fire clay was extracted from beneath the mined coal.

Figure 9.  The base of this location actually contains fire clay concealed by the coloration.

vi. Casts:

An unusual feature encountered in eastern Pennsylvania is referred to as a cast.  The artifacts depicted in Figure 10 are actually fossils that originated from the intrusion of sediment into the space originally occupied by a portion of tree that became trapped in a bog.  The indicated objects are found lying atop the “Mammoth” coal seam in the southern anthracite region of Pennsylvania.  They are composed of the same materials as their immediate environment, so they often contain high concentrations of REEs and can be harvested while removing the overburden from the coal seam, but they often weigh several hundred kilos each.

Figure 10.  A selection of casts obtained during the course of mining the “Mammoth” seam.

vii. Reclaimed Refuse Piles:

While Refuse piles can serve as a direct source of coal byproducts, these sites usually contain a large amount of coal missed during the separation process.  Many refuse piles are currently being reclaimed to refine and extract the amount of coal contained therein.  The refined product can be used as a low-quality product to fuel cogeneration plants designed to simultaneously produce both electricity and steam. The waste material obtained during refinement contains a higher portion of waste (less coal) than typical refuse piles. Figure 11 illustrates a “cogen” plant located in Cambria County, Pennsylvania fired by an extensive, local refuse source.

Figure 11. View of a “cogen” plant from the site of a refined mining waste product.

viii. Settling Ponds and Acid Mine Drainage (AMD) Sludge:

Material passed through a breaker and cleaning unit is washed and floated to separate the coal from the waste material. The runoff is screened to remove the larger sediment while the waste water usually goes to a settlement pond where the smaller particles eventually settle to the bottom. Similarly, AMD locations produce sludge along the course of the waterway. Both types of material offer a prime opportunity, since the REEs are concentrated in the sludge and the fine particle size is conducive to processes such as solvent extraction. Several typical locations were examined during the project.

## III: Handheld XRF

The XRF technique relies upon a high-energy x-ray source that interacts with a material and excites the electronic structure of contained elements with the subsequent release of energy in the form of fluorescence. Each element has a characteristic spectrum associated with the electron binding energy, whereby outer electrons emit different energies when excited. Consequently, it becomes possible to differentiate between and quantify different elements within a given sample. The sample characteristics, such as particle size, affect the count rate so sample texture must be taken into consideration.

Field observation of samples is not the best way to select representative samples, so one of the objectives of this project was to provide a means of taking data in the field that confirmed the presence of REEs within a given sample. In order to detect and measure the heavier elements, the instrument should have a voltage source of at least 50 keV. The portable XRF instrument selected was a 50 keV Niton XL3t 500 model with a silver (Ag) x-ray source that was modified to detect REEs. Even in that case, the unit was limited to detecting the LREEs La, Ce, Pr, and Nd., since the fluorescence of heavier REEs requires an excitation voltage higher than 50 keV. A typical XRF spectrum is illustrated in Figure 12. Typically, XRF takes the shape of a whale, where the hump originates from the scattering of emitted photons. Coincidentally, the $K_{\alpha}$ and $K_{\beta}$ emissions provide the most information, and heavier elements, such as REEs, have their emissions overlapped by the humped portion of the spectrum.

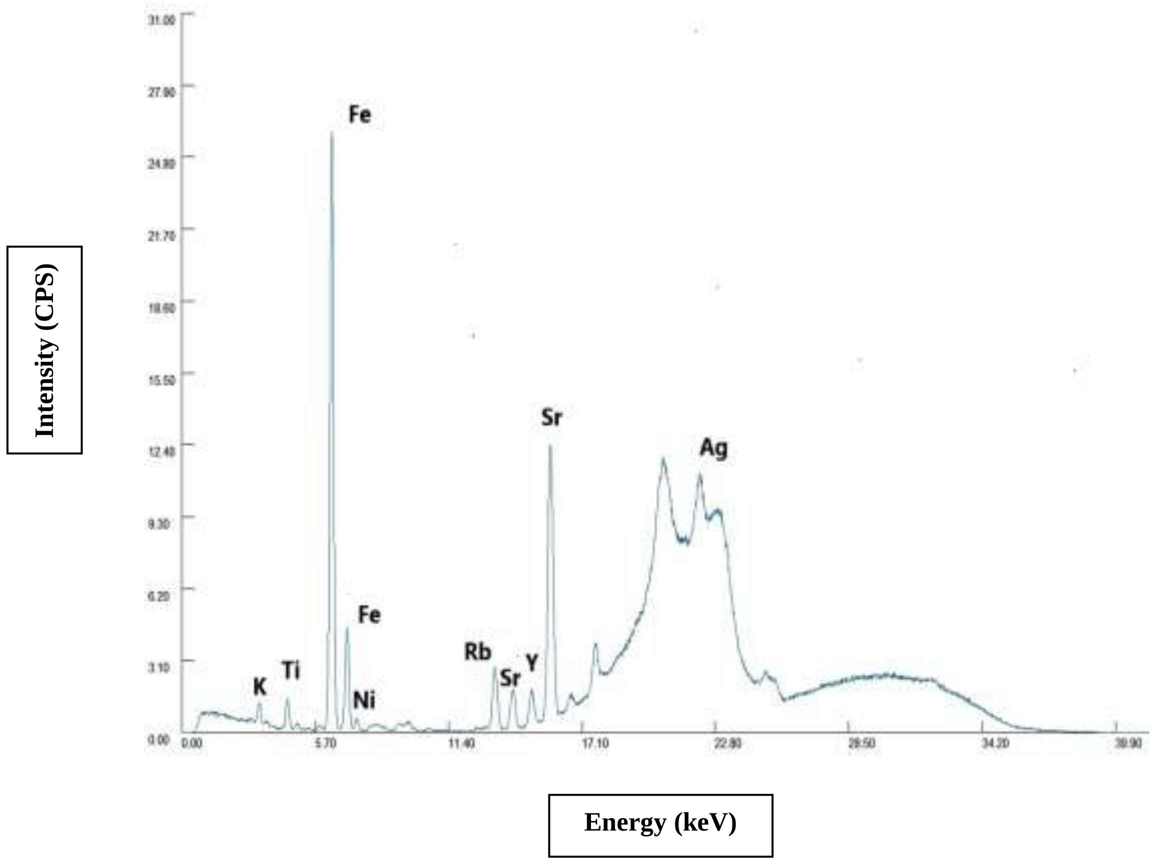



Figure 12. Typical XRF spectrum showing the scattering between 17 keV and 35 keV.

A feature of the XRF spectrometer is that the exposure time is adjustable. The detection capability increases with the exposure time, so increasing the exposure by 4 times improves the detection limit to ½. However, an exposure time beyond two minutes does not improve the detection capability much. It will be shown later that using a tracer element associated with REEs can reduce the field time to an exposure of 30 seconds. The instrument contains filters that improve the sensitivity for certain elements. The “High Range” filter is used to optimize sensitivity for elements barium (Ba) through silver (Ag). The “Main Range” optimizes sensitivity for elements manganese (Mn) through bismuth (Bi). The “Low Range” optimizes sensitivity for elements titanium (Ti) through chromium (Cr). The amount of time spent in each range is also adjustable, so most of the exposure time should be allocated to the “High” range for detecting the REEs.

**IV: Sample Selection and Preparation**

i. Cores: The coal seam had been removed from each of the 6.35-cm diameter cores. Therefore, at least two samples were selected from each core, one adjoining the top of the coal seam and one adjoining the bottom. In some cases, multiple samples were selected from sections that exhibited interesting features. The core location was recorded and measured (for reference) by contact of the XRF unit with the core surface. Approximately 2-cm of core length was chiseled from the selected location and secured in one-gallon Ziplok bags. The core section was then initially crushed using a sledge hammer and steel plate. Smaller samples were then passed through a 911 Metallurgy Corp. laboratory crusher. Following the crushing procedure, the material was heated in air within a convection oven at 150 °C for a sufficient period to remove any adsorbed water. The dried material was then passed through a series of stainless-steel sieves measuring 4000 μm, 500 μm, and 125 μm, while each component was segregated in its own bag. The finest material was coned and quartered prior to XRF and potential chemical analyses.

ii. Refuse Piles: Numerous refuse piles, active and inactive, were surveyed during the project. The piles usually encompassed a large area, so samples were selected at multiple locations to observe any sample variations. Grab samples weighing approximately 2 kg were selected from a level approximately one foot below the surface in order to avoid surfaces exposed to the weather. Samples were secured in one-gallon Ziplok bags prior to transport from the field to the laboratory. If the samples were moist, the material was heated in air within a convection oven at 150 °C for a sufficient period to remove any adsorbed water. The entire sample was then crushed using a sledge and steel plate, with the smaller pieces being passed through a 911 Metallurgy Corp. laboratory crusher. The crushed material was subsequently passed through a series of stainless-steel sieves measuring 4000 μm, 500 μm, and 125 μm with each component segregated in its own bag. The finest material was coned, quartered, and retained for XRF and potential chemical analyses.

iii. Coal Cleaning Sites: Each coal producer maintained a central breaker and cleaning site from which various samples were selected. These included run-of-mine coal, cleaned coal, and coal refuse. Grab samples weighing approximately 2 kg were selected from the input run-of-mine coal, clean coal exiting the washer, refuse separated from the input coal, washing debris, and pond sediment if it was available locally. Samples were secured in one-gallon Ziplok bags prior to transport from the field to the laboratory. If the samples were moist, the material was heated in air within a convection oven at 150 °C to remove adsorbed water. Each sample was then crushed using a sledge hammer and steel plate. crushed using a 911 Metallurgy Corp. laboratory crusher. The dried material was subsequently passed through a series of stainless-steel sieves measuring 4000 μm, 500 μm, and 125 μm, while each component was segregated in its own bag. The finest material was coned, quartered, and retained for XRF and potential chemical analyses.

iv.	Open Pit:  Above ground mine locations included both active and inactive sites.  The operators controlled at least several mining sites, some of which were vast in area (several square miles).  Samples selected from these sites included coal taken directly from the seam, top and/or bottom rock, random rocks located adjacent to seams being mined, and rocks that had characteristics believed to be associated with REEs.  Grab samples weighing approximately 2 kg were removed from coal seams and top and/or bottom rock strata using a hammer and chisel.  Grab samples of individual rocks that shared the same appearance were also obtained.  Samples were secured in one-gallon Ziplok bags prior to transport from the field to the laboratory.  If the samples were moist, the material was heated in air within a convection oven at 150 °C for a sufficient period to ensure adsorbed water was driven off.  Each sample was then crushed using a sledge hammer and steel plate prior to further processing in a 911 Metallurgy Corp. laboratory crusher.  The entire sample was subsequently passed through a series of stainless-steel sieves measuring 4000 µm, 500 µm, and 125 µm, with each component segregated in its own bag.  The finest material was coned, quartered, and retained for XRF and potential chemical analyses.

v.	Clay Deposits:  Clay deposits were encountered at a few active mining sites.  Clays were found both at intervening spots in the excavation as well as deposits lying under the coal seam being mined.  These locations were found in western Pennsylvania, although similar deposits might be expected at all mining sites.  Approximately 2 kg of sample was removed using a shovel or trowel.  As with the sample types above, the clays were secured in one-gallon Ziplok bags prior to transport from the field to the laboratory.  Clay samples were in a wet state, so the material was heated in air within a convection oven at 150 °C for a sufficient period to ensure adsorbed water was driven off.  Each sample was then crushed using a sledge hammer and steel plate prior to further processing in a 911 Metallurgy Corp. laboratory crusher.  The entire sample was subsequently passed through a series of stainless-steel sieves measuring 4000 µm, 500 µm, and 125 µm, with each component segregated in its own bag.  The finest material was coned, quartered, and retained for XRF and potential chemical analyses.

vi.	Casts:  It should be mentioned at this point that the nomenclature for individual coal seams in the northern and southern anthracite regions depends upon the local terminology.  As indicated earlier in the report, casts were encountered lying atop the “Mammoth” coal seam in the southern anthracite region.  The “Mammoth” seam is different in the northern and southern anthracite regions.  Depending upon the size of the tree that formed the cast, these objects can weigh more than several hundred kg.  The stone is extremely hard and resistant to crushing.  Approximately 2 kg of sample was removed from the cast using a sledge hammer and chisel.  The samples were secured in one-gallon Ziplok bags prior to transport from the field to the laboratory.  The material was first dried in air within a convection oven at 150 °C.  Each sample was then crushed using a sledge hammer and steel plate prior to further processing in a 911 Metallurgy Corp. laboratory crusher.  The entire sample was subsequently passed through a series of stainless-steel sieves measuring 4000 µm, 500 µm, and 125 µm, with each component segregated in its own bag.  The finest material was coned, quartered, and retained for XRF and potential chemical analyses.

vii.	Reclaimed Refuse Piles:  The procedure used to secure samples from the reclaimed refuse piles was identical to that applied to refuse piles.  The only difference was that the waste product was more concentrated with rock and had less coal.

viii.  Settling Ponds and AMD Sludge: Several samples were obtained from settling ponds located on the site of breaker units. In one case sludge from the effluent of an active AMD site was collected downstream of the mine opening. Approximately 2 kg of sample was removed from the stream sediment using a trowel. The samples were secured in one-gallon Ziplok bags prior to transport from the field to the laboratory. The material was obviously wet, so it was first dried in air within a convection oven at 150 °C. Each sample was then crushed using a sledge hammer and steel plate prior to further processing in a 911 Metallurgy Corp. laboratory crusher. The entire sample was subsequently passed through a series of stainless-steel sieves measuring 4000 μm, 500 μm, and 125 μm, with each component segregated in its own bag. The finest - material was coned, quartered, and retained for XRF and potential chemical analyses.

## V: Sample Characterization

### A. XRF

All field samples were exposed to laboratory characterization using XRF. One feature of the handheld unit is that it can be placed in direct contact with a sample, so that provides an opportunity to select specific samples in the field for later characterization. The sensitivity is dependent upon exposure time and sample properties such as particle size, so field use is confined to interpreting whether a particular sample is expected to contain a significant concentration of REEs. Although the XRF device was modified to detect the LREEs, the sensitivity for those elements is low for short exposure times (<30 sec). Consequently, the best way to make field determinations is to identify and use a tracer element tied to REE concentration. A useful method is described later.

In the laboratory, selected sections of core were first characterized with the XRF unit in contact with the core surface. Sections selected for removal were determined by the LREE concentration, 1500-2000 ppm; surface measurements were always at least 2 times greater than later small particle measurements. Experience has shown that the texture of the REE-containing rocks is not coarse. Those materials are formed by sedimentation, so an early decision was made to reduce the field samples to the smallest particle size. Subsequently, all laboratory XRF characterization was limited to a particle size <38 μm.

The selected core sample was then crushed and sized as described earlier. Having been coned and quartered, each powder sample was loaded into a 32 mm diameter sample cup fitted with a 3 μm thick mylar film. The powder was backed with polyethylene fiber and then sealed into the sample cup with a plastic cap. The sample was then placed within a mobile test stand to which the XRF analyzer had been attached. The analyzer communicated directly with a PC from which operation parameters were established and output data was monitored.

Prior to each characterization period, a standard sample (NIST 2709a) was measured to confirm that the instrument was in calibration. This particular standard reference material was chosen, because it contained all the usual elements encountered in coal mining. Experience gained during XRF characterization resulted in changed operating parameters, such as exposure time and the relative amount of time devoted to the three filter regions. Ultimately, the best sensitivity was obtained for an exposure time of 600 sec and filter sequences of 5%, 5%, and 90% time in the low, main, and high element regions, respectively.

There are three characterization modes in the Niton XL3t 500 unit: a soil mode, two mining modes, and a geology mode. There are two mining modes, because the spectral peaks of copper (Cu) and tantalum (Ta) overlap as do those of zinc (Zn) and hafnium (Hf). The measurement can be optimized by selection of Cu/Zn or Ta/Hf. It was decided that the measurements would be standardized by using the mining (Cu/Zn) mode for all measurements. Following characterization, each sample's data was downloaded and saved.

The XRF characterization for all other samples followed that of core samples with the exception that surface measurements were not taken. The characteristics of all samples selected during the project are included in Attachment 1. XRF data are not included, since it was determined that chemical analysis would be done using ICP-MS. However, the XRF data was used to choose samples suitable for ICP-MS analysis and it was used to find a tracer element tied to REEs. There were 239 samples that were subjected to XRF analysis. An illustration of the spectrometer connected to the remote stand is provided in Figure 13.

Figure 13. Mobile characterization stands with spectrometer and sample ready for insertion.

## B. ICP-MS

The preferred method for determination of REE concentration is ICP-MS. The XRF data was used as a guideline in deciding upon which samples to submit for ICP-MS chemical analysis. A concentration of 1000 ppm LREEs was chosen as a suitable standard, since it became clear that the XRF data was usually about 5 times the ICP-MS data and was dominated by the total of La, Ce, Pr, and Nd. Ultimately, 78 samples were selected for ICP-MS analysis. It is not surprising that no coal samples had a sufficient concentration for ICP-MS analysis. Attachment 2 outlines the REE concentration of all samples submitted for analysis.

The analytical work was performed by Huffman-Hazen Labs in Golden, CO. The ground samples were dissolved in a nitric/perchloric acid solution and then heated in HF acid contained in a PTFE cup to evaporate water and volatilize $SiF_4$. It can be observed in the attachment that 11 samples contained >300 ppm total REEs and that the highest concentrations were found in two samples of fire clay from western Pennsylvania associated with the Pittsburgh coal seam. The majority of the samples, however, were associated with anthracite seams in eastern Pennsylvania.

C. Selection of a Tracer Element

In order to use a handheld XRF spectrometer in the field to select potential samples, one project objective was to find an element associated with REEs that could be used to estimate the REE. Laboratory XRF characterization indicated that the mining mode detected Y, when present, within the first few elements detected and reported in any sample. Depending upon the exposure time the sensitivity for Y increased with increasing exposure time, but the final result was always close to the value detected after 30 seconds and had a 2σ of about 5%. Since Y is associated with the HREEs and the fraction of HREEs compared to total REEs was approximately 0.2, it was decided that Y could be used to estimate the total REE concentration.

Excel analysis was used to correlate the Y concentration obtained using ICP-MS with that obtained for total HREE, as shown in Figure 14(a).

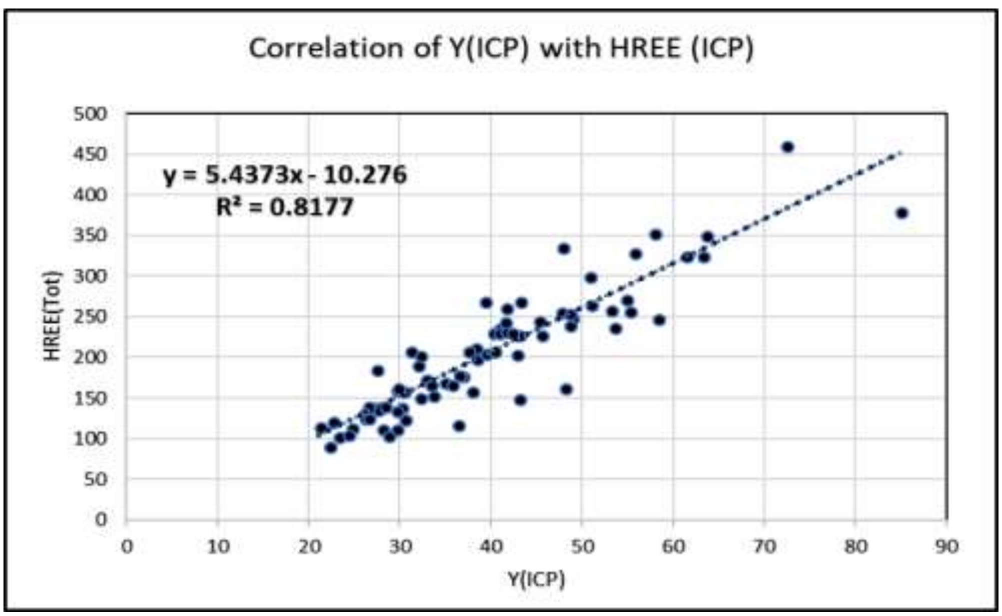



**Figure 14(a). Correlation of total HREE concentration with Y as measured using ICP-MS.**

The Y concentration obtained using ICP-MS was then compared to the Y concentration obtained with XRF as indicated in Figure 14(b).

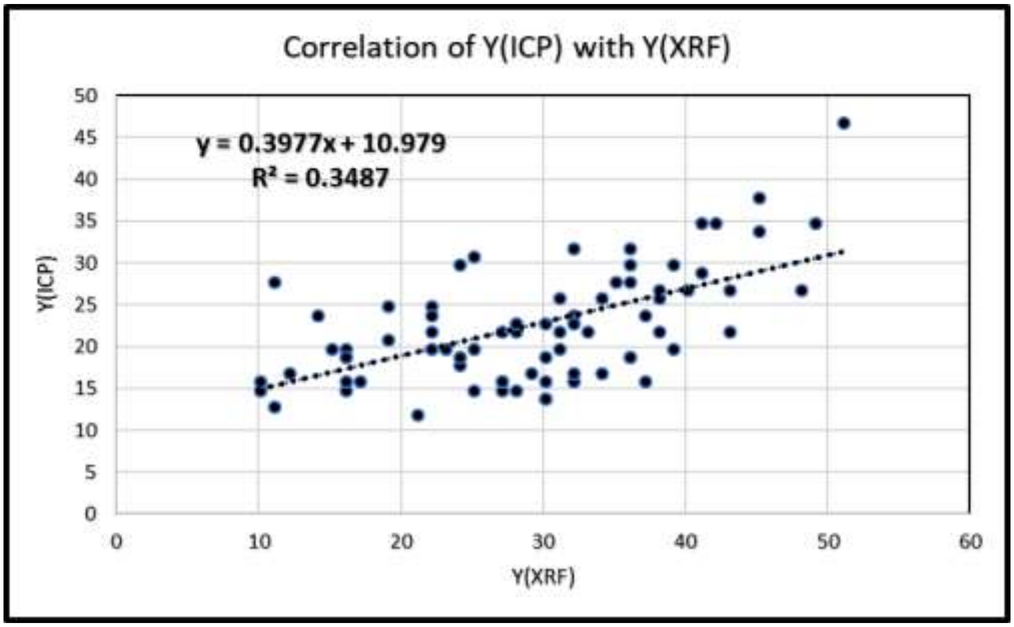



**Figure 14(b). Correlation of total Y (ICP) concentration with Y (XRF).**

Substitution of the $Y_{XRF}$ correlation with $Y_{ICP}$ in Figure 13(b) into the correlation of $Y_{ICP}$ with $Here_{toga}$ in Figure 13(a), followed by substitution of the $Y_{XRF}$ correlation with the $Y_{ICP}$ correlation in Figure 13(b) results in the following:

$$(HREE)_{Total} = h_{ere} = 5.4358\ (Y_{ICP}) - 9.9715,$$

$$Y_{ICP} = [0.3977\ (Y_{XRF}) + 10.979],$$

$$HREE_{Total} = (5.4358)\ [0.3977\ (Y_{XRF}) + 10.979] - 9.9715,$$

$$HREE_{Total} = 2.1618\ (Y_{XRF}) + 59.6796 - 9.9715$$

$$HREE_{Total} = 2.1618\ (Y_{XRF}) + 49.7081$$

Knowing that the total REE concentration is 5 times the HREE concentration allows one to determine the estimated total REE concentration as:

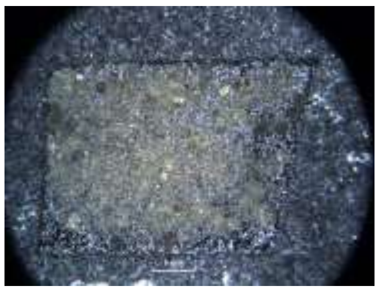
$$REE_{Total} = 5\ (HREE)_{Total}$$

$$REE_{Total} = 5\ [2.1618\ (Y_{XRF}) + 49.7081] = 10.81\ (Y_{XRF}) + 248.54$$

It turns out that this is not a good predictor of expected REE concentration due to the relatively poor correlation of Y(ICP) with Y(XRF). The most important point to take away is that the Y(ICP) concentration correlates closely with the total REE concentration, indicating that a specific inorganic source is responsible for the HREE concentration. Since the relative abundance of REEs is much greater for the LREEs and Th is detectable when the LREE concentration reaches a significant level, it may be more practical to use either Th or Ba as a tracer. This was explored using XRF measurements, but the results were similar to what was obtained for Y.  The association was made with all ICP samples, so it's possible that some sample types should be excluded from the analysis.

D.  Scanning Electron Microscope (SEM) Analysis

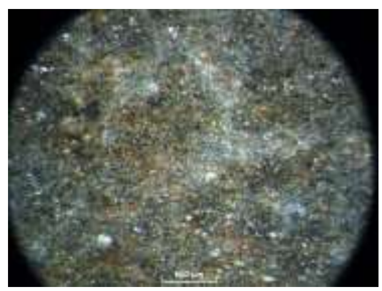
The texture of the best samples was smooth with a fine particle structure.  The particle size was on the order of <50 μm, which made SEM a desirable tool to determine the inorganic source of the REE concentration.  Nearly all samples examined were metamorphized from sedimentary deposits, so all samples contained numerous inorganic species, some of which could not be identified with either energy dispersive or wavelength dispersive x-ray analysis (EDX or WDX).



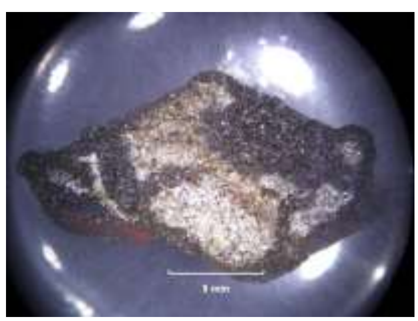
(a)

(b)

(c)



(d)



(e)

Figure 15.  Optical microscopy view of five samples (a-e) selected for SEM analysis.

Five samples known to contain >300 ppm REEs were selected for SEM observation.  The samples were designated FC-1, JE-8, JE15, JE-23, and JE-27.  The sample sizes were on the order of >1 cm, with the exception of one sample (FC-1) of fire clay with a <38 μm particle size. The samples were first examined using optical microscopy to determine general features, such as surface characteristics and particle size, with the expectation of finding interesting inclusions for analysis. The samples are displayed in Figure 15 (a-e), respectively, at low magnification.

SEM/EDX analysis was performed on a JEOL 840 SEM at 20kV and 100 nm beam current, and it was equipped with windowless Evex EDX detector as well as J. Geller WDX analysis systems. For the WDX examination, a number of rare earth element standards (REEx) were examined to establish peak positions and relative intensities for the REEs listed in Table I.

**Table I. `Wavelength (WDX) REE Peak Positions**

| Element | Transition | Crystal Analyzer | Measured Peak Position (mm) |
|---|---|---|---|
| La | Lα1 | PET | 85.10 |
| Ce | Lα1 | PET | 81.71 |
| Pr | Lα1 | PET | 78.48 |
| Nd | Lα1 | PET | 75.57 |
| Sm | Lα1 | PET | 70.01 |
| Eu | Lα1 | PET | 67.26 |
| Gd | Lα1 | PET | 64.80 |
| Tb | Lα1 | PET | 62.49 |
| Dy | Lα1 | LiF | 132.90 |
| Ho | Lα1 | LiF | 128.50 |
| Er | Lα1 | LiF | 124.20 |
| Tm | Lα1 | LiF | 120.20 |
| Yb | Lα1 | LiF | 116.30 |
| Lu | Lα1 | LiF | 112.65 |

P and Y were recorded using a thallium acid phthalate (TAP) crystal analyzer. Using two spectrometers simultaneously with the TAP crystal at the P spectrometer position and the pentaerythritol (PET) crystal analyzer at the Ce spectrometer position, areas of interest were searched for by manually moving through the grain boundary phase of the examined sample until an elevated signal was detected. Settings used during analysis are recorded in Table II. WDX scans were generally 0.05 mm step size at 1 second intervals.

**Table II. Wavelength (WDX) Settings**

| Spectrometer dSpec Settings | | | | | |
|---|---|---|---|---|---|
| **Spectrometer** | **Crystal** | **Bias** | **Gain** | **Baseline** | **Window** |
| 1 | TAP | 1715 | 10 | 20 | 80 |
| 3 | PET | 1780 | 14 | 45 | 80 |

Preparation of the solid samples consisted of embedding them in epoxy and then polishing the surface to display particles lying at the surface of the specimen. Sample FC-1 (a powder) was applied directly to carbon (C) tape, while JE-8 and JE-15 were coated with a thin film of Au/Pd prior to analysis. Samples JE-23 and JE-27 were also coated prior to analysis but with a thin film of C. An appropriate rare earth element standard (REE3) was examined as a first step to establish peak positions and relative intensities for La, Ce, and Pr using a PET crystal analyzer along with a GaP standard for P using a TAP crystal analyzer. SEM/EDX analysis was performed on a JEOL 840 SEM at 20kV and 100 nm beam current, and equipped with a windowless Evex EDX detector, and J. Geller WDX analysis systems.

SEM/EDX analysis and SEM/WDX analysis revealed that it is possible to detect µm-sized particles containing rare earth elements in the samples. In Sample JE-15 Ce, La, and Pr were detected. The areas containing these elements also contained P, which aided in further analysis for separating mineral species. It was found that phosphorus was present in higher concentrations than the rare earth elements. Varying levels of Al and Si were also present in these areas, most likely arising from the underlying substrate. However, it's also possible in some cases that the REEs were present as impurities in various Al-silicates that are difficult to ascertain without further analysis or they may be major components of mixed phosphates. As an example, Table III lists possible RE phosphate compounds and mixed alkali-RE phosphate compounds formed at high temperatures.

SEM/EDX analysis and SEM/WDX analysis also revealed that two distinct types of REE-containing minerals were present: (1) the lighter REEs containing $PO_x$ were identified as monazite; and (2) the heavier REEs were present in xenotime particles demonstrated to contain both $PO_x$ and $Y_xO_y$. The RE elemental distributions are presented in Table III. Most of the mineral particles observed were very small, on the order of 1 µm to 5 µm in diameter.

**Table III. Possible Phosphate Compound Formed Under Magma Conditions**

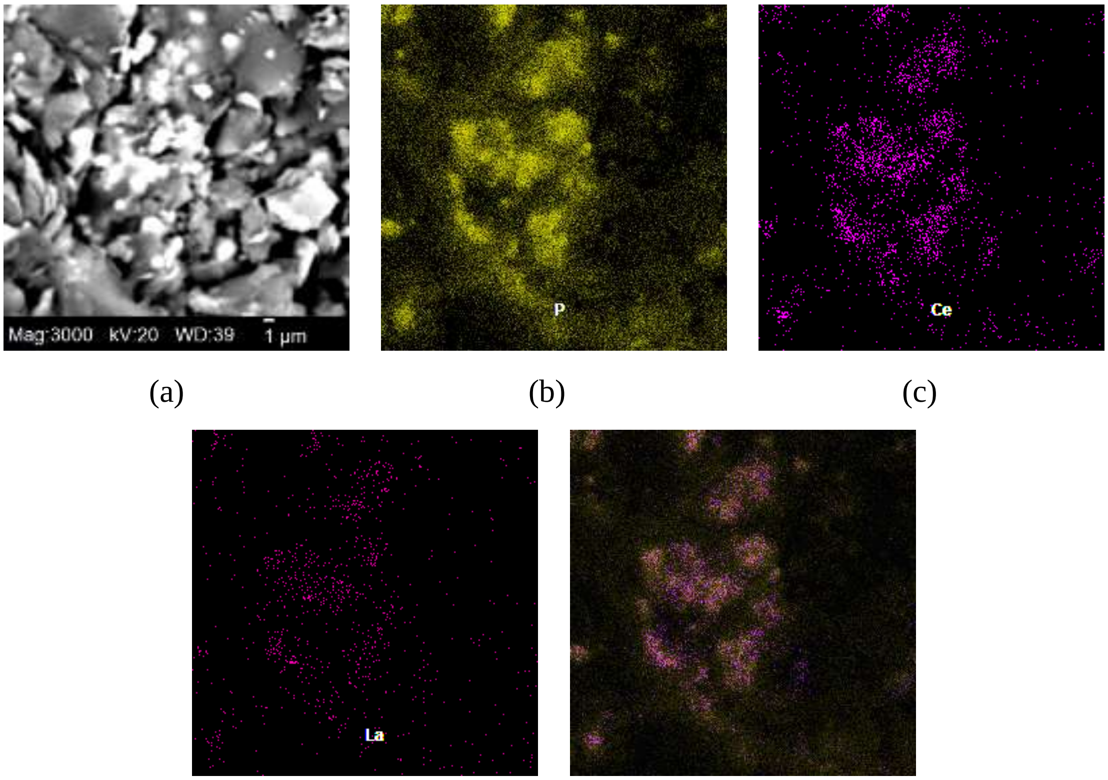
| | | | | | |
|---|---|---|---|---|---|
| $REPO_4$ | $RE_3PO_7$ | $RE(PO_3)_3$ | $REP_5O_{12}$ | $RE_4(P_4O_{12})_3$ | $RE_7P_3O_{18}$ |
| $REP_2O_7$ | $RE_2P_4O_{13}$ | $RE_{12}P_2O_{23}$ | $RE_4(P_2O_7)_3$ | $RE_8P_2O_{17}$ | $APO_3$ |
| $AREP_2O_7$ | $A_2RE(PO_3)_5$ | $A_4RE_2P_4O_{15}$ | $A_3RE_4(PO_4)_5$ | $ARE(PO_3)_4$ | $A_3RE(PO_4)_2$ |

These sedimentary rock samples contain a number of common minerals. The mineral identification was accomplished by looking at different particles and construing the relative element abundance from the peak heights. Some of the potential minerals identified so far are listed in Table IV.

**Table IV. Different Minerals Detected in Sample JE-15**

| Elements Detected | Possible Mineral | Formula |
|---|---|---|
| Si, Zr, O | zircon | $ZrSiO_4$ |
| Si, O | quartz, | $SiO_2$ |
| Ti, O | rutile | $TiO_2$ |
| Fe, O | hematite, magnetite | $Fe_2O_3$, $Fe_3O_4$ |
| Al, Si, K, O | feldspar | $KAlSi_3O_8$ |
| Al, Si, K, O | mica | $KAl_2(Si_3AlO_{10})(OH)_2$ |
| Ti, Fe, O | ilmenite | $FeTiO_3$ |
| Al, Si, K, Mg, Fe, Ti, O | Fireclay | Al-silicate base |
| P, Ce, La, Pr, O | Monazite | $(Ce, La)PO_4$ |
| P, Y, Lu, Er, Ho, Dy, O | Xenotime | $YPO_4$ |

At this point all the REEs detected primarily in JE-15 appear to be consistent with monazite, a phosphate-based RE mineral containing primarily LREEs. Figure 16 illustrates the EDX map of a portion of the surface of JE-15. First, it will be noticed that the particle sizes are very small, and this is consistent with all reports associated with the particle size encountered in current coal-associated REE studies. The average particle size is about 5 μm as seen in Figure 16(a). Scans for P (b), Ce (c), La (d), and P-Ce-La (e) are seen to overlap, confirming that the P-phase is likely monazite containing the LREEs. Also, the broad area content of the matrix seems to be an Al-Si compound but not an aluminum silicate. Meanwhile, a scan for Ce and La indicates that those elements are not contained within the $SiO_2$ particle or the broad area shown in Figure 17(a-g).




(a) (b) (c)

(d) (e)

Figure 16. Elemental scans of JE-15 surface for P (b), Ce (c), La (c), and P-Ce-La (e).

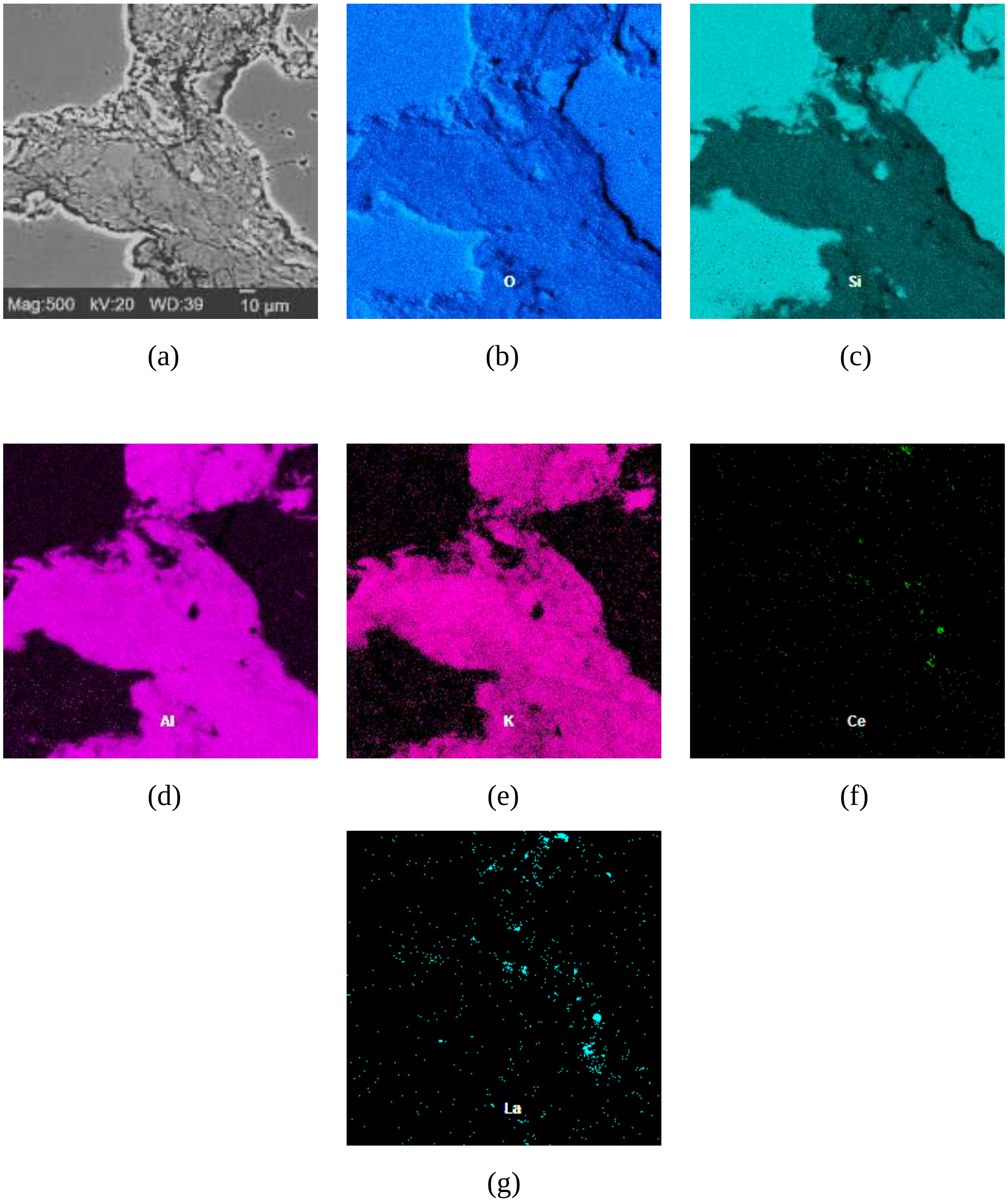
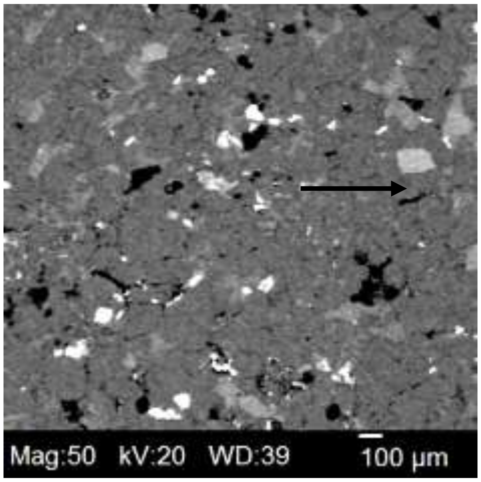
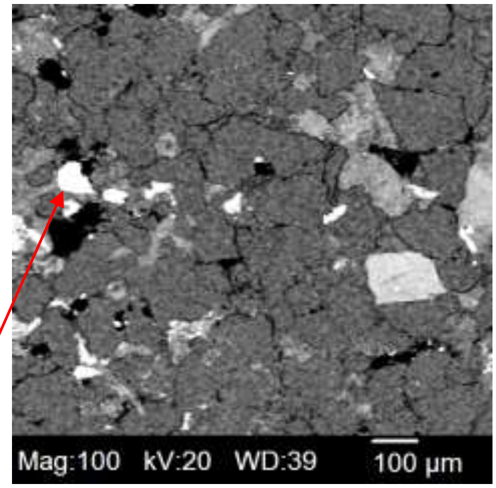



Figure 17. EDX scan of JE-15 for O, Si, Al, K, Ce, and La, establishing the presence and absence of specific mineral species.

The EDX scan of a different particle within JE-15 is shown in Figure 18. This figure enables one to distinguish that zircon is one of the included species, but this particle does not contain any REEs as a major component. However, it should be pointed out that natural zircon normally contains a concentration of REEs as well as Th. One would expect that the LREEs would be the major RE impurity in zircon. Furthermore, Figure 19 indicates that LREEs are present not only in the monazite phase but to a degree in what proves to be the xenotime phase that has been detected in the other samples.




This phase appears to be zircon without REE impurities based upon the EDX spectrum, which shows a prevalence of Zr, Si, and O and an absence of La, Ce, and Pr within the 50 µm-size particle.

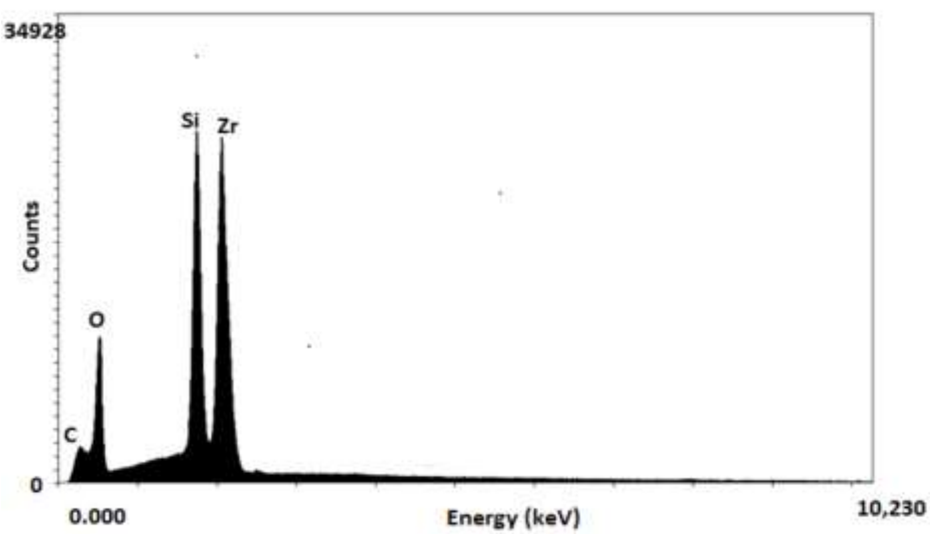
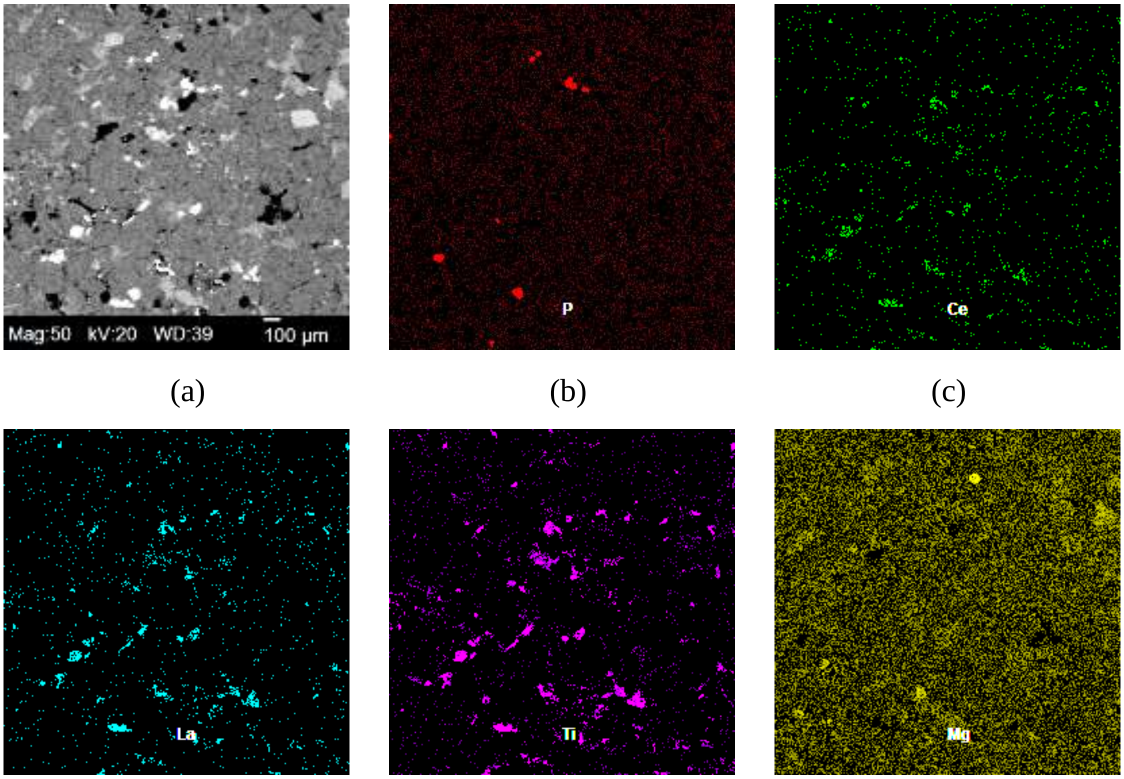



Figure 18. EDX scan of a 50 µm-size particle believed to be zircon.

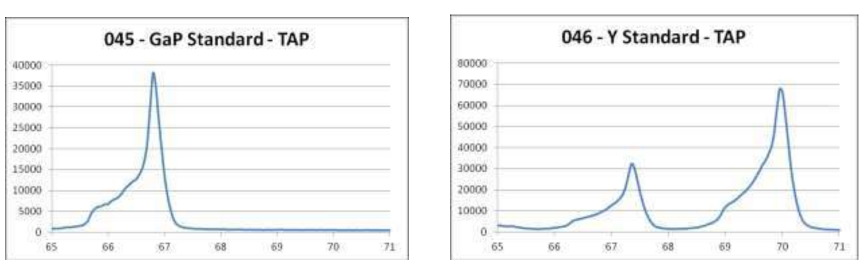



(a) (b) (c)

(d) (e) (f)

Figure 19. EDX scan of JE-15, indicating two phases containing LREEs.

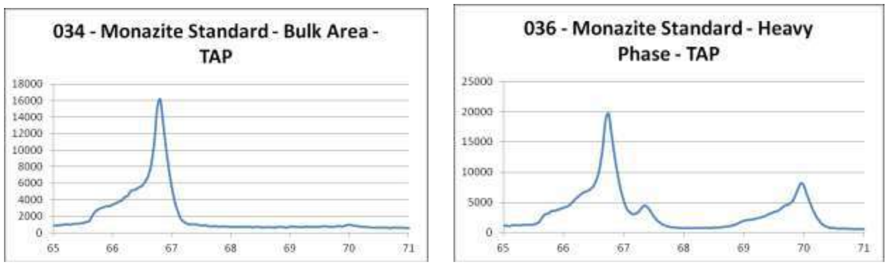
In order to separately identify the monazite and xenotime phases, a GaP standard, a Y standard, and a monazite standard were utilized. The monazite standard was shown (scans not included) to contain both a light and a heavy phase like the phases observed in the various samples. The samples were scanned between 65 mm and 71 mm for which peaks of both P and Y exist. Figure 20 illustrates the peaks observed for the respective scans using the GaP and Y standards.




(a) (b)

Figure 20. Spectrometer scans (TAP) of standard samples for P (a) and Y (b).

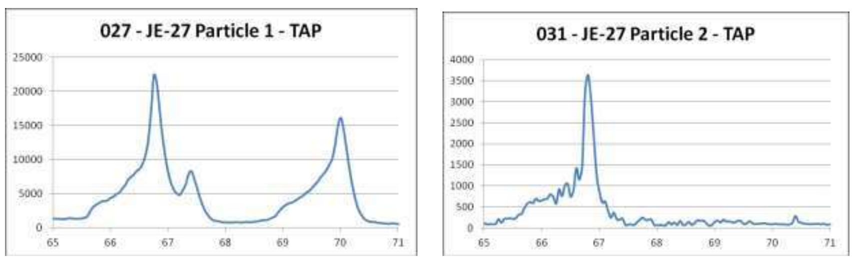
A bulk scan was then made of the monazite standard that showed the definite presence of P, as expected (Figure 21(a). Subsequently, a specific particle within the monazite standard was scanned (Figure 21(b). Since this scan contained both P and Y peaks, the definite presence of xenotime within the monazite standard was established.




(a) (b)

Figure 21. Spectrometer scans (TAP) of the monazite standard (a) and a selected particle (b).

Finally, two separate particles found within JE-27 and known to contain REEs were each scanned, and these scans showed a conclusive difference between the two particles, as demonstrated in Figure 22.




(a) (b)

Figure 22. Demonstration of xenotime (a) and monazite (b) presence in JE-27.

This was strong, but inconclusive, evidence of two separate RE-containing phases. Historically, monazite contains primarily the LREEs, while xenotime contains primarily the HREEs. One would like to demonstrate that separate particles contain primarily either LREEs or HREEs. Consequently, WDX (LiF) scans of the so-called "heavy" phase within the monazite standard and particle 1 within JE-27 were conducted between 90 mm and 150 mm, a segment that contains the HREE peaks. Figure 23 includes the result of those scans, which show that, not only does particle 1 contain Y, but also it contains primarily the HREEs. This is conclusive evidence that particle 1 of JE-27 is the xenotime phase

.

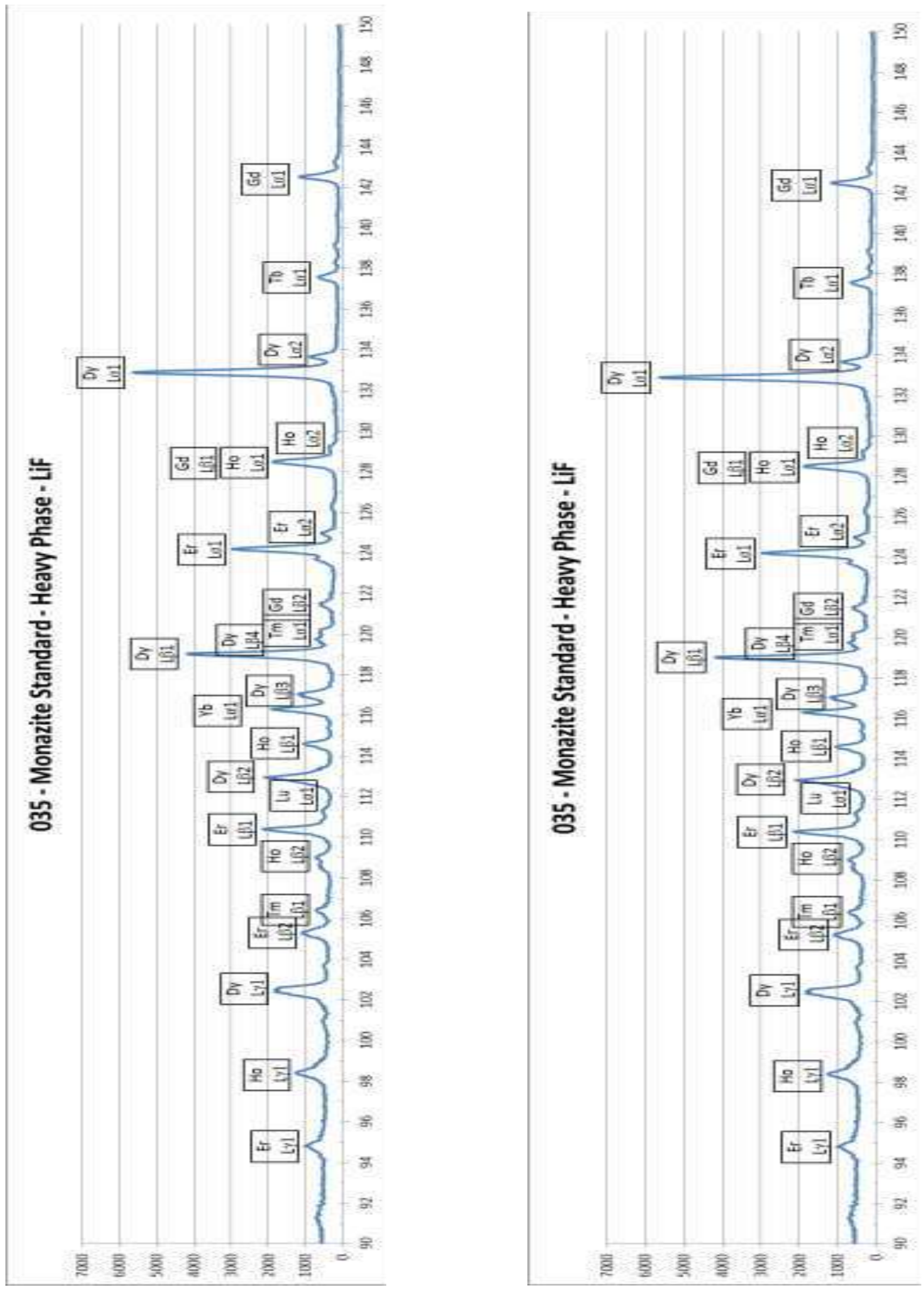
A comparison of the preceding result was made with particle 2 of JE-27. WDX (LiF) scans were made of the bulk monazite standard and particle 2 of JE-27 within the range of 90-150 mm. The result of those scans is shown in Figure 24, which undoubtedly indicates the presence of LREEs within the same range as particle 1, which contains primarily HREEs. These results indicate that, at least in the case of JE-27, the samples may be expected to contain both monazite and xenotime phases. Samples JE-8, JE-15, and JE-27 conclusively contain the monazite phase.

One property that complicates a conclusive identity of many of the mineral species associated with coal-related samples is the size of the RE-ion. The lanthanide series (La-Lu) decreases linearly in ionic radii from La through Lu; this is referred to as the lanthanide contraction. However, more complex phosphates are complicated by the coordination number, which can vary dependent upon the mineral species. It's noticed that the samples contain both monazite $(La,Ce)PO_4$ and xenotime ($YPO_4$), but the orthophosphates ($REPO_4$) change their physical structure at room temperature from monoclinic to tetragonal at about midpoint in the series at Gd. Table V illustrates this change in atomic radii within the lanthanide series.

**Table V. Rare-Earth Ortho Phosphate Structure Compared to Ionic Radius**

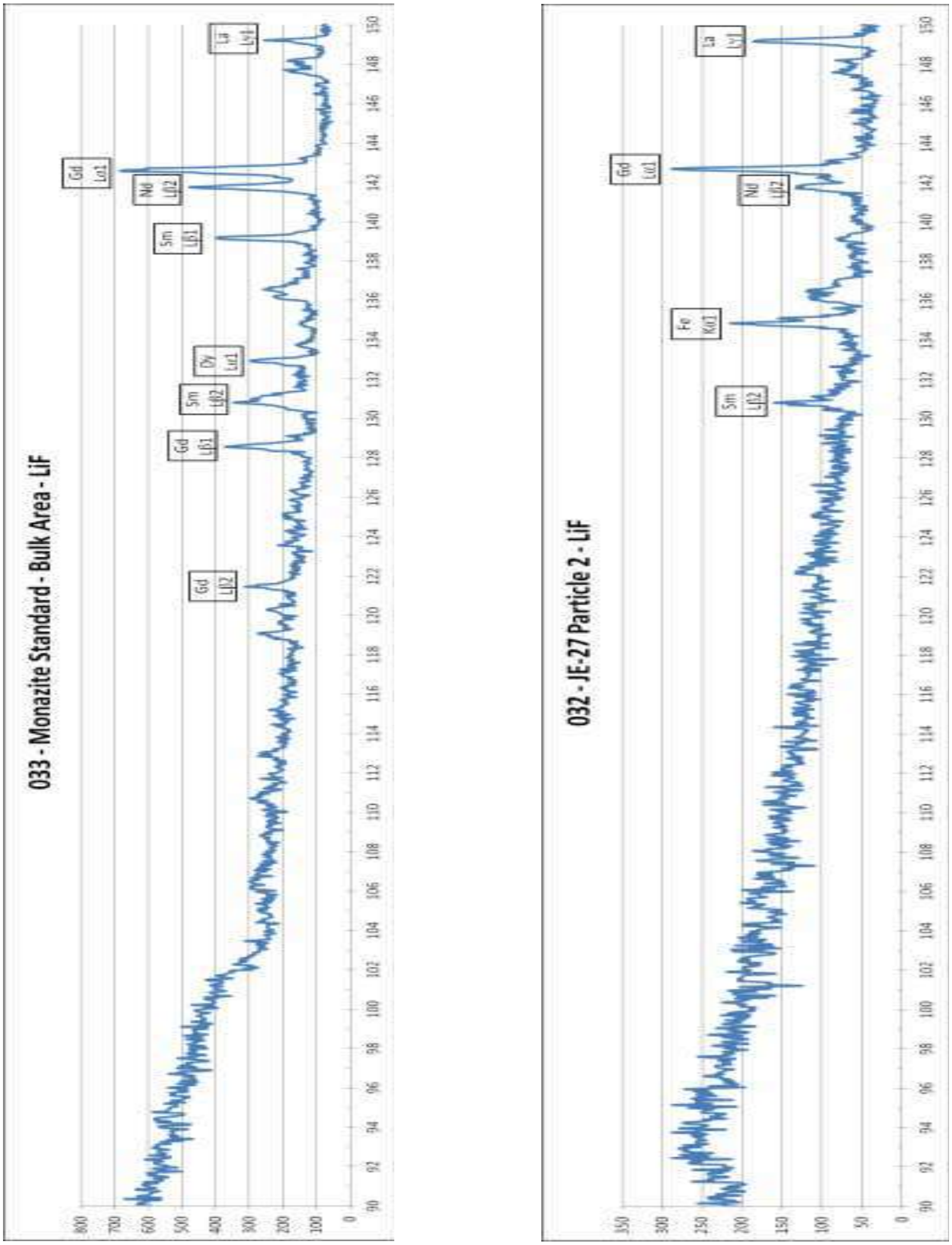
| RE | La | Ce | Pr | Nd | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ionic Radius (Å)** | 1.14 | 1.07 | 1.06 | 1.04 | 1.00 | 0.98 | 0.97 | 0.93 | 0.92 | 0.91 | 0.89 | 0.87 | 0.86 | 0.85 |
| **$REPO_4$** | M | M | M | M | M | M | M | X | X | X | X | X | X | X |

M = monazite, X = xenotime




(a) (b)

Figure 23. WDX (LiF) scans of the “heavy” phase (a) within the monazite standard and particle 1 (b) contained within sample JE-27




(a) (b)

Figure 24. WDX (LiF) scans of the bulk monazite standard (a) and JE-27 particle 2 (b), showing that the particle 2 REE concentration is markedly different from particle 1.

Table VI outlines some of the elements commonly encountered in this project along with their ionic radii and preferred coordination. Each element has a preferred coordination when

**Table VI. Comparison of the Valence, Coordination and Ionic Radii of Some Elements**

| Element | Valence | Coordination | Ionic Radius Å |
|---|---|---|---|
| K | 1+ | 4 | 1.38 |
| Ca | 2+ | 6 | 1.00 |
| | | 8 | 1.07 |
| | | 12 | 1.35 |
| Si | 4+ | 4 | 0.26 |
| P | 5+ | 4 | 0.17 |
| Al | 3+ | 6 | 0.53 |
| Ce | 3+ | 6 | 1.03 |
| | | 12 | 1.29 |
| | 4+ | 6 | 0.8 |
| La | 3+ | 6 | 1.06 |
| | | 8 | 1.18 |
| | | 12 | 1.32 |
| Pr | 3+ | 6 | 1.01 |
| | | 8 | 1.14 |
| | 4+ | 6 | 0.78 |
| | | 8 | 0.99 |
| Fe | 2+ | 4 | 0.63 |
| | | 6 | 0.61 |
| | 3+ | 4 | 0.9 |
| | | 6 | 0.55 |
| Th | 4+ | 6 | 1.00 |
| | | 8 | 1.06 |
| | | 12 | >1.01 |
| Sc | 3+ | 6 | 0.73 |
| | | 8 | 0.87 |
| Y | 3+ | 6 | 0.89 |
| | | 8 | 1.02 |
| | | 12 | >1.1 |

confined to a particular physical structure, but it's possible for one element to have more than one coordination site within the same mineral structure. For instance, Fe has both a tetrahedral and octahedral coordination in magnetite ($Fe_2O_4$), where the valence state can be either 3+ or 4+. A similar occurrence can occur for the other elements as well, so by examining the elements commonly encountered in this project one can understand how difficult it may be to determine specifically which minerals are involved and which ones can be expected to contain REEs. Interestingly, Sc is assumed to be associated with the LREEs, whereas its ionic radius is quite small compared to the LREEs. More than likely, scandium occupies an octahedral site in some of the minerals encountered in this project. Notably, it can readily substitute for Y in xenotime.

## VI. Summary of the Project

Going into the project it was not clear what type of coal-associated by-product would be most desirable for field sampling. Considerable guidelines emerge after conducting a random sampling approach. Coal samples provide a background only after ashing and examination of the ash, and it's concluded that neither bituminous nor anthracite coal contain >300 ppm REEs. Both top rock and bottom rock are likely sample sources to contain >300 ppm REEs. At least in western Pennsylvania, reddog and underclay may be expected to contain >300 ppm REEs, and, in particular, fire clay should be examined. SEM analysis shows that coal related by-products contain numerous mineral species, some of which need to be studied further. However, SEM/EDX/WDX shows that at least two minerals are the source of REEs. These are both phosphate compounds, monazite and xenotime. Monazite is expected to be the source of the LREEs, which dominate the lanthanides, and xenotime is expected to be the source of HREEs observed. It's not clear how this breaks out with respect to western and eastern Pennsylvania, but the majority of samples containing>300 ppm REEs came from eastern Pennsylvania. The other likely source in eastern Pennsylvania is either fireclay or feldspar. Finally, the study of exploratory cores would serve as a good source for determining the concentration and the linear extent of high REE concentrations.

## VII. References

(1) Barnes, J. H., 2004, "Rocks and Minerals of Pennsylvania," (4th ed.): Pennsylvania Geological Survey, 4th ser., Educational Series 1, 30 pp.

## VII: Attachments

### 1. Semi-quantitative Laboratory Analysis of Selected REEs Using Portable XRF[#]

| Sample Number | Sample Type | Concentration (ppm) La | Ce | Pr | Nd | Y | Location |
|---|---|---|---|---|---|---|---|
| WPFACO04 | Shale | 119 | 183 | 232 | 513 | 30 | Georges Twp., Fayette, PA |
| WPFACO05 | Spoil | N/A | N/A | N/A | N/A | N/A | Georges Twp., Fayette, PA |
| WPFACO07 | Spoil | BDL | BDL | BDL | BDL | 19 | Georges Twp., Fayette, PA |
| WPFACO10 | Coal | N/A | N/A | N/A | N/A | N/A | Georges Twp., Fayette, PA |
| WPFAFA05 | Coal | N/A | N/A | N/A | N/A | N/A | Georges Twp., Fayette,, PA |
| WPWEMA02 | Spoil | BDL | BDL | BDL | BDL | 16 | Mt. Pleasant Twp., Westmoreland, PA |
| WPWEMA04 | Spoil | BDL | BDL | BDL | BDL | 20 | Mt. Pleasant Twp., Westmoreland, PA |
| WPWEMA10 | Coal | N/A | N/A | N/A | N/A | N/A | Mt. Pleasant Twp., Westmoreland, PA |
| OHHA01-01 | Core* | N/A | N/A | N/A | N/A | N/A | Monroe Township, Harrison, OH |
| OHHA01-02 | Core* | N/A | N/A | N/A | N/A | N/A | Monroe Township, Harrison, OH |
| OHHA01-03 | Core* | N/A | N/A | N/A | N/A | N/A | Monroe Township, Harrison, OH |
| OHHA01-04 | Core* | N/A | N/A | N/A | N/A | N/A | Monroe Township, Harrison, OH |
| OHHA01-05 | Core* | N/A | N/A | N/A | N/A | N/A | Monroe Township, Harrison, OH |
| WPWE01-01 | Core* | N/A | N/A | N/A | N/A | N/A | Derry Twp., Westmoreland, PA |
| WPWE01-02 | Core* | N/A | N/A | N/A | N/A | N/A | Derry Twp., Westmoreland, PA |
| WPWE01-03 | Core* | N/A | N/A | N/A | N/A | N/A | Derry Twp., Westmoreland, PA |
| WPIN01-01 | Core* | N/A | N/A | N/A | N/A | N/A | Burrell Township, Indiana, PA |
| WPIN01-02 | Core* | N/A | N/A | N/A | N/A | N/A | Burrell Township, Indiana, PA |
| WPIN01-03 | Core* | N/A | N/A | N/A | N/A | N/A | Burrell Township, Indiana, PA |
| WPIN01-04 | Core* | N/A | N/A | N/A | N/A | N/A | Burrell Township, Indiana, PA |
| WPIN01-05 | Core* | N/A | N/A | N/A | N/A | N/A | Burrell Township, Indiana, PA |
| WPIN02-01 | Core* | N/A | N/A | N/A | N/A | N/A | Black Lick Twp., Indiana, PA |
| WPIN02-02 | Core* | N/A | N/A | N/A | N/A | N/A | Black Lick Twp., Indiana, PA |
| WPIN02-03 | Core* | N/A | N/A | N/A | N/A | N/A | Black Lick Twp., Indiana, PA |

| Sample Number | Sample Type | Concentration (ppm) La | Ce | Pr | Nd | Y | Location |
|---|---|---|---|---|---|---|---|
| WPIN02-04 | Core* | N/A | N/A | N/A | N/A | N/A | Black Lick Twp., Indiana, PA |
| WPAR01-01 | Core* | 224 | 217 | 286 | 499 | 33 | Kittanning Twp., Armstrong, PA |
| WPAR01-02 | Core* | <106 | <140 | <122 | 270 | 11 | Kittanning Twp., Armstrong, PA |
| WPAR01-03 | Core* | N/A | N/A | N/A | N/A | N/A | Kittanning Twp., Armstrong, PA |
| WPAR01-04 | Core* | N/A | N/A | N/A | N/A | N/A | Kittanning Twp., Armstrong, PA |
| WPAR01-05 | Core* | N/A | N/A | N/A | N/A | N/A | Kittanning Twp., Armstrong, PA |
| WPAR01-06 | Core* | N/A | N/A | N/A | N/A | N/A | Kittanning Twp., Armstrong, PA |
| WPAR01-07 | Core* | N/A | N/A | N/A | N/A | N/A | Kittanning Twp., Armstrong, PA |
| WPFA03-01 | Core* | N/A | N/A | N/A | N/A | N/A | Parks Township, Fayette, PA |
| WPFA03-02 | Core* | N/A | N/A | N/A | N/A | N/A | Parks Township, Fayette, PA |
| WPFA03-03 | Core* | N/A | N/A | N/A | N/A | N/A | Parks Township, Fayette, PA |
| WPFA03-04 | Core* | N/A | N/A | N/A | N/A | N/A | Parks Township, Fayette, PA |
| WPFA03-05 | Core* | N/A | N/A | N/A | N/A | N/A | Parks Township, Fayette, PA |
| WPFA03-06 | Core* | N/A | N/A | N/A | N/A | N/A | Parks Township, Fayette, PA |
| WPFA03-07 | Core* | N/A | N/A | N/A | N/A | N/A | Parks Township, Fayette, PA |
| WPFA03-08 | Core* | N/A | N/A | N/A | N/A | N/A | Parks Township, Fayette, PA |
| WPFA03-09 | Core* | N/A | N/A | N/A | N/A | N/A | Parks Township, Fayette, PA |
| WPFA03-10 | Core* | N/A | N/A | N/A | N/A | N/A | Parks Township, Fayette, PA |
| WPFA03-11 | Core* | N/A | N/A | N/A | N/A | N/A | Parks Township, Fayette, PA |
| WPFA03-12 | Core* | N/A | N/A | N/A | N/A | N/A | Parks Township, Fayette, PA |
| WPCA01-01 | Core* | N/A | N/A | N/A | N/A | N/A | Croyle Township, Cambria, PA |
| WPCA01-02 | Core* | N/A | N/A | N/A | N/A | N/A | Croyle Township, Cambria, PA |
| WPCA01-03 | Core* | N/A | N/A | N/A | N/A | N/A | Croyle Township, Cambria, PA |
| WPCA01-04 | Core* | N/A | N/A | N/A | N/A | N/A | Croyle Township, Cambria, PA |
| WPCA01-05 | Core* | N/A | N/A | N/A | N/A | N/A | Croyle Township, Cambria, PA |
| WPIN03-01 | Core* | N/A | N/A | N/A | N/A | N/A | Green Township, Indiana, PA |
| WPIN03-02 | Core* | N/A | N/A | N/A | N/A | N/A | Green Township, Indiana, PA |
| WPIN03-04 | Core* | N/A | N/A | N/A | N/A | N/A | Green Township, Indiana, PA |

| Sample Number | Sample Type | Concentration (ppm) La | Ce | Pr | Nd | Y | Location |
|---|---|---|---|---|---|---|---|
| WPIN03-05 | Core* | N/A | N/A | N/A | N/A | N/A | Green Township, Indiana, PA |
| WPIN03-06 | Core* | N/A | N/A | N/A | N/A | N/A | Green Township, Indiana, PA |
| WPIN03-07 | Core* | N/A | N/A | N/A | N/A | N/A | Green Township, Indiana, PA |
| WPIN03-08 | Core* | N/A | N/A | N/A | N/A | N/A | Green Township, Indiana, PA |
| WPIN03-09 | Core* | N/A | N/A | N/A | N/A | N/A | Green Township, Indiana, PA |
| WPIN03-10 | Core* | N/A | N/A | N/A | N/A | N/A | Green Township, Indiana, PA |
| WPIN03-11 | Core* | N/A | N/A | N/A | N/A | N/A | Green Township, Indiana, PA |
| WPIN03-12 | Core* | N/A | N/A | N/A | N/A | N/A | Green Township, Indiana, PA |
| WPIN03-03 | Core* | N/A | N/A | N/A | N/A | N/A | Green Township, Indiana, PA |
| WPFACO07 | Spoil | <73 | <74 | <101 | <133 | 19 | Georges Twp., Fayette, PA |
| WPCARE01-10 | Refuse | BDL | BDL | BDL | BDL | 15 | Cambria Twp., Cambria, PA |
| WPCLRE02-01 | Filt. Cake | BDL | BDL | BDL | BDL | 14 | Karthaus Twp., Clearfield, PA |
| WPCLRE02-06 | Coal | <55 | <56 | <77 | <102 | 3 | Karthaus Twp., Clearfield, PA |
| WPCLRE02-04 | Roof rock | 255 | 327 | 521 | 701 | 30 | Karthaus Twp., Clearfield, PA |
| WPCLRE02-09 | Refuse | BDL | BDL | BDL | BDL | 16 | Karthaus Twp., Clearfield, PA |
| WPCLRE04-02 | Coal | BDL | BDL | BDL | BDL | 5 | Burnside Twp., Clearfield, PA |
| WPCLRE04-03 | Coal | BDL | BDL | BDL | BDL | 15 | Burnside Twp., Clearfield, PA |
| WPCLRE02-14 | Refuse | BDL | BDL | BDL | BDL | 18 | Karthaus Twp., Clearfield, PA |
| WPCLRE02-11 | Refuse | BDL | BDL | BDL | BDL | 14 | Karthaus Twp., Clearfield, PA |
| WPFACO09 | Spoil | BDL | BDL | BDL | BDL | 17 | Georges Twp., Fayette, PA |
| WPCLRE04-01 | Coal | BDL | BDL | BDL | BDL | 9 | Burnside Twp., Clearfield, PA |
| WPCLRE05-01 | Coal | BDL | BDL | BDL | BDL | 18 | Decatur Twp., Clearfield, PA |
| EPSCLA23 | Coal | BDL | BDL | BDL | BDL | 3.9 | Rush Twp., Schuylkill, PA |
| EPSCLA18 | Spoil | BDL | 113 | 158 | 205 | 20 | Rush Twp., Schuylkill, PA |
| WPCLRE04-04 | Coal | BDL | BDL | BDL | BDL | 11 | Burnside Twp., Clearfield, PA |
| EPSCLA03 | Mam Coal | BDL | BDL | BDL | BDL | 10 | Tamaqua, Schuylkill, PA |
| EPCALA16 | Orch Bot Rock | 97 | 110 | 154 | 223 | 30 | Lansford, Carbon, PA |
| EPSCLA15 | Mam Coal | BDL | BDL | BDL | BDL | 9 | Coaldale, Schuylkill, PA |

| Sample Number | Sample Type | Concentration (ppm) | | | | | Location |
|---|---|---|---|---|---|---|---|
| | | La | Ce | Pr | Nd | Y | |
| EPSCLA14 | Mam Bot Rock | 103 | 134 | 122 | 228 | 36 | Coaldale, Schuylkill, PA |
| EPCALA22 | Holmes Coal | BDL | BDL | BDL | BDL | 10 | Nesquehoning, Carbon, PA |
| EPCALA17 | Orch. OB | 116 | 129 | 194 | 253 | 20 | Lansford, Carbon, PA |
| EPCALA19 | Unk. Spoil | 82 | 97 | 113 | 181 | 27 | Nesquehoning, Carbon, PA |
| EPSCLA13 | Drilling Sand | 113 | 120 | 170 | 267 | 10 | Coaldale, Schuylkill, PA |
| EPSCLA05 | Prep. Rej. | BDL | 55 | BDL | 94 | 16 | Tamaqua, Schuylkill, PA |
| EPSCLA01 | AMD Sludge | 120 | 91 | 151 | 253 | 12 | Tamaqua, Schuylkill, PA |
| EPSCLA02 | Orchard Coal | BDL | BDL | BDL | BDL | 12 | Tamaqua, Schuylkill, PA |
| EPSCLA10 | Drilling Sand | 108 | 130 | 185 | 253 | 16 | Tamaqua, Schuylkill, PA |
| EPSCLA04 | Casting over Mam | 72 | 116 | 110 | 232 | 33 | Tamaqua, Schuylkill, PA |
| EPSCLA06 | Old Spoil | BDL | BDL | BDL | 235 | 27 | Tamaqua, Schuylkill, PA |
| WPCLRE02-01 | Filt. Cake | BDL | BDL | BDL | BDL | 14 | Karthaus Twp., Clearfield, PA |
| WPCLRE03-01 | Coal | <55 | <56 | <76 | <101 | 13 | Girard Twp., Clearfield, PA |
| WPCLRE03-03 | Coal | <56 | <57 | <77 | <103 | 11 | Girard Twp., Clearfield, PA |
| WPCLRE02-02 | Wsh Fines | 175 | 187 | 335 | 378 | 19 | Karthaus Twp., Clearfield, PA |
| WPCERE01-02 | OB Rock | <81 | <90 | <113 | <153 | 20 | Rush Twp., Centre, PA |
| WPCLRE01-12 | UKB FL | BDL | BDL | BDL | BDL | 42 | Girard Twp., Clearfield, PA |
| WPCARE01-12 | Refuse | BDL | BDL | BDL | BDL | 15 | Cambria Twp., Cambria, PA |
| WPCARE01-13 | Refuse | BDL | BDL | BDL | BDL | 14 | Cambria Twp., Cambria, PA |
| WPWEMA08 | Spoil | BDL | BDL | BDL | BDL | 20 | Mt. Pleasant Twp., Westmoreland, PA |
| WPCARE01-08 | Refuse | BDL | BDL | BDL | BDL | 18 | Cambria Twp., Cambria, PA |
| WPFACO02 | Spoil | <80 | <82 | <111 | <149 | 19 | Georges Twp., Fayette, PA |
| WPWEMA03 | Spoil | <79 | <119 | <109 | <146 | 18 | Mt. Pleasant Twp., Westmoreland, PA |

| Sample Number | Sample Type | Concentration (ppm) La | Ce | Pr | Nd | Y | Location |
|---|---|---|---|---|---|---|---|
| WPFAFA03 | Spoil | <78 | <80 | <108 | <145 | 13 | Georges Twp., Fayette, PA |
| WPFAFA04 | Spoil | <138 | <94 | <115 | <154 | 20 | Georges Twp., Fayette, PA |
| WPFAFA02 | Spoil | <78 | <88 | <110 | <147 | 16 | Georges Twp., Fayette, PA |
| WPWEMA06 | Spoil | 161 | 225 | 268 | 398 | 41 | Mt. Pleasant Twp., Westmoreland, PA |
| WPCLRE01-15 | Clean | <71 | <72 | <99 | <131 | 13 | Girard Twp., Clearfield, PA |
| ***WPFANU05 | Wild Coal | <44 | <43 | <61 | <79 | 11 | N. Union Twp., Fayette, PA |
| WPFANU04 | Rk TOC | 144 | 208 | 203 | 304 | 43 | N. Union Twp., Fayette. PA |
| WPFANU01 | Wild Coal Top | <47 | <45 | <63 | <83 | 10 | N. Union Twp., Fayette. PA |
| WPFANU03 | Rk TOC | <164 | 110 | <142 | 233 | 31 | N. Union Twp., Fayette. PA |
| WPSORE01-04 | Refuse | <98 | <139 | <114 | <243 | 27 | Jenner Twp., Somerset, PA |
| WPWEMA02 | Refuse | <69 | <70 | <94 | <124 | 16 | Mt. Pleasant Twp., Westmoreland, PA |
| WPWEMA04 | Refuse | <101 | <113 | <110 | <145 | 20 | Mt. Pleasant Twp., Westmoreland, PA |
| WPFANU02 | Rk BOC Above FC | <102 | <104 | <142 | <187 | 29 | N. Union Twp., Fayette, PA |
| WPFANU06 | Wild Coal Parting | 172 | 188 | <140 | 238 | 25 | N. Union Twp., Fayette, PA |
| WPFANU07 | Pbgh Coal Bot | <52 | <50 | <70 | <92 | 4 | N. Union Twp., Fayette, PA |
| WPFANU08 | Wild Coal | <58 | <58 | <79 | <103 | 10 | N. Union Twp., Fayette, PA |
| ALJCMC01-03 | Wash Ref | <74 | <76 | <102 | <136 | 20 | Twp. 21 South, Shelby, AL |
| WPFANU09 | Parting Pbgh Coal | <62 | <62 | <86 | <112 | 13 | N. Union Twp., Fayette, PA |
| WPCARO01-02 | UK Floor | <98 | 130 | <138 | 228 | 24 | Cambria Twp., Cambria, PA |
| WPARRO01-06 | LK Bony | 164 | 326 | <110 | <146 | 46 | Kittanning Twp., Armstrong, PA |
| WPINRO02-02 | Floor | 198 | 282 | 267 | 515 | 31 | Burrell Twp., Indiana, PA |
| WPINRO03-03 | Floor | 122 | 158 | 141 | 246 | 33 | Burrell Twp., Indiana, PA |
| WPINRO03-02 | Floor | <89 | <143 | <121 | <163 | 37 | Burrell Twp., Indiana, PA |

| Sample Number | Sample Type | Concentration (ppm) | | | | | Location |
|---|---|---|---|---|---|---|---|
| | | La | Ce | Pr | Nd | Y | |
| WPCARO01-01 | Floor | 201 | 259 | 336 | 629 | 20 | Cambria Twp., Cambria, PA |
| WPCARO01-03 | UK Floor | 324 | 278 | 466 | 749 | 22 | Cambria Twp., Cambria, PA |
| OHHA01-01 | BOC Floor | 169 | 205 | 206 | 443 | 42 | Nottingham Twp., Harrison, OH |
| WPINRO03-07 | TOC Roof | 162 | 253 | 421 | 729 | 62 | Burrell Twp., Indiana, PA |
| WPINRO03-04 | BOC Floor | 220 | 202 | 263 | 494 | 31 | Burrell Twp., Indiana, PA |
| WPARRO01-03 | MAH Roof | 144 | 165 | 241 | 355 | 38 | Kittanning Twp., Armstrong, PA |
| WPARRO01-07 | Bony/Shal e | 208 | 234 | 319 | 676 | 43 | Kittanning Twp., Armstrong, PA |
| WPFARO03-14 | TOC Gr Rk | <104 | 166 | 242 | 423 | 34 | Parks Twp. Fayette, PA |
| WPWERO01-02 | TOC Gr Rk | 119 | 117 | <137 | <247 | 28 | Derry Twp., Westmoreland, PA |
| WPINRO02-01 | Roof | 206 | 225 | 324 | 587 | 32 | Burrell Twp., Indiana, PA |
| WPFARO03-15 | Gr Roof Rk | 118 | 123 | 187 | 368 | 38 | Parks Twp. Fayette, PA |
| WPFARO03-16 | Roof | 166 | 211 | 233 | 468 | 37 | Parks Twp. Fayette, PA |
| WPFARO03-17 | Roof | 198 | 233 | 186 | 440 | 37 | Parks Twp. Fayette, PA |
| ALJCMC01-02 | Coal | <42 | <41 | <56 | <73 | 9 | Twp 21 South, Shelby, AL |
| ALJCMC01-01 | Raw Feed | <65 | <64 | <89 | <118 | 12 | Twp. 21 South, Shelby, AL |
| WPFANU11 | Fireclay | 182 | 183 | 214 | 431 | 113 | N. Union Twp., Fayette, PA |
| ALSCMC01-02 | Coal | <45 | <45 | <62 | <81 | 11 | Twp. 21 South, Shelby, AL |
| ALSCMC01-03 | Feed Coal | <66 | <66 | <91 | <119 | 18 | Twp. 21 South, Shelby, AL |
| ALSCMC01-04 | Coarse Ref | 114 | <97 | <133 | <174 | 26 | Twp. 21 South, Shelby, AL |
| EPSCBL04 | Mid Spoil | <48 | <48 | <65 | <86 | 12 | Mahanoy Twp., Schuylkill, PA |
| EPSCBL01 | Drill Sand | 149 | 162 | 250 | 428 | 17 | Mahanoy Twp., Schuylkill, PA |
| EPSCBL05 | IB T-M | 163 | 135 | 248 | 465 | 36 | Mahanoy Twp., Schuylkill, PA |
| EPSCBL06 | IB M-B | 254 | 269 | 367 | 676 | 38 | Mahanoy Twp., Schuylkill, PA |

| Sample Number | Sample Type | Concentration (ppm) La | Ce | Pr | Nd | Y | Location |
|---|---|---|---|---|---|---|---|
| EPSCBL07 | Prim Bot | <45 | <45 | <61 | <79 | 8 | Mahanoy Twp., Schuylkill, PA |
| EPCOBL08 | Buck OB | 283 | 352 | 559 | 845 | 16 | Conyngham Twp., Columbia, PA |
| EPSCBL15 | Brk Fines | <47 | <47 | <64 | <84 | 13 | Mahanoy Twp., Schuylkill, PA |
| EPSCBL18 | Bot Rk Buck | 122 | 169 | 226 | 398 | 30 | Mahanoy Twp., Schuylkill, PA |
| EPSCBL13 | Brk Middl | <67 | <81 | <92 | <122 | 25 | Mahanoy Twp., Schuylkill, PA |
| EPSCBL17 | Refuse | <76 | <89 | <106 | <195 | 21 | Mahanoy Twp., Schuylkill, PA |
| EPCOBL09 | OB Cong | 138 | 100 | 190 | 232 | 10 | Conyngham Twp., Columbia, PA |
| EPLUBL23 | Hol T Spl | <93 | <133 | <113 | <159 | 14 | Hazle Twp., Luzerne, PA |
| EPLUBL20 | Mam Coal | <44 | <43 | <58 | <78 | 10 | Hazle Twp., Luzerne, PA |
| EPLUBL22 | Mam T Rk | 181 | 247 | 297 | 562 | 36 | Hazle Twp., Luzerne, PA |
| EPLUBL24 | Hol B Spl | 225 | 255 | 327 | 502 | 48 | Hazle Twp., Luzerne, PA |
| EPLUBL21 | Mam B Rk | 166 | 258 | 354 | 515 | 36 | Hazle Twp., Luzerne, PA |
| EPSCBL02 | Mam B Rk | <91 | 170 | 165 | 228 | 25 | Mahanoy Twp., Schuylkill, PA |
| EPSCBL12 | Brk Ref | 137 | 137 | <130 | 319 | 27 | Mahanoy Twp., Schuylkill, PA |
| EPSCBL03 | Mam T Rk | 305 | 251 | 383 | 583 | 16 | Mahanoy Twp., Schuylkill, PA |
| EPSCBL16 | Silt Ref | <80 | <80 | <110 | <146 | 22 | Mahanoy Twp., Schuylkill, PA |
| EPSCBL14 | Brk Sludg | <69 | <68 | <94 | <124 | 18 | Mahanoy Twp., Schuylkill, PA |
| EPLUBL25 | Brk Ref | 210 | 235 | 230 | 506 | 38 | Hazle Twp., Luzerne, PA |
| ALSCMC01-05 | Fine Ref | <69 | <68 | <95 | <124 | 21 | Twp. 21 South, Shelby, AL |
| EPCOBL10 | Shiny OB | 216 | 192 | 211 | 522 | 32 | Conyngham Twp., Columbia, PA |
| WPFACO05 | Shale | <104 | <106 | <116 | <160 | 22 | Georges Twp., Fayette, PA |
| EPLUJE01-10 | Surf Shale | 118 | 174 | 229 | 379 | 32 | Hazle Twp., Luzerne, PA |
| EPLUJE01-25 | Bot Rock | 117 | 120 | 169 | 295 | 7 | Hazle Twp., Luzerne, PA |
| EPLUJE02-15 | Mudstone | 220 | 229 | 179 | 427 | 45 | Hazle Twp., Luzerne, PA |
| EPLUJE02-17 | Bot Rock | 129 | 146 | <137 | 245 | 33 | Hazle Twp., Luzerne, PA |

| Sample Number | Sample Type | Concentration (ppm) La | Ce | Pr | Nd | Y | Location |
|---|---|---|---|---|---|---|---|
| EPLUJE02-18 | Bot Rock | <103 | <147 | <205 | <173 | 39 | Hazle Twp., Luzerne, PA |
| EPLUJE02-20 | Sandstone Cong | 203 | 204 | 314 | 548 | 10 | Hazle Twp., Luzerne, PA |
| EPLUJE01-12 | Shale | 249 | 348 | 411 | 733 | 41 | Hazle Twp., Luzerne, PA |
| EPLUJE03-07 | Mudstone | 209 | 203 | 244 | 355 | 36 | Hazle Twp., Luzerne, PA |
| EPLUJE01-11 | Or-Gr Sandstone | 156 | 215 | 194 | 454 | 34 | Hazle Twp., Luzerne, PA |
| EPLUJE03-08 | Bot Rock | 181 | 232 | 281 | 515 | 49 | Hazle Twp., Luzerne, PA |
| EPLUJE04-04 | ROM | <54 | <54 | <74 | <97 | 17 | Paint Twp., Luzerne, PA |
| EPLUJE01-13 | Cong | 155 | 204 | 248 | 375 | 16 | Hazle Twp., Luzerne, PA |
| EPLUJE03-06 | Top Rock | <100 | 180 | 152 | 310 | 22 | Hazle Twp., Luzerne, PA |
| EPLUJE02-14 | Mam Part | <51 | <50 | <69 | <90 | 4 | Hazle Twp., Luzerne, PA |
| EPLUJE04-01 | Refuse | 148 | 209 | 221 | 456 | 28 | Paint Twp., Luzerne, PA |
| EPLUJE01-09 | Drill Sand | 206 | 204 | 285 | 564 | 25 | Hazle Twp. Luzerne, PA |
| EPLUJE04-23 | Fine Gr Rock | 207 | 253 | 307 | 642 | 51 | Foster Twp., Luzerne, PA |
| EPLUJE02-19 | Surf Gr Rk | 154 | 155 | 230 | 347 | 37 | Hazle T3wp., Luzerne, PA |
| EPLUJE04-03 | Cogen Rej | <66 | <67 | <91 | <120 | 18 | Paint Twp., Luzerne, PA |
| EPSCJE01-59 | Coal Part | <55 | <54 | <74 | <99 | 13 | Norwegian Twp., Schuylkill, PA |
| EPLUJE04-22 | Mudstone | <55 | 149 | <124 | 268 | 13 | Foster Twp., Luzerne, PA |
| EPSCJE01-56 | Bot Rock | 133 | 187 | 133 | 321 | 40 | Norwegian Twp., Schuylkill, PA |
| EPSCJE01-58 | Fine Gr Sandst | 272 | 293 | 333 | 688 | 37 | Norwegian Twp., Schuylkill, PA |
| EPSCJE01-57 | Coarse Gr Sand | 106 | 152 | 219 | 353 | 25 | Norwegian Twp., Schuylkill, PA |
| EPSCJE01-60 | Red Sand | 92 | 109 | 211 | 316 | 13 | Norwegian Twp., Schuylkill, PA |
| EPCOJE02-54 | Wild Coal OB | 178 | 175 | 199 | 432 | 43 | Conyngham Township, Columbia, PA |
| EPCOJE02-53 | Wild Coal | <48 | <47 | <66 | <86 | 19 | Conyngham Township, Columbia, PA |

| Sample Number | Sample Type | Concentration (ppm) La | Ce | Pr | Nd | Y | Location |
|---|---|---|---|---|---|---|---|
| EPLUJE04-02 | Refuse | 188 | 226 | 274 | 534 | 26 | Paint Twp., Luzerne, PA |
| WPWERO01-07 | BOC Gray Stone | 293 | 292 | 389 | 616 | 31 | Derry Twp., Westmoreland, PA |
| EPCOJE02-52 | Blk Stone Wh Qtz | 105 | 116 | 144 | 241 | 13 | Conyngham Township, Columbia, PA |
| EPSCJE02-50 | Shale | 182 | 211 | 247 | 357 | 42 | Frailey Twp., Schuylkill, PA |
| EPSCJE01-61 | Bot Rk Shale | <81 | <114 | <109 | <191 | 17 | Norwegian Twp., Schuylkill, PA |
| EPSCJE02-51 | Weathered Sediment | 168 | 173 | 260 | 452 | 45 | Frailey Twp., Schuylkill, PA |
| EPLUJE05-21 | Shale | <62 | <62 | <84 | <110 | 22 | Foster Twp., Luzerne, PA |
| EPLUJE05-26 | Gr Sand | <92 | <94 | 155 | 333 | 8 | Foster Twp., Luzerne, PA |
| EPSCJE04-44 | Surf Cong | 116 | 134 | 163 | 324 | 12 | Mahanoy Twp. Schuylkill, PA |
| EPSCJE04-45 | Coal | <56 | <55 | <76 | <100 | 20 | Mahanoy Twp. Schuylkill, PA |
| EPSCJE02-49 | Wild Coal | <57 | <56 | <78 | <102 | 23 | Frailey Twp., Schuylkill, PA |
| EPCOJE01-47 | Shale | 154 | 198 | 232 | 410 | 50 | Conyngham Twp., Columbia, PA |
| EPSCJE04-43 | Shale | 111 | 169 | 158 | 301 | 23 | Mahanoy Twp. Schuylkill, PA |
| EPSCJE04-42 | Gr Sand | 131 | <89 | 151 | 286 | 11 | Mahanoy Twp. Schuylkill, PA |
| EPCOJE01-48 | Bot Rk Gr Sandstone | 98 | 139 | 177 | 222 | 11 | Conyngham Twp., Columbia, PA |
| EPLUJE05-33 | Bot rock | 155 | 114 | 178 | 262 | 14 | Foster Twp., Luzerne, PA |
| EPLUJE05-37 | Top Rock | 150 | 172 | <130 | 345 | 32 | Foster Twp., Luzerne, PA |
| EPLUJE05-36 | Midl Coal | <105 | <82 | <127 | <144 | 46 | Foster Twp., Luzerne, PA |
| EPLUJE05-41 | Refuse | <115 | <75 | <112 | <136 | 24 | Foster Twp., Luzerne, PA |
| EPSCJE05-55 | AMD Sludge | 311 | 315 | 700 | 1082 | 24 | Frailey Twp., Schuylkill, PA |
| EPLUJE05-40 | Pott Cong | 107 | 95 | <123 | <163 | 6 | Foster Twp., Luzerne, PA |
| EPLUJE05-38 | Gr Surf Rk | <67 | <68 | <93 | <122 | 43 | Foster Twp., Luzerne, PA |
| EPLUJE05-34 | B Mud Rk | 150 | 148 | 191 | 391 | 29 | Foster Twp., Luzerne, PA |
| EPLUJE05-35 | Gr B Rk | 167 | 186 | 221 | 373 | 28 | Foster Twp., Luzerne, PA |

| Sample Number | Sample Type | Concentration (ppm) La | Ce | Pr | Nd | Y | Location |
|---|---|---|---|---|---|---|---|
| EPLUJE05-29 | Banded Sandstone | 117 | 165 | 207 | 359 | 23 | Foster Twp., Luzerne, PA |
| EPLUJE05-31 | Bot Coal | <70 | <71 | <97 | <128 | 15 | Foster Twp., Luzerne, PA |
| EPLUJE05-27 | Red Sandstone | 117 | 193 | 243 | 356 | 39 | Foster Twp., Luzerne, PA |
| EPLUJE05-39 | Potts Clay | 116 | 186 | 172 | 321 | 22 | Foster Twp., Luzerne, PA |
| EPLUJE05-30 | Top Coal | <66 | <67 | <91 | <120 | 24 | Foster Twp., Luzerne, PA |
| EPLUJE05-32 | Mica Sand | 188 | 159 | 207 | 393 | 22 | Foster Twp., Luzerne, PA |
| EPLUJE05-28 | Orange Sandstone | 175 | 216 | 291 | 407 | 34 | Foster Twp., Luzerne, PA |
| EPLUJE02-16 | Mica Sand | 189 | 220 | 300 | 501 | 21 | Hazle Twp., Luzerne, PA |
| EPLUJE04-24 | Very Hard Sandstone | 96 | 109 | 163 | 224 | 10 | Foster Twp., Luzerne, PA |
| EPSCJE01-62 | Fine Grain Sandstone | 118 | 134 | 224 | 471 | 35 | Norwegian Twp., Schuylkill, PA |

*Core samples were measured in-situ with the “test all geo” mode and prior to revision of the XRF unit to contain the REE library.

**Beginning 300 sec exposure (earlier at 180 sec)

***Beginning 600 sec exposure (earlier at 300 sec)

# Sc not available in “mining” mode

## 2. ICP-MS Analyses of Selected Samples (ppm)*

| Sample | La | Ce | Pr | Nd | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu | Sc | Y | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EPSCLA 10 | 18 | 38 | 4.6 | 17 | 3.3 | 0.8 | 3.0 | 0.5 | 2.4 | 0.5 | 1.4 | 0.2 | 1.5 | 0.2 | 7.6 | 15 | 114 |
| EPSCLA 19 | 40 | 83 | 9.9 | 37 | 6.9 | 1.4 | 6.2 | 0.9 | 4.6 | 0.9 | 2.7 | 0.4 | 2.7 | 0.4 | 17 | 22 | 236 |
| EPSCLA 20 | 33 | 72 | 8.6 | 34 | 6.2 | 1.3 | 5.7 | 0.8 | 4.2 | 0.9 | 2.4 | 0.4 | 2.3 | 0.4 | 16 | 15 | 203.2 |
| WPCLRE 02-04 | 33 | 75 | 8.9 | 31 | 6.6 | 1.4 | 6.2 | 0.9 | 4.9 | 1.0 | 2.7 | 0.4 | 2.7 | 0.4 | 18 | 19 | 212.1 |
| EPSCLA 14 | 44 | 102 | 12 | 43 | 8.0 | 1.6 | 7.1 | 1.1 | 5.0 | 1.0 | 2.6 | 0.4 | 2.6 | 0.4 | 20 | 19 | 269.8 |
| WPCLRE 02-02 | 32 | 70 | 8.2 | 32 | 6.2 | 1.4 | 6.0 | 0.9 | 4.6 | 0.9 | 2.4 | 0.4 | 2.3 | 0.3 | 12 | 25 | 204.6 |
| EPSCLA 01 | 24 | 43 | 4.9 | 19 | 3.4 | 0.7 | 3.6 | 0.5 | 2.5 | 0.5 | 1.4 | 0.2 | 1.2 | 0.2 | 17 | 17 | 139.1 |
| EPCALA 21 | 38 | 82 | 9.7 | 36 | 6.7 | 1.3 | 6.2 | 0.9 | 4.5 | 0.9 | 2.4 | 0.4 | 2.5 | 0.4 | 17 | 22 | 230.9 |
| WPCLRE 01-13 | 35 | 76 | 9.1 | 34 | 6.4 | 1.3 | 5.7 | 0.8 | 4.2 | 0.8 | 2.4 | 0.4 | 2.4 | 0.4 | 16 | 14 | 208.9 |
| EPCALA 16 | 30 | 65 | 7.4 | 27 | 4.9 | 1.0 | 4.3 | 0.6 | 3.0 | 0.7 | 1.9 | 0.3 | 2.2 | 0.4 | 23 | 14 | 185.7 |
| **WPWEM A06** | **57** | **122** | **15** | **54** | **10** | **2.1** | **9.8** | **1.4** | **7.3** | **1.4** | **3.9** | **0.6** | **3.8** | **0.6** | **36** | **29** | **353.9** |
| EPCALA 17 | 28 | 60 | 7.2 | 27 | 4.9 | 1.0 | 4.3 | 0.6 | 3.1 | 0.6 | 1.8 | 0.3 | 1.8 | 0.3 | 13 | 20 | 173.9 |
| WPCLRE 01-12 | 22 | 47 | 5.6 | 21 | 3.9 | 0.9 | 3.6 | 0.5 | 2.6 | 0.5 | 1.5 | 0.2 | 1.6 | 0.2 | 8.8 | 16 | 135.9 |
| EPSCLA 09 | 37 | 80 | 9.7 | 37 | 7.2 | 1.5 | 6.3 | 1.0 | 4.7 | 0.9 | 2.5 | 0.4 | 2.6 | 0.4 | 18 | 22 | 231.2 |
| EPSCLA 13 | 14 | 29 | 3.6 | 13 | 2.4 | 0.6 | 2.2 | 0.3 | 1.8 | 0.4 | 1.0 | 0.2 | 1.1 | 0.2 | 6.4 | 15 | 91.2 |
| EPSCLA 04 | 45 | 101 | 11 | 42 | 8.1 | 1.7 | 7.4 | 1.1 | 5.2 | 1.0 | 2.8 | 0.4 | 2.8 | 0.4 | 18 | 22 | 269.9 |
| WPCARE 01-16 | 36 | 75 | 8.5 | 32 | 6.0 | 1.2 | 5.5 | 0.8 | 4.2 | 0.8 | 2.3 | 0.4 | 2.2 | 0.3 | 13 | 21 | 209.2 |
| WPCARO 02-01 | 21 | 46 | 5.2 | 20 | 3.7 | 0.8 | 3.5 | 0.5 | 3.2 | 0.6 | 1.9 | 0.3 | 1.9 | 0.2 | 13 | 18 | 139.8 |
| WPCARO 03 | 17 | 35 | 4.1 | 16 | 3.3 | 0.8 | 3.5 | 0.5 | 2.7 | 0.6 | 1.5 | 0.2 | 1.4 | 0.1 | 6.6 | 19 | 112.3 |
| WPCLRE 05-02 | 18 | 50 | 4.9 | 18 | 3.6 | 0.8 | 3.3 | 0.5 | 2.9 | 0.6 | 1.8 | 0.3 | 1.9 | 0.2 | 14 | 16 | 136.8 |
| WPCLRE 06-04 | 20 | 45 | 5.5 | 21 | 4.2 | 0.8 | 4.0 | 0.6 | 3.3 | 0.7 | 2.0 | 0.3 | 2.1 | 0.2 | 16 | 15 | 140.7 |
| WPSORE 01-09 | 19 | 41 | 5.0 | 20 | 3.8 | 0.7 | 3.5 | 0.5 | 2.7 | 0.5 | 1.5 | 0.2 | 1.5 | 0.1 | 5.0 | 20 | 125.0 |

| Sample | La | Ce | Pr | Nd | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu | Sc | Y | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WPFARO 03-17 | 23 | 58 | 6.1 | 23 | 4.4 | 0.9 | 4.2 | 0.6 | 3.4 | 0.7 | 2.0 | 0.3 | 2.1 | 0.2 | 16 | 16 | 160.9 |
| WPCARE 02-03 | 17 | 35 | 4.1 | 16 | 3.3 | 0.8 | 3.5 | 0.5 | 2.7 | 0.6 | 1.5 | 0.2 | 1.4 | 0.1 | 6.6 | 19 | 112.3 |
| WPSORE 01-03 | 28 | 70 | 7.8 | 29 | 6.0 | 1.3 | 5.9 | 0.9 | 4.6 | 1.0 | 2.6 | 0.4 | 2.6 | 0.3 | 19 | 20 | 199.4 |
| WPFANU 04 | 41 | 98 | 11 | 43 | 7.6 | 1.6 | 7.0 | 1.0 | 5.0 | 1.0 | 2.5 | 0.4 | 2.5 | 0.2 | 18 | 22 | 261.8 |
| WPSORE 01-08 | 21 | 46 | 5.2 | 20 | 3.7 | 0.8 | 3.5 | 0.5 | 3.2 | 0.6 | 1.9 | 0.3 | 1.9 | 0.2 | 13 | 18 | 169.4 |
| WPFANU 06 | 22 | 50 | 5.4 | 19 | 3.6 | 0.8 | 3.3 | 0.5 | 2.9 | 0.6 | 1.8 | 0.3 | 1.9 | 0.2 | 14 | 15 | 141.3 |
| WPSORE 01-01 | 23 | 54 | 6.4 | 24 | 4.7 | 1.0 | 4.3 | 0.7 | 3.5 | 0.8 | 2.1 | 0.4 | 2.2 | 0.3 | 16 | 16 | 159.4 |
| WPINRO 02-01 | 30 | 70 | 7.8 | 29 | 5.5 | 1.2 | 5.0 | 0.7 | 3.8 | 0.7 | 2.1 | 0.3 | 2.1 | 0.2 | 16 | 17 | 191.4 |
| WPFANU 03 | 41 | 87 | 10 | 38 | 7.0 | 1.4 | 6.5 | 0.9 | 4.8 | 1.0 | 2.7 | 0.4 | 2.8 | 0.3 | 19 | 22 | 244.8 |
| EPLUJE 05-32 | 29 | 63 | 7.4 | 28 | 5.1 | 0.9 | 4.2 | 0.7 | 3.2 | 0.6 | 1.7 | 0.3 | 1.8 | 0.3 | 7.6 | 24 | 177.8 |
| EPLUJE 05-28 | 40 | 88 | 11 | 41 | 8.1 | 1.7 | 6.8 | 1.0 | 4.8 | 0.9 | 2.4 | 0.4 | 2.5 | 0.4 | 11 | 26 | 246 |
| EPLUJE 05-35 | 31 | 63 | 7.3 | 27 | 4.7 | 0.8 | 3.8 | 0.6 | 3.1 | 0.7 | 2.1 | 0.3 | 2.4 | 0.4 | 9.3 | 23 | 179.5 |
| EPLUJE 05-39 | 26 | 62 | 6.5 | 24 | 4.5 | 0.9 | 4.1 | 0.7 | 3.5 | 0.7 | 2.0 | 0.3 | 2.0 | 0.3 | 7.9 | 22 | 167.4 |
| EPSCJE 05-55 | 25 | 50 | 6.1 | 24 | 4.7 | 1.0 | 5.5 | 0.9 | 4.8 | 1.0 | 2.7 | 0.4 | 2.3 | 0.4 | 4.4 | 30 | 163.2 |
| EPLUJE 05-37 | 36 | 74 | 8.6 | 32 | 5.5 | 1.0 | 4.5 | 0.7 | 3.6 | 0.7 | 2.3 | 0.4 | 2.7 | 0.5 | 10 | 24 | 206.5 |
| **EPLUJE 04-23** | **58** | **124** | **16** | **62** | **13** | **2.7** | **12** | **1.8** | **9.7** | **1.9** | **5.5** | **0.8** | **5.4** | **0.8** | **19** | **47** | **379.6** |
| EPLUJE 05-29 | 22 | 47 | 5.5 | 21 | 3.9 | 0.9 | 3.3 | 0.5 | 2.3 | 0.4 | 1.3 | 0.2 | 1.4 | 0.2 | 5.6 | 20 | 135.5 |
| EPSCJE 02-51 | 40 | 82 | 9.8 | 37 | 7.1 | 1.3 | 7.0 | 1.1 | 6.2 | 1.3 | 3.7 | 0.6 | 3.7 | 0.6 | 13 | 34 | 248.4 |
| EPLUJE 03-07 | 44 | 95 | 11 | 41 | 7.7 | 1.6 | 7.3 | 1.1 | 5.9 | 1.1 | 3.3 | 0.5 | 3.2 | 0.5 | 15 | 28 | 266.2 |
| **EPSCJE 01-56** | **51** | **109** | **13** | **49** | **9.0** | **1.6** | **7.9** | **1.2** | **5.8** | **1.2** | **3.2** | **0.5** | **3.4** | **0.5** | **17** | **27** | **300.3** |
| **EPLUJE 01-12** | **54** | **115** | **14** | **52** | **10** | **2.2** | **9.5** | **1.4** | **7.0** | **1.3** | **3.8** | **0.6** | **3.9** | **0.6** | **15** | **35** | **325.3** |
| **EPLUJE 05-27** | **57** | **121** | **15** | **56** | **10** | **2.4** | **9.2** | **1.3** | **6.4** | **1.2** | **3.3** | **0.5** | **3.3** | **0.5** | **13** | **30** | **330.1** |
| EPLUJE 05-33 | 19 | 71 | 4.9 | 19 | 3.5 | 0.5 | 2.9 | 0.4 | 1.9 | 0.4 | 1.1 | 0.2 | 1.1 | 0.2 | 1.1 | 24 | 151.2 |

| Sample | La | Ce | Pr | Nd | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu | Sc | Y | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EPLUJE 01-13 | 17 | 40 | 4.2 | 16 | 2.8 | 0.7 | 2.5 | 0.4 | 2.0 | 0.4 | 1.1 | 0.2 | 1.2 | 0.2 | 4.2 | 20 | 112.9 |
| EPSCBL 10 | 43 | 95 | 11 | 43 | 8.4 | 1.5 | 7.2 | 1.1 | 5.8 | 1.2 | 3.2 | 0.5 | 3.2 | 0.5 | 8.4 | 32 | 272.6 |
| EPSCBL 22 | 41 | 91 | 10 | 40 | 7.8 | 1.6 | 7.4 | 1.1 | 6.0 | 1.2 | 3.3 | 0.5 | 3.1 | 0.5 | 14 | 30 | 258.5 |
| **EPLUJE 03-08** | **58** | **125** | **15** | **56** | **11** | **2.3** | **9.7** | **1.4** | **7.1** | **1.4** | **3.9** | **0.6** | **3.9** | **0.6** | **20** | **35** | **350.9** |
| EPLUJE 02-20 | 16 | 39 | 3.9 | 14 | 2.6 | 0.6 | 2.2 | 0.3 | 1.8 | 0.4 | 1.0 | 0.2 | 1.1 | 0.2 | 3.8 | 16 | 103.1 |
| EPCOJE 01-48 | 17 | 39 | 4.1 | 16 | 2.9 | 0.7 | 2.7 | 0.4 | 2.1 | 0.4 | 1.2 | 0.2 | 1.1 | 0.2 | 2.6 | 28 | 118.6 |
| EPLUJE 04-01 | 35 | 73 | 8.5 | 32 | 6.1 | 1.3 | 5.5 | 0.8 | 4.3 | 0.9 | 2.5 | 0.4 | 2.5 | 0.4 | 13 | 23 | 209.2 |
| EPSCBL 25 | 37 | 79 | 9.4 | 35 | 7.0 | 1.4 | 6.3 | 0.9 | 4.9 | 1.0 | 2.8 | 0.4 | 2.8 | 0.4 | 14 | 26 | 228.3 |
| EPLUJE 01-09 | 27 | 60 | 6.6 | 25 | 4.9 | 1.0 | 4.3 | 0.7 | 3.2 | 0.7 | 1.8 | 0.3 | 2.0 | 0.3 | 9.2 | 20 | 167 |
| EPCOBL 08 | 15 | 34 | 3.9 | 15 | 3.1 | 0.8 | 3.0 | 0.5 | 2.4 | 0.5 | 1.4 | 0.2 | 1.5 | 0.2 | 4.7 | 19 | 105.2 |
| EPCOJE 01-47 | 40 | 77 | 9.4 | 35 | 7.7 | 1.6 | 6.8 | 1.0 | 5.3 | 1.1 | 3.4 | 0.5 | 3.8 | 0.6 | 14 | 31 | 238.2 |
| **EPCOJE 01-50** | **55** | **117** | **20** | **73** | **8.1** | **1.2** | **7.2** | **1.2** | **7.0** | **1.4** | **4.2** | **0.6** | **4.2** | **0.6** | **19** | **35** | **325.7** |
| EPSCBL 18 | 39 | 84 | 9.9 | 36 | 6.7 | 1.3 | 5.9 | 0.9 | 2.7 | 0.4 | 4.5 | 0.9 | 2.9 | 0.4 | 14 | 23 | 232.5 |
| **WPWER O01-07** | **67** | **130** | **14** | **47** | **8.1** | **1.8** | **7.7** | **1.1** | **5.1** | **1.0** | **2.9** | **0.5** | **3.0** | **0.5** | **21** | **26** | **336.7** |
| EPLUBL 21 | 41 | 88 | 10 | 40 | 7.9 | 1.7 | 7.7 | 1.1 | 5.8 | 1.1 | 3.2 | 0.5 | 3.2 | 0.5 | 14 | 32 | 257.7 |
| EPLUBL 24 | 39 | 90 | 10 | 38 | 7.3 | 1.6 | 6.9 | 1.1 | 5.6 | 1.1 | 3.1 | 0.4 | 3.1 | 0.5 | 15 | 27 | 249.7 |
| EPSCBL 03 | 22 | 48 | 5.5 | 21 | 3.9 | 1.0 | 3.3 | 0.5 | 2.4 | 0.5 | 1.4 | 0.3 | 1.4 | 0.3 | 5.6 | 16 | 133.1 |
| **EPLUJE 02-15** | **87** | **176** | **20** | **73** | **14** | **3** | **13** | **1.8** | **8.5** | **1.6** | **4.2** | **0.6** | **4.0** | **0.6** | **16** | **38** | **461.3** |
| EPCOJE 02-54 | 39 | 83 | 9.7 | 37 | 7.3 | 2.0 | 7.1 | 1.0 | 5.4 | 1.1 | 3.0 | 0.4 | 3.0 | 0.5 | 14 | 27 | 240.5 |
| EPLUJE 05-34 | 28 | 59 | 6.8 | 25 | 4.2 | 0.7 | 3.5 | 0.6 | 3.0 | 0.6 | 2.0 | 0.3 | 2.3 | 0.4 | 10 | 17 | 163.4 |
| EPSCJE 01-58 | 38 | 83 | 9.8 | 37 | 6.8 | 1.4 | 6.2 | 0.9 | 4.6 | 0.9 | 2.8 | 0.4 | 2.8 | 0.4 | 10 | 24 | 229 |
| EPLUJE 05-21 | 40 | 83 | 9.4 | 35 | 6.4 | 1.3 | 5.9 | 0.9 | 4.9 | 1.0 | 2.8 | 0.4 | 2.8 | 0.5 | 14 | 23 | 231.3 |
| EPSCJE 01-62 | 44 | 93 | 11 | 43 | 7.6 | 1.3 | 6.6 | 0.9 | 4.8 | 0.9 | 2.7 | 0.4 | 2.9 | 0.5 | 8.6 | 28 | 256.2 |

| Sample | La | Ce | Pr | Nd | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu | Sc | Y | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EPLUJE 02-16 | 18 | 42 | 4.7 | 18 | 3.4 | 0.7 | 3.1 | 0.4 | 2.2 | 0.4 | 1.2 | 0.2 | 1.4 | 0.2 | 8.1 | 12 | 116 |
| EPSCBL06 | 39 | 94 | 9.6 | 36 | 7.0 | 1.6 | 6.9 | 1.0 | 5.2 | 1.1 | 3.2 | 0.5 | 3.1 | 0.5 | 20 | 27 | 256 |
| EPSCBL05 | 22 | 42 | 5.5 | 21 | 4.1 | 1.0 | 4.2 | 0.6 | 3.6 | 0.7 | 2.2 | 0.4 | 2.4 | 0.4 | 25 | 19 | 154 |
| EPSCBL12 | 18 | 42 | 4.5 | 17 | 3.2 | 0.7 | 2.9 | 0.4 | 2.4 | 0.5 | 1.5 | 0.3 | 1.8 | 0.3 | 14 | 16 | 126 |
| EPSCBL01 | 16 | 36 | 3.9 | 15 | 2.8 | 0.7 | 2.6 | 0.4 | 2.0 | 0.4 | 1.2 | 0.2 | 1.3 | 0.2 | 7.7 | 16 | 106 |
| EPLUJE01-11 | 20 | 44 | 4.9 | 18 | 3.3 | 0.7 | 2.9 | 0.4 | 2.2 | 0.5 | 1.4 | 0.2 | 1.5 | 0.3 | 8.1 | 17 | 125 |
| EPLUJE02-18 | 20 | 46 | 5.6 | 22 | 4.8 | 1.1 | 4.8 | 0.8 | 4.6 | 0.9 | 2.8 | 0.4 | 3.0 | 0.5 | 22 | 20 | 159 |
| WPSORE 01-12 | 20 | 43 | 4.7 | 18 | 3.3 | 0.7 | 3.0 | 0.5 | 2.4 | 0.5 | 1.4 | 0.2 | 1.4 | 0.2 | 10 | 13 | 122 |
| **WPFAN U11** | **58** | **128** | **18** | **79** | **18** | **4.2** | **22** | **3.2** | **18** | **3.6** | **9.6** | **1.3** | **7.8** | **1.1** | **22** | **97** | **491** |
| **WPFAN U13** | **35** | **97** | **16** | **81** | **26** | **6.6** | **34** | **4.9** | **25** | **4.3** | **10** | **1.2** | **6.8** | **1.0** | **34** | **109** | **492** |

***Samples containing >300 ppm REEs are in bold type.**

## 3. Compiled properties of Samples Subjected to ICP-MS Analysis

| Sample Reference Number | Sample Type | Description | Furthest Upstream Sample # |
|---|---|---|---|
| EPCALA19 | Random Spoil | Spoil from unknown location | EPCALA19 |
| EPSCLA10 | Drilling Sand | Residue from core drill at 32 feet depth | EPSCLA10 |
| EPCALA20 | Interburden | Rock with a grey sheen | EPCALA20 |
| WPCLRE02-04 | Roof rock | Grey colored rock | WPCLRE02-04 |
| EPSCLA14 | Bottom Rock | Grey colored rock | EPSCLA14 |
| WPCLRE02-02 | Washplant Fines | Particulate waste with coal | WPCLRE02-02 |
| EPSCLA01 | AMD Sludge | Relocated from mine effluent | EPSCLA01 |
| EPCALA21 | Bottom Rock | Brown colored rock | EPCALA21 |
| WPCLRE01-13 | Overburden | Grey colored rock | WPCLRE01-13 |
| EPCALA16 | Bottom Rock | Grey colored rock | EPCALA16 |
| WPWEMA06 | Reddog | Refuse | WPWEMA06 |
| EPCALA17 | Overburden | Grey colored rock | EPCALA17 |
| WPCLRE01-14 | Interburden | Grey colored rock | WPCLRE01-14 |
| EPSCLA09 | Interburden | Grey colored rock | EPSCLA09 |
| EPSCLA13 | Drilling Sand | Various colored particulate | EPSCLA13 |
| EPSCLA04 | Casting | Tree-shaped geological remnant | EPSCLA04 |
| WPCARE01-16 | Refuse | Mixed rock | WPCARE01-16 |
| WPCLRE05-02 | Floor rock | Grey colored rock | WPCLRE05-02 |
| WPCLRE06-04 | Overburden | Grey colored rock | WPCLRE06-04 |
| WPFARO03-17 | Top of Coal | Grey colored rock | WPFARO03-17 |
| WPCARO02-03 | Floor rock | Grey colored rock | WPCARO02-03 |
| WPSORE01-09 | Sandstone | Grey colored rock | WPSORE01-09 |
| WPSORE01-03 | Refuse | Shale | WPSORE01-03 |
| WPFANU04 | Top of Coal | Grey colored rock | WPFANU04 |
| WPSORE01-08 | Screen Reject | Mixed rock | WPSORE01-08 |
| WPFANU06 | Parting | Rock | WPFANU06 |
| WPSORE01-01 | Screen Reject | Mixed rock | WPSORE01-01 |
| WPINRO02-01 | Roof rock | Grey colored rock | WPINRO02-01 |
| WPFANU03 | Roof rock | Grey colored rock | WPFANU03 |
| EPLUJE05-32 | Micaceous sandstone | Conglomerate mix | EPLUJE05-32 |
| EPLUJE05-28 | Sandstone | Orange colored rock | EPLUJE05-28 |
| EPLUJE05-35 | Bottom Rock | Grey mudstone | EPLUJE05-35 |
| EPLUJE05-39 | Clay | Pottsville conglomerate | EPLUJE05-39 |
| EPSCJE05-55 | Sludge | AMD | EPSCJE05-55 |
| EPLUJE05-37 | Top Rock | Grey colored rock | EPLUJE05-37 |
| EPLUJE04-23 | Rock | Brown fine-grained rock | EPLUJE04-23 |
| EPLUJE05-29 | Sandstone | Banded | EPLUJE05-29 |
| EPSCJE02-51 | Weathered sediment | Grainy soil | EPSCJE02-51 |

| Sample Reference Number | Level 1 Attribute | Level 2 Attribute | Coal Basin | Geological Group |
|---|---|---|---|---|
| EPCALA19 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania |
| EPSCLA10 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania |
| EPCALA20 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania |
| WPCLRE02-04 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| EPSCLA14 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania |
| WPCLRE02-02 | Resource Production | Coal Separations | Northern Appalachia | Western Pennsylvania |
| EPSCLA01 | Resource Production | Other | Northern Appalachia | Eastern Pennsylvania-South |
| EPCALA21 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania-South |
| WPCLRE01-13 | Resource Production | Coal Mining | Northern Appalachia | Western PA |
| EPCALA16 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania-South |
| WPWEMA06 | Utilization | Coal Reserve | Northern Appalachia | Western Pennsylvania |
| EPCALA17 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania-South |
| WPCLRE01-14 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| EPSCLA09 | Resource Production | Coal Mining | Northern Appalachia | Eastern PA - Southern |
| EPSCLA13 | Resource Production | Coal Mining | Northern Appalachia | Eastern PA - Southern |
| EPSCLA04 | Resource Production | Coal Mining | Northern Appalachia | Eastern PA - Southern |
| WPCARE01-16 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| WPCLRE05-02 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| WPCLRE06-04 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| WPFARO03-17 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| WPCARO02-03 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| WPSORE01-09 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| WPSORE01-03 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| WPFANU04 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| WPSORE01-08 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| WPFANU06 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| WPSORE01-01 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| WPINRO02-01 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| WPFANU03 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| EPLUJE05-32 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE05-28 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE05-35 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE05-39 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPSCJE05-55 | Resource Production | Other | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE05-37 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE04-23 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE05-29 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPSCJE02-51 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |

| Sample Reference Number | Associated Coal Seam | State | County | Site |
|---|---|---|---|---|
| EPCALA19 | Unknown | PA | Carbon | Nesquehoning Township |
| EPSCLA10 | "Mammoth" | PA | Schuylkill | Tamaqua Township |
| EPCALA20 | "Primrose/Orchard" | PA | Carbon | Nesquehoning Township |
| WPCLRE02-04 | Upper Freeport | PA | Clearfield | Karthaus Township |
| EPSCLA14 | "Mammoth" | PA | Schuylkill | Coaldale Township |
| WPCLRE02-02 | Mixed production | PA | Clearfield | Karthaus Township |
| EPSCLA01 | Mixed Anthracite | PA | Schuylkill | Tamaqua Township |
| EPCALA21 | "Holmes" | PA | Carbon | Nesquehoning Township |
| WPCLRE01-13 | Upper Kittanning | PA | Clearfield | Goshen Township |
| EPCALA16 | "Orchard" | PA | Carbon | Lansford Township |
| WPWEMA06 | Pittsburgh | PA | Westmoreland | Mount Pleasant Township |
| EPCALA17 | "Orchard" | PA | Carbon | Lansford Township |
| WPCLRE01-14 | Lower Freeport-Upper Kittanning Split | PA | Clearfield | Goshen Township |
| EPSCLA09 | "Mammoth" | PA | Schuylkill | Tamaqua Township |
| EPSCLA13 | "Mammoth" | PA | Schuylkill | Coaldale Township |
| EPSCLA04 | "Mammoth" | PA | Schuylkill | Tamaqua Township |
| WPCARE01-16 | Upper Kittanning | PA | Cambria | Cambria Township |
| WPCLRE05-02 | Middle Kittanning | PA | Clearfield | Decatur Township |
| WPCLRE06-04 | Lower Kittanning | PA | Clearfield | Decatur Township |
| WPFARO03-17 | Upper Kittanning | PA | Fayette | Parks Township |
| WPCARO02-03 | Upper Kittanning | PA | Cambria | Cambria Township |
| WPSORE01-09 | Middle Kittanning | PA | Somerset | Jenner Township |
| WPSORE01-03 | Middle Kittanning | PA | Somerset | Jenner Township |
| WPFANU04 | Wild coal | PA | Fayette | North Union Tpwnship |
| WPSORE01-08 | Middle Kittanning | PA | Somerset | Jenner Township |
| WPFANU06 | Wild coal | PA | Fayette | North Union Tpwnship |
| WPSORE01-01 | Middle Kittanning | PA | Somerset | Jenner Township |
| WPINRO02-01 | Upper Freeport | PA | Indiana | Burrell Township |
| WPFANU03 | Wild coal | PA | Fayette | North Union Tpwnship |
| EPLUJE05-32 | "Mammoth" | PA | Luzerne | Foster Township |
| EPLUJE05-28 | "Mammoth" | PA | Luzerne | Foster Township |
| EPLUJE05-35 | "Mammoth" | PA | Luzerne | Foster Township |
| EPLUJE05-39 | "Mammoth" | PA | Luzerne | Foster Township |
| EPSCJE05-55 | "Mammoth" | PA | Schuylkill | Frailey Township |
| EPLUJE05-37 | "Mammoth" | PA | Luzerne | Foster Township |
| EPLUJE04-23 | "Mammoth" | PA | Luzerne | Foster Township |
| EPLUJE05-29 | "Mammoth" | PA | Luzerne | Foster Township |
| EPSCJE02-51 | "Mammoth" | PA | Schuylkill | Frailey Township |

| Sample Reference Number | Location | Size Fraction Analyzed (um) | Digestion Method |
|---|---|---|---|
| EPCALA19 | Disposal Site | <40 | HF plus nitric/perchloric acid |
| EPSCLA10 | Core Drilling | <40 | HF plus nitric/perchloric acid |
| EPCALA20 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPCLRE02-04 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| EPSCLA14 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPCLRE02-02 | Disposal Site | <40 | HF plus nitric/perchloric acid |
| EPSCLA01 | Disposal Site | <40 | HF plus nitric/perchloric acid |
| EPCALA21 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPCLRE01-13 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| EPCALA16 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPWEMA06 | Reserve | <40 | HF plus nitric/perchloric acid |
| EPCALA17 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPCLRE01-14 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| EPSCLA09 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| EPSCLA13 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| EPSCLA04 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPCARE01-16 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPCLRE05-02 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPCLRE06-04 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPFARO03-17 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPCARO02-03 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPSORE01-09 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPSORE01-03 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPFANU04 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPSORE01-08 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPFANU06 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPSORE01-01 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPINRO02-01 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| WPFANU03 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| EPLUJE05-32 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| EPLUJE05-28 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| EPLUJE05-35 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| EPLUJE05-39 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| EPSCJE05-55 | Inactive Mining Site | <40 | HF plus nitric/perchloric acid |
| EPLUJE05-37 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| EPLUJE04-23 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| EPLUJE05-29 | Active Mining Site | <40 | HF plus nitric/perchloric acid |
| EPSCJE02-51 | Active Mining Site | <40 | HF plus nitric/perchloric acid |

| Sample Reference Number | Analytical Technique | Dry Mass Basis | Element | | | | Lanthanides (ppm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sc | Y | La | Ce | Pr | Nd | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu |
| EPCALA19 | ICP-MS | Dry Mass Basis | 17 | 22 | 40 | 83 | 9.9 | 37 | 6.9 | 1.4 | 6.2 | 0.9 | 4.6 | 0.9 | 2.7 | 0.4 | 2.7 | 0.4 |
| EPSCLA10 | ICP-MS | Dry Mass Basis | 7.6 | 15 | 18 | 38 | 4.6 | 17 | 3.3 | 0.8 | 3 | 0.5 | 2.4 | 0.5 | 1.4 | 0.2 | 1.5 | 0.2 |
| EPCALA20 | ICP-MS | Dry Mass Basis | 16 | 15 | 33 | 72 | 8.6 | 34 | 6.2 | 1.3 | 5.7 | 0.8 | 4.2 | 0.9 | 2.4 | 0.4 | 2.3 | 0.4 |
| WPCLRE02-04 | ICP-MS | Dry Mass Basis | 18 | 19 | 33 | 75 | 8.9 | 31 | 6.6 | 1.4 | 6.2 | 0.9 | 4.9 | 1 | 2.7 | 0.4 | 2.7 | 0.4 |
| EPSCLA14 | ICP-MS | Dry Mass Basis | 20 | 19 | 44 | 102 | 12 | 43 | 8 | 1.6 | 7.1 | 1.1 | 5 | 1 | 2.6 | 0.4 | 2.6 | 0.4 |
| WPCLRE02-02 | ICP-MS | Dry Mass Basis | 12 | 25 | 32 | 70 | 8.2 | 32 | 6.2 | 1.4 | 6 | 0.9 | 4.6 | 0.9 | 2.4 | 0.4 | 2.3 | 0.3 |
| EPSCLA01 | ICP-MS | Dry Mass Basis | 17 | 17 | 24 | 43 | 4.9 | 19 | 3.4 | 0.7 | 3.6 | 0.5 | 2.5 | 0.5 | 1.4 | 0.2 | 1.2 | 0.2 |
| EPCALA21 | ICP-MS | Dry Mass Basis | 17 | 22 | 38 | 82 | 9.7 | 36 | 6.7 | 1.3 | 6.2 | 0.9 | 4.5 | 0.9 | 2.4 | 0.4 | 2.5 | 0.4 |
| WPCLRE01-13 | ICP-MS | Dry Mass Basis | 16 | 14 | 35 | 76 | 9.1 | 34 | 6.4 | 1.3 | 5.7 | 0.8 | 4.2 | 0.8 | 2.4 | 0.4 | 2.4 | 0.4 |
| EPCALA16 | ICP-MS | Dry Mass Basis | 23 | 14 | 30 | 65 | 7.4 | 27 | 4.9 | 1 | 4.3 | 0.6 | 3 | 0.7 | 1.9 | 0.3 | 2.2 | 0.4 |
| WPWEMA06 | ICP-MS | Dry Mass Basis | 36 | 29 | 57 | 122 | 15 | 54 | 10 | 2.1 | 9.8 | 1.4 | 7.3 | 1.4 | 3.9 | 0.6 | 3.8 | 0.6 |
| EPCALA17 | ICP-MS | Dry Mass Basis | 13 | 20 | 28 | 60 | 7.2 | 27 | 4.9 | 1 | 4.3 | 0.6 | 3.1 | 0.6 | 1.8 | 0.3 | 1.8 | 0.3 |
| WPCLRE01-14 | ICP-MS | Dry Mass Basis | 8.8 | 16 | 22 | 47 | 5.6 | 21 | 3.9 | 0.9 | 3.6 | 0.5 | 2.6 | 0.5 | 1.5 | 0.2 | 1.6 | 0.2 |
| EPSCLA09 | ICP-MS | Dry Mass Basis | 18 | 22 | 37 | 80 | 9.7 | 37 | 7.2 | 1.5 | 6.3 | 1.0 | 4.7 | 0.9 | 2.5 | 0.4 | 2.6 | 0.4 |
| EPSCLA13 | ICP-MS | Dry Mass Basis | 6.4 | 15 | 14 | 29 | 3.6 | 13 | 2.4 | 0.6 | 2.2 | 0.3 | 1.8 | 0.4 | 1.0 | 0.2 | 1.1 | 0.2 |
| EPSCLA04 | ICP-MS | Dry Mass Basis | 18 | 22 | 45 | 101 | 11 | 42 | 8.1 | 1.7 | 7.4 | 1.1 | 5.2 | 1.0 | 2.8 | 0.4 | 2.8 | 0.4 |
| WPCARE01-16 | ICP-MS | Dry Mass Basis | 13 | 21 | 36 | 75 | 8.5 | 32 | 6.0 | 1.2 | 5.5 | 0.8 | 4.2 | 0.8 | 2.3 | 0.4 | 2.2 | 0.3 |
| WPCLRE05-02 | ICP-MS | Dry Mass Basis | 14 | 16 | 18 | 50 | 4.9 | 18 | 3.6 | 0.8 | 3.3 | 0.5 | 2.9 | 0.6 | 1.8 | 0.3 | 0.9 | 0.2 |
| WPCLRE06-04 | ICP-MS | Dry Mass Basis | 16 | 15 | 20 | 45 | 5.5 | 21 | 4.2 | 0.8 | 4 | 0.6 | 3.3 | 0.7 | 2 | 0.3 | 2.1 | 0.2 |
| WPFARO03-17 | ICP-MS | Dry Mass Basis | 16 | 16 | 23 | 58 | 6.1 | 23 | 4.4 | 0.9 | 4.2 | 0.6 | 3.4 | 0.7 | 2.0 | 0.3 | 2.1 | 0.2 |
| WPCARO02-03 | ICP-MS | Dry Mass Basis | 8.2 | 25 | 21 | 45 | 5.3 | 21 | 4.8 | 1.4 | 6.9 | 1 | 4.7 | 0.9 | 2.3 | 0.3 | 1.8 | 0.2 |
| WPSORE01-09 | ICP-MS | Dry Mass Basis | 5 | 20 | 19 | 41 | 5 | 20 | 3.8 | 0.7 | 3.5 | 0.5 | 2.7 | 0.5 | 1.5 | 0.2 | 1.5 | 0.1 |
| WPSORE01-03 | ICP-MS | Dry Mass Basis | 19 | 20 | 28 | 70 | 7.8 | 29 | 6 | 1.3 | 5.9 | 0.9 | 4.6 | 1 | 2.6 | 0.4 | 2.6 | 0.3 |
| WPFANU04 | ICP-MS | Dry Mass Basis | 18 | 22 | 41 | 98 | 11 | 43 | 7.6 | 1.6 | 7 | 1 | 5 | 1 | 2.5 | 0.4 | 2.5 | 0.2 |
| WPSORE01-08 | ICP-MS | Dry Mass Basis | 15 | 19 | 26 | 55 | 6.8 | 26 | 4.8 | 1 | 4.7 | 0.7 | 4.2 | 0.8 | 2.4 | 0.4 | 2.3 | 0.3 |
| WPFANU06 | ICP-MS | Dry Mass Basis | 14 | 15 | 22 | 50 | 5.4 | 19 | 3.6 | 0.8 | 3.3 | 0.5 | 2.9 | 0.6 | 1.8 | 0.3 | 1.9 | 0.2 |
| WPSORE01-01 | ICP-MS | Dry Mass Basis | 16 | 16 | 23 | 54 | 6.4 | 24 | 4.7 | 1 | 4.3 | 0.7 | 3.5 | 0.8 | 2.1 | 0.4 | 2.2 | 0.3 |
| WPINRO02-01 | ICP-MS | Dry Mass Basis | 16 | 17 | 30 | 70 | 7.8 | 29 | 5.5 | 1.2 | 5 | 0.7 | 3.8 | 0.7 | 2.1 | 0.3 | 2.1 | 0.2 |
| WPFANU03 | ICP-MS | Dry Mass Basis | 19 | 22 | 41 | 87 | 10 | 38 | 7 | 1.4 | 6.5 | 0.9 | 4.8 | 1 | 2.7 | 0.4 | 2.8 | 0.3 |
| EPLUJE05-32 | ICP-MS | Dry Mass Basis | 7.6 | 34 | 29 | 63 | 7.4 | 29 | 5.9 | 0.9 | 4.2 | 0.7 | 3.2 | 0.6 | 1.7 | 0.3 | 1.8 | 0.3 |
| EPLUJE05-28 | ICP-MS | Dry Mass Basis | 11 | 26 | 40 | 88 | 11 | 41 | 8.1 | 1.7 | 6.8 | 1 | 4.8 | 0.9 | 2.4 | 0.4 | 2.5 | 0.4 |
| EPLUJE05-35 | ICP-MS | Dry Mass Basis | 9.3 | 23 | 31 | 63 | 7.3 | 27 | 4.7 | 0.8 | 3.8 | 0.6 | 3.1 | 0.7 | 2.1 | 0.4 | 2.4 | 0.4 |
| EPLUJE05-39 | ICP-MS | Dry Mass Basis | 7.9 | 22 | 26 | 62 | 6.5 | 24 | 4.5 | 0.9 | 4.1 | 0.7 | 3.5 | 0.7 | 2 | 0.3 | 2 | 0.3 |
| EPSCJE05-55 | ICP-MS | Dry Mass Basis | 4.4 | 30 | 25 | 50 | 6.1 | 24 | 4.7 | 1 | 5.5 | 0.9 | 4.8 | 1 | 2.7 | 0.4 | 2.3 | 0.4 |
| EPLUJE05-37 | ICP-MS | Dry Mass Basis | 10 | 24 | 36 | 74 | 8.6 | 32 | 5.5 | 1 | 4.5 | 0.7 | 3.6 | 0.7 | 2.3 | 0.4 | 2.7 | 0.5 |
| EPLUJE04-23 | ICP-MS | Dry Mass Basis | 19 | 47 | 58 | 124 | 16 | 62 | 13 | 2.7 | 12 | 1.8 | 9.7 | 1.9 | 5.5 | 0.8 | 5.4 | 0.8 |
| EPLUJE05-29 | ICP-MS | Dry Mass Basis | 5.6 | 20 | 22 | 47 | 5.5 | 21 | 3.9 | 0.9 | 3.3 | 0.5 | 2.3 | 0.4 | 1.3 | 0.2 | 1.4 | 0.2 |
| EPSCJE02-51 | ICP-MS | Dry Mass Basis | 13 | 34 | 40 | 82 | 9.8 | 37 | 7.1 | 1.3 | 7 | 1.1 | 6.2 | 1.3 | 3.7 | 0.6 | 3.7 | 0.6 |

| Sample Reference Number | Total REE (ppm) | Total REE+Sc+Y | Secondary Analytical Technique | Secondary Digestion Technique |
|---|---|---|---|---|
| EPCALA19 | 197.0 | 236.0 | XRF | N/A |
| EPSCLA10 | 91.4 | 114.0 | XRF | N/A |
| EPCALA20 | 172.2 | 203.2 | XRF | N/A |
| WPCLRE02-04 | 175.1 | 212.1 | XRF | N/A |
| EPSCLA14 | 230.8 | 269.8 | XRF | N/A |
| WPCLRE02-02 | 167.6 | 204.6 | XRF | N/A |
| EPSCLA01 | 105.1 | 139.1 | XRF | N/A |
| EPCALA21 | 191.9 | 230.9 | XRF | N/A |
| WPCLRE01-13 | 178.9 | 208.9 | XRF | N/A |
| EPCALA16 | 148.7 | 185.7 | XRF | N/A |
| WPWEMA06 | 288.9 | 353.9 | XRF | N/A |
| EPCALA17 | 140.9 | 173.9 | XRF | N/A |
| WPCLRE01-14 | 111.1 | 135.9 | XRF | N/A |
| EPSCLA09 | 191.2 | 231.2 | XRF | N/A |
| EPSCLA13 | 69.8 | 91.2 | XRF | N/A |
| EPSCLA04 | 229.9 | 269.9 | XRF | N/A |
| WPCARE01-16 | 175.2 | 209.2 | XRF | N/A |
| WPCLRE05-02 | 105.8 | 135.8 | XRF | N/A |
| WPCLRE06-04 | 109.7 | 140.7 | XRF | N/A |
| WPFARO03-17 | 128.9 | 160.9 | XRF | N/A |
| WPCARO02-03 | 116.6 | 149.8 | XRF | N/A |
| WPSORE01-09 | 100.0 | 125.0 | XRF | N/A |
| WPSORE01-03 | 160.4 | 199.4 | XRF | N/A |
| WPFANU04 | 221.8 | 261.8 | XRF | N/A |
| WPSORE01-08 | 135.4 | 169.4 | XRF | N/A |
| WPFANU06 | 112.3 | 141.3 | XRF | N/A |
| WPSORE01-01 | 127.4 | 159.4 | XRF | N/A |
| WPINRO02-01 | 158.4 | 191.4 | XRF | N/A |
| WPFANU03 | 203.8 | 244.8 | XRF | N/A |
| EPLUJE05-32 | 148.0 | 189.6 | XRF | N/A |
| EPLUJE05-28 | 209.0 | 246.0 | XRF | N/A |
| EPLUJE05-35 | 147.3 | 179.6 | XRF | N/A |
| EPLUJE05-39 | 137.5 | 167.4 | XRF | N/A |
| EPSCJE05-55 | 128.8 | 163.2 | XRF | N/A |
| EPLUJE05-37 | 172.5 | 206.5 | XRF | N/A |
| EPLUJE04-23 | 313.6 | 379.6 | XRF | N/A |
| EPLUJE05-29 | 109.9 | 135.5 | XRF | N/A |
| EPSCJE02-51 | 201.4 | 248.4 | XRF | N/A |

| Sample Reference Number | Secondary Elemental Identification Results (ppm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ca | Fe | K | Ti | Zr | Sn | Ba | Nb | Th | U | S2 |
| EPCALA19 | 1249 | 31729 | 15779 | 4599 | 261 | BDL | 367 | 14.5 | 8.44 | BDL | BDL |
| EPSCLA10 | 2509 | 17277 | 14624 | 2735 | 174 | BDL | 315 | 6.22 | 4.67 | BDL | BDL |
| EPCALA20 | 1441 | 63379 | 21114 | 4438 | 234 | BDL | 587 | 12.69 | 10.12 | BDL | 36561 |
| WPCLRE02-04 | 1909 | 35435 | 7462 | 3057 | 98 | BDL | 73 | 10.43 | 5.3 | BDL | 31952 |
| EPSCLA14 | 959 | 26448 | 20575 | 6244 | 279 | BDL | 840 | 20.61 | 11.4 | BDL | BDL |
| WPCLRE02-02 | 5120 | 80499 | 9127 | 4390 | 122 | BDL | 495 | 8.5 | 5.45 | BDL | 62937 |
| EPSCLA01 | 242651 | 31984 | 3616 | BDL | 78 | BDL | 104 | 4.37 | BDL | BDL | 7643 |
| EPCALA21 | 1326 | 14904 | 19164 | 6163 | 372 | 11.58 | 430 | 18.68 | 8.06 | BDL | BDL |
| WPCLRE01-13 | 4150 | 38284 | 16114 | 6667 | 352 | BDL | 381 | 17.14 | 5.62 | BDL | 6415 |
| EPCALA16 | 1253 | 29874 | 27738 | 5528 | 257 | 14.46 | 638 | 17.61 | 10.97 | BDL | BDL |
| WPWEMA06 | 1814 | 68822 | 12859 | 5519 | 290 | 35.75 | 526 | 20.41 | 11.27 | BDL | 21924 |
| EPCALA17 | 3431 | 28724 | 18833 | 4274 | 277 | BDL | 381 | 11.72 | 7.14 | BDL | 5841 |
| WPCLRE01-14 | 2282 | 20467 | 15580 | 2903 | 214 | BDL | 386 | 9.27 | BDL | BDL | 3702 |
| EPSCLA09 | 1253 | 29874 | 27738 | 5528 | 257 | 14.46 | 638 | 17.61 | 10.97 | BDL | BDL |
| EPSCLA13 | 1142 | 67833 | 16181 | 6476 | 243 | 14.16 | 502 | 38.28 | 16.34 | BDL | 26089 |
| EPSCLA04 | 3431 | 28724 | 18833 | 4274 | 277 | BDL | 381 | 11.72 | 7.14 | BDL | 5841 |
| WPCARE01-16 | 128956 | 27520 | 4650 | 2051 | 127 | BDL | 240 | 9.26 | 4.77 | BDL | 61569 |
| WPCLRE05-02 | 4756 | 45691 | 16204 | 4914 | 300 | BDL | 429 | 14.79 | 5.26 | BDL | BDL |
| WPCLRE06-04 | 14814 | 68919 | 17397 | 3380 | 189 | BDL | 498 | 12.35 | 5.37 | BDL | BDL |
| WPFARO03-17 | 5105 | 57482 | 17432 | 1965 | 244 | BDL | 415 | 6.77 | 7.75 | 5.72 | BDL |
| WPCARO02-03 | 211917 | 28727 | 9055 | 2947 | 82 | BDL | 405 | 6.77 | 2.74 | BDL | 18412 |
| WPSORE01-09 | 37512 | 29617 | 5823 | 3624 | 262 | BDL | 232 | 6.88 | 2.35 | BDL | 5461 |
| WPSORE01-03 | 16288 | 53143 | 19302 | 4817 | 150 | BDL | 500 | 12.83 | 8.88 | BDL | 23503 |
| WPFANU04 | 6137 | 25381 | 10403 | 5796 | 227 | BDL | 589 | 16.66 | 12.34 | 8.08 | 8072 |
| WPSORE01-08 | 36081 | 53185 | 12734 | 4594 | 164 | BDL | 357 | 11.84 | 5.51 | BDL | 24419 |
| WPFANU06 | 1830 | 39462 | 12553 | 5616 | 214 | BDL | 381 | 18.84 | 8.29 | BDL | 10409 |
| WPSORE01-01 | 4407 | 31058 | 12991 | 4852 | 185 | BDL | 207 | 13.74 | 8.11 | BDL | 15765 |
| WPINRO02-01 | 2316 | 56522 | 19910 | 5113 | 184 | BDL | 611 | `15.13 | 6.09 | BDL | BDL |
| WPFANU03 | 4539 | 48945 | 12794 | 5243 | 200 | BDL | 391 | 16.33 | 10.78 | 2.86 | 8540 |
| EPLUJE05-32 | 803 | 13879 | 10509 | 5002 | 465 | BDL | 301 | 1306 | 6.45 | BDL | BDL |
| EPLUJE05-28 | 1244 | 21359 | 18024 | 5064 | 424 | BDL | 410 | 13.9 | 7.08 | BDL | BDL |
| EPLUJE05-35 | 994 | 11721 | 17171 | 6027 | 651 | BDL | 464 | 18.74 | 7.88 | BDL | BDL |
| EPLUJE05-39 | 1124 | 32038 | 9887 | 4123 | 329 | BDL | 260 | 12.57 | 6.48 | BDL | BDL |
| EPSCJE05-55 | 2987 | 280104 | 4979 | BDL | 153 | BDL | 394 | 3.53 | BDL | BDL | BDL |
| EPLUJE05-37 | 1346 | 5166 | 17377 | 6281 | 708 | BDL | 392 | 19.06 | 9.24 | BDL | BDL |
| EPLUJE04-23 | 1192 | 55830 | 24011 | 5887 | 240 | BDL | 765 | 16.94 | 9.18 | BDL | BDL |
| EPLUJE05-29 | 1190 | 10705 | 12971 | 3285 | 213 | BDL | 266 | 10.67 | 4.69 | BDL | BDL |
| EPSCJE02-51 | 1684 | 24287 | 12647 | 5372 | 482 | BDL | 363 | 16.68 | 8.37 | 2.81 | BDL |

| Sample Reference Number | Notes |
|---|---|
| EPCALA19 | Sr, Rb, As, Pb, Ta, Hf, Co, Mn detected |
| EPSCLA10 | Sr, Rb, Pb detected |
| EPCALA20 | Mo, Sr, Rb, As, Pb, Co, Mn, Ta, Hf detected |
| WPCLRE02-04 | Mo, Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| EPSCLA14 | Nb, Sr, Rb, As, Pb, Ta, Co, Mn detected |
| WPCLRE02-02 | Mo. Sr, Rb, As, Pb, Ta, Hf, Co, Mn detected |
| EPSCLA01 | Sr, Rb, W, Hf, Ni, Co, Mn detected |
| EPCALA21 | Sr, Rb, As, Pb, Co, Mn, Hf detected |
| WPCLRE01-13 | Sr, Rb, Mn detected |
| EPCALA16 | Sr, Rb, As, Pb, Re, Ta, Hf, Co, Mn deected |
| WPWEMA06 | Mo, Sr, As, Rb, Pb, Ni, Co, Mn, Cr, V detected |
| EPCALA17 | Sr, Rb, As, Pb, Ta, Hf, Co, Mn detected |
| WPCLRE01-14 | Sr, Rb, As, Pb, Co, Mn detected |
| EPSCLA09 | Sr, Rb, As, Pb, Re, Ta, Hf, Co, Mn present |
| EPSCLA13 | Sr, Rb, Pb, As, Zn, Cu, Ni, Cr, V, Cs present |
| EPSCLA04 | Sr, Rb, As, Pb, Ta, Hf, Co, Mn present |
| WPCARE01-16 | Mo, Sr. Rb, As, Pb, Zn, Cu, Co, Mn detected |
| WPCLRE05-02 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| WPCLRE06-04 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| WPFARO03-17 | Mo, Sr, Rb, As, Pb, W, Zn, Cu, Ni, Co, Mn detected, |
| WPCARO02-03 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| WPSORE01-09 | Mo, Sr, Rb, As, Pb, Zn, Mn detected |
| WPSORE01-03 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| WPFANU04 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| WPSORE01-08 | Mo, Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| WPFANU06 | Mo, Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| WPSORE01-01 | Mo, Sr, Rb, Sas, Pb, Zn, Cu, Co, Mn detected |
| WPINRO02-01 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| WPFANU03 | Mo, Sr, Rb, As, Pb, Z, Cu, Ni, Co, Mn detected |
| EPLUJE05-32 | Mo, Sr, Rb, As, Pb, Zn, Co, Mn detected |
| EPLUJE05-28 | Mo, Sr, Rb, As, Pb, Zn, Co, Mn detected |
| EPLUJE05-35 | Sr, Rb, As, Pb, Cu. Co, Mn detected |
| EPLUJE05-39 | Mo, Sr, Rb, As, Pb, Zn, Cu, Mn detected |
| EPSCJE05-55 | Sr, Rb, As, Pb, Zn, Ni, Mn detected |
| EPLUJE05-37 | Mo, Sr, Rb, As, Pb, Co, Mn detected |
| EPLUJE04-23 | Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| EPLUJE05-29 | Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| EPSCJE02-51 | Mo, Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |

## 3. Compiled properties of Samples Subjected to ICP-MS Analysis (cont.)

| Sample Reference Number | Sample Type | Description | Furthest Upstream Sample # |
|---|---|---|---|
| EPLUJE03-07 | Mudstone | Grey colored rock | EPLUJE03-07 |
| EPSCJE01-56 | Bottom Rock | Grey colored rock | EPSCJE01-56 |
| EPLUJE01-12 | Shale | Grey colored rock | EPLUJE01-12 |
| EPLUJE05-27 | Sandstone | Red colored stone | EPLUJE05-27 |
| EPLUJE05-33 | Bottom Rock | Grey Sandstone | EPLUJE05-33 |
| EPLUJE01-13 | Conglomerate | Various colored rock | EPLUJE01-13 |
| EPSCBL10 | Overburden | Shiny Grey colored rock | EPSCBL10 |
| EPSCBL22 | Top Rock | Grey colored rock | EPSCBL22 |
| EPLUJE03-08 | Bottom Rock | Grey colored rock | EPLUJE03-08 |
| EPLUJE02-20 | Sandstone | Conglomerate mix | EPLUJE02-20 |
| EPCOJE01-48 | Bottom Rock | Grey Sandstone | EPCOJE01-48 |
| EPLUJE04-01 | Refuse | Mixed rock | EPLUJE04-01 |
| EPSCBL25 | Breaker Refuse | Mixed rock | EPSCBL25 |
| EPLUJE01-09 | Drilling Sand | Fine particulate matter | EPLUJE01-09 |
| EPCOBL08 | Overburden | Grey colored rock | EPSCBL08 |
| EPCOJE01-47 | Shale | Fine grained with organic fossils | EPCOJE01-47 |
| EPCOJE01-50 | Shale | Fine grained with organic fossils | EPCOJE01-50 |
| EPSCBL18 | Bottom Rock | Grey colored rock | EPSCBL18 |
| WPWERO01-07 | Core | Grey colored rock floor | WPWERO01-07 |
| EPLUBL21 | Bottom Rock | Grey colored rock | EPLUBL21 |
| EPLUBL24 | Bottom Split | Grey colored rock | EPLUBL24 |
| EPSCBL03 | Top Rock | Grey colored rock | EPSCBL03 |
| EPLUJE02-15 | Top Rock | "mudstone" | EPLUJE02-15 |
| EPCOJE02-54 | Overburden | Grey colored rock | EPCOJE07-54 |
| EPLUJE05-34 | Bottom Rock | Grey colored rock | EPLUJE05-34 |
| EPSCJE01-58 | Sandstone | Fine grained grey rock | EPSCJE01-58 |
| EPLUJE05-21 | Shale | Black colored | EPSCJE05-21 |
| EPSCJE01-62 | Sandstone | Fine grained grey rock | EPSCJE01-62 |
| EPLUJE02-16 | Micaceous sandstone | Grey colored rock | EPLUJE02-16 |
| EPSCBL06 | Interburden | Middle-Bottom rock | EPSCBL06 |
| EPSCBL05 | Interburden | Top-Middle rock | EPSCBL05 |
| EPSCBL12 | Breaker Refuse | Mixed rock | EPSCBL12 |
| EPSCBL01 | Drilling Sand | Fine particulate matter | EPSCBL01 |
| EPLUJE01-11 | Sandstone | Orange-grey color | EPLUJE01-11 |
| EPLUJE02-18 | Bottom Rock | | EPLUJE02-18 |
| WPSORE01-12 | Pond sludge | yellow collored sediment | WPSORE01-12 |
| WPFANU11 | Fire Clay | Grey colored sediment | WPFANU11 |
| WPFANU13 | Fire Clay | Grey colored sediment | WPFANU13 |

| Sample Reference Number | Level 1 Attribute | Level 2 Attribute | Coal Basin | Geological Group |
|---|---|---|---|---|
| EPLUJE03-07 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPSCJE01-56 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE01-12 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE05-27 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE05-33 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE01-13 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPSCBL10 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - south |
| EPSCBL22 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - south |
| EPLUJE03-08 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE02-20 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPCOJE01-48 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE04-01 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPSCBL25 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania-South |
| EPLUJE01-09 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPCOBL08 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - south |
| EPCOJE01-47 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPCOJE01-50 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPSCBL18 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - south |
| WPWERO01-07 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| EPLUBL21 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - south |
| EPLUBL24 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - south |
| EPSCBL03 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - south |
| EPLUJE02-15 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPC0JE02-54 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE05-34 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPSCJE01-58 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE05-21 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPSCJE01-62 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE02-16 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPSCBL06 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - south |
| EPSCBL05 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - south |
| EPSCBL12 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - south |
| EPSCBL01 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - south |
| EPLUJE01-11 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| EPLUJE02-18 | Resource Production | Coal Mining | Northern Appalachia | Eastern Pennsylvania - north |
| WPSORE01-12 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| WPFANU11 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |
| WPFANU13 | Resource Production | Coal Mining | Northern Appalachia | Western Pennsylvania |

| Sample Reference Number | Associated Coal Seam | State | County | Site |
|---|---|---|---|---|
| EPLUJE03-07 | "Mammoth" | PA | Luzerne | Hazle Township |
| EPSCJE01-56 | "Mammoth" | PA | Schuylkill | Norwegian Township |
| EPLUJE01-12 | "Mammoth" | PA | Luzerne | Hazle Township |
| EPLUJE05-27 | "Mammoth" | PA | Luzerne | Foster Township |
| EPLUJE05-33 | "Mammoth" | PA | Luzerne | Foster Township |
| EPLUJE01-13 | "Mammoth" | PA | Luzerne | Hazle Township |
| EPSCBL10 | "Buck" | PA | Schuylkill | Conyngham Township |
| EPSCBL22 | "Mammoth" | PA | Luzerne | Hazle Township |
| EPLUJE03-08 | "Mammoth" | PA | luzerne | Hazle Township |
| EPLUJE02-20 | "Mammoth" | PA | Luzerne | Hazle Township |
| EPCOJE01-48 | "Mammoth" | PA | Columbia | Conyngham Township |
| EPLUJE04-01 | "Mammoth" | PA | Luzerne | Paint Township |
| EPSCBL25 | Mixed | PA | Schuylkill | Hazle Township |
| EPLUJE01-09 | "Mammoth" | PA | Luzerne | Hazle Township |
| EPCOBL08 | "Buck" | PA | Columbia | Conyngham Township |
| EPCOJE01-47 | "Mammoth" | PA | Columbia | Conyngham Township |
| EPCOJE01-50 | "Mammoth" | PA | Columbia | Conyngham Township |
| EPSCBL18 | "Buck" | PA | Schuylkill | Mahanoy Township |
| WPWERO01-07 | Middle Kittanning | PA | Westmoreland | Derry Township |
| EPLUBL21 | "Mammoth" | PA | Luzerne | Hazle Township |
| EPLUBL24 | "Holmes" | PA | Luzerne | Hazle Township |
| EPSCBL03 | "Mammoth" | PA | Schuylkill | Mahanoy Township |
| EPLUJE02-15 | "Mammoth" | PA | Luzerne | Hazle Township |
| EPC0JE02-54 | "Mammoth" | PA | Schuylkill | Frailey Township |
| EPLUJE05-34 | "Mammoth" | PA | Luzerne | Foster Township |
| EPSCJE01-58 | "Mammoth" | PA | Schuylkill | Norwegian Township |
| EPLUJE05-21 | "Mammoth" | PA | Luzerne | Foster Township |
| EPSCJE01-62 | "Mammoth" | PA | Schuylkill | Norwegian Township |
| EPLUJE02-16 | "Mammoth" | PA | Luzerne | Hazle Township |
| EPSCBL06 | "Primrose" | PA | Schuylkill | Mahanoy Township |
| EPSCBL05 | "Primrose" | PA | Schuylkill | Mahanoy Township |
| EPSCBL12 | Mixed | PA | Schuylkill | Mahanoy Township |
| EPSCBL01 | "Mammoth" | PA | Schuylkill | Mahanoy Township |
| EPLUJE01-11 | "Mammoth" | PA | Luzerne | Hazle Township |
| EPLUJE02-18 | "Mammoth" | PA | Luzerne | Hazle Township |
| WPSORE01-12 | Mixed | PA | Somerset | Jenner Township |
| WPFANU11 | Pittsburgh | PA | Fayette | North Union Tpwnship |
| WPFANU13 | Pittsburgh | PA | Fayette | North Union Tpwnship |

| Sample Reference Number | Location | Size Fraction Analyzed (um) | Digestion Method |
|---|---|---|---|
| EPLUJE03-07 | EPLUJE03-07 | <40 | HF plus nitric/perchloric acid |
| EPSCJE01-56 | EPSCJE01-56 | <40 | HF plus nitric/perchloric acid |
| EPLUJE01-12 | EPLUJE01-12 | <40 | HF plus nitric/perchloric acid |
| EPLUJE05-27 | EPLUJE05-27 | <40 | HF plus nitric/perchloric acid |
| EPLUJE05-33 | EPLUJE05-33 | <40 | HF plus nitric/perchloric acid |
| EPLUJE01-13 | EPLUJE01-13 | <40 | HF plus nitric/perchloric acid |
| EPSCBL10 | EPSCBL10 | <40 | HF plus nitric/perchloric acid |
| EPSCBL22 | EPSCBL22 | <40 | HF plus nitric/perchloric acid |
| EPLUJE03-08 | EPLUJE03-08 | <40 | HF plus nitric/perchloric acid |
| EPLUJE02-20 | EPLUJE02-20 | <40 | HF plus nitric/perchloric acid |
| EPCOJE01-48 | EPCOJE01-48 | <40 | HF plus nitric/perchloric acid |
| EPLUJE04-01 | EPLUJE04-01 | <40 | HF plus nitric/perchloric acid |
| EPSCBL25 | EPSCBL25 | <40 | HF plus nitric/perchloric acid |
| EPLUJE01-09 | EPLUJE01-09 | <40 | HF plus nitric/perchloric acid |
| EPCOBL08 | EPCOBL08 | <40 | HF plus nitric/perchloric acid |
| EPCOJE01-47 | EPCOJE01-47 | <40 | HF plus nitric/perchloric acid |
| EPCOJE01-50 | EPCOJE01-50 | <40 | HF plus nitric/perchloric acid |
| EPSCBL18 | EPSCBL18 | <40 | HF plus nitric/perchloric acid |
| WPWERO01-07 | WPWERO01-07 | <40 | HF plus nitric/perchloric acid |
| EPLUBL21 | EPLUBL21 | <40 | HF plus nitric/perchloric acid |
| EPLUBL24 | EPLUBL24 | <40 | HF plus nitric/perchloric acid |
| EPSCBL03 | EPSCBL03 | <40 | HF plus nitric/perchloric acid |
| EPLUJE02-15 | EPLUJE02-15 | <40 | HF plus nitric/perchloric acid |
| EPC0JE02-54 | EPC0JE02-54 | <40 | HF plus nitric/perchloric acid |
| EPLUJE05-34 | EPLUJE05-34 | <40 | HF plus nitric/perchloric acid |
| EPSCJE01-58 | EPSCJE01-58 | <40 | HF plus nitric/perchloric acid |
| EPLUJE05-21 | EPLUJE05-21 | <40 | HF plus nitric/perchloric acid |
| EPSCJE01-62 | EPSCJE01-62 | <40 | HF plus nitric/perchloric acid |
| EPLUJE02-16 | EPLUJE02-16 | <40 | HF plus nitric/perchloric acid |
| EPSCBL06 | EPSCBL06 | <40 | HF plus nitric/perchloric acid |
| EPSCBL05 | EPSCBL05 | <40 | HF plus nitric/perchloric acid |
| EPSCBL12 | EPSCBL12 | <40 | HF plus nitric/perchloric acid |
| EPSCBL01 | EPSCBL01 | <40 | HF plus nitric/perchloric acid |
| EPLUJE01-11 | EPLUJE01-11 | <40 | HF plus nitric/perchloric acid |
| EPLUJE02-18 | EPLUJE02-18 | <40 | HF plus nitric/perchloric acid |
| WPSORE01-12 | WPSORE01-12 | <40 | HF plus nitric/perchloric acid |
| WPFANU11 | WPFANU11 | <40 | HF plus nitric/perchloric acid |
| WPFANU13 | WPFANU13 | <40 | HF plus nitric/perchloric acid |

| Sample Reference Number | Analytical Technique | Dry Mass Basis | Element | | Lanthanides (ppm) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sc | Y | La | Ce | Pr | Nd | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu |
| EPLUJE03-07 | ICP-MS | Dry Mass Basis | 15 | 28 | 44 | 95 | 11 | 41 | 7.7 | 1.6 | 7.3 | 1.1 | 5.9 | 1.1 | 3.3 | 0.5 | 3.2 | 0.5 |
| EPSCJE01-56 | ICP-MS | Dry Mass Basis | 17 | 27 | 51 | 109 | 13 | 49 | 9 | 1.6 | 7.9 | 1.2 | 5.8 | 1.2 | 3.3 | 0.5 | 3.4 | 0.5 |
| EPLUJE01-12 | ICP-MS | Dry Mass Basis | 15 | 35 | 54 | 114 | 15 | 52 | 10 | 2.2 | 9.5 | 1.4 | 7 | 1.3 | 3.8 | 0.6 | 3.9 | 0.6 |
| EPLUJE05-27 | ICP-MS | Dry Mass Basis | 13 | 30 | 57 | 121 | 15 | 56 | 10 | 2.4 | 9.2 | 1.3 | 6.4 | 1.2 | 3.3 | 0.5 | 3.3 | 0.5 |
| EPLUJE05-33 | ICP-MS | Dry Mass Basis | 1.1 | 24 | 19 | 71 | 4.9 | 19 | 3.5 | 0.5 | 2.9 | 0.4 | 1.9 | 0.4 | 1.1 | 0.2 | 1.1 | 0.2 |
| EPLUJE01-13 | ICP-MS | Dry Mass Basis | 4.2 | 20 | 17 | 40 | 4.2 | 16 | 2.8 | 0.7 | 2.5 | 0.4 | 2 | 0.4 | 1.1 | 0.2 | 1.2 | 0.2 |
| EPSCBL10 | ICP-MS | Dry Mass Basis | 8.4 | 32 | 43 | 95 | 11 | 43 | 8.4 | 1.5 | 7.2 | 1.1 | 5.8 | 1.2 | 3.2 | 0.5 | 3.2 | 0.5 |
| EPSCBL22 | ICP-MS | Dry Mass Basis | 14 | 30 | 41 | 91 | 10 | 40 | 7.8 | 1.6 | 7.4 | 1.1 | 6 | 1.2 | 3.3 | 0.5 | 3.1 | 0.5 |
| EPLUJE03-08 | ICP-MS | Dry Mass Basis | 20 | 35 | 58 | 125 | 15 | 56 | 11 | 2.3 | 9.7 | 1.4 | 7.1 | 1.4 | 3.9 | 0.6 | 3.9 | 0.6 |
| EPLUJE02-20 | ICP-MS | Dry Mass Basis | 3.8 | 16 | 16 | 39 | 3.9 | 14 | 2.6 | 0.6 | 2.2 | 0.3 | 1.8 | 0.4 | 1 | 0.2 | 1.1 | 0.2 |
| EPCOJE01-48 | ICP-MS | Dry Mass Basis | 2.6 | 28 | 17 | 39 | 4.1 | 16 | 2.9 | 0.7 | 2.7 | 0.4 | 2.1 | 0.4 | 1.2 | 0.2 | 1.1 | 0.2 |
| EPLUJE04-01 | ICP-MS | Dry Mass Basis | 13 | 23 | 35 | 73 | 8.5 | 32 | 6.1 | 1.3 | 5.5 | 0.8 | 4.3 | 0.9 | 2.5 | 0.4 | 2.5 | 0.4 |
| EPSCBL25 | ICP-MS | Dry Mass Basis | 14 | 26 | 37 | 79 | 9.4 | 35 | 7 | 1.4 | 6.3 | 0.9 | 4.9 | 1 | 2.8 | 0.4 | 2.8 | 0.4 |
| EPLUJE01-09 | ICP-MS | Dry Mass Basis | 9.2 | 20 | 27 | 60 | 6.6 | 25 | 4.9 | 1 | 4.3 | 0.7 | 3.2 | 0.7 | 1.8 | 0.3 | 2 | 0.3 |
| EPCOBL08 | ICP-MS | Dry Mass Basis | 4.7 | 19 | 15 | 34 | 3.9 | 15 | 3.1 | 0.8 | 3 | 0.5 | 2.4 | 0.5 | 1.4 | 0.2 | 1.5 | 0.2 |
| EPCOJE01-47 | ICP-MS | Dry Mass Basis | 14 | 31 | 40 | 77 | 9.4 | 35 | 7.7 | 1.6 | 6.8 | 1 | 5.3 | 1.1 | 3.4 | 0.5 | 3.8 | 0.6 |
| EPCOJE01-50 | ICP-MS | Dry Mass Basis | 19 | 35 | 55 | 117 | 20 | 73 | 8.1 | 1.2 | 7.2 | 1.2 | 7 | 1.4 | 4.2 | 0.6 | 4.2 | 0.6 |
| EPSCBL18 | ICP-MS | Dry Mass Basis | 14 | 23 | 39 | 84 | 9.9 | 37 | 6.6 | 1.3 | 5.9 | 0.9 | 2.7 | 0.4 | 4.5 | 0.9 | 2.9 | 0.4 |
| WPWERO01-07 | ICP-MS | Dry Mass Basis | 21 | 26 | 67 | 130 | 14 | 47 | 8.1 | 1.8 | 7.7 | 1.1 | 5.1 | 1 | 2.9 | 0.5 | 3 | 0.5 |
| EPLUBL21 | ICP-MS | Dry Mass Basis | 14 | 32 | 41 | 88 | 10 | 40 | 7.9 | 1.7 | 7.7 | 1.1 | 5.8 | 1.1 | 3.2 | 0.5 | 3.2 | 0.5 |
| EPLUBL24 | ICP-MS | Dry Mass Basis | 15 | 27 | 39 | 90 | 10 | 38 | 7.3 | 1.6 | 6.9 | 1.1 | 5.6 | 1.1 | 3.1 | 0.4 | 3.1 | 0.5 |
| EPSCBL03 | ICP-MS | Dry Mass Basis | 5.6 | 16 | 22 | 48 | 5.5 | 21 | 3.9 | 1 | 3.3 | 0.5 | 2.4 | 0.5 | 1.4 | 0.3 | 1.4 | 0.3 |
| EPLUJE02-15 | ICP-MS | Dry Mass Basis | 16 | 38 | 87 | 176 | 20 | 73 | 14 | 3 | 13 | 1.8 | 8.5 | 1.6 | 4.2 | 0.6 | 4 | 0.6 |
| EPCOJE02-54 | ICP-MS | Dry Mass Basis | 14 | 27 | 39 | 83 | 9.7 | 37 | 7.3 | 2 | 7.1 | 1 | 5.4 | 1.1 | 3 | 0.4 | 3 | 0.5 |
| EPLUJE05-34 | ICP-MS | Dry Mass Basis | 10 | 17 | 28 | 59 | 6.8 | 25 | 4.2 | 0.7 | 3.5 | 0.6 | 3 | 0.6 | 2 | 0.3 | 2.3 | 0.4 |
| EPSCJE01-58 | ICP-MS | Dry Mass Basis | 10 | 24 | 38 | 83 | 9.8 | 37 | 6.8 | 1.4 | 6.2 | 0.9 | 4.6 | 0.9 | 2.8 | 0.4 | 2.8 | 0.4 |
| EPLUJE05-21 | ICP-MS | Dry Mass Basis | 14 | 23 | 40 | 83 | 9.4 | 35 | 6.4 | 1.3 | 5.9 | 0.9 | 4.9 | 1 | 2.8 | 0.4 | 2.8 | 0.5 |
| EPSCJE01-62 | ICP-MS | Dry Mass Basis | 8.6 | 28 | 44 | 93 | 11 | 43 | 7.6 | 1.3 | 6.6 | 0.9 | 4.8 | 0.9 | 2.7 | 0.4 | 2.9 | 0.5 |
| EPLUJE02-16 | ICP-MS | Dry Mass Basis | 8.1 | 12 | 18 | 42 | 4.7 | 18 | 3.4 | 0.7 | 3.1 | 0.4 | 2.2 | 0.4 | 1.2 | 0.2 | 1.4 | 0.2 |
| EPSCBL06 | ICP-MS | Dry Mass Basis | 20 | 27 | 39 | 94 | 9.6 | 36 | 7 | 1.6 | 6.9 | 1 | 5.2 | 1.1 | 3.2 | 0.5 | 3.1 | 0.5 |
| EPSCBL05 | ICP-MS | Dry Mass Basis | 25 | 19 | 22 | 42 | 5.5 | 21 | 4.1 | 1 | 4.2 | 0.6 | 3.6 | 0.7 | 2.2 | 0.4 | 2.4 | 0.4 |
| EPSCBL12 | ICP-MS | Dry Mass Basis | 14 | 16 | 18 | 42 | 4.5 | 17 | 3.2 | 0.7 | 2.9 | 0.4 | 2.4 | 0.5 | 1.5 | 0.3 | 1.8 | 0.3 |
| EPSCBL01 | ICP-MS | Dry Mass Basis | 7.7 | 16 | 16 | 36 | 3.9 | 15 | 2.8 | 0.7 | 2.6 | 0.4 | 2 | 0.4 | 1.2 | 0.2 | 1.3 | 0.2 |
| EPLUJE01-11 | ICP-MS | Dry Mass Basis | 8.1 | 17 | 20 | 44 | 4.9 | 18 | 3.3 | 0.7 | 2.9 | 0.4 | 2.2 | 0.5 | 1.4 | 0.2 | 1.5 | 0.3 |
| EPLUJE02-18 | ICP-MS | Dry Mass Basis | 22 | 20 | 20 | 46 | 5.6 | 22 | 4.8 | 1.1 | 4.8 | 0.8 | 4.6 | 0.9 | 2.8 | 0.4 | 3 | 0.5 |
| WPSORE01-12 | ICP-MS | Dry Mass Basis | 10 | 13 | 20 | 43 | 4.7 | 18 | 3.3 | 0.7 | 3 | 0.5 | 2.4 | 0.5 | 1.5 | 0.2 | 1.4 | 0.2 |
| WPFANU11 | ICP-MS | Dry Mass Basis | 22 | 97 | 58 | 128 | 18 | 79 | 18 | 4.2 | 22 | 3.2 | 18 | 3.6 | 9.6 | 1.3 | 7.8 | 1.1 |
| WPFANU13 | ICP-MS | Dry Mass Basis | 34 | 109 | 35 | 97 | 16 | 81 | 26 | 6.6 | 34 | 4.9 | 25 | 4.3 | 10 | 1.2 | 6.8 | 1 |

| Sample Reference Number | Total REE (ppm) | Total REE+Sc+Y | Secondary Analytical Technique | Secondary Digestion Technique |
|---|---|---|---|---|
| EPLUJE03-07 | 223.2 | 266.2 | XRF | N/A |
| EPSCJE01-56 | 256.4 | 300.4 | XRF | N/A |
| EPLUJE01-12 | 275.3 | 325.3 | XRF | N/A |
| EPLUJE05-27 | 287.1 | 330.1 | XRF | N/A |
| EPLUJE05-33 | 126.1 | 151.2 | XRF | N/A |
| EPLUJE01-13 | 88.7 | 112.9 | XRF | N/A |
| EPSCBL10 | 224.6 | 265.0 | XRF | N/A |
| EPSCBL22 | 214.5 | 258.5 | XRF | N/A |
| EPLUJE03-08 | 295.9 | 350.9 | XRF | N/A |
| EPLUJE02-20 | 83.3 | 103.1 | XRF | N/A |
| EPCOJE01-48 | 88.0 | 118.6 | XRF | N/A |
| EPLUJE04-01 | 173.2 | 209.2 | XRF | N/A |
| EPSCBL25 | 188.3 | 228.3 | XRF | N/A |
| EPLUJE01-09 | 137.8 | 167.0 | XRF | N/A |
| EPCOBL08 | 81.5 | 105.2 | XRF | N/A |
| EPCOJE01-47 | 193.2 | 238.2 | XRF | N/A |
| EPCOJE01-50 | 300.7 | 354.7 | XRF | N/A |
| EPSCBL18 | 196.4 | 233.4 | XRF | N/A |
| WPWERO01-07 | 289.7 | 336.7 | XRF | N/A |
| EPLUBL21 | 211.7 | 257.7 | XRF | N/A |
| EPLUBL24 | 207.7 | 249.7 | XRF | N/A |
| EPSCBL03 | 111.5 | 133.1 | XRF | N/A |
| EPLUJE02-15 | 407.3 | 461.3 | XRF | N/A |
| EPC0JE02-54 | 199.5 | 240.5 | XRF | N/A |
| EPLUJE05-34 | 136.4 | 163.4 | XRF | N/A |
| EPSCJE01-58 | 195.0 | 229.0 | XRF | N/A |
| EPLUJE05-21 | 194.3 | 231.3 | N/A | N/A |
| EPSCJE01-62 | 219.6 | 256.2 | XRF | N/A |
| EPLUJE02-16 | 95.9 | 116.0 | XRF | N/A |
| EPSCBL06 | 208.7 | 255.7 | XRF | N/A |
| EPSCBL05 | 110.1 | 154.1 | XRF | N/A |
| EPSCBL12 | 95.5 | 125.5 | XRF | N/A |
| EPSCBL01 | 82.7 | 106.4 | XRF | N/A |
| EPLUJE01-11 | 100.3 | 125.4 | XRF | N/A |
| EPLUJE02-18 | 117.3 | 159.3 | XRF | N/A |
| WPSORE01-12 | 99.4 | 122.4 | XRF | N/A |
| WPFANU11 | 371.8 | 490.8 | XRF | N/A |
| WPFANU13 | 348.8 | 491.8 | XRF | N/A |

| Sample Reference Number | Secondary Elemental Identification Results (ppm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ca | Fe | K | Ti | Zr | Sn | Ba | Nb | Th | U | S2 |
| EPLUJE03-07 | 1473 | 27735 | 21205 | 5376 | 242 | BDL | 583 | 15.65 | 12.02 | 3.12 | BDL |
| EPSCJE01-56 | 1237 | 11386 | 17661 | 5866 | 339 | BDL | 458 | 18.13 | 10.76 | BDL | BDL |
| EPLUJE01-12 | 2052 | 51166 | 30638 | 5853 | 441 | BDL | 773 | 19.25 | 8.85 | BDL | BDL |
| EPLUJE05-27 | 1395 | 22434 | 20744 | 5489 | 489 | BDL | 442 | 17.14 | 6.88 | BDL | BDL |
| EPLUJE05-33 | 1252 | 6836 | 4612 | 2259 | 400 | BDL | 126 | 7.9 | 2.95 | BDL | BDL |
| EPLUJE01-13 | 1423 | 16654 | 15281 | 1700 | 244 | BDL | 283 | 4.25 | 3.03 | BDL | BDL |
| EPSCBL10 | 1299 | 20241 | 19197 | 4982 | 292 | BDL | 567 | 15.26 | 8.79 | BDL | BDL |
| EPSCBL22 | 2186 | 60893 | 16356 | 5125 | 359 | BDL | 579 | 16.84 | 7.74 | BDL | BDL |
| EPLUJE03-08 | 1297 | 49132 | 22030 | 6202 | 386 | BDL | 625 | 19.45 | 10.15 | 3.03 | BDL |
| EPLUJE02-20 | 1226 | 32159 | 11363 | 2396 | 162 | BDL | 319 | 7.25 | 2.58 | BDL | BDL |
| EPCOJE01-48 | 805 | 10461 | 10997 | 1798 | 127 | BDL | 230 | 5.21 | 2 | BDL | BDL |
| EPLUJE04-01 | 2648 | 31074 | 19108 | 5888 | 277 | BDL | 542 | 15.45 | 8.85 | BDL | BDL |
| EPSCBL25 | 1760 | 35499 | 19564 | 5674 | 309 | BDL | 613 | 17.02 | 7.97 | BDL | BDL |
| EPLUJE01-09 | 1452 | 29561 | 18563 | 4450 | 296 | BDL | 478 | 10.76 | 6.86 | BDL | BDL |
| EPCOBL08 | 12183 | 69976 | 7608 | BDL | 181 | BDL | 334 | 7.28 | 1.86 | BDL | BDL |
| EPCOJE01-47 | 1370 | 10313 | 20171 | 10212 | 573 | BDL | 543 | 30.01 | 12.64 | BDL | BDL |
| EPCOJE01-50 | 1218 | 22143 | 18566 | 5972 | 414 | BDL | 578 | 18.77 | 11.05 | BDL | BDL |
| EPSCBL18 | 1276 | 23884 | 15670 | 6142 | 454 | BDL | 439 | 18.76 | 11.22 | BDL | BDL |
| WPWERO01-07 | 2434 | 50651 | 7644 | 7343 | 277 | BDL | 435 | 21.22 | 16.48 | 15.53 | 34934 |
| EPLUBL21 | 3191 | 75684 | 16254 | 4286 | 339 | BDL | 561 | 15.36 | 5.95 | BDL | BDL |
| EPLUBL24 | 1513 | 31824 | 23487 | 5247 | 384 | BDL | 758 | 19.76 | 11.62 | 4.64 | BDL |
| EPSCBL03 | 6754 | 26892 | 15657 | 2908 | 157 | BDL | 477 | 7.73 | 4.1 | BDL | BDL |
| EPLUJE02-15 | 1053 | 7424 | 1203 | 6059 | 488 | BDL | 811 | 22.82 | 16.04 | 2.72 | BDL |
| EPC0JE02-54 | 1438 | 24583 | 15892 | 5389 | 415 | BDL | 496 | 16.04 | 11.36 | BDL | BDL |
| EPLUJE05-34 | 1306 | 7521 | 19830 | 5835 | 439 | BDL | 454 | 18.83 | 9 | BDL | BDL |
| EPSCJE01-58 | 1827 | 50401 | 17614 | 5037 | 377 | BDL | 629 | 13.87 | 6.84 | BDL | BDL |
| EPLUJE05-21 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| EPSCJE01-62 | 964 | 13298 | 14426 | 4633 | 605 | BDL | 390 | 13.98 | 6.89 | BDL | BDL |
| EPLUJE02-16 | 1298 | 53686 | 18848 | 5280 | 224 | BDL | 503 | 16.59 | 4.33 | BDL | BDL |
| EPSCBL06 | 3702 | 40876 | 21016 | 5267 | 246 | BDL | 1036 | 18.24 | 8.76 | BDL | BDL |
| EPSCBL05 | 1263 | 42102 | 21594 | 5582 | 244 | BDL | 847 | 18.49 | 11.88 | BDL | BDL |
| EPSCBL12 | 1264 | 19085 | 17364 | 5479 | 322 | BDL | 416 | 16.28 | 9.3 | BDL | BDL |
| EPSCBL01 | 1887 | 20421 | 15560 | 2637 | 146 | BDL | 467 | 7.5 | 3.47 | BDL | BDL |
| EPLUJE01-11 | 1247 | 19126 | 21855 | 4889 | 325 | BDL | 445 | 13.23 | 7.42 | BDL | BDL |
| EPLUJE02-18 | 1316 | 13169 | 22945 | 8604 | 297 | BDL | 811 | 22.82 | 16.04 | 2.72 | BDL |
| WPSORE01-12 | 1617 | 93768 | 11572 | 2981 | 86 | BDL | 172 | 5.59 | 4.27 | BDL | 26538 |
| WPFANU11 | 20602 | 84995 | 12408 | 4299 | 134 | BDL | 360 | 11.19 | 5.97 | 6.96 | 8475 |
| WPFANU13 | 17172 | 156606 | 10789 | 3066 | 114 | BDL | 398 | 8.32 | BDL | 11.33 | 18613 |

| Sample Reference Number | Notes |
|---|---|
| EPLUJE03-07 | Mo, Sr, Rb, Pb, Zn, Cu, Co, Mn detected |
| EPSCJE01-56 | Mo, Sr, Rb, As, Pb, Zn, Cu. Co, Mn detected |
| EPLUJE01-12 | Sr, Rb, As, Pb, Zn, Cu, Ni, Mn detected |
| EPLUJE05-27 | Mo, Sr, Rb, As, Pb, Zn, Co, Mn detected |
| EPLUJE05-33 | Mo, Sr, Rb, As, Pb, Co, Mn detected |
| EPLUJE01-13 | Sr, Rb, As, Pb, Zn, Co, Mn detected |
| EPSCBL10 | Mo, Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| EPSCBL22 | Mo, Sr, Rb, As, Zn, Pb, Cu, Ni, Co, Mn detected |
| EPLUJE03-08 | Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| EPLUJE02-20 | Sr, Rb, As, Pb, Zn, Mn detected |
| EPCOJE01-48 | Mo, Sr, Rb, As, Pb, Zn, Co, Mn detected |
| EPLUJE04-01 | Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| EPSCBL25 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| EPLUJE01-09 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Mn detected |
| EPCOBL08 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Mn detected |
| EPCOJE01-47 | Mo, Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| EPCOJE01-50 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| EPSCBL18 | Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| WPWERO01-07 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| EPLUBL21 | Mo, Sr, Rb, As, Pb, Zn Cu, Ni, Mn detected |
| EPLUBL24 | Mo, Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| EPSCBL03 | Sr, Rb, As, Pb, Zn, Mn detected |
| EPLUJE02-15 | Mo, Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| EPC0JE02-54 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| EPLUJE05-34 | Mo, Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| EPSCJE01-58 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| EPLUJE05-21 | N/A |
| EPSCJE01-62 | Mo, Sr, Rb, As, Pb, Zn, Co, Mn detected |
| EPLUJE02-16 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| EPSCBL06 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| EPSCBL05 | Mo, Sr, Rb, As, Pb, Zn, Cou, Ni, Co, Mn detected |
| EPSCBL12 | Mo, Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| EPSCBL01 | Sr, Rb, As, Pb, Zn, Co, Mn detected |
| EPLUJE01-11 | Sr, Rb, As, Pb, Zn, Co, Mn detected |
| EPLUJE02-18 | Mo, Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| WPSORE01-12 | Mo, Sr, Rb, As, Pb, Zn, Cu, Co, Mn detected |
| WPFANU11 | Mo, Sr, Rb, As, Pb, Zn, Cu, Ni, Co, Mn detected |
| WPFANU13 | Sr, Rb, As, Pb, Zn, Cu, Ni, Mn detected |