CRITICAL MINERAL ENRICHMENT IN LIGNITES BENEATH THE RHAME BED (PALEOCENE) OF THE SLOPE FORMATION IN THE WILLISTON BASIN OF NORTH DAKOTA

by

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On the cover: The bright white, kaolinized mudstone of the Rhame bed outcrops at measured section 303 of this report in T136N, R103W, Sec. 35, Slope County. Its distinctive silcrete is visible in the upper half of the bed. The Rhame bed marks the top of the Slope Formation, which is better represented by the somber gray mudstone below. The H lignite sits directly upon the Rhame bed here and marks the base of the Bullion Creek Formation, a unit characterized by lighter gray and yellow colors.

Table of Contents

Abstract....iv
Acknowledgements....v
Introduction....1
General Geology....4
Previous Studies of the Slope Formation....5
Nomenclature and Correlations of the Harmon, Hanson, and H Lignites....8
Correlating the Rhame Bed Northeast Across Logging Camp Ranch (Ranger Township)....12
Field Methods....18
Laboratory Methods....18
Analytical Results (Rare Earth Elements)....21
New Sampling of the Harmon, Hanson, and H lignites, and Coals Within the Rhame Bed....23
Analytical Results (Non-REE Critical Minerals)....30
Limited-Scope Mining in Sections 7 (Harmon coal) and 16 (Rhame bed coal)....37
Discussion....39
Conclusions....45
References....47
Appendix A....50
Appendix B....239
Appendix C....258

Tables

1. Summarized analytical results of this report....22
2. Relevant classifications and thresholds for REE concentrations in coal....23
3. Total rare earth element enrichment (dry coal basis) by stratigraphic unit....23
4. REE concentrations for lateral samples in T136N, R102W, Sec. 7....25
5. REE concentrations for lateral samples in T136N, R102W, Sec. 16....26
6. REE concentrations for lateral samples in T136N, R102W, Sec. 8....27
7. Analytical results for vertical and lateral samples through an REE-enriched lignite in T136N, R102W, Sec. 16..28
8. Analytical results for vertical and lateral samples through an REE-enriched lignite in T136N, R102W, Sec. 8....29
9. Analytical results for vertical samples through an REE-enriched lignite at measured section 284....31
10. Analytical results for vertical samples through an REE-enriched lignite west of measured section 284....32
11. Analytical results for vertical samples through an REE-enriched lignite at measured sections 210 & 213....33

Figures

1. NDGS critical mineral study sample sites....2
2. Map of the measured sections in this report outside of Ranger Township....3
3. The number of analyzed samples by stratigraphic position....5
4. History of stratigraphic nomenclature for three coals in Ranger Township....8
5. Silcrete of the Rhame bed at measured section 295....10
6. The H bed tonstein near measured section 294....11
7. The Slope and Bullion Creek Formations with well-developed Rhame bed at measured section 284....13
8. The Rhame bed and Harmon-Hanson-H lignites at measured section 219....14
9. The Rhame bed and Harmon-Hanson-H lignites at measured section 76....14
10. The greenish tint of the Rhame bed below the Harmon-Hanson-H lignites at measured section 76....15

11. The Rhame bed where it is well-developed with a silcrete in place at measured section 302 16
12. The Rhame bed where it is not obvious in T136N, R102W, Sec. 16..17
13. The Rhame bed where it is much more distinctive in T136N, R102W, Sec. 22...17
14. The Rhame bed east of Logging Camp Ranch at measured section 245 19
15. The H lignite bed and Rhame bed below along West River Road in southern Billings County...........................19
16. Measured geologic section locations and revised bedrock geology map for Ranger Township........................20
17. Lateral sampling locations in T136N, R102W, Sec. 7..25
18. Lateral sampling locations in T136N, R102W, Sec. 16 26
19. Lateral sampling locations in T136N, R102W, Sec. 8..27
20. Sampling an REE-enriched lignite at measured section 97 28
21. Sampling an REE-enriched lignite at measured section 123...29
22. Sampling an REE-enriched lignite at measured section 284...31
23. Sampling an REE-enriched lignite west of measured section 284...32
24. Sampling an REE-enriched lignite at measured sections 210 & 213 33
25. UCC-normalized REE distribution plots..34
26. UCC-normalized concentrations of critical elements in samples enriched in the REE...36
27. Excavation of the top of the Harmon lignite in T136N, R102W, Sec. 7 in June of 2018 38
28. Excavation of a lignite within the Rhame bed in T136N, R102W, Sec. 16 in January of 2020 38
29. An REE-enriched lignite between the H and Harmon-Hanson lignites in T136N, R102W, Sec. 21 41
30. REE concentrations plotted against a generic stratigraphic column for the Slope/Bullion Creek contact.......42
31. The Rhame bed at measured section 285 where a thick bright white sandstone occurs at its base.................43

Abstract

North Dakota lignite has the potential to be a new source of mineral commodities that are vital to the economic and national security of the United States. There is little to no current domestic production for many of the raw mineral materials needed to manufacture many components in energy and defense applications, in addition to a wide array of modern electronic consumer goods. The U.S. currently relies on imports of many of these commodities, termed critical minerals, including the sixteen rare earth elements (REE). Some of the REEs (e.g., lanthanum and cerium) are relatively abundant and overproduced by traditional hard rock mines, but other, less abundant REEs (e.g., dysprosium, terbium, scandium) are highly valuable and thus may be economic at relatively low concentrations if cost-effective extraction methods can be developed. Broadly speaking, techniques which need to break down REE-bearing primary minerals to extract the elements are costly, but in coal, especially low ranks like lignite, an appreciable percentage of the REE content may be weakly bound into organic complexes and easily extracted. REE concentrations in U.S. coal are generally around three times lower than the average concentrations in rocks and sediment near the Earth's surface but occasionally can be found enriched or significantly enriched 5 to 10 times higher than average upper continental crust. Other high-value critical elements (e.g., gallium and germanium) may also occur in economic concentrations in lignite and could be co-produced with the REEs. With higher relative proportions of the more valuable REEs and other critical elements, easy extraction, and lower amounts of radioactive contaminants like thorium, lignite may be an economical source of REEs at far lower concentrations than traditional ores. The U.S. Department of Energy has proposed coal containing 300 ppm REE could be a potentially promising feedstock.

The North Dakota Geological Survey (NDGS) has collected 324 samples of lignite and carbonaceous mudstone that exceed 300 ppm REE, from 1,706 samples collected from outcrops across western North Dakota. REEs are known to be mobilized by acidic waters during the weathering of clastic sediments. North Dakota lignites are found to be slightly enriched (364 to 910 ppm REE) where they occur below uplands that have experienced long-term, low-intensity modern weathering, and can be enriched (910 to 1,820 ppm REE) or even significantly enriched (over 1,820 ppm REE) where they occur below intervals of intense Paleocene weathering.

The first REE-enriched lignite identified by the NDGS was from the Logging Camp Ranch area in Slope County, where several samples from the Harmon, Hanson, and H lignite interval showed elevated REE concentrations. The 768 sample analyses from 165 measured geologic sections in this report detail that initial elevated REE concentrations from the top of the Harmon lignite are very localized, likely the result of upland weathering as the slight REE enrichment is confined to a small terrace. The H lignite bed has been miscorrelated by previous authors, causing the name to previously be assigned to an REE-enriched coal in the Logging Camp Ranch area, but the detailed correlation in this report suggests an overlying, non-enriched lignite is the H bed, and the thinner REE-enriched lignite(s) below are unnamed coals within a zone of weathered strata known as the Rhame bed. The Rhame bed is a 10- to 30-foot (3 to 9 m) thick sequence of kaolinized sediment that was apparently weathered during an extended period of little to no deposition when the climate was much warmer than today, roughly 61 million years ago. Lignites below this thick bed of kaolinite can be significantly enriched in antimony, arsenic, barium, beryllium, germanium, lithium, molybdenum, uranium, and total REE, including the highest dry coal basis concentration (2,792 ppm REE) and dry ash basis concentration (5,642 ppm REE) from this project to date.

Acknowledgments

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Looking northwest across Logging Camp Ranch to Tepee Buttes. Bullion Butte is in the background.

Introduction

U.S. coal is currently being evaluated as a potential alternative source of the rare earth elements (REE) and other critical minerals. Nonfuel minerals identified as critical by the U.S. Department of the Interior are those which are from a supply chain that is vulnerable to disruption and essential in the manufacturing of a product, the absence of which would have substantial consequences for the U.S. economy or national security. The most recent list (DOI, 2022) includes aluminum, antimony, arsenic, barite, beryllium, bismuth, cesium, chromium, cobalt, fluorspar, gallium, germanium, graphite, hafnium, indium, iridium, lithium, magnesium, manganese, nickel, niobium, palladium, platinum, rhodium, rubidium, ruthenium, tantalum, tellurium, tin, titanium, tungsten, vanadium, zinc, zirconium and the sixteen rare earth elements (REE). The REE (lanthanum, cerium, praseodymium, neodymium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, scandium, and yttrium) are often discussed as a group because of their similar chemical properties and the fact they typically occur together in nature. Rare earths are also often the first commodities mentioned when discussing critical minerals due to their importance in modern electronic components, the historic outsourcing of U.S. production, and overtures by China to use their outsized control over global supplies to disrupt the manufacturing sectors of unfriendly countries.

The U.S. Department of Energy has made significant investments in evaluating whether extraction from coal could supply the country with some of these critical mineral commodities, especially the REE. In theory, relatively low REE levels in coal are concentrated 20-fold or more upon burning and become economic in the ash. Coal is cheaply burned or is already economically mined and combusted as part of thermal power generation across the country. In practice, the burning process locks a portion of the REE in aluminosilicate glasses, which would require costly levels of acid digestion to extract (Taggart et al., 2016). Other elements, including many considered critical, occur in coal at concentrations promising enough to be potentially competitive with traditional ores (Dai and Finkelman, 2018). This is especially relevant as an REE extraction operation may need to co-produce other value-added mineral commodities (e.g., gallium, germanium) to be economic.

Lignite, the lowest rank of coal, has the advantageous characteristic of easily uptaking some critical minerals from fluids moving through the rock column. Likewise, research on the occurrence of rare earth elements in low-rank coals by the University of North Dakota College of Engineering & Mines has shown a significant proportion of REEs are weakly bound in organic complexes, likely carboxylic acid functional groups, and are readily extracted from raw lignite with dilute acids (Laudal et al., 2018). The heavier REEs appear to be especially organically associated, which adds to the economic outlook for lignite as these are generally the more valuable elements. Traditional igneous ores are mostly enriched in the light REE, causing a market oversupplied of these elements relative to the heavy REE. Other elements not appearing on the most recent list of critical minerals are known to sometimes concentrate in lignite and have historically been produced from it. These minerals may still contribute to the economic potential of lignite. Uranium was removed from the DOI's list of critical minerals in 2022, after appearing in the initial list in 2018. Uranium was produced from lignite in Billings, Golden Valley, Slope, and Stark counties of North Dakota in the 1960s (Murphy, 2015). Molybdenum has not been listed as a critical mineral due to a low risk of supply disruption, yet it is a strategic commodity that commonly occurs with uranium and has recently been a target of exploration in North Dakota, along with uranium, arsenic, and germanium (Murphy, 2008; Kruger, 2023).

The North Dakota Geological Survey has authored seven reports on rare earth elements and other critical minerals (REE-CM) as observed in the lignites of Western North Dakota. The most recent of these reports gives detailed summaries of those previous to it (see Introduction – Project Background in Kruger et al., 2022 and Murphy et al., 2023). These investigations began in the fall of 2015 and to date have yielded a total of 1,706 laboratory-analyzed samples and 306 measured geological sections (fig. 1).

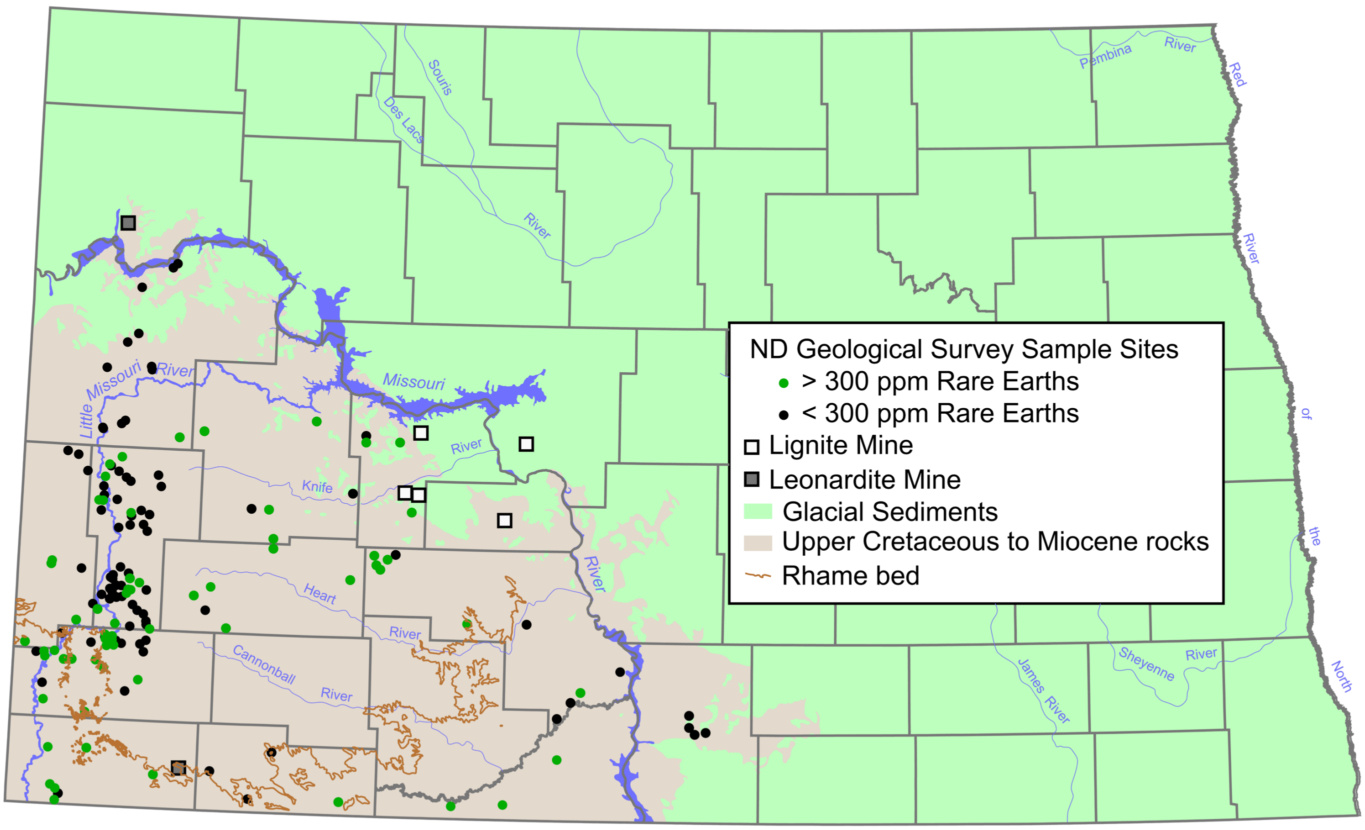


Figure 1. NDGS critical mineral study sample sites. The Rhame bed is outlined in brown, compiled from the contact of the Bullion Creek and Slope Formations from Clayton (1980) and mapping by Wehrfritz (1978).

Previous works by researchers in different basins and in higher ranks of coals have identified elevated rare earth element concentrations in coal by mechanisms for which there is little indication of occurrence in North Dakota lignites. Volcanic ashes have been identified as contributors to the REE content of coals (e.g., Kentucky, Wyoming, and Colorado; Hower et al., 1999; Gregory et al., 2022). NDGS investigations of tuffs, bentonites, tonsteins, and the proximal carbonaceous beds suggest pyroclastics are not a significant driver of significant REE enrichment in North Dakota lignites. Meteoric waters are understood to transport uranium, molybdenum, and other elements into lignites in North Dakota via infiltrational pathways, but a clear relationship in the enrichment of uranium and REE has not been observed, likely because of different source beds (Murphy et al., 2023).

There has been some evidence that relatively recent infiltration and weathering of Quaternary uplands produced moderate REE enrichment in the coals just below these permeable surfaces, often in thin coals or near the tops of thicker coals (Moxness et al., 2021; 2022). Previous work within the study area of this project identified enrichment at the very top of the Harmon coal where it occurs just below the local terrace level (Kruger et al., 2017; Murphy et al., 2018). However, topographically controlled weathering and infiltration cannot explain the most highly enriched lignites in the study area, which are often overlain by thick lignites that are mostly non-enriched.

In Murphy and others (2023) the NDGS identified significant enrichment of REE in lignites within or just below the lower Bear Den Member of the Golden Valley Formation. REE and other critical minerals were likely present in low to moderate abundances in the siliciclastic sediments of the Bear Den Member, but downward-percolating acidic waters mobilized ions from primary and secondary mineral grains and leached them from the upper part of the profile and redistributed them into its lower portions, concentrating them where lignites occur and preferentially incorporate them into organic complexes. This interval is identifiable in the field as a thick kaolinitic zone recording an ancient weathering profile created during an unusually warm climate event called the Paleocene-Eocene thermal maximum. The Rhame bed at the top of the Slope Formation is another well-studied paleosol, with a similar thick zone of kaolinite with a bed of silcrete, and also represents an ancient weathering profile located within the study area of this report. The Rhame bed may have experienced a similar degree of weathering as to that of the Bear Den Member and is proximal to the highly enriched coals below the Harmon/Hanson coal beds previously identified by Kruger and others (2017) and Murphy and others (2018), but the detailed correlation of the weathered zone and enriched lignites had not been performed prior to this report, preventing a direct link between the two. This report revisits the sites containing the Harmon/Hanson/H lignite interval of Kruger and others (2017) and Murphy and others (2018) as they relate to the Rhame bed weathering zone, correlated across Logging Camp Ranch from more distinctive outcrops from the west and south (fig. 2).

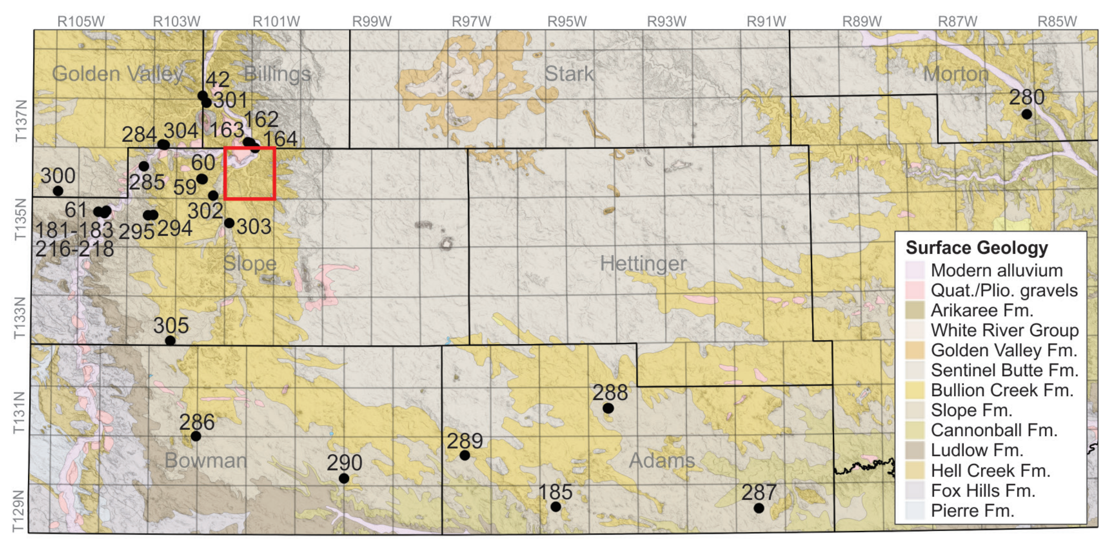


Figure 2. Map of the measured sections of this report overlayed on the surficial geology of Clayton (1980) for far southwestern North Dakota. Ranger Township (T136N, R102W; red box) contains an additional 131 measured sections and revised bedrock geology detailed in Figure 15.

General Geology

The landscape of southwestern North Dakota is dominated by rocks of the Fort Union Group (Paleocene). The majority of these rocks are nonmarine (Ludlow, Slope, Bullion Creek, and Sentinel Butte Formations); only the Cannonball Formation was deposited in a marine setting. Fort Union strata consists of alternating beds of sandstone, siltstone, mudstone, claystone, and lignite; the latter is absent from the Cannonball Formation. Several studies of the Bullion Creek (previously the Tongue River) and Sentinel Butte Formations determined montmorillonite and illite are the dominant clay minerals with lesser amounts of chlorite and kaolinite (Chew and Boyd, 1960; Sigsby, 1966; Emanuel et al., 1976; Brekke, 1979). There are two major kaolinite-rich stratigraphic units exposed at the surface in western North Dakota, the Rhame bed of the Slope Formation and the Bear Den Member of the Golden Valley Formation (fig. 3). The Rhame Bed and Bear Den Member are roughly 1,000 feet (305 m) apart stratigraphically, range in color from dazzling white to gold, purple, or light gray; consist of variable lithologies (claystone, mudstone, siltstone, sandstone, and occasionally lignite); range from 5-40 feet (1.5-12m) in thickness; Paleocene in age (the Bear Den Member is latest Paleocene in age); and are thought to have formed as a result of leaching during an intense period of weathering (Moore, 1976; Wehrfritz, 1978; Murphy et al., 2023). The weathering phenomenon that created the Rhame bed occurred approximately 61 million years ago during mid-Paleocene time. The warm and humid intensive weathering that led to the creation of the kaolinite clays in the Bear Den Member occurred just prior to the beginning of the Eocene Epoch, approximately 56 million years ago, and is referred to as the Paleocene-Eocene thermal maximum (PETM) (Clechenko et al., 2007). In addition to these two major horizons, thin, discontinuous, wedge-shaped, bright-white, kaolinite-rich beds also occur within the Fort Union Group in western North Dakota as noted by Murphy (2009, 2013) and Murphy and others (2023).

The Bear Den and Camels Butte Members of the Golden Valley Formation, along with the upper Sentinel Butte Formation, were the subject of a critical mineral study by Murphy and others (2023). Twenty-one geologic sections were measured across five counties and 122 rock samples were collected across this stratigraphic interval. The study determined that critical minerals were enriched (REE up to 2,500 ppm) in the lower half of the Bear Den Member and the uppermost beds in the underlying Sentinel Butte Formation. At the same time the Bear Den study was being undertaken, a much larger study of the Rhame bed was being completed in six counties to the west, south, and east of that project (Figure 1).

Prior to 1977, the rocks that are now recognized as the Slope Formation were previously included in the upper half of the Ludlow Formation. The Slope Formation also includes roughly 60 feet (18 m) of rock that had previously been included in the basal portion of the Tongue River Formation (Moore, 1976). The unconformity at the top of this bleached zone represents the contact of the Slope Formation with the overlying Bullion Creek Formation in North Dakota. It is well exposed along the Little Missouri River and Deep Creek in Slope County, ND, and can be traced across scattered outcrops from eastern Montana to near Mandan, North Dakota. In eastern Montana, it marks the contact of the Ludlow and Tongue River Members of the Fort Union Formation.

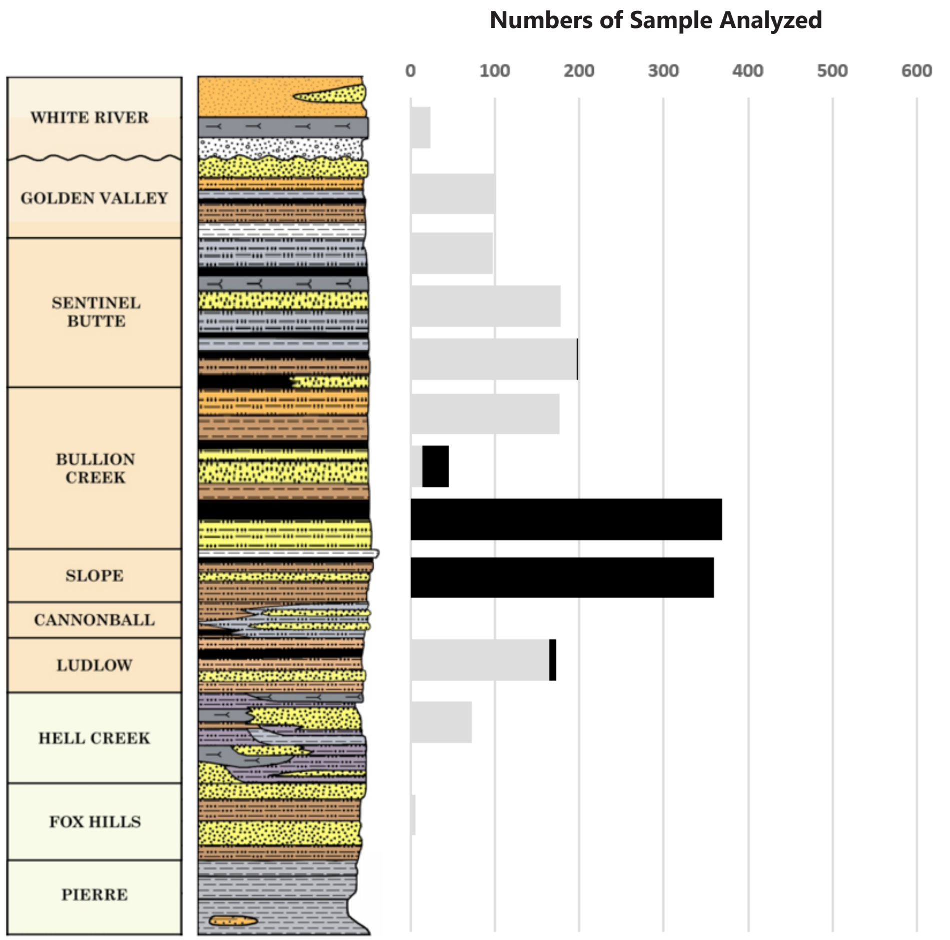


Figure 3. The number of rock samples analyzed during the NDGS critical mineral's project plotted against their stratigraphic position. The samples included in this report are shown in black, illustrating the focus on the Harmon-Hanson-H lignite interval in the lower Bullion Creek Formation and the Rhame bed weathering zone in the Slope Formation.

Previous Studies of the Slope Formation

Over the years, a number of studies have been undertaken to determine the clay mineralogy of Cretaceous and Paleocene claystones in North Dakota. The Bear Den Member has been the focus of several of those studies, but the Rhame bed has primarily been the focus of stratigraphic studies. The Fourth Biennial Report of the North Dakota Geological Survey (1906), dealt entirely with the clay resources of North Dakota. At least some of what we now call the Rhame bed was mapped by Babcock and Clapp (1906) as "high-grade clays," in their map of western North Dakota. In the accompanying report, these white beds were alternately referred to as the "white fire clays" by Leonard (1906) and the "white fire clays," "white clays," and "fire clays," by Clapp and Babcock (1906).

Hares (1928) mapped the surface geology of an 1,800 square mile (4,700 km2) area that he called the Marmarth lignite field. The field is bounded on the west by the Montana/North Dakota state line, on the south by the North Dakota/South Dakota state line, extends east as far as the town of Bowman, and to the north six miles (10 km) shy of the town of Medora. In addition to mapping the formation contacts, Hares mapped the extent of the major coal beds and their clinker deposits. Hares also measured the thicknesses of lignites and their bounding and inclusive lithologies at 761 localities within his study area. In the lower part of the Tongue River Member, Hares reported a silicious bed that he called a quartzite noting that the rock is vitreous yellow or gray in color, consists of almost pure silica, and contains molds of stems 0.5 – 2 inches (1-5 cm) in diameter and up to two feet (0.6 m) or more in length. He also observed that the bed was not continuous throughout his study area. Hares identified the silicious bed 148 feet (45.1 m) below the Harmon clinker at Post Office Butte near Rhame but noted this stratigraphic interval decreased to the north. Roughly 20 miles (32 km) to the northwest (T135N, R104W), he noted the white zone (with "quartzite" in place) was present 70 feet (21 m) below the Harmon lignite. Along Deep Creek (17 miles/27 km to the northeast, T135N, R102W, Sec. 31), Hares determined there is 67 feet (20 m) of rock between the Harmon clinker and the base of the H Bed lignite, which immediately overlies the weathering zone. Although Hares noted that it is Leonard's "H bed" lignite which rests on this quartzitic layer in T134N, R105W, he pointed out that one characteristic of the H bed was the presence of a thin (roughly 2-inch (5 cm) thick) shale parting a little above the midpoint of the bed. Murphy and others (2018) demonstrated that a split in the overlying Harmon bed had caused Hares to miscorrelate the H bed with his overlying Hansen (now Hanson) bed in a number of localities (see nomenclature and correlation section). The H bed contains a thin tonstein (Hares' shale parting) that ranges in stratigraphic position from the upper 1/6 to the upper half of the bed.

Both the Bear Den Member and Rhame bed have been utilized in North Dakota for the manufacture of ceramics (Murphy, 1995). A brick and tile plant operated just to the north of the town of Hettinger from the late 1930s through the mid-1960s that likely utilized the Rhame bed. In addition, the Rhame bed appears to have been a source for at least some of University of North Dakota ceramic professor Margaret Cable's well-known pottery from the 1920s to the 1950s (Murphy, 1998).

Benson (1953) noted that there was a brightly colored bed 50 – 75 feet (15 - 23 m) below the Harmon bed that was identical in appearance, except with less yellow staining, to the lower member of the Golden Valley Formation (the Bear Den Member). At the top of that bed was a silicified zone that was less pronounced than the silicified zone (the Taylor bed) at the top of the lower member of the Golden Valley Formation. Benson noted the bed could be traced from Medicine Pole Hills in Bowman County to a point roughly 13 miles (21 km) east of Amidon in Slope County.

Freas (1959) mapped and sampled the Rhame bed along 28 square miles (73 sq. km) of Deep Creek in Slope County as part of a project that was focused more on the Bear Den Member. His project was supported by the Northern Pacific Railway Company. Chew and Boyd (1960) reported the alumina content of five Rhame bed samples along Deep Creek in an area first mapped and sampled by Freas. The alumina content of these samples averaged 21.4%. Chew and Boyd concluded that the main controls on the alumina content of the samples were the clay mineralogy and the percentage of clay minerals. Unfortunately, neither the Freas nor the Chew and Boyd samples were tied to measured sections.

Moore (1976) measured 46 geologic sections in T134-136N, R104-106W, generated 14 cross-sections, and provided a thorough history of the evolution of the nomenclature involving Hell Creek and Ludlow strata from the early 1900s through the 1970s. As a result of his fieldwork, Moore informally named a thin (up to several feet thick [< 1m]), loose pebble to indurated white siliceous rock layer (Hares' quartzite) the "white siliceous bed." He noted that laterally, the white siliceous bed ranges from a continuous layer that holds up surfaces and caps buttes to an intermittent rubble zone that locally protects shoulders on outcrops. Moore observed that the white siliceous rock was underlain by a bleached white zone, several tens of feet (up to 10 m) thick that consisted of variable lithologies, apparently the first scientist to note an association between the two. Moore also noted that in addition to various shades of white, locally the bleached zone can be subtle shades of green and lavender. Moore noted the siliceous zone was often overlain by a lignite or a carbonaceous claystone, i.e., consistently associated with an organic-rich bed. Moore suggested that the white siliceous bed and the underlying bleached zone were associated with an unconformity and possibly represented paleosol remnants. Moore further suggested that placing the upper contact of the Ludlow Formation at the top of the white siliceous bed, rather than at a somewhat arbitrary color change, would provide a more useful and consistent contact.

Clayton and others (1977) restricted the Ludlow Formation to the lower half of the formation (from the top of the Hell Creek Formation to the top of the T Cross lignite) and renamed the upper half of the Ludlow Formation (from the top of the T Cross lignite to the top of the "white bleached zone") the Slope Formation. They noted the bright zone is "commonly associated with a siliceous bed" and likely represents a long-lived weathering surface mappable from near Mandan, ND, to eastern Montana, and into northwestern South Dakota. Their proposed type section locality in northwestern Slope County contains the lower contact of the Slope Formation, but not the upper contact. Clayton and others also renamed the lithostratigraphic unit overlying the Slope Formation (previously known as the Tongue River Formation) the Bullion Creek Formation. In doing so, they placed the base of the Bullion Creek Formation at the top of the Rhame bed and left the upper contact with the overlying Sentinel Butte Formation unchanged.

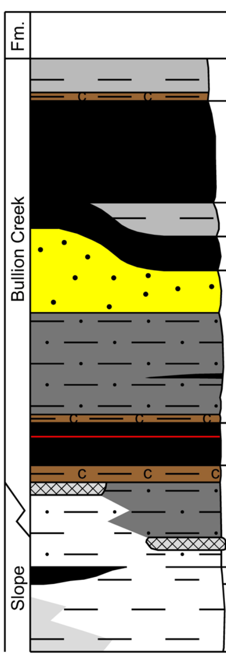
Wehrfritz (1978) studied Moore's (1976) white siliceous bed and the underlying white beds in southwestern North Dakota, naming the rocks in question the Rhame bed. In her study, Wehrfritz measured 25 geologic sections across the bed, generated three cross-sections from those measured sections, and mapped outcrops of the Rhame bed in southeastern Golden Valley, west-central Slope, and north-central Bowman counties on 1:24,000 scale maps (7.5′ quadrangles). The contacts on her field maps were transferred onto 1:63,360 scale county maps (Plate 1 of her thesis). Additionally, Wehrfritz termed the siliceous bed a silcrete and recognized the underlying bleached zone as a deep-weathering profile, which "probably formed during a period of little erosion or deposition, under a stable land surface covered by thick vegetation, in a warm and humid climate" (p. 87) The silcrete "may be absent, [but] the underlying white to very light gray sand, silt or clay is always present" (p. 6). Wehrfritz found the bleached zone was very irregular in thickness but was on average 20 feet (6.1 m) thick and was normally overlain by a 1.7-foot-thick (0.5 m) lignite. She also noted the silcrete and white zone were sometimes separated by a gray siltstone or claystone that averaged 4.6 feet (1.4 m) thick. In at least one locality, she found two silcrete layers within the Rhame bed, and at another locality the silcrete was present within the white siltstone. In support of her conclusions regarding the silcrete and weathering horizon, Wehrfritz provided a review of scientific articles on silcretes and deep-weathering profiles from around the World. She noted that most of the previous geologists had commented on the silcrete layer, but only a few had noted the underlying bright-white beds.

A partial explanation would be that many of the previous authors had witnessed the silcrete only as lag deposits after 10s or 100s of feet/meters of the underlying rock had been removed. While Wehrfritz's thesis is a thorough stratigraphic study of the Rhame bed, she did not attempt to determine its chemistry or clay mineralogy. Wehrfritz followed the nomenclature of Hares (1928), recognizing the first lignite above the Rhame bed silcrete as the H bed.

Murphy (2013) studied both the Rhame bed and the Bear Den Member for a project that evaluated the alumina content of these horizons to determine the suitability of manufacturing ceramic proppant from these kaolinite-rich units. He measured 40 geologic sections through the Rhame bed in Golden Valley, Slope, Bowman, Adams, Hettinger, Grant, and Morton counties and collected 120 Rhame bed rock samples. In addition to aluminum oxide, 32 other analytical results were reported including oxides of titanium, vanadium, chromium, cobalt, gallium, rubidium, strontium, yttrium, zirconium, niobium, molybdenum, barium, uranium, and hafnium. X-ray diffraction analysis was run on the samples in an attempt to determine the relative abundance of kaolinite at the Rhame bed localities.

Nomenclature and Correlations of the Harmon, Hanson, and H Lignites

A.G. Leonard (1908) named three coals in ascending order the G, H, and I beds and placed them in the Great Bend Group of the Fort Union (fig. 4). Great Bend refers to the area where the north-flowing Little Missouri River bends to the east (T137N, R103W, Sec. 31) to flow around Bullion Butte before resuming its course as a north-flowing river. Leonard ended his Great Bend Group where his I bed (Harmon bed) dips under the Little Missouri River (T138N, R102W, Sec. 5). He noted that all three of his beds (G, H, I) occur along the stretch where Deep, Sand, and Bullion Creeks empty into the Little Missouri River. Both Deep and Sand Creeks enter the Little Missouri River within Logging Camp Ranch (T136N, R102W). Leonard also noted that along the north section line of Section 1 (T136N, R103W), beds H and I had become a single 17.5 foot-thick (5.3 m) bed. One mile to the east (T136N, R102W, Sec. 6), his measured section contains all three beds.



Leonard (1908)	Leonard and Smith (1909)	Hares (1928)	Hares (1928) #264	Murphy et al. (2018)	This Study
I	Harmon	Harmon	Harmon	Harmon	Harmon
H		Hansen	not present	lower Harmon	Hanson
G		H	Hansen	Hanson	H
			H	H	

Figure 4. A selected history of stratigraphic nomenclature for three of the coals in Ranger Township, Slope County.

In T136N, R104W (Sections 21 and 28), Leonard's I and H bed are separated by 35 feet (11 m) of rock and beds H and G are separated by 70 feet (21 m). He observed that the coals came closer and closer together towards the east; with 10 feet (3.0 m) of rock separating beds I and H and 55 feet (17 m) separating beds H and G in Section 3 (T136N, R103W), and only 4.5 feet (1.4 m) separating the I and H beds and 14 feet (4.26 m) separating beds H and G in Section 1 of that same township.

Leonard and Smith (1909) named the lowest lignite exposed in their Sentinel Butte lignite field the Harmon bed. They noted the coal was exposed within the Sentinel Butte lignite field north of Wibaux, Montana and just to the south of the field boundary along the east bank of the Little Missouri River a short distance upriver from the Harmon Ranch (T138N, R102W, Sec. 5). On August 27, 1907, A.G. Leonard wrote in his fieldnotes "The Harmon coal bed outcrops on the river near the schoolhouse in section 6." On September 4, 1907, he wrote "The Harmon coal bed has thus been traced continuously for 18 miles across three townships…" Interestingly, his notes from the 1907 field season contain at least a dozen references to the name "Harmon coal bed" two years before that name would appear in publication.

Hares (1928) used Leonard and Smith's Harmon bed but renamed the H bed the "Hansen" bed (spelling changed to Hanson by Warrick, 1982 and Murphy, 2003) and renamed the G bed the H bed. He determined the H bed was situated on the quartzitic layer (Rhame bed silcrete) in T135N, R104W (fig. 5). Hares also noted the H bed had a very persistent 2-inch-thick shale parting a little above the middle of the bed (fig. 6). In all likelihood, Hares was referring to a widespread tonstein. A tonstein is volcanic ash that was deposited in a swamp and preserved within the acidic peat that is typically altered primarily to kaolinite (Bohor and Triplehorn, 1993). He noted the H bed is best developed in townships (T135N and T136N, R104W) where it is five feet (1.5 m) thick but is less than 2 feet (0.6 m) thick in T135N, R102 and 103W. Hares also determined the H bed lies approximately 100 feet (30 m) above the Yule lignite. Hares noted there are three main coals below the terrace in sections 4, 5, and 6 (T136N, R102W) with the middle coal being the Hanson, but noted this bed appears to unite with the Harmon bed in T137N, R102W. He placed the Harmon bed 20 feet (6.1 m) or less above the Hanson. Hares stated the Hanson bed is separated from the H bed by 16 feet (4.9 m) in Section 1 (T136N, R103W), but noted the interval is variable from place to place.

Much of the sampling for this report was centered within Ranger Township (T136N, R102W). Within this township, the six measured sections of Leonard (1908) were spaced approximately 1.3 miles (2.1 km) apart, the 18 coal sections of Hares' (1928) were spaced 1-2 miles (2-3 km) apart, and Warwick and Luck's (1995) three sections were spaced approximately 1.0 mile (1.6 km) apart. Wehrfritz (1978) did not measure any sections within this township. In contrast, Murphy and others' (2018) 31 measured sections were spaced 0.2 miles (0.3 km) apart. In addition to the large number of closely spaced measured sections of Murphy and others, expanded upon in this report, modern correlation attempts have the advantage over Leonard, Hares, and Warwick (1982) of knowing that one of the three beds of Leonard's Great Bend Group, noted by Hares as well-exposed in Sections 3, 5, 6, and 7 (T136N, R102W), contains a tonstein. Bohor and others (1976) were among the first to report tonsteins in Mesozoic and Cenozoic coals in the Rocky Mountain region including the Powder River Basin in Wyoming and Montana. Zircons within the tonsteins

Figure 5. Boulders of the "quartzitic layer" of Hares (1928) with molds of plant stems eroding in place just below the H lignite in T135N, R104W, Sec. 16 (measured section 295 of this report). Bright white strata occur just below the silcrete at this locality, as is typical elsewhere for the Rhame bed weathering zone, although the silcrete is not always present.

have been dated using fission track dating methods. Warwick and others (1995) discovered the tonstein in Ranger Township and reported the tonstein-bearing lignite as the H bed with a radiometric date of 61.23 + 0.38 Ma. Warwick and others (2004) reported additional information on this discovery, along with another tonstein discovery in the underlying Slope Formation. Belt and others (2004) verified the presence of a tonstein in the H coal with an additional date (61.06 + 0.33 Ma) obtained within one mile of the Warwick and others (1995) locality.

In Hares' section 264 (T136N, R102W, Sec. 16), he has the Harmon bed, an 18.25 foot (5.6 m) thick coal, underlain by the "Hansen" bed, an 8.25 foot (2.5 m) thick coal, underlain by the H bed, a 1.7 foot (0.5 m) thick coal. In this case, he applied the name "Hansen" to the coal that contains a tonstein. This locality is one of the first measured sections of this study and Hares' stratigraphic picks were used to correlate the coals from section 16 outwards in all four directions (Murphy et al., 2018). The three main coals in this study, the Harmon, Hanson, and H, thin and thicken through this area. Additionally, the Harmon splits into the Hanson and then recombines through this area and correlations would be difficult if it were not for the tonstein-bearing coal. Without the benefit of knowing that his "shale parting" in the H bed was a tonstein, Hares (1928) miscorrelated the Hanson and the H bed at several localities. Twelve of the measured sections in this study were previously measured by either Leonard (3 sites) or Hares (11 sites). Of the twelve (54, 71, 81, 126, 133, 159, 164, 219, 246, 294, 295, and 302), the ten sites that contained the

Figure 6. A tonstein (orange arrow) occurs near the middle of the 6.5 foot (2.0 m) thick H bed in T135N, R104W, Sec. 15, just 3.5 feet (1.1 m) above the Rhame bed silcrete, which represents the contact of the Bullion Creek and Slope Formations. The tonstein was sampled nearby at measured sections 294 and 295 of this report.

Harmon bed or Harmon clinker were correctly identified by Leonard (I bed) and/or Hares every time. Conversely, the lower Harmon split was identified by Leonard as his H bed at three localities and by Hares as his "Hansen" bed at three localities. The tonstein-bearing Hanson bed of Murphy and others (2018) was twice identified by Leonard as his G bed, five times by Hares as his "Hansen" bed and another five times as his H bed. The H bed of Murphy and others was twice identified as the H bed by Hares. In Section 5 (T136N, R102W), Hares (1928) labeled the coals exposed in the cliff face (in descending order) the Harmon, "Hansen", and H beds. One-quarter of a mile (0.4 km) to the southeast, Warwick and Luck (1995) applied the same names to the three thick (>5 feet, 1.5 m) coals exposed in Section 8. At, or very near the same Section 8 locality, Murphy and others (2018; measured section 69) labeled these three main coals the Harmon, Lower Harmon, and the Hanson, applying H bed to a thin coal/carbonaceous mudstone lying beneath the Hanson bed. In this area, the coal with the tonstein was recognized as the H bed by Warwick and Luck (1995), Warwick and others (2004), and Belt and others (2004), but as the Hanson bed by Murphy and others (2018) after correlating the "Hansen" bed of Hares to the northwest from Section 16 (T136N, R102W).

As previously mentioned, Hares (1928) notes the H bed sits on the quartzitic layer (Rhame bed silcrete) in T135N, R104W and it contains a 2-inch (5 cm) shale parting a little above the middle of the bed (presumed tonstein). Wehrfritz (1978) retained Hares (1928) nomenclature and called the lignite above the Rhame bed in her measured sections the H bed. She noted it was on average 2.5 feet (0.76 m) thick and was present in roughly two-thirds of her outcrops.

Warwick (1982) and Warwick and Luck (1995) also place the H bed immediately above the Rhame bed. Warwick and others (2004) as well as Belt and others (2004) placed the H bed in that same stratigraphic position, recognizing it as the tonstein-bearing lignite. Of the half dozen detailed stratigraphic reports in and around Ranger Township, Murphy and others (2018) is the only one that has the tonstein-bearing coal as the Hanson bed, rather than the H bed. Since the formalization of stratigraphic nomenclature comes with usage, this report recognizes the tonstein-bearing lignite above the Rhame bed as the H bed which then makes the Hanson bed the lower Harmon split.

Correlating the Rhame Bed Northeast Across Logging Camp Ranch (Ranger Township)

Wehrfritz (1978) applied the name Rhame bed to both the silcrete, when present, and the underlying brightly colored beds of variable lithologies. Since then, the name Rhame bed has been used by a number of authors including Warwick (1982), Warwick and Luck (1995), Belt and others (2002), Warwick and others (2004), Murphy (2013), etc. This study has followed Wehrfritz and applied the name Rhame bed to both the silcrete and the associated bleached or weathered zone.

As discussed in the Previous Studies section, the strata between the Harmon lignite bed (lower Bullion Creek Fm.) and the drab-colored strata characteristic of the Ludlow Formation have been reinterpreted and redefined several times by various authors since Leonard (1908). The contact between the Bullion Creek Formation (formerly part of the Tongue River Fm.) and the underlying Slope Formation (the upper part of the original Ludlow Formation) was terminated several miles upriver (west) from the Logging Camp Ranch area (T136N, R102W) as recently as Carlson (1983). Hares (1928) mapped the most northeastward extent of the original Ludlow Formation (T136N, R104W, Sec. 1), with a contact 60 feet (18.3 m) below the Rhame bed. Moore (1976), despite recognizing the stratigraphically higher contact, did not extend his map of the upper Ludlow Formation any further east than Hares. The Slope Formation of Carlson (1983), with a “white siliceous zone” at its upper contact, only extended into Section 3 (T136N, R104W), two miles (three km) short of Hares placement. All three map the furthest downriver exposures in the area where the Little Missouri turns to the east along the border of T136N, R104W and T137N, R103W, some five to eight miles (eight to 13 km) upriver (west) of Ranger Township (fig. 7). It is possible the rugged terrain in this area hampered detailed field investigations, or the scale of the maps did not facilitate the inclusion of isolated, vertical outcrops of the Slope Formation along the Little Missouri River Valley walls in these townships (T136N, R103W and R104W). As the northeastern dip of these beds (20 ft/mile; 3.8 m/km) exceeds the gradient of the Little Missouri River in this area, they may have presumed the Slope Formation is not exposed within the Logging Camp Ranch area, dictating that strata at the base of Tepee Buttes and elsewhere through Ranger Township are part of the lower Bullion Creek Formation. This interpretation was used in the initial reports from this critical minerals project (Kruger et al., 2017; Murphy et al., 2018). Additionally, brightly colored beds were not encountered consistently at this stratigraphic level across the area. Wehrfritz (1978) traced the Rhame bed eastward into the west half of Section 6 (T136N, R102W). Warwick and Luck (1995) expanded the Rhame bed an additional mile (0.6 km) to the southeast in measured section 96 (T136N, R102W, Sec. 8). Belt and others (2004) traced both the Rhame bed, calling it the Rhame zone, and the H bed, calling it the H-coal zone, for approximately 11 miles (17.7 km), from T136N, R104W into T136N, R102W. Throughout their cross sections, the Rhame zone directly underlies the H-coal zone and both zones are of variable thickness.

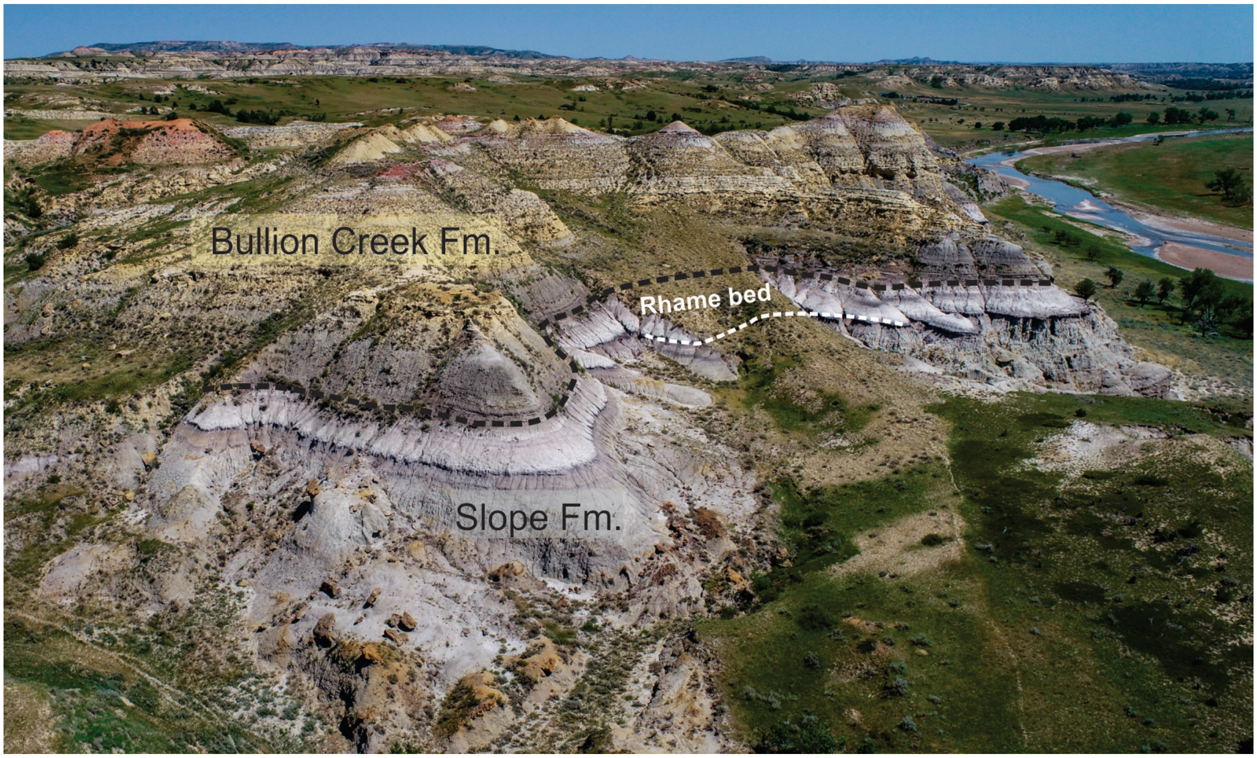


Figure 7. The contact of the Slope and Bullion Creek Formations (dashed black line) in T137N, R103W, Sec. 32, in the area where the Little Missouri River turns to the east. The Rhame bed (white dashed line at base) is well-developed and easily traced across good exposures through this area and upriver, but downriver it becomes less obvious and is not as continuously exposed. Drone photo taken August 2023 looking east from measured section 284 of this report. The Harmon clinker caps the foreground outcrop.

Wehrfritz (1978, p. 55) states: "The most northeastward outcrop of the Rhame Bed in the entire study area is at the level of the river, at the base of Tepee Buttes, in Sec. 6, T.136N., R.102W., Slope County. Tepee Buttes is capped by the Sentinel Butte Formation, so the entire Bullion Creek Formation is exposed on the west-facing side, in strikingly laterally continuous beds." Indeed, the top of the bright white zone is present at the base of the outcrops in Section 6 (fig. 8; measured section 219 of this study) traceable from the west, just below the H lignite bed. But this exposure is not truly at the base of the Little Missouri River, as colluvium obscures the lowest 40 feet (12 m) of the section. Colluvium is not present just downriver in Section 5 on the southeastern flank of Tepee Buttes, where a subtle but noticeably lighter zone just below the H bed is exposed some 72 feet (22 m) below the base of the Harmon bed (fig. 9, measured section 76, this study), consistent with the thickness of this interval as noted nearby by Hares (1928). At least 145 feet (44.2 m) of strata is exposed below the base of the Harmon bed on the southeastern face of Tepee Buttes, suggesting the Rhame bed and additional upper Slope Formation strata should be exposed in this area beyond the most northeasterly outcrop of Wehrfritz (1978).

None of the distinctive silcrete was identified in situ at Logging Camp Ranch, but its absence is also consistent with the nearest sections of both Hares and Wehrfritz to the south, where only the bright-colored zone is present. Interestingly, the base of the Rhame bed at the Tepee Buttes section has a pale greenish tint (fig. 10), which was also noted by Wehrfritz (1978, p. 52, 55) in more extensive exposures to the west. Moore (1976, p. 35) also noted that "locally associated with the bleached

Figure 8. The Rhame bed and Harmon-Hanson-H lignites northwest of Tepee Buttes (visible in the upper right side of the photo) at measured section 219 (T136N, R102W, Sec. 6). Although Wehrfritz (1978) believed the Rhame bed dipped below ground in this area, the Little Missouri River cuts perpendicular to dip direction downriver and the Rhame bed is well exposed at several sites. Drone photo taken in November 2020 facing southeast.

Figure 9. The Rhame bed and Harmon-Hanson-H lignites southeast of Tepee Buttes at measured section 76 (T136N, R102W, Sec. 5). The color change between the Slope and Bullion Creek Formations, along with the brightness of the Rhame bed itself, is subtle in this area. Drone photo taken in November 2020 facing northeast.

zone are subtle green and lavender colors, both of which are absent from weathered surfaces of the main body of the Ludlow (Slope) and the overlying Tongue River (Bullion Creek) Formation." An overall color change is typically observable between the lighter yellow colors of Bullion Creek strata and somber grays of the Slope Formation, but no obvious change is immediately apparent in the 50 feet (15 m) of strata exposed below the bright-colored zone at Tepee Buttes. Moore (1976) noted the generally brighter nature of beds in the upper portion of the Ludlow (now Slope) Formation, just below the white siliceous zone, in the area west of Logging Camp Ranch (T136N, R104W, Sec. 32). The confusion created by this color variation is one reason he used the more consistently distinct white siliceous zone as the upper formation contact.

Since it represents an unconformable weathering profile, the Rhame bed is variable in its development and its exact stratigraphic position relative to other beds. In some outcrops, the distinctive silcrete is in place and the coloration is bright white (fig. 11), making identification of the weathering zone obvious and thus the contact of the Slope and Bullion Creek Formations readily apparent. Its weak brightness and lack of silcrete along the outcrops near Tepee Buttes and just to the south in Sections 7 and 16 (fig. 12) of Ranger Township in the study area of Murphy and others (2018) did not make its position immediately apparent, but where it is more strongly developed it is consistently identified at or near the base of an interval containing the Harmon, Hanson, and H bed lignites or their clinker (fig. 13). Tracing these individual lignites between

Figure 10. A wedge of greenish Rhame bed strata is more easily visible in this oversaturated photo of measured sections 73 and 76 (T136N, R102W, Sec. 5). Strata within the weathering zone is typically bright white, light gray, or light tan, but here it has a greenish tint. It may also include hues of pink or purple.

Figure 11. An example of the Rhame bed where it is well-developed at measured section 302 along Deep Creek just southwest of Logging Camp Ranch (T136N, R103W, Sec. 35). It includes a silcrete in place (white arrow) and offers a sharp contrast between its bright white mudstones and the darker grays below. The H lignite bed and its distinctive tonstein immediately overly the Rhame bed in this area. Drone Photo taken in October 2022 looking east.

widely spaced outcrops can be difficult, as they thicken, thin, and split over short distances (See Coal Correlation discussion in Murphy et al., 2018), but the H lignite is easily correlated in the field across the Logging Camp Ranch area due to the distinct pinkish-orange tonstein which is consistently present in the upper half of the bed. Based on the works of Hares (1928), Moore (1976), and Wehrfritz (1978) in northern Slope County, the Rhame bed consistently occurs 0 to 20 feet (0 – 6.1 m) below the base of the H bed, often containing thin lignites within or below it.

Thus, the approximate stratigraphic interval that should contain the Rhame bed, 70 feet (21 m) below the base of the Harmon lignite or 10 feet (3.0 m) below the base of the H bed (with some variability as an unconformable surface), is exposed across the Logging Camp Ranch area, for many miles downriver beyond the furthest northeastward outcrop of Wehrfritz (1978). It was a reasonable assumption of Wehrfritz that the beds continued to dip below the river to the northeast, but the river flows southeast from this point, parallel to dip direction, and downcuts 45 ft (14 m) from where it briefly flows into Billings County northwest of Tepee Buttes (T137N, R102W, Sec. 33) to where it does so again four miles (6 km) to the east. The base of the H bed is only 20 feet (6 m) above the river base in T137N, R102W, Sec. 33, but considerably more of the underlying interval is exposed across Ranger Township (T136N, R102W) to the southeast. The base of the H bed is 55 feet (17 m) above the river in Section 6, 95 feet (29 m) above it in

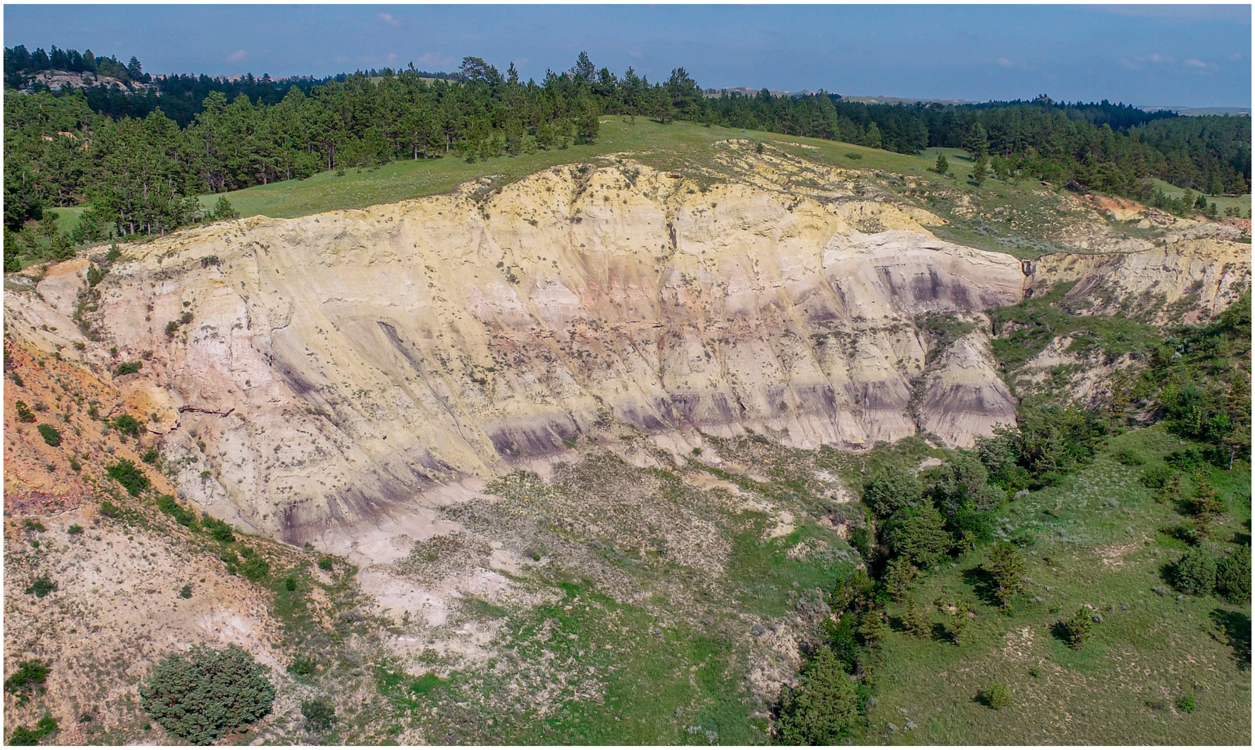


Figure 12. The Rhame bed is not especially obvious at the base of this outcrop in T136N, R102W, Sec. 16., the first site where REE enrichment (>910 ppm) was identified during this project. It is far more obvious just one mile to the southeast (fig. 14). See Figure 17 for measured section locations at this site. 2018 drone photo taken looking east.

Figure 13. The Rhame bed is especially bright and well exposed along Sand Creek in T136N, R102W, Sec. 22. The Harmon, Hanson, and H lignites are mostly burned, although a portion of the H bed is still present on the right side of the photo. A thin lignite separates the Rhame bed from the thick, underlying yellow sandstone. Drone photo taken November 2020 taken looking northeast. Measured sections 180, 199, 200, and 210-213 are from this outcrop.

Section 5, 105 ft (32 m) in Section 9, and 80 ft (24 m) in Section 3. Bright strata in the stratigraphic position of the Rhame bed, with a maximum brightness typically around 10 feet (3 m) below the H bed, can also be traced in every section to the southeast from measured section 219 west of Tepee Buttes. Thick outcrops of the Rhame bed can even be found in draws east of Logging Camp Ranch in Section 23 (fig. 14). The top of the Rhame bed (and base of the H lignite) is at an elevation of approximately 2,460 ft (750 m), still 70 feet (21 m) above the Little Missouri River where crosses from Slope to Billings County northeast of Logging Camp Ranch (fig. 15). Based on the identification of the Rhame bed in outcrops along Deep Creek, Sand Creek, and the Little Missouri River, the uppermost bedrock unit over much of Ranger Township is the Slope Formation (fig. 16), although it is obscured by alluvium over much of its extent.

Field Methods

A majority of samples were collected utilizing shovels at an outcrop, where approximately six to twelve inches (15 to 30 cm) of rock material was first cleared from the outcrop face to expose less-weathered rock for sampling. Samples were taken at desired intervals by digging further into the rock face and removing 1,000 to 3,000g (2.2 to 6.6 lbs.) of rock, typically in 3-inch (7.5-cm) intervals, and placing the material into a gallon-sized (3.8 l) Ziploc bag. Alternatively, samples of similar size were collected utilizing a battery-operated drill fitted with a three-inch diameter soil auger head attachment and drilled either horizontally into the side of an outcrop or vertically down into a coal near the ground surface. Larger samples were split, with 1 kg (2.2 lbs.) of sample submitted for analysis and the remaining sample material archived at the Geological Survey's warehouse in Bismarck. Typically, the tops of the beds were sampled first and then the middle and bottoms were sampled if the top proved to be enriched. Lignites within the Rhame bed were sampled in detail (one-inch/2.5 cm intervals) in Sections 8 and 16 (T136N, R102W). Additionally, a number of additional geologic sections were measured in Sections 7, 8, and 16 in order to expand on the conclusions in Murphy and others (2018).

Samples were collected from 2015 through 2022 and include some previously reported samples from the Logging Camp Ranch area to reevaluate them in a wider sampling context. Of the 768 samples included in this report, 92 were first reported in NDGS Report of Investigation No. 117 (Kruger et al., 2017, measured sections 42 and 53 through 61), but three samples (53A, 61E, and 61G) have been re-analyzed and include new non-REE critical mineral data. All 113 samples previously reported in Report of Investigation No. 119 (Murphy et al., 2018, measured sections 67 through 97) are included in this report, and six of these (87D, 92A, 93A, 94A, 95A, and 96A) have new non-REE critical mineral analyses. Eleven samples are included from Report of Investigation No. 131 (Kruger et al., 2022, measured sections 162 and 163). In addition, this report presents the analytical results of 552 previously unpublished samples. The lithologies of the 768 samples include 544 lignites, 168 carbonaceous mudstones or claystones, 21 non-organic-rich mudstones and claystones, 21 tonsteins, five sandstones, five nodules or concretions, and four natural coal ashes.

Laboratory Methods

Samples, each approximately 1,000 grams or more by weight, were analyzed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) at Standard Laboratories in Freeburg, Illinois. Additionally, 19 samples were analyzed by the Earth and Environmental Research Center at

Figure 14. The Rhame bed outcrops in more typical thick, white, unvegetated beds east of Logging Camp Ranch at measured section 245 (T136N, R102W, Sec. 23), the most easterly exposure identified in Slope County.

Figure 15. The H lignite bed with the Rhame bed below along West River Road in T137N, R101W, Sec. 32. The base of the H lignite is still some 60 feet (18 m) above the Little Missouri River base here, suggesting the uppermost Slope Fm. likely outcrops for several miles northward into Billings County. Harmon bed clinker caps the outcrop.

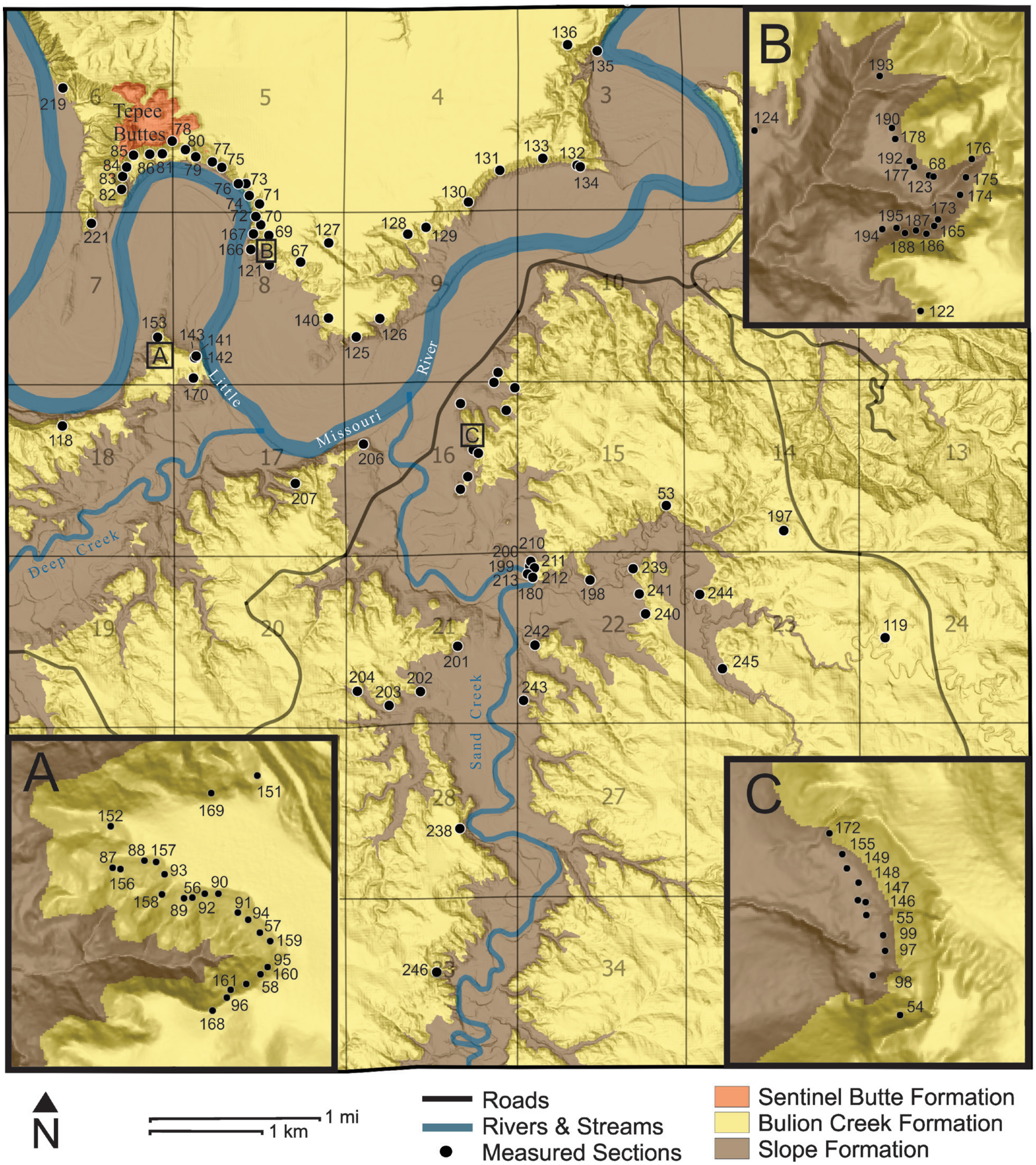


Figure 16. Measured geologic section locations and revised bedrock geology for Ranger Township (T136N, R102W). Logging Camp Ranch spans the central and northwestern parts of the township. See Figure 2 for its location within Slope County and its relationship to other measured sections included in this report.

the University of North Dakota in Grand Forks. The total REE concentrations from 222 samples in this report were modeled using laboratory-reported concentrations of seven rare earth elements (Ce, Er, Gd, La, Nd, Sc, Y) and the methodology outlined by Kruger (2020). Estimated concentrations, entirely from samples estimated to contain less than 300 ppm REE, are marked with a tilde (~) in Appendix A.

Samples collected in 2015 and 2016 were analyzed for the 14 naturally occurring lanthanides and yttrium, which were combined and presented as total rare earth concentrations. Beginning in 2017, concentrations for the element scandium were reported and included in the total rare earth concentrations as it was found that, in coal, scandium was more likely to accumulate along with the other rare earths than it is in more conventional REE deposits. This report contains 37 of these older samples without scandium analyses. In 2018, the U.S. Department of Interior finalized a list of 35 critical minerals (DOI, 2018). In response, the rock analysis was expanded to all on that list that potentially could be found in coal, except the platinum group. After approximately 50 analyses, the expanded list was trimmed of those critical elements that had not shown any promise. Later, the list of analyses was further reduced to a dozen elements (beyond the rare earth elements) that showed potential for economic development.

Analytical Results (Rare Earth Elements)

Table 1 contains a summary of the analytical results of the 768 rock samples in this report. Of these, 362 samples are from the Slope Formation (including the Rhame bed) and 398 are from the Bullion Creek Formation. The vast majority of the Bullion Creek samples are from the lowermost 60 feet (18 m) which contains the Harmon, Hanson, and H lignites. One sample (78A) is likely from the HT Butte lignite near the top of Tepee Buttes, which marks the base of the Sentinel Butte Formation. Seven samples are also from the T-cross lignite, which represents the top of the Ludlow Formation, or the coal just below it.

Of the 768 samples, 176 contained over 300 ppm REE (including yttrium and scandium). All of these samples were lignites, brown paper shales, or organic-rich mudstones, with the exception of sample 73T (325 ppm), an H bed tonstein sample that likely included some of the surrounding coal, and sample 284I3r (333 ppm), a kaolinite-rich claystone roof sample of a coal within the Rhame bed. Twenty samples of the H bed tonstein averaged 147 ppm REE. Five roof samples of coals within the Rhame bed averaged 184 ppm REE. The elevated REE contents of the one tonstein and one claystone sample would still be considered “normal” under the classification system of Dai and others (2015), who felt the degree of enrichment is more easily discussed in relation to average values of upper continental crust (UCC). Multiples of 0.5, 2, 5, 10, and 100 times the UCC define depleted, normal, slightly enriched, enriched, significantly enriched, and unusually enriched coals, respectively (Table 2). For the summed rare earth elements, these thresholds are 91, 364, 910, 1,820, and 18,200 ppm, based on an average upper crustal abundance of 182 ppm (Taylor and McLennan, 1985; updated in McLennan, 2001). Using this classification, three samples are significantly enriched in the REE (Table 3), all from a lignite within the Rhame bed at measured section 284. Sample 284I2t, the upper two inches (5 cm) of a 12-inch thick (30 cm) lignite, contained 2,792 ppm REE, the highest sample concentration yet reported in this project. Seventeen samples are considered enriched in REE, 93 are slightly enriched, 507 are normal, and 148 are depleted.

Table 1. Summarized analytical results of this report. Some older REE analyses do not include ash yield data. Abbreviations: A is the atomic number of the element; n is the number of samples analyzed.

					Analyses (all lithologies; concentrations in ppm)								
					Dry Coal/Rock Basis				Ash Basis				
Chemical Group		Element	Symbol	A	n	MAX	MIN	MEAN	n	MAX	MIN	MEAN
Alkali Metals		Lithium	Li	3	330	302	1.1	40	329	766	7.9	66
		Rubidium	Rb	37	135	162	1	42	135	177	3	68
		Cesium	Cs	55	315	16.4	0.03	5.4	314	18.0	0.09	7.6
Alkaline Earth Metals		Beryllium	Be	4	299	30.7	0.3	4.1	298	104	0.6	10
		Magnesium	Mg	12	313	32800	604	6200	312	66700	683	14100
		Strontium	Sr	38	156	2850	31	340	155	4910	39	960
		Barium	Ba	56	179	11500	43	1095	178	27600	180	2700
Rare Earth Elements	Lanthanides	Lanthanum	La	57	768	526	1.8	36	731	1980	15.1	178
		Cerium	Ce	58	768	1090	4.0	80	731	955	8.0	80
		Praseodymium	Pr	59	523	124	0.6	11	486	261	3.1	28
		Neodymium	Nd	60	768	483	1.9	38	731	1070	5.1	90
		Samarium	Sm	62	523	98.2	0.3	9.8	486	237	2.3	24
		Europium	Eu	63	523	19.5	0.07	2.2	486	53.0	0.24	5.6
		Gadolinium	Gd	64	768	81.4	0.3	7.8	731	211	0.6	19
		Terbium	Tb	65	523	11.1	0.06	1.4	486	30.2	0.21	3.7
		Dysprosium	Dy	66	524	54.1	0.4	8.0	487	184	1.1	21
		Holmium	Ho	67	523	11.9	0.07	1.5	486	40.5	0.16	4.1
		Erbium	Er	68	768	34.8	0.18	3.7	731	118	0.25	10
		Thulium	Tm	69	522	4.62	<0.02	0.59	486	15.7	≤0.02	1.6
		Ytterbium	Yb	70	523	27.8	0.14	3.8	486	94.6	0.41	10.0
		Lutetium	Lu	71	522	4.24	<0.02	0.55	486	14.4	≤0.02	1.5
Rare Earth Elements	Transition Metals	Scandium	Sc	21	731	45.5	1.3	13.4	726	250	1.6	32
Rare Earth Elements	Transition Metals	Yttrium	Y	39	768	346	1.7	33	731	1180	2.1	90
Transition Metals		Titanium	Ti	22	306	13100	79	2300	305	14500	802	3800
		Vanadium	V	23	267	477	3	110	266	1680	9	221
		Chromium	Cr	24	236	403	2	68	235	1460	2	140
		Manganese	Mn	25	74	9460	14	290	74	12600	16	600
		Cobalt	Co	27	190	89.2	0.4	14.4	190	425	0.5	39
		Zirconium	Zr	40	268	845	7.5	158	267	2440	28.5	360
		Niobium	Nb	41	275	50.9	0.7	12	274	113	2.9	23
		Molybdenum	Mo	42	304	73.7	0.2	9.9	303	216	0.3	25
		Hafnium	Hf	72	198	12	0.4	3	197	42	1.1	8
		Tantalum	Ta	73	223	4.31	0.05	0.83	222	5.84	0.32	1.43
		Tungsten	W	74	180	367	0.7	5	179	466	1.3	10
Post-Transition Metals		Gallium	Ga	31	359	80.9	1.7	20.9	358	188	4.7	37
		Indium	In	49	42	0.13	<0.02	n/a	42	0.39	≤0.02	n/a
		Tin	Sn	50	46	10.1	<0.2	2.5	46	14.9	≤0.7	4.2
		Bismuth	Bi	83	42	0.89	<0.10	n/a	42	1.66	≤0.12	n/a
Metalloids		Germanium	Ge	32	470	193	<1	11	469	1150	≤1	26
		Arsenic	As	33	109	246	0.87	31	109	353	0.94	61
		Antimony	Sb	51	189	22.7	0.11	3.5	182	59.1	0.52	8.3
		Tellerium	Te	52	42	0.52	<0.10	n/a	42	1.02	≤0.03	n/a
Actinides		Thorium	Th	90	134	49.3	1.0	13.6	134	99.7	3.7	25.9
		Uranium	U	92	400	58.5	0.5	10.4	399	152	0.7	23.8

Table 2. Relevant classifications and thresholds for REE concentrations in coal, including the highest concentrations known from ND lignite prior to this NDGS critical minerals project (2015 to present) and the highest sample from previous NDGS reports. Values for the upper continental crust from Taylor and McLennan (1985), updated in McLennan (2001).

Economically Relevant REE Concentrations	Total REE (ppm or %)	Enrichment Classification (Dai et al., 2015)
	1.82%	Unusually Enriched (100 times UCC)
Highest REE Concentration from ND Lignite (NDGS Study) (Murphy et al., 2023)	2,570	
	1,820	Significantly Enriched (10 times UCC)
	910	Enriched (5 times UCC)
	364	Slightly Enriched (2 times UCC)
Threshhold for Potentially Promising REE Concentrations in Coal (U.S. Dept. of Energy)	300	
	182	Normal; Average Upper Continental Crust (UCC)
Highest Previously Reported REE Concentration from ND Lignite (USGS COALQUAL Database; Palmer et al., 2015)	165	
	91	Depleted (0.5 times UCC)
Average REE Contents of U.S. Coal (Finkelman, 1993)	66	

Table 3. Total rare earth element enrichment (dry coal basis) by stratigraphic unit. Enrichment classification of Dai and others (2015) based on an average upper crustal abundance of 182 ppm REE (including yttrium and scandium) reported by McLennan (2001). Abbreviations: n is the number of samples.

		Degree of REE Enrichment (% of samples)				
Stratigraphic Interval	n	Depleted <91 ppm	Normal 91 to 363 ppm	Slightly Enriched 364 to 909 ppm	Enriched 910 to 1819 ppm	Significantly Enriched ≥1820 ppm
Bullion Creek Fm. above Harmon	71	21%	79%			
Harmon lignite	110	41%	55%	4%		
Hanson lignite	41	46%	59%			
H lignite	121	29%	67%	4%		
Lignites within/below Rhame bed	259		65%	28%	6%	1%
Slope Fm. below Rhame bed	102	17%	79%	4%		

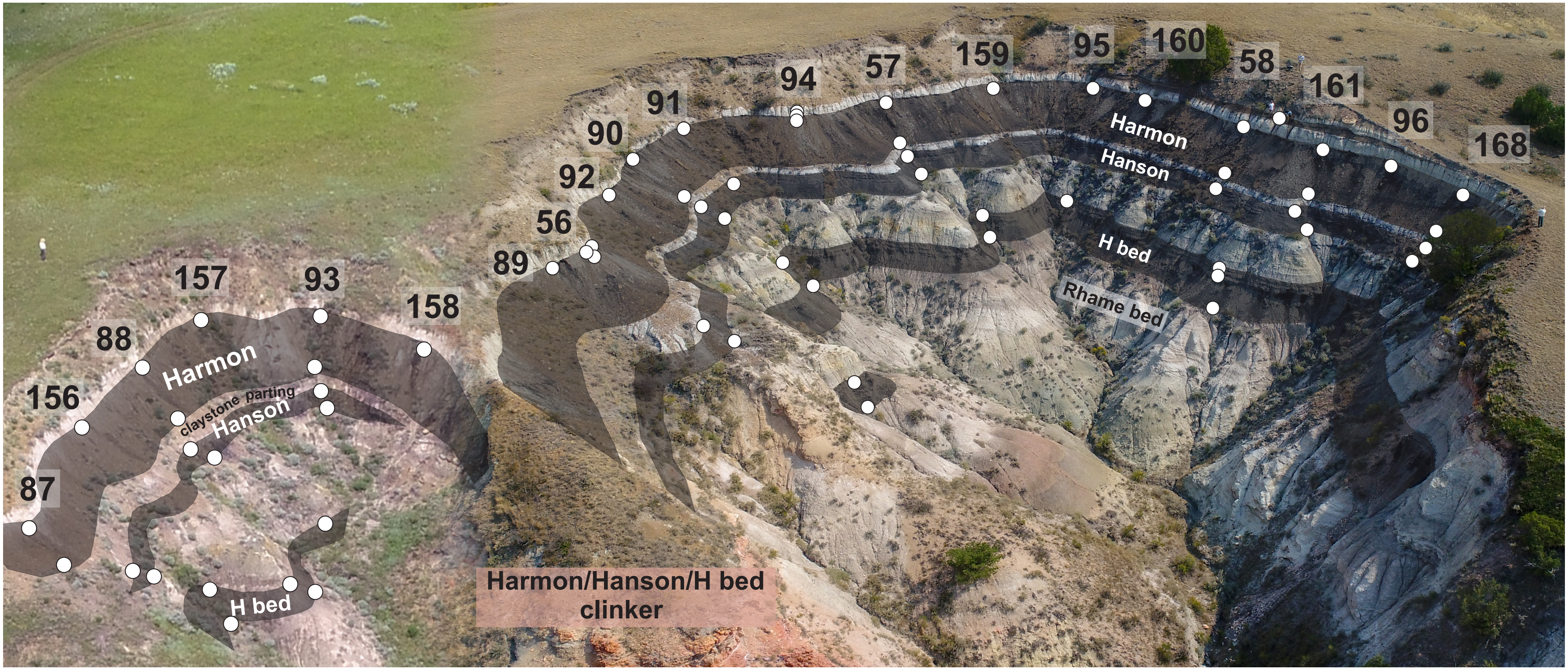
Of the 113 samples that were at least slightly enriched in REE (≥364 ppm), 91 were from lignites or stratigraphically proximal carbonaceous beds within or just below the Rhame bed weathering zone. None of the 63 samples from mostly thin, Bullion Creek lignites occurring in the strata overlying the Harmon bed contained concentrations above the 364 ppm REE threshold. Out of 153 samples from the Harmon and Hanson lignite beds, only four samples surpassed the 364 ppm REE threshold, all from the top of the Harmon bed (555 ppm max) in T136N, R102W, Sec. 7. Six of the 144 samples from the H bed narrowly exceeded 364 ppm REE (402 ppm max), but a five to eight inch (13 to 20 cm) thick coal a few feet (1 m) above the top of the H bed is locally present in Sections 21 and 22 of T136N R102W, where seven of nine samples were slightly enriched to enriched (1,277 ppm max). Of the 107 samples from the Slope Formation that were not within or directly below the Rhame bed, four samples exceeded 364 ppm (544 ppm max), all from the area near the type section of the Slope Formation (measured sections 61, 181-183, and 216-218), including two from the base of the Yule lignite.

New Sampling of the Harmon, Hanson, and H Lignites, and Coals Within the Rhame Bed

Despite the broad stratigraphic and geographic distribution of initial sampling by Kruger and others (2017), the two highest REE concentrations from 352 samples in that report were both from lignite beds in the Logging Camp Ranch area: the top of the Harmon lignite in T136N, R102W, Sec. 7, and a thinner coal just two miles (3 km) away in Sec. 16, identified by Hares (1928) as the H bed, but now understood to be an unnamed coal within the Rhame bed weathering zone. In an effort to determine if these two beds were inherently enriched or if the high REE concentrations were localized, Murphy and others (2018) conducted lateral sampling of these same strata along more extensive outcrops to the north. They did not find any additional locations where the top of the Harmon bed contained elevated concentrations of REE but did identify a second site where the coal within the Rhame bed was enriched. The additional analyses presented in this report support and expand upon the conclusions of Murphy and others (2018). Outside of the Sec. 7 terrace (fig. 17; table 4), the average REE concentrations of 43 samples from the top of the Harmon bed is just 105 ppm, with none exceeding the 555 ppm identified by Kruger and others (2017; sample 56FII). Lateral samples of the coal(s) within the Rhame bed have shown the opposite result. Further sampling near the original sample in Sec. 16 showed the top two inches (5 cm) can reach 1,598 ppm (fig. 18, table 5), significantly higher than the original 603 ppm sample from Kruger and others (2017; sample 54A). Lateral sampling from the second site identified by Murphy and others (2018; sample 68F) in Sec. 8 shows REE concentrations are consistently elevated even where the coal is weakly developed (fig. 19; table 6). A lignite of similar thickness in the same stratigraphic position 11 miles (18 km) to the west contains REE concentrations up to 2,792 ppm (Sample 284I2, Appendix A).

This stark contrast in overall REE concentrations between the Harmon bed and the coal within the Rhame bed is better understood after the correlation of the Rhame bed weathering zone across Logging Camp Ranch in this report and the identification of similar REE enrichment in lignites below a broadly analogous profile in the Golden Valley Formation (Murphy et al., 2023). Before this pedogenic enrichment model was developed for the Williston Basin, REE contributions from tonsteins (volcanic ash deposited into coal swamps) had been investigated, as these beds have been identified as sources of REE enrichment in other coal basins. The H bed contains a prominent 2-inch thick tonstein and one of the three early samples of it (73T) contained slightly elevated REE concentrations at 325 ppm. This report contains additional analyses of the H bed tonstein from across Logging Camp Ranch and over 10 miles (16 km) to the southwest. The 20 total samples of the H bed tonstein averaged 135 ppm REE, with none exceeding the early analysis. In case the REE had leached from the tonstein into the surrounding lignite, the 3 inches (2.6 cm) of lignite above and below the tonstein was sampled in seven locations. Lignite immediately above the H bed tonstein averaged 129 ppm REE with a high of 166 ppm, while lignite samples below it averaged 138 ppm with a high of 234 ppm. These results suggest the volcanic ash that entered the swamp as the H bed was deposited was not especially enriched in the REE, although it does contain elevated levels of gallium, tin, and thorium (see Critical Minerals Results).

This report also includes more detailed vertical sampling of coal(s) within the Rhame bed, including one-inch sample intervals through Kruger and others' (2017) original sample site in Sec. 16 (fig. 20) and Murphy and others' (2018) second site where it is more clay-rich in Sec. 8 (fig. 21). Both of these profiles show relatively consistent decreases in enrichment from top to bottom (tables 7 and 8), as would be expected if the REE were being transported into the lignite from descending fluids. In these detailed vertical profiles, the upper inch or two is shown to be less REE-enriched, likely because the upper margins contain higher proportions of siliciclastics as noted in the field and suggested by the ash yield. The samples from the upper margins are also proportionally more enriched in the light than the heavy REEs (fig. 25A & B) than are the



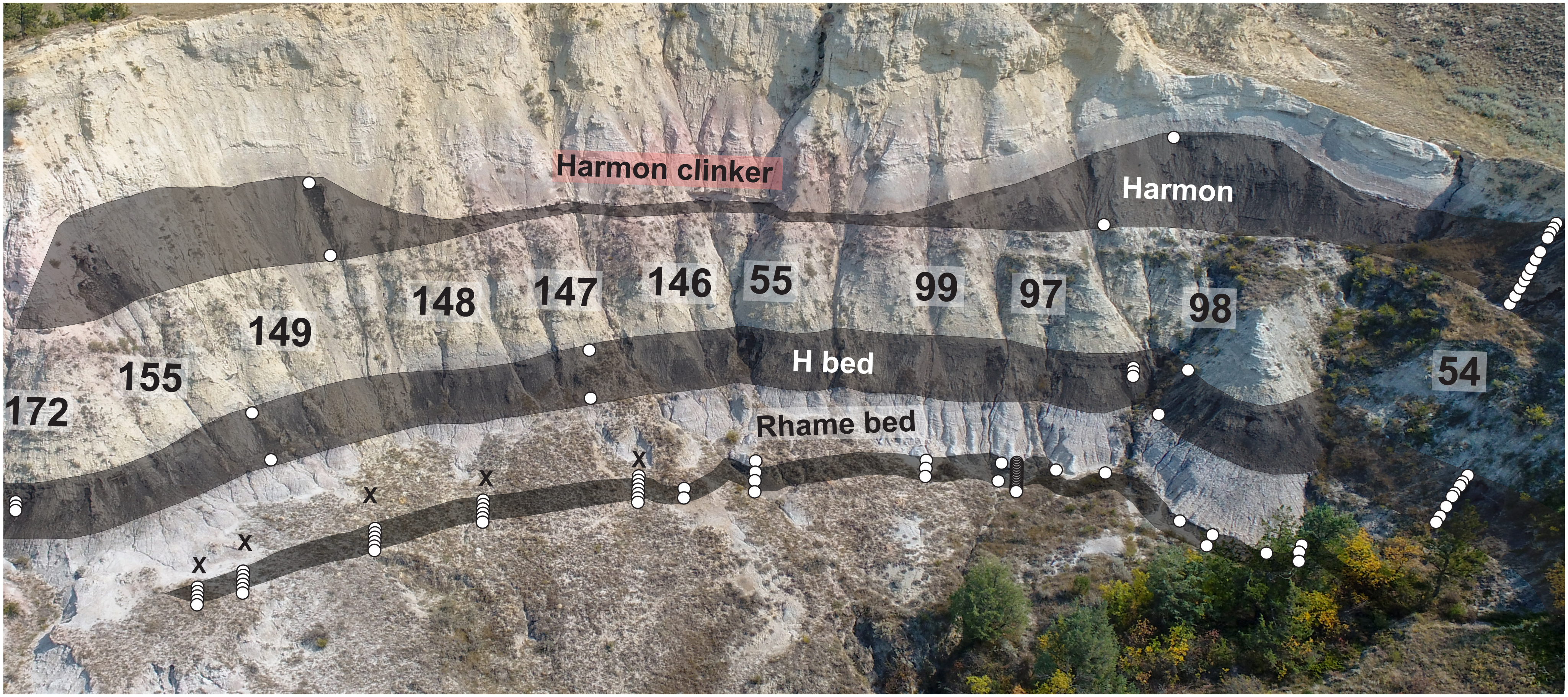
Measured Sections	87	156	88	157	93	158		89	56		92	90	91	94	57	159	95	160	58	161	96	168
Coal above Harmon							Harmon/Hanson/H bed are burned												140			
Harmon roof														200								
Harmon top	227	222	274	85	439	272		343	493	555	324	412	349	217	295	166	299	104	350	126	214	177
Below Harmon top									104					132								
Harmon base	69		82		77							42			47				68	53		235
Hanson roof (parting)																						
Hanson top	261		202		165				295			176	103		143				36	134		347
Hanson base	101		62		243			53				59			59					77		56
H bed roof									344*													
H bed top	283			290	105			402	288*				304		102		239		284			
H bed tonstein									74*										173			
H bed base	154			120				64					85		68				36			

(coal below Rhame bed is absent)

(*) Indicates the sample location was outside the photo on the back side of the butte

▲ **Figure 17.** Measured sections and sample locations (white dots) in T136N, R102W, Sec. 7. The Harmon bed is split by a few feet (~1 m) of claystone in this area and the lower Harmon is called the Hanson bed. The expression of the Rhame bed is weak in this area, and no coal occurs in the interval below. Composite image of drone photos taken in the summer and fall of 2018 looking northeast. Roughly two tons of lignite was excavated from the top foot (0.3 m) of the Harmon bed between sections 89 and 159 during June of 2018.

◄ **Table 4.** Total REE concentrations (ppm; dry coal basis) for samples in the figure above. REE enrichment is fairly localized to the top few inches of the Harmon bed, primarily in the area adjacent to measured section 56, although occasionally concentrations along the top of the Hanson and H bed are also slightly elevated.



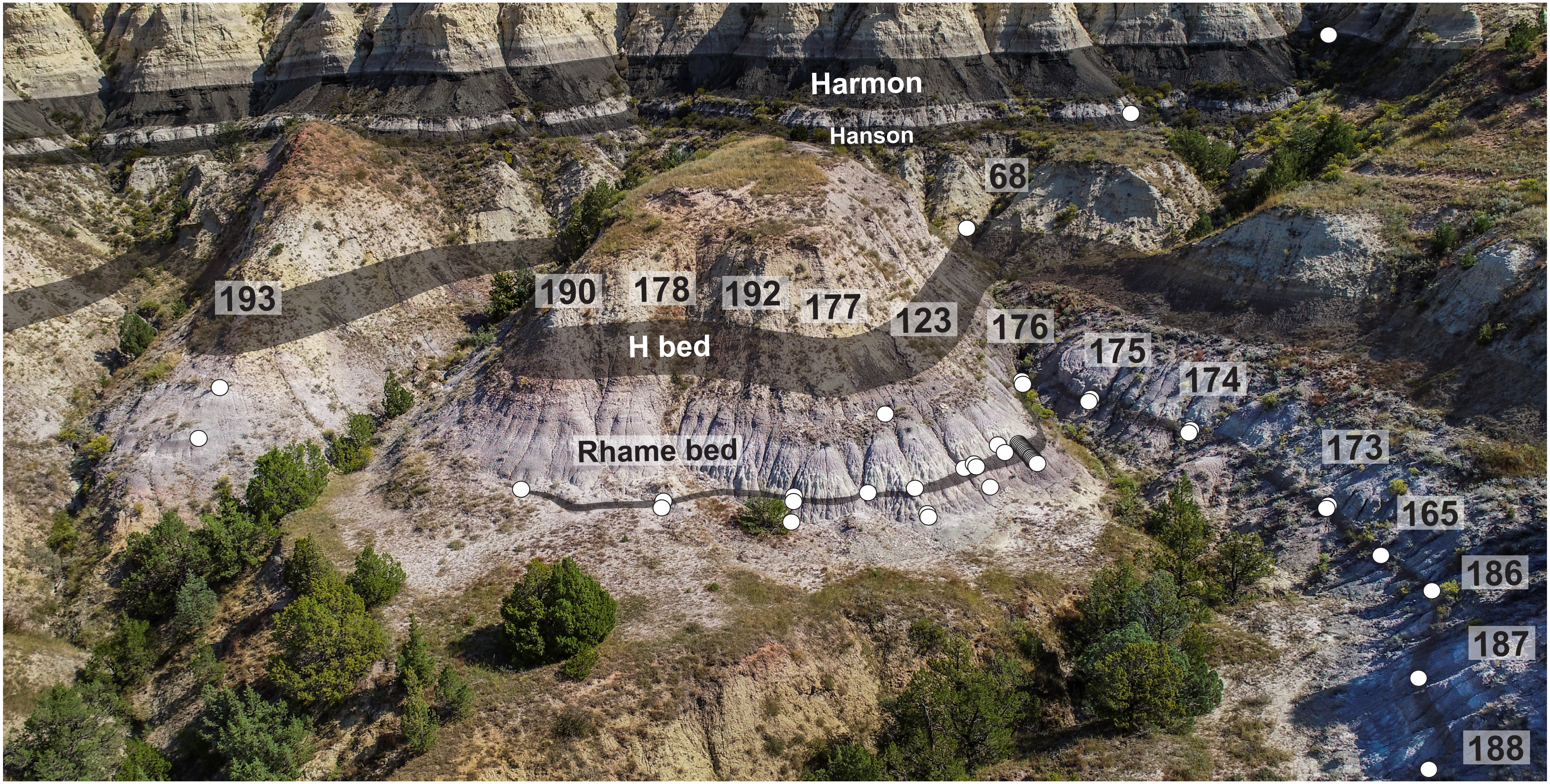
Measured Sections	172	155	149	148	147	146	55	99	97				98		54	
Harmon top			110										45			83*
Harmon middle																37a*
Harmon base			164										269			36*
H bed top			153		56								111			206*
H bed above tonstein	166												104			82a*
H bed tonstein	106												78			
H bed below tonstein	143												155			36a*
H bed base			76		81								126			34*
Rhame bed (roof of lower coal)					189		92*			123						
Coal below Rhame bed top	241	235	256	304	600	415	365*	247	1026	803a	434	1066	1598	780	802	603*
Coal below Rhame bed middle	482	282	338	380	455	214		207		763a				332		499*
Coal below Rhame bed middle	467	529	327	665	489		287	473	539	496a						227*
Coal below Rhame bed middle	370	539	186	358	270					514a						
Coal below Rhame bed base	237	227	154	218	178		164*			485a						
Coal below Rhame bed floor		151	159	179	168					343a						

(a) Represents averages of multiple samples - see Appendix A for detailed analyses

(*) Indicates total REE concentrations do not include scandium

▲ **Figure 18.** Measured sections and sample locations (white dots) in T136N, R102W, Sec. 16. Black X's mark auger holes above a thin coal below the Rhame bed where it is not exposed at the surface. The Harmon bed does not contain a parting; thus no Hanson bed occurs in this area. The coal below the Rhame bed becomes more clay-rich before pinching out toward the north (left). Drone photo from 2018 looking east. Forty-four tons of lignite was excavated in January 2020 from the thin lower coal between sections 55 and 54.

◄ **Table 5.** Total REE concentrations (ppm; dry coal basis) for samples in the figure above. The Harmon and H lignites contain REE concentrations relatively normal for coal, but the lignite below the Rhame bed weathering zone is enriched, especially where the lignite is less clayey in sections 97, 98, and 54.



Measured Sections	193	190	178	192	177	68		123		176	175	174	173	165	186	187	188
Harmon top						232											
Hanson top						137											
H bed top						214											
Carb. zone below H bed	186				201												
Rhame bed (roof of lower dark claystone)								248									
Dark claystone below Rhame bed top		258	322	653	653	638	511	609	723a	332	427	332	273	366	402	284	147
Dark claystone below Rhame bed middle							404		404a								
Dark claystone below Rhame bed middle									319a								
Dark claystone below Rhame bed base			276	225					315a	250	259	250	273				
Carb. zone below dark claystone	287			245	229a		211										

(a) Represents averages of multiple samples - see Appendix A for detailed analyses

▲ **Figure 19.** Measured sections and sample locations (white dots) in T136N, R102W, Sec. 8. A dark gray to black organic-rich claystone is present near the base of the Rhame bed weathering zone in this area in the approximate stratigraphic position of the enriched lignite nearby in Sec. 16. The dark claystone pinches out to the northwest (left) and just outside the photo to the south (bottom right). Drone photo taken in 2018 looking northeast.

◄ **Table 6.** Total REE concentrations (ppm; dry coal basis) for samples in the figure above. Out of the 40 samples attributed to the dark claystone, the average ash yield was 91% by weight. REE enrichment is inversely correlated, as the eight samples under 90% ash from this bed averaged 530 ppm REE.

Figure 20. Sampling at measured section 97 (T136N, R102W, Sec. 16). Eighteen inches (46 cm) of lignite was sampled below the Rhame bed weathering zone, a light gray to tan, fine-grained sandstone. Each vertical inch (2.5 cm) was collected in 2 kg (4.4 lb.) samples (white arrows) until reaching a brown claystone floor. A sample (black arrow) of the overlying sandstone was also analyzed. Photo taken facing east after sampling. This area was later excavated as part of the 44-ton collection in 2020.

Table 7. Select analytical results (in ppm) of the most promising REEs (blue), other critical minerals (green), and radioactive contaminants (orange) for the samples shown above. Also included are four lateral samples from the top two inches (5 cm) of the bed after it had been excavated up to 15 feet (4.6 m) back into the cliff face in January 2020, prior to reclamation.

Sample ID	Sample Interval		Ash Yield	ΣREE	ΣREE	Dy	Gd	Nd	Pr	Tb	Sc	Co	Ga	Ge	Th	U
97ss	Overlying sandstone roof		96.40%	127	123	1.9	2.6	19.1	5.2	0.30	6.7					
97-1	0 to 1	0 to 2.5	75.86%	549	417	8.4	11.4	66.9	18.1	1.59	19.9	8.7	28.0	5	40.2	7.7
97-2	1 to 2	2.5 to 5.1	66.48%	1275	847	17.7	26.6	144	37.6	3.63	27.6	9.8		9		
97-3	2 to 3	5.1 to 7.6	49.43%	2317	1145	25.3	36.9	196	51.2	5.17	38.3	11.5	22.4	13	49.3	18.5
97-4	3 to 4	7.6 to 10.2	27.73%	3415	947	20.6	28.4	166	43.3	4.02	43.5	16.0		13		
97-5	4 to 5	10.2 to 12.7	26.60%	2719	723	15.0	21.1	131	32.7	2.94	35.7	17.4		13		
97-6	5 to 6	12.7 to 15.2	27.46%	2250	618	12.5	17.8	111	28.0	2.42	27.9	16.6		12		
97-7	6 to 7	15.2 to 17.7	29.84%	1626	485	10.3	14.8	90.7	22.5	2.04	22.3		8.9	10		15.2
97-8	7 to 8	17.7 to 20.3	21.83%	2201	480	10.5	14.7	87.3	21.8	2.03	22.1					
97-9	8 to 9	20.3 to 22.9	20.25%	2581	523	11.7	16.4	95.7	23.5	2.26	23.6					
97-10	9 to 10	22.9 to 25.4	20.17%	2640	532	12.3	17.0	94.9	23.6	2.32	21.8					
97-11	10 to 11	25.4 to 27.9	15.60%	3392	529	13.3	17.0	90.6	22.8	2.42	19.0					
97-12	11 to 12	27.9 to 30.5	11.93%	4028	481	12.8	15.6	80.2	20.3	2.26	17.0		9.7	15		9.7
97-13	12 to 13	30.5 to 33.0	16.96%	3197	542	15.4	18.4	89.0	22.9	2.68	17.1					
97-14	13 to 14	33.0 to 35.6	19.11%	2395	458	13.4	15.5	73.8	19.0	2.31	15.7					
97-15	14 to 15	35.6 to 38.1	17.80%	2550	454	13.5	16.0	76.8	19.5	2.37	16.2					
97-16	15 to 16	38.1 to 40.6	22.15%	2014	446	13.0	15.9	78.0	19.6	2.32	17.4					
97-17	16 to 17	40.6 to 43.2	35.35%	923	326	9.3	11.2	56.2	13.9	1.64	16.8	17.6	16.1	14	5.8	9.5
97-18	17 to 18	43.2 to 45.7	68.38%	376	257	5.2	7.0	42.7	11.1	0.94	14.2		21.0	5	9.1	6.9
54A2	0 to 2	0 to 5.1	28.01%	2864	802	21.0	32.4	165	37.3	4.32	30.0	13.2	9.4	13	23.4	19.3
97A2	0 to 2	0 to 5.1	26.53%	4020	1066	23.0	33.3	177	45.9	4.71	28.7	25.1	12.3	11	26.1	13.6
97A3	0 to 2	0 to 5.1	46.05%	942	434	9.0	13.2	72.0	18.5	1.84	19.2	15.3	24.4	12	35.3	15.7
98A2	0 to 2	0 to 5.1	28.33%	5642	1598	41.2	59.9	302	73.9	8.39	41.0	31.3	15.4	17	23.2	25.7
	in	cm	(weight %)	(ash basis)	(dry coal basis)											

Figure 21. Nineteen inches (46 cm) of black claystone at measured section 123 (T136N, R102W, Sec. 8). Each vertical inch (2.5 cm) was collected in 2 kg (4.4 lb.) samples (white arrows) until the claystone became medium gray. One sample of the overlying light gray mudstone roof (Rhame bed weathering zone) was also collected (black arrow).

Table 8. Select analytical results (in ppm) of the most promising REEs (blue), other critical minerals (green), and radioactive contaminants (orange) for the samples shown on the left. Also included are 15 lateral samples from the top few inches (5 to 10 cm) of the bed nearby (see fig. 18). Lateral samples 68F2 and 123F may have incorporated a localized lens of coalified wood, as samples of this type of material have previously returned similarly high germanium concentrations. These two samples also contain some of the lowest ash yields of all samples in this interval at this site.

Sample ID	Sample Interval		Ash Yield	ΣREE	ΣREE	Dy	Gd	Nd	Pr	Tb	Sc	Co	Ga	Ge	Th	U
123Fr	Overlying mudstone roof		94.52%	~263	~248	~5.9	7.0	41.0	~10.7	~1.07	10.9		17.7	3		
123-1	0 to 1	0 to 2.5	91.51%	851	779	18.3	26.3	141	35.1	3.62	17.6	16.3		26		22.0
123-2	1 to 2	2.5 to 5.1	86.13%	952	820	23.4	29.2	137	33.3	4.27	21.3	21.9		44	3.2	24.0
123-3	2 to 3	5.1 to 7.6	88.36%	645	570	16.8	19.4	89.1	22.2	2.86	19.4	18.5		41		16.4
123-4	3 to 4	7.6 to 10.2	88.85%	531	472	13.5	15.8	71.6	17.9	2.31	18.3	17.6		54		12.5
123-5	4 to 5	10.2 to 12.7	90.86%	434	394	10.9	12.6	58.7	14.8	1.83	18.0	15.9		34		10.6
123-6	5 to 6	12.7 to 15.2	89.75%	384	345	9.4	10.6	50.5	12.9	1.61	17.5	15.4		37		8.6
123-7	6 to 7	15.2 to 17.7	90.14%	378	340	9.4	10.6	50.6	12.8	1.60	18.2	15.7		44		8.2
123-8	7 to 8	17.7 to 20.3	90.94%	378	344	9.2	10.4	50.5	13.1	1.60	18.6	16.2		23		8.4
123-9	8 to 9	20.3 to 22.9	90.22%	349	315	8.5	9.4	46.3	11.8	1.43	18.7					
123-10	9 to 10	22.9 to 25.4	90.20%	349	315	8.5	9.4	45.9	11.8	1.42	19.3		31.1	23		8.1
123-11	10 to 11	25.4 to 27.9	90.52%	337	305	8.2	9.0	44.2	11.4	1.38	18.4					
123-12	11 to 12	27.9 to 30.5	90.65%	338	306	8.1	9.0	44.2	11.5	1.37	19.0					
123-13	12 to 13	30.5 to 33.0	90.58%	347	314	8.2	9.1	45.7	11.8	1.39	19.4					
123-14	13 to 14	33.0 to 35.6	91.02%	355	323	8.1	9.2	47.9	12.4	1.41	19.5					
123-15	14 to 15	35.6 to 38.1	91.35%	351	320	8.1	9.3	47.4	12.5	1.39	19.3		31.2	5		8.6
123-16	15 to 16	38.1 to 40.6	90.78%	340	309	7.9	8.9	45.1	11.7	1.37	18.8					
123-17	16 to 17	40.6 to 43.2	91.11%	359	327	8.2	9.7	49.1	12.7	1.43	19.3					
123-18	17 to 18	43.2 to 45.7	91.30%	344	314	8.0	9.2	45.7	12.0	1.38	19.4					
123-19	18 to 19	45.7 to 48.3	91.66%	331	303	7.9	8.8	44.6	11.6	1.32	18.8		30.3	3		7.8
68F	0 to 3	0 to 7.6	77.39%	824	638	19.0	23.4	110	26.7	3.46	19.9					
68F2	0 to 3	0 to 7.6	79.67%	641	511	14.4	18.3	86.6	21.1	2.63	17.2	18.2		192		
123F	0 to 3	0 to 7.6	73.52%	829	609	17.9	22.3	105	25.3	3.27	18.2	20.1		193		
165F	0 to 4	0 to 10.2	91.53%	399	366	9.5	11.6	56.1	14.1	1.69	18.1		30.9	4		14.5
173F	0 to 3	0 to 7.6	87.73%	312	273	8.1	8.3	36.3	9.1	1.31	19.1		31.8	4		8.5
174F	0 to 3	0 to 7.6	92.29%	433	400	12.4	12.4	54.9	13.7	1.97	19.1		36.6	4		9.4
175F	0 to 3	0 to 7.6	91.41%	467	427	12.8	13.9	61.2	15.3	2.15	20.5		34.7	5		15.1
176F	0 to 3	0 to 7.6	91.78%	362	332	9.9	10.7	46.4	11.6	1.63	19.0		33.6	4		11.6
177F	0 to 2	0 to 5.1	91.94%	710	653	16.1	21.6	109	27.6	3.04	15.5		23.4	7		8.7
178F	0 to 3	0 to 7.6	95.12%	339	322	7.3	9.8	55.3	14.1	1.40	12.8		20.1	4		5.0
186F	0 to 3	0 to 7.6	93.07%	432	402	9.8	12.5	67.6	16.9	1.82	16.6		29.0	4		
187F	0 to 3	0 to 7.6	94.67%	299	284	6.1	7.9	46.7	12.0	1.15	14.2		23.4	4		
188F	0 to 2	0 to 5.1	96.31%	152	147	2.6	3.1	21.5	5.8	0.45	12.0		20.6	3		
190F	0 to 3	0 to 7.6	94.91%	272	258	5.1	7.0	43.3	11.2	0.98	13.3		22.2	4		
192F	0 to 3	0 to 7.6	92.22%	708	653	16.1	22.1	117	29.3	3.18	14.8		22.4	7		
	in	cm	(weight %)	(ash basis)	(dry coal basis)											

more organic-rich samples below. In these cases, the highest REE concentrations came from the second or third inch (2.5 to 7.6 cm) from the top of the bed. Enrichment near the top of the seam is by far the most common vertical distribution, including at the most enriched site west of Logging Camp Ranch (measured section 284, Appendix A) where 3-inch (7.6 cm) samples through a stratigraphically equivalent lignite near the base of the Rhame bed are higher at the top than the bottom (fig. 22; Table 9). Nearby, the lignite is thinner (10 inches / 25 cm), but the top two inches (5 cm) contain 2,792 ppm REE, while the bottom is similar at 651 ppm (fig. 23; Table 10). Although it is the most common scenario, the most enrichment does not always occur at the top of the seam. Just to the southeast of Sec. 16 in Sec. 22, samples toward the base of the coal within the Rhame bed seem to be the most enriched (fig. 24; Table 11). This may be due to lateral groundwater flow along the base of the bed, or, seeing as how REE concentrations are inversely correlated with ash yield, heterogeneity within the organics of the coal itself may play a role. These coals, which are more enriched toward the bottom of the bed, are also noteworthy for their proportionally higher enrichment in the heavy REE (fig. 25C). Overall, REE distributions from lignite samples associated with the Rhame bed weathering zone show disproportional normalized enrichment of europium, gadolinium, terbium, and dysprosium relative to the other REEs (M-type of Seredin and Dai, 2012), typical of acidic natural waters and similar lignite samples (fig. 25D) associated with the analogous Bear Den weathering profile in Murphy and others (2023).

Analytical Results (Non-REE Critical Minerals)

Amongst the 768 samples in this report, the highest concentrations for all elements (the 16 rare earths and 28 others) were from one of the 567 newly reported samples. In addition, the sample analyses in this report contain the eight-year project's highest concentrations of beryllium (30.4 ppm), chromium (403 ppm), cesium (16.4 ppm), gallium (80.9 ppm), lithium (302 ppm), magnesium (32,800 ppm), rubidium (162 ppm), strontium (2,850 ppm), tantalum (4.31 ppm), thorium (49.3 ppm), tin (10.1 ppm), and tungsten (367 ppm). In this report, the highest concentrations for 35 of the 44 elements investigated were found in samples of carbonaceous lithologies (lignite, brown paper shale, or organic-rich mudstone). The highest concentrations of magnesium, strontium, tellurium, and titanium came from samples of natural coal ash and the highest tin concentrations came from samples of tonsteins. The highest antimony, arsenic, and tungsten concentrations came from a sandstone concretion, and the highest manganese concentration was found in an iron-manganese nodule. The sandstone concretion (sample 71conc) contained 22.7 ppm antimony, 246 ppm arsenic, and 367 ppm tungsten, the highest concentrations in this report. The tungsten concentration is four times higher than any other sample in the project to date and over 30 times higher than the next highest sample in this report, 213J4, an REE-enriched lignite sample within the Rhame bed with 11.2 ppm tungsten. The highest antimony and arsenic concentrations from carbonaceous samples in this report are 20.2 ppm and 159 ppm from samples 301A and 300A, respectively. An iron-manganese nodule (sample 216nod) contained 9,460 ppm manganese, over ten times higher than sample 216Jt from the type section of the Slope Formation, which is this report's highest manganese concentration from a coal at 729 ppm. The top seven tin concentrations were from samples of the H bed tonstein (76T, 246T, 73T2, 219T, 79T, and 240T) as well as a natural coal ash (53ash). The highest of these, sample 76T at 10.1 ppm tin, was over twice as enriched as the highest carbonaceous sample, 284Ib, the bottom of a coal within the Rhame bed, at 4.4 ppm tin. Natural coal ash samples contained the highest concentrations of magnesium (sample 243ash at 32,800 ppm),

Figure 22. Sampling at measured section 284 (T137N, R103W, Sec. 32). Twelve feet (3.7 m) of white to light gray claystone, mudstone, and siltstone, representing the Rhame bed weathering zone, overlies a 17-inch (43-cm) thick lignite. Five 2,000-gram (4.4-lb.) samples representing 3-inch (7.6-cm) intervals were collected across the lignite. Analytical results show the upper 6.5 inches (17 cm) of the bed is significantly enriched in REE, with decreasing, but still elevated, concentrations below.

Table 9. Select analytical results (in ppm) for the samples shown above. The most economic REEs are shown in blue, and the other critical minerals (elements) most promising for co-production from lignite are in green. Radioactive contaminants are in orange. The lanthanide REEs, Co, Ge, and U are most enriched at the top of the bed, while Sc, Ga, and Th may be more enriched in the middle or the base.

Sample ID	Sample Interval		Ash Yield	ΣREE	ΣREE	Dy	Gd	Nd	Pr	Tb	Sc	Co	Ga	Ge	Th	U
284lt	0 to 3	0 to 7.6	55.74%	3281	**1829**	39.5	53.7	307	78.0	7.57	24.9	43.4	37.0	45	8.2	26.1
284ltm	3.5 to 6.5	8.9 to 16.5	45.97%	3999	**1838**	44.2	55.3	298	75.0	8.06	29.4	23.2	18.7	24	11.8	20.9
284lm	7 to 10	17.8 to 25.4	36.53%	2048	**748**	23.1	25.2	109	26.1	3.87	28.9	17.0	25.3	29	9.4	9.7
284lmb	10.5 to 13.5	26.7 to 34.3	44.00%	1583	**697**	18.9	22.6	109	26.1	3.32	25.5	12.5	17.7	19	10.5	10.5
284lb	14 to 17	35.6 to 43.2	66.78%	977	**653**	14.3	19.9	108	27.0	2.66	22.0	7.0	37.6	24	18.9	11.5
	in	cm	(weight %)	(ash basis)	(dry coal basis)											

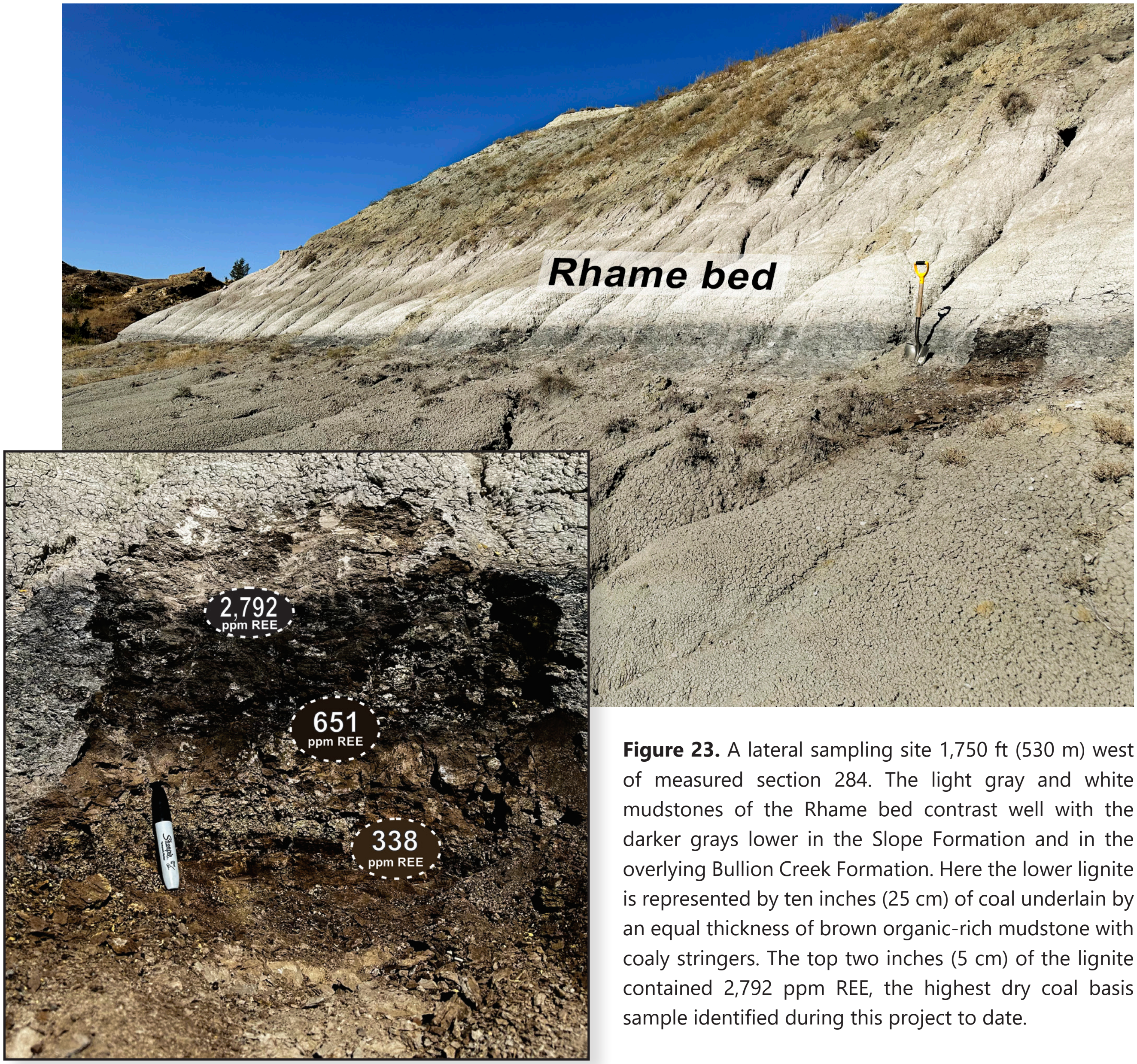


Figure 23. A lateral sampling site 1,750 ft (530 m) west of measured section 284. The light gray and white mudstones of the Rhame bed contrast well with the darker grays lower in the Slope Formation and in the overlying Bullion Creek Formation. Here the lower lignite is represented by ten inches (25 cm) of coal underlain by an equal thickness of brown organic-rich mudstone with coaly stringers. The top two inches (5 cm) of the lignite contained 2,792 ppm REE, the highest dry coal basis sample identified during this project to date.

Table 10. Select analytical results (in ppm) for the most promising REEs (blue), other critical minerals (green), and radioactive contaminants (orange) for the samples shown above. Also included is a nearby roof sample of very light brown claystone from the Rhame bed where it exhibited an especially greasy feel in hand (high kaolinite content). The only element showing a similar distribution to the REEs (enrichment at the top of the bed) was U. Co, and Ge were more enriched in the middle sample where the coal was more developed.

Sample ID	Sample Interval		Ash Yield	ΣREE	ΣREE	Dy	Gd	Nd	Pr	Tb	Sc	Co	Ga	Ge	Th	U
284l3r	Overlying kaolinite roof		91.74%	363	**333**	6.4	8.8	54.7	14.1	1.24	14.9	10.9	23.2	4		5.3
284l2t	0 to 2	0 to 5.1	55.10%	5068	**2792**	54.1	81.4	483	124	11.1	26.2	32.4	18.3	21	11.1	20.8
284l2m	7 to 10	17.8 to 25.4	35.62%	1829	**651**	16.2	20.1	97.8	23.8	2.90	21.4	33.2	24.3	33	11.5	8.0
284l2b	15 to 18	35.6 to 43.2	52.26%	647	**338**	9.5	10.9	51.8	12.3	1.62	20.1	20.7	29.9	18		13.7
	in	cm	(weight %)	(ash basis)	(dry coal basis)											

Figure 24. Sampling at measured sections 210 (left) and 213 (right), 400 feet (120 m) apart in T136N, R102W, Sec. 22. The carbonaceous material was 15 inches (38 cm) thick at section 210 and 22 inches (56 cm) thick at section 213. Five samples were taken vertically through the bed at each location. Results show that the lignite within the Rhame bed weathering zone in this area contains higher REE concentrations near the bottom than at the top of the bed, which is unusual compared to other sampling locations. This is likely because the highest-grade lignite occurs closer to the bottom of the bed at these sites, and the top is uncharacteristically more clay-rich.

Table 11. Select analytical results (in ppm) of the most promising REEs (blue), other critical minerals (green), and radioactive contaminants (orange) for the samples shown above. The lanthanides, germanium, and uranium are inversely correlated to ash yield within these sample profiles, suggesting organic association.

Sample ID	Sample Interval		Ash Yield	ΣREE	ΣREE	Dy	Gd	Nd	Pr	Tb	Sc	Co	Ga	Ge	Th	U
210J1	0 to 3	0 to 7.6	85.49%	370	**316**	8.5	10.0	47.9	11.8	1.48	17.9	12.2	29.1	4	22.1	13.7
210J2	3 to 6	7.6 to 15.2	87.48%	344	**301**	7.5	9.1	46.6	11.6	1.32	14.8		28.0	4	13.7	8.7
210J3	6 to 9	15.2 to 22.9	59.60%	1446	**862**	25.8	33.0	153	35.4	4.68	23.9		24.9	35	21.6	31.9
210J4	9 to 12	22.9 to 30.5	44.74%	2437	**1090**	36.3	45.2	200	45.0	6.54	22.2	51.9	25.1	43	10.7	45.2
210J5	12 to 15	30.5 to 38.1	51.55%	1738	**896**	29.7	37.1	161	36.6	5.33	24.1		21.4	42	17.8	37.7
213J1	0 to 3	0 to 7.6	87.86%	496	**435**	13.2	16.1	71.6	17.0	2.43	18.6		31.3	7	20.8	12.2
213J2	5 to 8	12.7 to 20.3	71.42%	1530	**1092**	36.2	44.1	180	42.9	6.65	24.3		29.8	25	16.9	26.2
213J3	10 to 13	22.9 to 33.0	56.25%	2225	**1252**	39.7	43.4	160	40.4	6.76	18.7		20.6	27	14.8	23.7
213J4	15 to 18	38.1 to 47.7	29.39%	4567	**1342**	54.1	53.3	162	39.5	8.70	18.5	89.2	16.9	28	6.4	29.6
213J5	19 to 22	48.3 to 55.9	60.96%	1282	**782**	34.8	34.4	104	24.2	5.63	22.1		22.0	37	15.6	25.2
	in	cm	(weight %)	(ash basis)	(dry coal basis)											

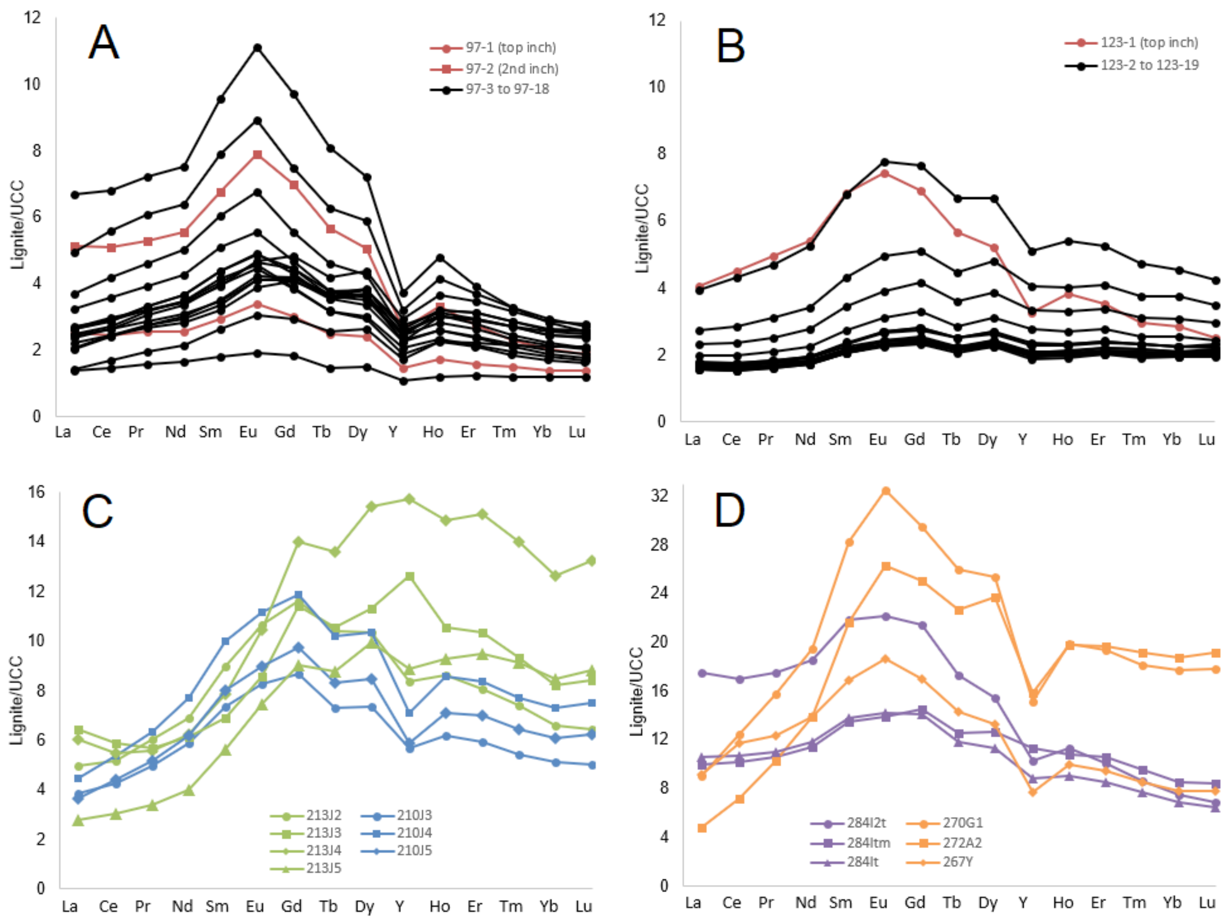


Figure 25. Normalized REE distribution plots for 1-inch vertical profiles through the enriched coal within the Rhame bed in T136N, R102W, Sec. 16 (A) and Sec. 8 (B). Samples show consistent decreasing enrichment with depth, except where the uppermost samples (red) are diluted with siliciclastics. In Sec. 22 (C) some samples are enriched in the heavy REEs, but most samples show the highest peak in the medium REEs, including the three significantly enriched samples in this report (D, purple) and the three from the Golden Valley Fm. (D, orange) in Murphy and others (2023).

strontium (243ash at 2,850 ppm), tellurium (243ash at 0.52 ppm), and titanium (211ash at 13,100 ppm). The highest concentrations of these elements in carbonaceous samples are 23,900 ppm magnesium (sample 183N), 1,260 ppm strontium (sample 183Hb), 0.21 ppm tellurium (sample 97-3), and 10,000 ppm titanium (sample 137A). Interestingly, samples of the H bed tonstein would represent the top six highest concentrations of gallium (65.5 to 57.3 ppm) if not for sample 303A, a sample from the top of the H bed where it is only 15 inches (38 cm) thick near HT Ranch where the tonstein position was unclear and may have been included in the sample. Samples of tonsteins would also represent most of the top samples of tantalum and thorium if not for samples 137A and 97-3, respectively. Sample 137A is also a sample from the top of the H bed where the tonstein position is unclear. Sample 97-3 is a sample of a coal within the Rhame bed.

Another noteworthy observation for the lower Bullion Creek and Slope Formation samples analyzed in this report includes the relative absence of uranium. Although coal has historically been an economic source of uranium in North Dakota (Murphy, 2015), and has received commercial interest as recently as 2008 (Murphy, 2008; Kruger, 2023), a mineral extraction operation targeting

REE and other valuable trace elements in lignite would likely seek to avoid the added costs associated with indirectly concentrating radioactive elements uranium and thorium above strict regulatory thresholds. With a high of just 58.5 ppm uranium and an average of 10.6 ppm across 393 analyses, the uranium concentrations in this report stand in sharp contrast to other sites and stratigraphic intervals investigated over the course of this project. Fourteen carbonaceous samples from Sentinel Butte in Golden Valley County (upper Sentinel Butte Formation) averaged 165 ppm uranium with a high of 1,480 ppm (Kruger et al., 2022). At Tracy Mountain (predominantly middle and upper Sentinel Butte Formation), 23 of the 157 analyses were higher than 58.5 ppm uranium, up to 200 ppm, and averaged 27 ppm overall. (Moxness et al., 2021). The Golden Valley and upper Sentinel Butte Formation averaged 16 ppm uranium across 122 samples, with a high of 144 ppm (Murphy et al., 2023). Conversely, 206 samples of the Hell Creek and Ludlow Formations contained even less uranium, 8.6 ppm average with a high of 53.9 ppm, (Moxness et al., 2022). This broad observation, that there tends to be more uranium in the strata above the Bullion Creek-Slope interval and less uranium below, lends support to the model of Denson and Gill (1965) who proposed volcanogenic sediment in the overlying Chadron, Brule, and Arikaree Formations was infiltrated and eroded by waters since the Miocene, which dissolved uranium and carried it downwards into the underlying coal-bearing strata. Murphy and others (2023) proposed that the significant enrichment of REE in lignites occurred earlier, in more localized intervals, independent from, and later overprinted by, the more uraniferous waters. Far fewer analyses of thorium have been collected over the course of this project, but the averages reported for the Golden Valley-upper Sentinel Butte Formation samples and Tracy Mountain samples (15.9 and 18.2 ppm, respectively) were higher than those in this report (13.6 ppm), which were in turn higher than the Hell Creek-Ludlow averages at 11.7 ppm thorium.

Other more desirable critical minerals may also be more enriched at these stratigraphically higher localities which are more likely to have been influenced by uraniferous waters. Sites in the Golden Valley and upper Sentinel Butte Formations contain higher maximum concentrations for many elements than sites in the Bullion Creek and Slope Formations, despite often being represented by a much smaller sample dataset. Molybdenum concentrations up to 3,800 ppm were identified in lignites at Sentinel Butte, up to 354 ppm in the Golden Valley Formation, and up to 233 ppm at Tracy Mountain, but the highest sample in this report was 73.7 ppm. The maximum concentration of arsenic in this report (246 ppm) is far lower than samples from both Sentinel Butte (up to 1,860 ppm) and Tracy Mountain (up to 698 ppm). Similarly, zirconium concentrations in this report (845 ppm max) do not reach enrichment levels seen in multiple samples from both Tracy Mountain (1,150 ppm max) and Sentinel Butte (1,000 ppm max). Cobalt was found in concentrations up to 253 ppm at Tracy Mountain, 202 ppm in the Golden Valley Formation, and 91.2 ppm at Sentinel Butte, but only 89.2 ppm in this report. Several analyses of vanadium from this report (up to 477 ppm) are higher than all but one previously reported sample from this project (519 ppm from Sentinel Butte). Conversely, lignite samples from this report dominate the project's list of highest beryllium, chromium, cesium, and rubidium concentrations. Three of the project's top eight beryllium samples (15.5 to 30.7 ppm Be) come from samples 213J3, J4, and J5, which were noted earlier for being unusually enriched in the heavy REEs. Figure 26 illustrates the degree to which other elements are enriched in samples with high REE concentrations. Samples 305B and Bb (18.7 and 16.1 ppm Be) are two of the other eight and also exhibit heavy REE enrichment. The project's top six analyses of chromium (227 to 403 ppm Cr) appear to correlate with rare earth enrichment, as those six samples average 941 ppm REE. The project's top

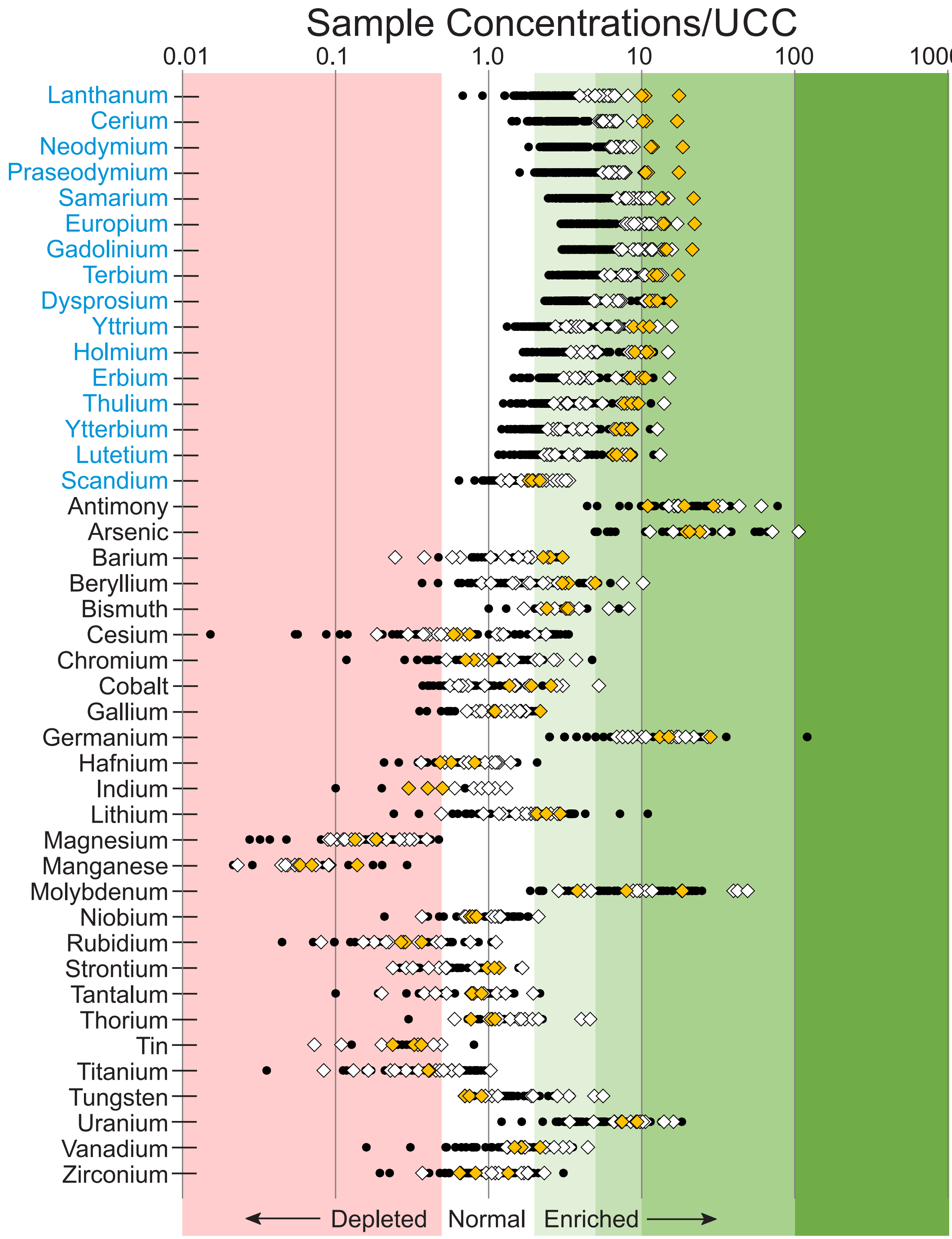


Figure 26. Analyses (dry coal basis) of 113 REE-enriched lignite and organic-rich mudstone samples in this report normalized to values of the upper continental crust (UCC). The elements most enriched in these samples are antimony, arsenic, germanium, molybdenum, uranium, and the REEs (text in blue). Diamonds represent the samples enriched (910 to 1,820 ppm in white) or significantly enriched (>1,820 ppm in gold) in ΣREE. Black dots represent samples slightly enriched in ΣREE (364 to 910 ppm). Beryllium, bismuth, cobalt, lithium, and tungsten are also occasionally enriched.

16 analyses of cesium (13.5 to 16.4 ppm Cs) are from samples often slightly enriched in REE, but with high clay contents (average ash yield of 91%). Rubidium appears to be distributed similarly. The top 10 concentrations from the project (124 to 162 ppm Rb) are from clay-rich samples averaging 91% ash. Two lithium analyses (302 and 265 ppm, samples 211Jf and 211J2) are also the highest in the project to date.

Limited-scope mining in Sections 7 (Harmon coal) and 16 (Rhame bed coal)

Since the early onset of the NDGS's rare earth sampling program, the NDGS has worked closely with research groups at the University of North Dakota by sharing information and sample material. Additionally, the NDGS has assisted with the permitting, coordination, performance, and reclamation of multiple small-scale mining operations by the University of North Dakota – College of Engineering & Mines (UND-CEM) to procure REE-enriched coal for extraction-demonstration testing. These limited mining efforts occurred under permits the NDGS obtained from the United States Forest Service and the North Dakota Department of State Trust Lands.

In June of 2018, the NDGS assisted UND-CEM in collecting two-and-a-half metric tons of coal mined from the top twelve inches (30 cm) of the Harmon bed in Section 7 (T136N, R102W) (fig. 27). The initial plan of work was to collect the top six inches (15 cm) of coal which previous sampling had indicated was the interval in which the highest concentrations occurred. Due to overburden collapse and difficulty in safely obtaining the total volume desired by digging the six-inch interval deep into the outcrop, the workplan was modified to include the top twelve inches of coal, with the knowledge that this would lower the average REE concentration. Ultimately, the average REE concentration of the coal taken was calculated to be 131 ppm (UND, 2021), and did not reach the 300+ ppm goal of the project.

An alternate location, Section 16 (T136N, R102W), was chosen and NDGS and UND-CEM returned to the Logging Camp Ranch area in November of 2018 to mine from the REE-enriched coal beneath the Rhame bed (fig. 28). The entire 1.5 feet (0.5 m) thickness of the coal was mined with the precision of hand tools (rock chisels, picks, and shovels), and a total of 7 metric tons of coal with an average REE concentration of 647 ppm was obtained (UND, 2021). In January 2020, the NDGS and UND-CEM returned to the Section 16 site to obtain more coal beneath the Rhame bed for large-scale demonstration projects. On this occasion, 44 metric tons of material was mined with the aid of two skid-steers from the entire thickness of the coal and several inches of the underlying carbonaceous clay over a length of approximately 70 feet (21.3 m). The tonnage transported to UND had an average REE concentration of 477 ppm (UND, 2020), lower than what was previously obtained in November of 2018 due to the inclusion of the lower clay, but still enriched material.

These mining efforts illustrate a contrast between differing enrichment environments. The targeting of a thin zone of REE concentration in material at the marginal top of a coal bed near the surface of a topographical high, such as seen in the Harmon bed at Section 7, requires higher selectivity of source material and offers less ability to successfully modify a workplan. Conversely, there is a much greater ability to obtain larger volumes of material from coal, like that mined in Section 16, below a highly weathered and kaolinized paleosol such as the Rhame bed or Bear Den Member of the Golden Valley Formation (Murphy et al, 2023).

Figure 27. Staff from the University of North Dakota College of Engineering & Mines prepare to excavate the uppermost portion of the Harmon lignite in T136N, R102W, Sec. 7 in June of 2018. Although early samples of the upper few inches contained up to 555 ppm REE, the enrichment in this setting was very thin and slight, likely because REEs were mobilized during relatively low-intensity weathering of the overlying Quaternary terrace.

Figure 28. Excavation of a lignite within the Rhame bed in T136N, R102W, Sec. 16 in January of 2020. UND-CEM, NDGS, and Microbeam staff, along with local ranchers John Hanson and Kelly Lorge, assisted with the excavation.

Discussion

Despite similar initial REE concentrations from the top of the Harmon (555 ppm) and coal within the Rhame bed (603 ppm) in Kruger and others (2017), subsequent sampling has shown that the REE enrichment in the Harmon is slight, thin, and localized, while enrichment in the coal within the Rhame bed can be significant, permeate the entire lignite (up to 17 in/43 cm at the thickest site), and is widespread across several counties. The frequent enrichment of coal(s) below the Rhame bed is consistent with the model proposed by Murphy and others (2023) where REE and other mobile cations are released during the kaolinization of aluminosilicate minerals by acidic waters in ancient weathering profiles. REEs migrate downwards through the profile until they are incorporated into organic complexes in underlying lignites or carbonaceous mudstones. The Rhame bed is a kaolinite-rich interval similar in thickness, lithology, and overall appearance to the Bear Den Member of the Golden Valley Formation (fig. 2), where paleopedogenic features have been studied in more detail (Harington et al., 2005; Clechenko et al., 2007). The overall levels of REE enrichment in underlying lignites are also similar between the two profiles. Carbonaceous mudstones (including original organics within brown paper shales and illuvial horizons of dark claystones) are often slightly enriched in REE (2 to 5 times UCC; 364 to 910 ppm), and higher-rank (lower ash) lignites are often enriched (5 to 10 times UCC; 910 to 1820 ppm). Lignites in the optimal position can even become significantly enriched (over 10 times UCC; >1,820 ppm), up to 2,570 ppm REE from below the Bear Den profile and 2,792 ppm from the Rhame bed. The localized enrichment at the top of the Harmon in T136N, R102W, Sec. 7 is likely due to its topographic position near the top of a terrace. Moxness and others (2021; 2022) identified frequent slight enrichment of REE in lignites below level, permeable uplands at Tracy Mountain and Mud Buttes, and proposed that these surfaces on the modern landscape have been subjected to low-intensity weathering since the late Pliocene or early Quaternary. The Harmon is only slightly enriched, and only in the upper few inches (~10 cm), similar to the thin lignites below other uplands which rarely exceed slight enrichment (<910 ppm REE).

Despite the important contributions of Wehrfritz (1978) and Christiansen (1984), further study is needed for a full pedogenic characterization of the Rhame bed to better understand the paleoenvironmental conditions under which this paleosol formed. The Bear Den Member of the Golden Valley Formation is well understood to have occurred during intense terrestrial weathering associated with the Paleocene-Eocene thermal maximum (PETM), but no analogous thermal event is known to have occurred during the early part of the Paleocene that would explain a comparably thick sequence of kaolinized sediment. The Rhame bed thus more likely represents an extended period of little to no deposition; longer-term, moderate-intensity weathering versus the shorter-term high-intensity weathering during the PETM. Peppe and others (2009) used magnetostratigraphic data to estimate an age of 62.90 to 63.20 Ma for the top of the Ludlow Member (Slope Formation), upon which the Rhame bed weathered. The H bed lignite often immediately overlies the Rhame bed, and it contains a tonstein dated to 61.23 ± 0.38 Ma by Warwick and others (1995). At measured section 295 in this report, the H bed tonstein occurs just three feet (0.9 m) above the Rhame bed silcrete, suggesting the age from the tonstein represents a time shortly after the resumption of deposition in the study area. These age estimates allow 1.29 to 2.35 million years for the Rhame bed to develop and a few feet (~1 m) of the H bed lignite to be deposited. This is potentially an order of magnitude longer than the elevated warmth associated with the PETM, which is believed to have lasted just 0.22 million years (Röhl et al., 2000). Global sea surface temperatures at the time the Rhame bed was developing (roughly 62 Ma) would have been around 6° C (11° F) cooler than the peak of the PETM and weathering of the Bear Den Member (Zachos et al., 2001), but still significantly warmer than today.

Of the 226 samples exceeding 364 ppm REE collected during this project to date, very rarely do they occur without an associated overlying (1) interval of kaolinite (weathering zones of the Rhame bed or Bear Den Member) or (2) flat, permeable upland surface representing a long-lived Quaternary landscape. Although the topographic position of the Harmon bed in T136N, R102W, Sec. 7 and its slight REE enrichment is consistent with the Quaternary upland infiltration model, a second lignite with localized REE enrichment was identified during this study that is neither below the Rhame bed weathering zone nor overlain by a flat, permeable upland, and therefore its enrichment is not easily explained. This thin (4 to 8 inch; 10 to 20 cm) lignite roughly 7 feet (2 m) above the H bed is enriched up to 1,277 ppm REE across T136N, R102W, Sec. 21. Eight total samples of the bed from four measured sections (201 through 204) across Sec. 21 contain an average of 731 ppm REE. Although it is possible that there was once a stable permeable surface overlying this area that has since been dissected, this explanation seems unlikely since no obvious remnants of any flat uplands occur in the immediate area. Additionally, where nearby overlying beds (the Harmon and Hanson) are unburnt, they are not enriched, suggesting Quaternary infiltration is not the likely pathway for the REE. This thin lignite in Sec. 21 is the first example of REE enrichment (>910 ppm REE) outside of one of these two settings, and the degree of REE enrichment in sample 204A2 (1,277 ppm; fig. 29) exceeds that of any sample attributed to Quaternary infiltration (1,089 ppm from the top of Tracy Mountain; Moxness et al., 2021). It is perhaps more likely that this and other thin zones of REE enrichment (where lignites above and below are not REE-enriched) may represent minor zones of Paleocene weathering with more subtle signs of paleopedogenesis. Although the mudstones overlying this bed were fairly light in color, this is fairly typical for the intervening clastic beds in the Harmon-Hanson-H interval, and it wasn't noted as particularly kaolinitic in the field. It may be that the weathering conditions which formed the Rhame bed did not abruptly end, and clastic sediments deposited after the H bed also experienced somewhat elevated rates of weathering. This may be true for the time after the deposition of the Hanson and Harmon bed as well, as all three beds occasionally contain elevated REE concentrations. A few feet (<1 m) of especially prominent white claystone occurs above the Harmon in Sec. 7 where the upper few inches of lignite is REE-enriched, but seeing as how this claystone is not as bright elsewhere, it may be a product of Quaternary weathering, as the gravels and loess overlying it on the terrace are especially permeable.

The results in this report support the exploration model proposed by Murphy and others (2023), in which it should be expected to find consistent REE enrichment in lignites below thick sequences of kaolinized sediment. Murphy and others noted several potential variables that could potentially affect the degree of REE enrichment and thus economic prospects of a given lignite as a feedstock for mineral extraction. Hypothetically, the optimal position for a lignite to receive the most descending REE cations would be at the base of the kaolinized sediment. This is the position of the most enriched samples in this report (fig. 30), but in the Bear Den Member some of the most enriched samples were collected from middle portions

Figure 29. An unusually REE-enriched lignite between the H and Harmon-Hanson lignites in T136N, R102W, Sec. 21. The top four inches (10 cm) of the bed (sample 204A2) contained 1,277 ppm REE, and the bottom four inches (10 cm) of the bed (sample 204A2b) contained 1,085 ppm REE.

of the kaolinized zone. Would those same lignites be more enriched had they occurred lower in the weathering profile, or are REE cations moving relatively short vertical distances through relatively impermeable claystones and mudstones? It is possible REE cations are only mobilizing a few feet (1 or 2 m) as the pH gradient moved through the profile over time. Additional work is underway to better understand the REE distributions through the clay-dominated portions of the Rhame bed and Bear Den Member, especially in light of the fact that the world's predominant source of heavy REEs are ores in South China where economic quantities of REEs are well-understood to adsorb to kaolinite and incorporate into associated secondary minerals.

The variable brightness and thickness of the Rhame bed are presumably rough proxies for the degree of weathering (kaolinization), and thus the amount of REE mobilization. Although this may largely be true, the lithology of the source beds appears to be an important variable as it pertains to the expression of the weathering in the field and the degree of REE enrichment in the lignites below. Because the Rhame bed and Bear Den are weathering profiles, they developed upon a river and floodplain landscape underlain by lignite, claystone, mudstone, siltstone, or sandstone

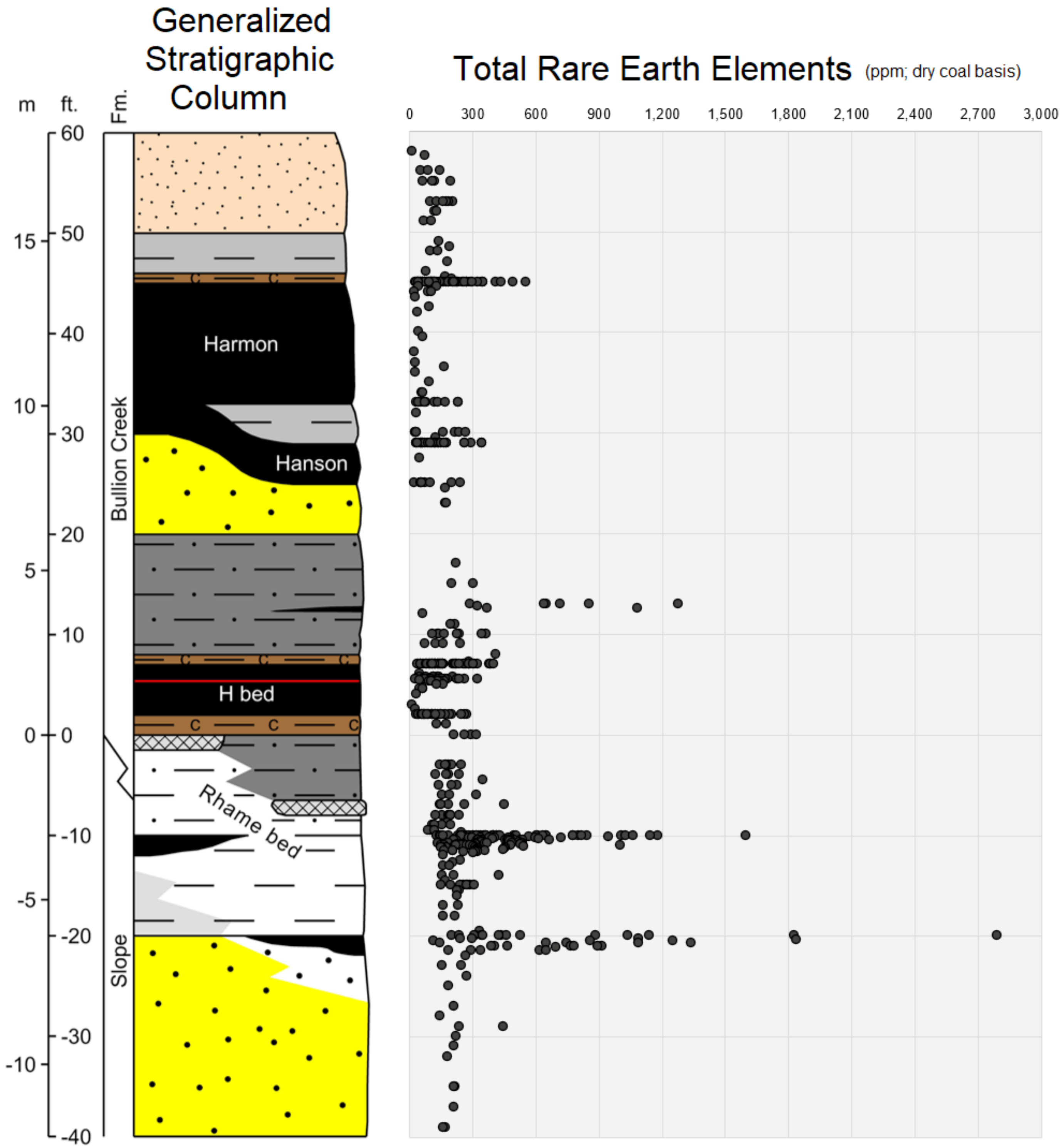


Figure 30. Rare earth element concentrations plotted against a generic stratigraphic column generated from the geologic sections in this report which span the Harmon-Hanson-H lignite interval and the underlying Rhame bed weathering zone. To condense the column, 45 samples from higher in the Bullion Creek Formation (none exceeding 319 ppm REE) and 108 samples from lower in the Slope Formation (none exceeding 565 ppm) were not included. Eight samples from the base of the Sentinel Butte and top of the Ludlow Formations were also excluded (235 ppm max). For depth plots of other critical minerals through this interval, see Appendix C.

in different areas. In sections where sandstones were weathered, the characteristically bright-colored Rhame bed and Bear Den Member are especially thick. These sites are of particular interest to this study, since in Denson and Gill's (1965) infiltrational model for uranium, the permeability of the overlying sediment played an important role in facilitating the movement of enriched waters into the underlying lignites. The apparent link between sandstones and thicker weathering zones would also seem to support a model in which permeability allowed acidic waters to penetrate deeper into the weathering profile, potentially leaching more REE cations from a larger thickness of sediment. Initial results suggest that this is not the case. Measured sections 284 and 285 offer contrasting examples of the lithologies and thicknesses of the Rhame bed and REE concentrations of lignites below. Measured section 284 contains three of the project's highest REE concentrations from a lignite below the Rhame bed where the weathering zone is moderately thin (12 ft / 3.7 m) and developed in mostly mudstone. Just 3.5 miles (5.6 km) to the southwest, at measured section 285, the Rhame bed is 36 feet (11 m) thick with a bright white 24-foot- (7.3-m) thick sandstone at its base (fig. 31). A 24-inch (61 cm) coal at the base of the sandstone should hypothetically be exposed to more REE-laden descending fluids from the thicker, more permeable overlying weathering profile, but its REE concentrations are an order of magnitude lower (~211 ppm).

Figure 31. Sampling a lignite below the Rhame bed at measured section 285 (T136N, R104W, Sec. 17) where the weathering zone is especially prominent due to a bright white, 24-foot (7.3-m) thick sandstone at its base. The lignite (Samples 285C and Cb) was not enriched in REE.

It is difficult to make definitive statements about REE mobility and links to source minerals without detailed profiles pairing the REE contents and mineralogy of the overlying weathering zone, but it appears lignites are more likely to enrich where the Rhame bed developed in claystone or mudstone. This may be due to lower amounts of quartz and higher amounts of REE-bearing aluminosilicates, or the increased surface area of sediment grains and higher levels of pre-existing ion-adsorbed REE cations. It's also likely that sandstones which are rich in quartz, a light-colored mineral, may become just as bright as the beds of kaolinite do with far less intense weathering. One unwashed (bulk) XRD analysis of sandstone from below the Rhame bed in measured section 143 contained 55% quartz, 24% carbonates, 11% feldspars, and 10% clays (Sample No. 9 of Anderson et al., 2019). The sample presumably represents much of the original mineralogy, as it was collected from the middle of an 85-foot (26-m) interval of sandstone where it was yellow, and not the upper, white-colored zone of sandstone (Rhame bed). An REE analysis of this yellow (unweathered) sandstone was 106 ppm at measured section 126, and a sample of the sandstone where it was white in measured section 118 contained 155 ppm. Further field study is needed to identify whether white sandstones in the Rhame bed are bright because of leaching (which would result in REE depletion) or colored by illuvial kaolinite (which would add clay content and potential for ion adsorbed REE).

Murphy and others (2023) identified REE-enriched lignites and carbonaceous mudstones within the middle and lower portions of the bright (kaolinized) zone in the Bear Den Member, especially around its base, but also found that lignites were often slightly enriched a short distance below, occasionally separated by up to 15 feet (4.6 m) of seemingly unweathered sediment. This suggests a roughly 30-foot-thick (9.1 m) interval in which lignites, where present, could have received descending REE. The further below the base of the weathering zone, the less REE enrichment is observed, presumably as REE cations are disseminating through the intervening profile. As with the Bear Den Member, lignites can be enriched either within or below the bright zone of kaolinization that represents the Rhame bed. As discussed earlier, the Bear Den profile developed relatively quickly under brief, high-intensity weathering conditions, and the Rhame bed likely developed more slowly, in a less intense climate, over a longer period. As a result, the Rhame bed exhibits more variability in its expression than the Bear Den Member. There was likely localized deposition throughout the weathering interval, as evidenced by areas where thicker intervals of Rhame bed contain multiple thin bright zones interbedded with relatively unweathered sediment. In these cases, lignites can exhibit elevated REE contents over a thicker interval. At measured section 285 in the Medicine Pole Hills, the sediments vary between light gray and gray (as opposed to the very light grays and whites where the Rhame bed is thinner and well-developed) over an interval of at least 70 feet (21 m) in thickness, with slight enrichment in coals below. Similarly, in measured section 280 in Morton County, both the degree of weathering and REE mobilization seem to be more weakly distributed over a larger thickness of sediment. Seven samples of five different beds through and below the Rhame bed average 309 ppm REE, but the maximum enrichment is only 446 ppm. Thus, the interval in which to expect REE-enriched lignites may be thicker than 30 feet (9.1 m) in the Rhame bed, but the degree of enrichment in these more diffuse weathering profiles may be lower.

It should be noted that field-based visual (brightness) and textural (kaolinite) clues are helpful but limited lines of evidence for estimating the REE contents of underlying lignites. At one of the most enriched sites in this report, Sec. 16 at Logging Camp Ranch, the Rhame bed is represented mostly by a mudstone which is only slightly lighter gray than the average overlying Bullion Creek mudstone, which is why Hares (1928) and Murphy and others (2018) did not recognize it. REE contents seem to be more closely correlated to the degree of development of the lignite than the weathering zone. Samples of lignites with lower ash contents (more organic content) appear to incorporate greater concentrations of REE than clayey organic beds. It remains unknown as to the total REE content a thick, low-ash lignite immediately below a heavily kaolinized interval of claystone could incorporate, but the samples in measured section 284 show that perhaps two feet (0.6 m) or more could be enriched, since the bottom three inches (8 cm) of a 17 inch (43 cm) lignite still contained 653 ppm REE, with increasingly greater REE contents (up to 2,792 ppm) in the portions of the bed above.

Conclusions

The Harmon, Hanson, and H lignites were first identified as a potentially promising interval of REE enrichment by Kruger and others (2017) at Logging Camp Ranch in north-central Slope County, ND. In extensive subsequent sampling of these beds in Murphy and others (2018) and this report, it appears that the REE enrichment first seen at the top of the Harmon lignite is relatively anomalous. Dozens of samples from the Harmon bed other outcrops in the area were analyzed, and none exceeded 300 ppm REE. It is likely that the original localized area of enrichment may be the product of the Harmon's position just below a stable, weathered late Pliocene or early Quaternary terrace. Thin zones of REE enrichment are found in lignites immediately below similar topographic settings just to the north in Billings County (Moxness et al., 2021) and to the south in Bowman County (Moxness et al., 2022). Therefore, the Harmon lignite bed does not appear to be inherently enriched in REE.

Conversely, thin lignites below the Harmon-Hanson-H lignite interval were found to contain consistently elevated REE concentrations. Extensive lateral sampling by the North Dakota Geological Survey of this underlying 10- to 30-foot (3.0- to 9.1-m) thick interval shows that lignites almost always exceed 300 ppm REE where they are well developed, and even carbonaceous mudstones and claystones commonly exceed the threshold. One sample of a 10-inch (25 cm) lignite 11 miles (18 km) west of Kruger and others' (2017) original sample site of an REE-enriched lignite in this position contained 2,790 ppm REE, the highest concentration identified by this project to date and approaching concentrations ten times higher than those considered promising by the DOE. Nearby, the top 6.5 inches (17 cm) of a 17-inch (43-cm) thick lignite averages 1,834 ppm REE and the entire bed averages 1,153 ppm. Detailed vertical sampling profiles show that the uppermost portions of the lignite beds generally contain the highest REE concentrations but that the degree of REE enrichment is tied to organic content. This data supports earlier conclusions that REE appear have been transported via infiltrating waters from above and are organically bound within the lignite.

The stratigraphic framework established in this report demonstrates that these elevated REE concentrations are associated with the kaolinite-rich Rhame bed, a deep zone of weathering that formed during a pause in deposition during the Paleocene (Moore, 1976; Wehrfritz, 1978). The intense weathering of sediments at this ancient surface is proposed to have leached REE and other critical minerals downward and concentrated them in the immediately underlying organic beds.

This zone is normally recognized in the field as a thick sequence of bright-colored sediments and a pedogenic silcrete, but the brightness can be variable and the distinctive silcrete is not always present, making mapping difficult. Thus, many of the previous mappers did not extend the Rhame bed north or eastward into the Logging Camp Ranch area. Detailed lateral tracing of its position in this study shows it is present just below the H bed and above the REE-enriched lignites associated with the first REE-enriched samples identified during this project (Murphy et al., 2018).

The REE-enriched lignite beds identified in this report are relatively thin and discontinuous, but the Rhame bed is known to occur at the surface or in the near subsurface from just west of Mandan, ND to the South Dakota border near Lemmon and the Montana border south of Golva, providing an extensive area over which to prospect for thicker lignites. The 17-inch (43-cm) thick lignite that exceeded 1,800 ppm REE at its top and was still enriched at 650 ppm REE at its base suggests the weathering of the Rhame bed is capable of enriching multiple feet (≤ 1 m) of underlying lignite in REE if 1) a sufficiently thick lignite occurs in the correct position just below the Rhame bed, 2) the lignite contains relatively high organic contents to bind REEs and is not clay-rich, and 3) the Rhame bed weathering is well-developed, especially where it intensely kaolinized claystones. Even a lignite which is a few feet thick (~1 m) would be considered unsuitable for mining in a traditional context, where much thicker coals are targeted for thermal power generation, but sufficiently enriched coals may be economic for commercial mineral extraction in much thinner zones. This is especially true if other valuable mineral commodities occur with the rare earths in the same feedstock. This study supports findings from lignites below similar weathering zones (Murphy et al., 2023) in that the most consistently co-enriched critical elements are antimony, arsenic, and germanium, but also finds that beryllium, bismuth, cobalt, lithium, and tungsten can also be enriched with the REE. The specific thickness, lateral extent, depth, and grade of rare earth and other critical element enrichment required for commercialization is unknown at this time but is the focus of ongoing studies.

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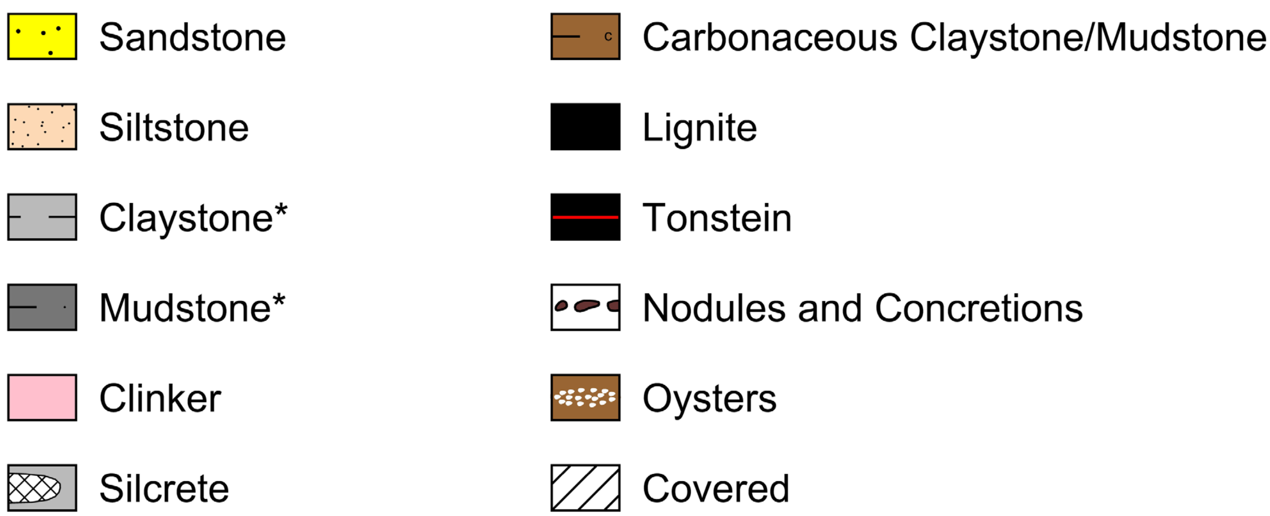
APPENDICES

Appendix A

Measured Sections and Contextualized Sample Analyses

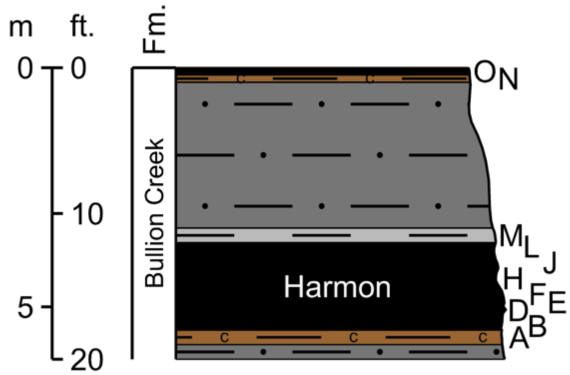


*Colors of claystone and mudstone vary according to those observed in the field

Note: Total REE concentrations (dry whole coal and dry ash basis) are denoted by a tilde (~) where minor lanthanides have been estimated using the methodology outlined in Kruger (2020).

REE Section 42

T.138N., R.103W., Sec.36, NE/SE
Elevation at top 2,500 ft.

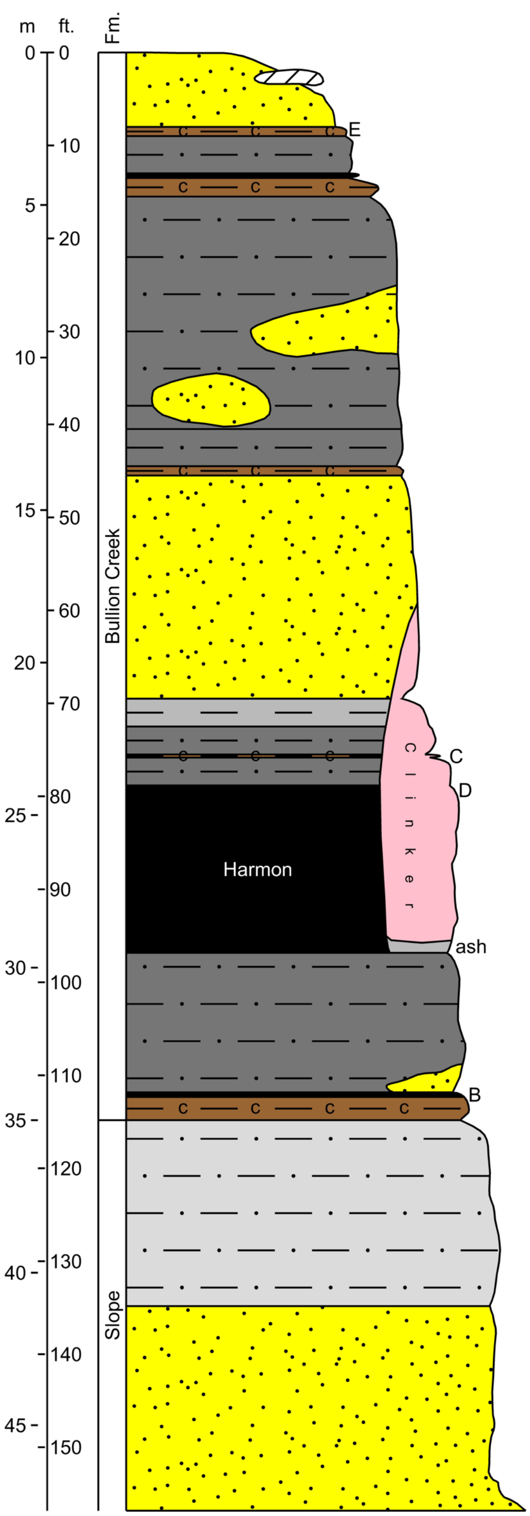


SAMPLE ID	LAB ANALYSIS (in µg/g)															TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
42O	58.8	3.6	2.20	0.90	4.1	0.71	29.1	0.35	25.6	6.8	4.8		0.59	0.33	2.24	19	159	
42N	72.9	4.5	2.58	1.16	5.3	0.85	35.1	0.38	32.4	8.6	6.3		0.76	0.38	2.48	21	195	
42M	40.7	2.4	1.55	0.62	2.7	0.49	21.2	0.25	17.9	4.8	3.3		0.41	0.24	1.60	13	111	
42L	13.7	1.7	1.06	0.43	1.7	0.36	6.6	0.15	7.0	1.7	1.6		0.29	0.15	0.98	11	48	
42J	5.8	0.5	0.29	0.08	0.5	0.10	3.0	0.04	2.5	0.7	0.5		0.08	0.04	0.25	3	17	88
42H	8.4	0.7	0.42	0.10	0.7	0.14	4.0	0.06	3.8	1.0	0.8		0.12	0.06	0.39	3	24	
42F	10.0	0.8	0.48	0.11	0.8	0.16	5.6	0.07	4.2	1.1	0.8		0.13	0.07	0.44	5	30	285
42E	11.0	1.2	0.78	0.19	1.2	0.26	5.0	0.12	5.5	1.4	1.2		0.20	0.11	0.74	9	38	
42D	7.1	1.0	0.60	0.19	1.1	0.22	3.2	0.07	3.9	0.9	0.9		0.17	0.08	0.49	7	27	97
42B	32.2	5.4	3.21	0.97	5.0	1.11	14.5	0.42	17.0	4.2	4.1		0.86	0.45	2.84	24	116	
42A	66.5	3.0	2.08	0.77	3.5	0.64	35.7	0.36	27.3	7.6	4.5		0.48	0.33	2.31	17	172	

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
42O																												
42N																												
42M																												
42L																												
42J																												
42H																												
42F																												
42E																												
42D																												
42B																												
42A																												

REE Section 53

T.136N., R.102W., Sec.15, SE/SE
Elevation at top 2,661 ft.



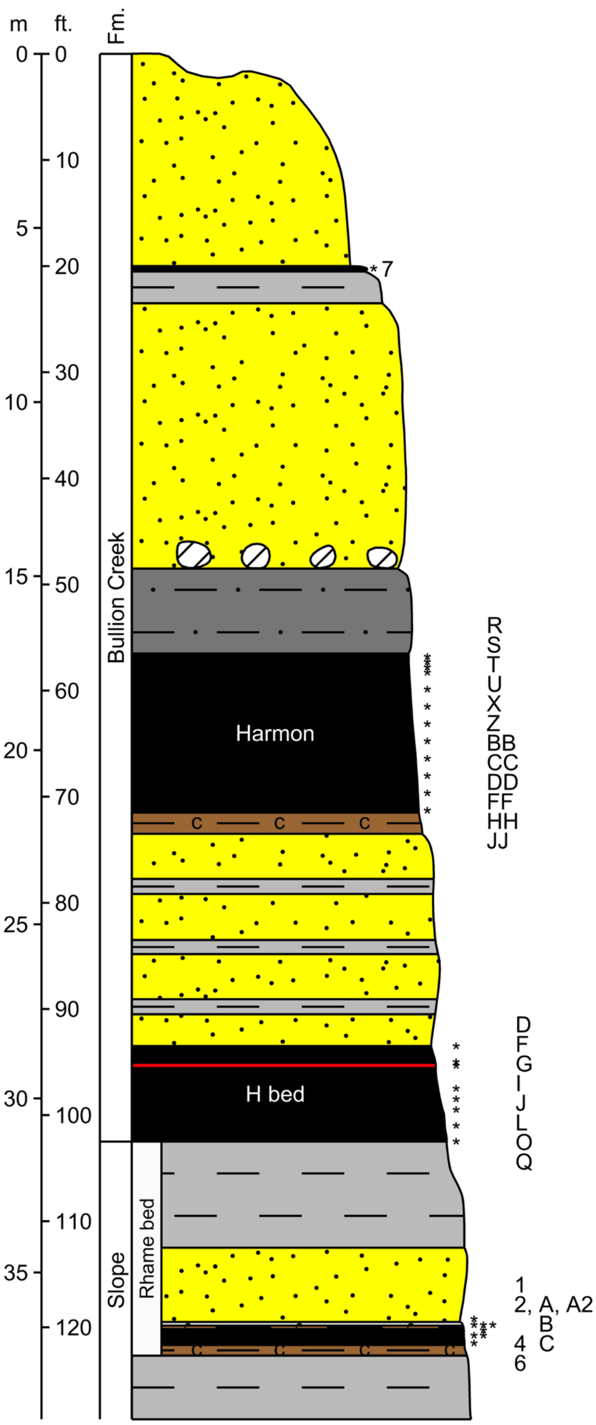
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
53E	55.4	4.7	2.93	1.14	5.0	0.99	28.4	0.44	26.3	6.7	5.1	11.4	0.76	0.42	2.75	27	179	203
53C	64.1	4.6	2.83	1.13	5.0	0.94	31.4	0.44	28.7	7.7	5.6	13.1	0.79	0.42	2.89	23	193	228
53D	18.2	4.2	3.66	0.62	2.7	1.08	9.4	0.65	8.9	2.2	2.1	13.9	0.54	0.57	4.01	30	103	289
53ash	81.1	5.0	2.85	1.38	5.4	1.00	54.7	0.39	29.0	8.3	5.2	11.2	0.82	0.40	2.62	27	236	252
53B	98.4	4.7	2.40	1.48	6.2	0.88	53.4	0.34	39.9	10.9	7.3	13.5	0.87	0.35	2.28	21	264	289

SAMPLE ID	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
	LAB ANALYSIS (in µg/g)																											
53E																												
53C																												
53D																												
53ash	2.59	20.2	6650	1.8	0.18	0.32	37	5.2	19.3	2	3.7	0.10	121	23300	972	6.4	35.5	6	2840	3.28	0.22	31.8	6.3	10500	6.9	7.6	61	133
53B																												

REE Section 54 & 55

T.136N., R.102W., Sec.16, NE/SW/NE

Elevation at top 2,616 ft.



SAMPLE ID	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	TOTAL REE Whole Coal	TOTAL REE Ash
	LAB ANALYSIS (in µg/g)																	
55-7	47.8	11.7	8.34	1.71	8.3	2.71	25.4	1.22	24.7	6.1	6.0	28.4	1.63	1.20	7.75	69	252	377
54R	16.6	4.5	2.79	0.76	3.8	0.95	7.3	0.37	9.9	2.2	2.7		0.69	0.38	2.39	28	83	
54S	11.4	1.4	0.82	0.29	1.4	0.29	7.7	0.10	5.0	1.2	1.1		0.22	0.11	0.66	11	43	
54T	7.7	0.7	0.43	0.16	0.8	0.15	3.8	0.05	3.6	0.9	0.7		0.12	0.06	0.33	6	26	
54U	8.8	0.7	0.39	0.18	0.7	0.14	5.0	0.05	3.8	1.0	0.7		0.11	0.06	0.34	5	27	
54X	16.1	0.8	0.43	0.18	0.8	0.15	11.5	0.06	4.8	1.5	0.8		0.13	0.06	0.38	4	42	
54Z	17.9	0.8	0.44	0.19	0.8	0.15	14.1	0.06	4.6	1.5	0.8		0.13	0.07	0.40	4	46	
54BB	9.0	0.8	0.42	0.21	0.8	0.15	3.6	0.05	3.8	1.0	0.8		0.13	0.06	0.36	4	25	
54CC	11.6	0.7	0.38	0.19	0.7	0.14	7.9	0.04	3.7	1.1	0.7		0.12	0.05	0.31	4	32	
54DD	11.8	0.6	0.33	0.17	0.7	0.12	7.2	0.04	3.8	1.2	0.7		0.11	0.05	0.27	3	30	
54FF	26.6	1.2	0.67	0.27	1.4	0.23	14.8	0.08	10.0	2.9	1.5		0.22	0.10	0.56	5	66	
54HH	11.8	1.0	0.56	0.23	1.1	0.19	5.0	0.08	5.7	1.5	1.2		0.17	0.09	0.53	5	34	
54JJ	13.5	0.7	0.45	0.23	0.9	0.14	7.0	0.07	5.7	1.5	1.0		0.12	0.07	0.46	4	36	
54D	78.1	4.7	2.61	1.28	5.4	0.88	37.9	0.37	33.5	9.0	6.4		0.81	0.37	2.47	22	206	
54F	10.8	2.5	1.68	0.34	2.0	0.54	5.3	0.26	5.9	1.4	1.7		0.36	0.25	1.68	14	49	
54G	37.0	3.9	2.46	0.47	3.5	0.80	16.6	0.34	16.9	4.6	3.7		0.62	0.35	2.27	21	115	
54I	23.6	1.7	1.01	0.29	1.7	0.34	13.6	0.14	8.7	2.5	1.6		0.28	0.14	0.89	9	65	
54J	13.3	0.8	0.41	0.16	0.8	0.15	8.0	0.04	4.3	1.3	0.8		0.13	0.05	0.31	4	35	
54L	5.7	0.4	0.18	0.07	0.3	0.07	3.3	0.02	1.9	0.6	0.3		0.06	0.02	0.14	2	15	
54O	10.8	0.7	0.38	0.16	0.8	0.14	6.4	0.04	3.9	1.1	0.7		0.12	0.05	0.31	4	30	
54Q	10.6	1.0	0.46	0.22	1.1	0.18	6.1	0.05	4.4	1.2	0.9		0.17	0.06	0.33	7	34	
55-1	36.2	1.5	0.99	0.52	2.0	0.32	18.0	0.18	15.6	4.2	2.7		0.27	0.16	1.16	8	92	
55-2	139	8.3	3.35	3.03	12.0	1.34	69.1	0.37	64.7	16.7	13.5		1.67	0.41	2.67	29	365	575
54A	206	17.9	7.69	7.55	26.1	3.04	72.9	0.88	136	30.3	32.9		3.66	1.04	6.35	51	603	
54A2	269	21.0	8.3	8.51	32.4	3.40	109	0.74	165	37.3	38.4	30.0	4.32	0.99	5.93	67.9	802	2864
54B	158	16.0	6.61	6.81	24.7	2.70	60.9	0.73	114	23.9	28.9		3.32	0.86	5.31	46	499	
54C	65.2	9.2	5.45	2.96	10.9	1.86	22.7	0.87	48.4	10.1	12.4		1.63	0.84	5.79	29	227	
55-4	94.7	8.2	4.60	2.04	8.9	1.66	42.7	0.58	45.0	11.9	9.0	13.9	1.41	0.63	3.95	38	287	1000
55-6	62.6	3.3	2.04	0.91	3.9	0.64	31.5	0.32	27.2	7.3	4.9		0.56	0.30	2.11	16	164	197

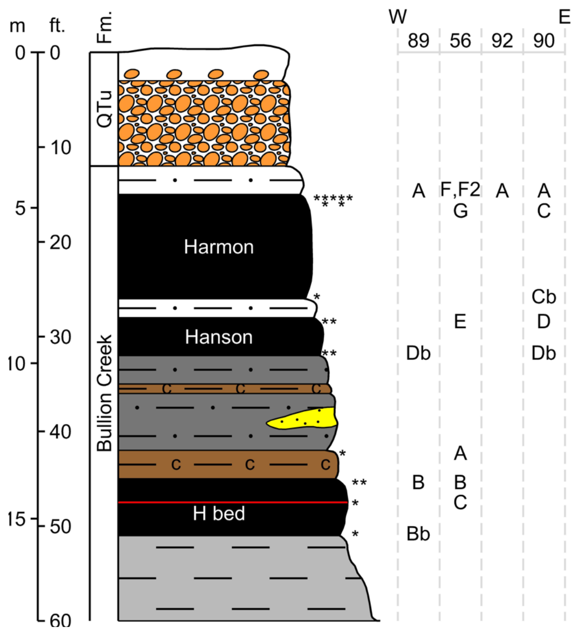
SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
55-7																												
54R																												
54S																												
54T																												
54U																												
54X																												
54Z																												
54BB																												
54CC																												
54DD																												
54FF																												
54HH																												
54JJ																												
54D																												
54F																												
54G																												
54I																												
54J																												
54L																												
54O																												
54Q																												
55-1																												
55-2																												
54A																												
54A2	5.61		725	3.6		0.25	241	13.2	9.4	13	6.0		17.3	2180		20.8	8.6			0.36				841	2.8	19.3	335	274
54B																												
54C																												
55-4																												
55-6																												

REE Section 56

T.136N., R.102W., Sec.7, SE/SE

Elevation at top 2,600 ft.

Includes directly adjacent sections 89, 90, and 92



SAMPLE ID	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	TOTAL REE Whole Coal	TOTAL REE Ash
	LAB ANALYSIS (in µg/g)																	
89A	98.5	13.7	7.31	2.74	14.4	2.67	42.2	0.89	50.7	12.5	12.1	13.5	2.38	1.00	6.23	62.4	343	835
56F	151	18.8	9.65	4.00	20.6	3.60	64.2	1.15	77.6	19.2	17.4	16.8	3.30	1.28	7.78	77	493	1437
56F2	165	20.6	10.1	4.80	23.6	3.87	68.4	1.20	91.2	22.5	20.9	17.7	3.80	1.35	7.97	92	555	1829
92A	99.0	11.8	5.70	3.15	14.5	2.14	29.4	0.66	61.2	14.4	14.8	17.1	2.19	0.76	4.74	42.9	324	841
90A	134	14.5	7.12	3.41	16.4	2.70	52.3	0.84	67.0	16.7	15.7	15.9	2.63	0.96	5.98	55.9	412	1017
56G	32.8	2.6	1.59	0.51	2.7	0.57	20.7	0.19	12.1	3.7	2.1	2.1	0.43	0.22	1.24	20	104	790
90C	88.7	7.3	3.69	2.06	9.0	1.33	35.5	0.47	45.3	11.4	10.0	15.8	1.36	0.52	3.35	27.1	263	368
90Cb	6.5		1.35		1.7		3.0		4.0			6.9				11.3	*~42*	*~572*
56E	105	7.8	3.61	2.42	9.8	1.35	41.6	0.46	52.3	13.3	11.2	18.1	1.46	0.49	3.17	23	295	1052
90D	62.7		1.94		5.5		27.4		30.8			10.8				13.6	*~176*	*~588*
89Db	8.8		1.62		1.7		4.1		5.2			7.6				16.1	*~53*	*~435*
90Db	7.5		2.02		1.7		3.8		4.3			14.6				16.5	*~59*	*~853*
56A	121	8.2	4.23	2.58	9.9	1.53	58.7	0.58	55.4	14.6	11.3	16.5	1.49	0.60	4.00	33	344	402
89B	120	12.0	6.51	3.47	14.2	2.28	49.8	0.82	69.1	16.6	14.9	24.3	2.13	0.88	5.64	58.9	402	965
56B	76.5	5.5	2.88	1.74	6.6	1.01	33.2	0.41	38.4	9.8	8.3	19.9	1.00	0.41	2.75	20	228	450
56C	32.1	0.9	0.40	0.22	1.3	0.14	16.3	0.05	11.2	3.4	1.9	1.6	0.17	0.05	0.34	4	74	90
89Bb	14.7		1.64		2.1		7.3		7.1			6.6				15.2	*~64*	*~207*

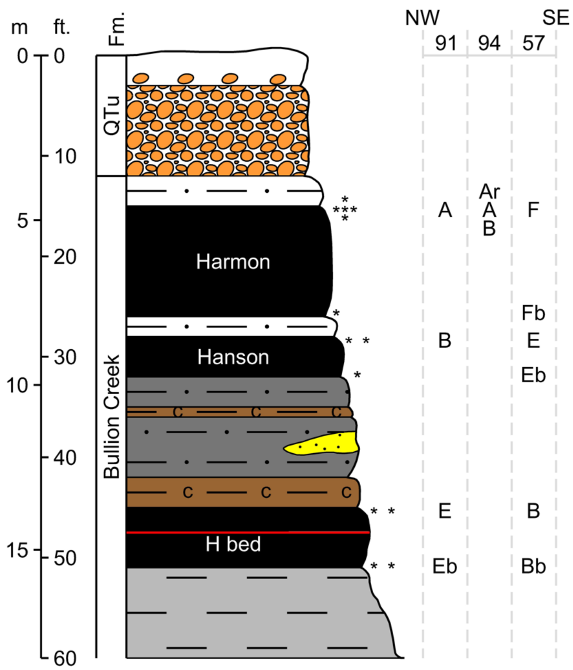
SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
89A																												
56F																												
56F2																												
92A	2.48		1510	1.4		1.05	39		7.1	3	2.7		14.0	2960		6.8	11.7		249	0.76				2040	3.7	11.8	41	113
90A																												
56G																												
90C																												
90Cb				1.1		0.43				3	0.7		5.2	2650				5				2.6		232		3.0		26.9
56E																												
90D				0.4		1.09				2	2.4		8.7	1720				19				6.1		561		14.0		88.5
89Db								12.4	7.3		0.6						2.5			0.07				197			11	
90Db				3.5		0.22				4	2.9		1.6	3490				3				2.8		181		5.5		169
56A																												
89B								9.1	18.1		12.0						17.4			0.81				2330			247	
56B																												
56C																												
89Bb								5.8	11.3		2.0						13.0			0.92				2310			25	

REE Section 57

T.136N., R.102W., Sec.7, SE/SE

Elevation at top 2,600 ft.

Includes directly adjacent sections 91 and 94



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
94Ar	69.8	4.5	2.42	1.20	5.3	0.82	31.3	0.32	31.0	8.2	6.2	15.9	0.79	0.33	2.32	19.7	200	293
91A	121.0	10.7	5.47	2.44	11.8	2.02	52.1	0.67	53.5	14.1	11.6	13.8	1.92	0.76	4.78	42.5	349	984
94A	63.9	7.84	4.15	1.71	8.41	1.5	32.9	0.51	34	8.7	7.49	9.03	1.36	0.58	3.61	31	217	1410
57F	101	8.5	4.33	2.10	9.6	1.60	47.2	0.53	44.6	12.0	9.2	9.1	1.54	0.60	3.60	39	295	1122
94B	30.9	5.7	3.63	0.80	4.7	1.23	18.0	0.49	13.2	3.3	3.1	8.8	0.87	0.52	3.38	33.4	132	396
57Fb	8.8	2.1	1.30	0.37	1.8	0.45	4.2	0.19	5.0	1.2	1.4	7.6	0.34	0.19	1.20	10.6	47	340
91B	35.8	2.7	1.32	0.87	3.4	0.49	15.9	0.17	17.0	4.4	3.7	6.6	0.51	0.18	1.21	8.8	103	327
57E	49.4	3.7	1.82	1.23	4.8	0.66	18.2	0.26	25.7	6.6	5.5	10.8	0.72	0.26	1.71	12	143	909
57Eb	7.0	2.8	2.06	0.37	1.8	0.64	3.4	0.32	4.1	0.9	1.1	13.8	0.36	0.30	2.02	17.9	59	601
91E	105	6.9	3.51	2.56	9.4	1.24	39.5	0.47	57.0	14.0	12.3	23.7	1.33	0.49	3.36	25.9	307	789
57B	31.6	2.4	1.15	0.89	3.3	0.43	14.3	0.15	18.3	4.4	4.0	9.9	0.45	0.16	0.99	10	102	310
91Eb	20.8		2.09		2.6		10.9		9.7			8.4				18.8	*~85*	*~265*
57Bb	17.1	2.4	1.60	0.39	2.0	0.53	9.0	0.23	7.4	2.0	1.6	6.1	0.37	0.23	1.46	15.2	68	261

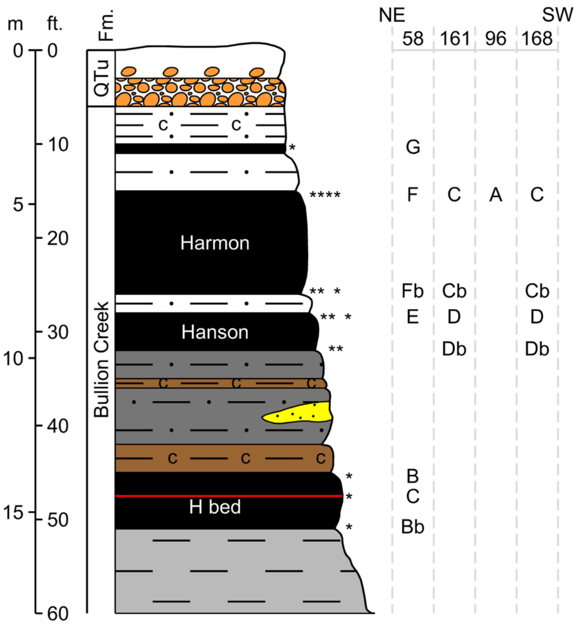
SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
94Ar																												
91A																												
94A	3.00		826	2.1		0.75	23		19.1	5	2.4		8.2	6860		5.0	11.3		351	0.32				729	6.4	13.6	16	91.6
57F																												
94B																												
57Fb	2.34		452	0.9		0.99	29		8.4	2	1.4		8.7	5500		0.8	6.9		282	0.27				749	0.8	3.6	55	43.7
91B																												
57E																												
57Eb	1.66	10.1	280	2.9	<0.10	0.24	18	4.4	11.7	4	1.8	<0.02	2.2	5620	148	2.4	5.4	3	292	0.07	<0.10	1.8	0.2	189	2.7	1.9	42	107
91E				1.2		6.34				9	6.7		17.0	3240				33				17.5		2100		16.2		319
57B																												
91Eb				2.6		0.28				19	3.1		14.4	3770				3				6.3		2160		3.3		179
57Bb	1.45		702	1.3		0.44	19		16.2	22	2.6		21.2	3640		1.7	9.3		232	0.46				1320	2.7	2.7	45	104

REE Section 58

T.136N., R.102W., Sec.7, SE/SE

Elevation at top 2,600 ft.

Includes directly adjacent sections 96, 161, and 168

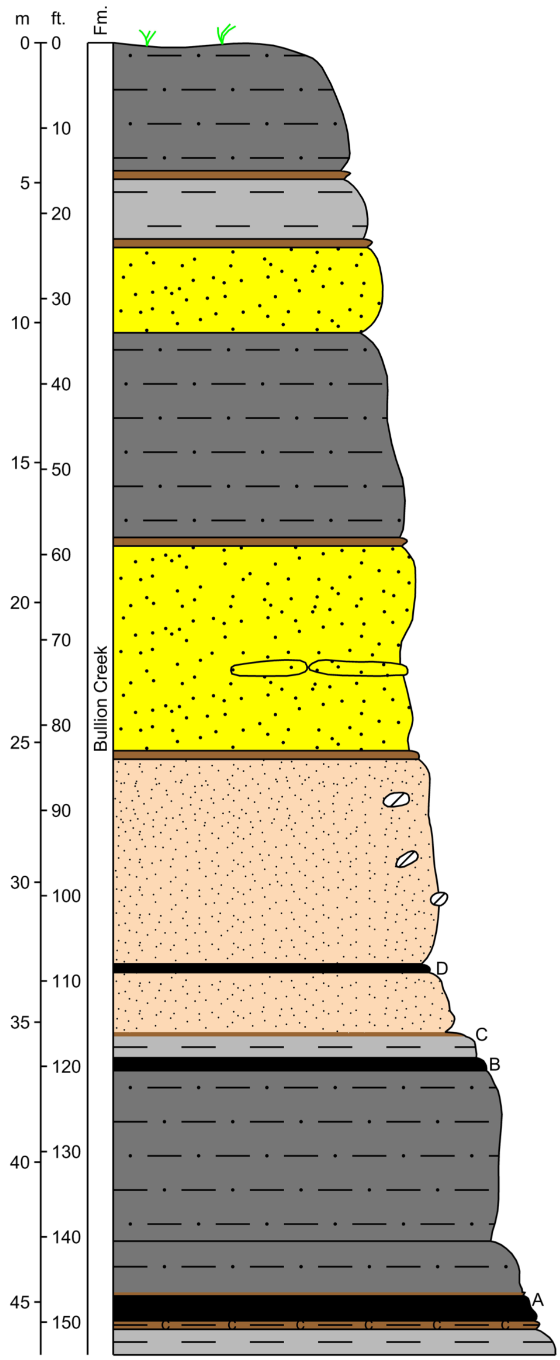


SAMPLE ID	LAB ANALYSIS (in µg/g)															TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
58G	31.1	5.5	3.62	1.27	4.9	1.23	14.4	0.52	16.3	4.0	4.0	9.1	0.86	0.52	3.28	39	140	295
58F	107	12.2	5.84	3.12	14.2	2.20	41.3	0.71	59.5	14.7	14.1	18.9	2.26	0.79	4.80	48	350	943
161C	32.8	4.3	2.64	0.72	4.0	0.91	20.3	0.35	13.2	3.5	2.8	10.0	0.67	0.37	2.35	26.8	126	268
96A	63.6	7.7	4.33	1.42	7.7	1.53	33.4	0.52	27.0	7.0	5.8	13.35	1.28	0.59	3.67	39.7	214	468
168C	46.7	6.2	3.74	1.06	5.7	1.29	28.4	0.50	19.3	5.0	4.3	10.1	0.97	0.52	3.38	39.5	177	456
58Fb	13.1		1.84		2.6		6.4		7.4			9.7				16.0	*~68*	*~384*
161Cb	10.8		1.45		2.0		4.8		5.4			8.2				11.6	*~53*	*~398*
168Cb	75.3		3.87		7.6		36.1		33.8			14.4				31.8	*~235*	*~704*
58E	9.9	0.6	0.29	0.28	0.9	0.10	3.6	0.05	6.2	1.5	1.4	8.5	0.12	0.05	0.33	2	36	227
161D	44.6	3.7	1.86	1.16	4.7	0.66	17.7	0.25	23.6	5.8	5.3	10.4	0.69	0.26	1.77	12.1	135	607
168D	120	9.3	4.51	2.91	11.6	1.64	43.7	0.56	62.3	15.3	14.1	22.4	1.77	0.62	4.03	32.5	347	1426
161Db	12.2	3.5	2.45	0.48	2.5	0.79	6.3	0.34	6.2	1.5	1.6	13.1	0.49	0.36	2.31	22.5	77	1459
168Db	8.3		1.85		1.9		3.9		4.8			9.3				17.7	*~56*	*~875*
58B	94.3	6.5	3.10	2.51	8.7	1.15	40.8	0.41	50.7	12.9	11.0	21.9	1.24	0.44	2.81	26	284	556
58C	73.5	2.7	1.30	0.46	3.6	0.48	32.0	0.16	27.7	8.3	4.8	2.2	0.51	0.18	1.12	14	173	237
58Bb	9.9		0.82		1.2		4.6		3.8			2.3				8.2	*~36*	*~217*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
58G																												
58F																												
161C																												
96A	2.56		2050	2.8		1.27	17		15.5	3	2.5		18.8	6680		9.3	9.0		520	0.59				1450	3.4	10.0	25	96.5
168C																												
58Fb								7.5	11.6		1.7						7.6			0.27				757			50	
161Cb				1.3		1.34				2	1.5		10.5	3150				11				5.3		790		5.4		51.0
168Cb								19.7	17.6		2.7						10.2			0.45				1130			53	
58E																												
161D				0.3		0.38				2	0.7		6.2	1010				6				5.7		434		12.1		22.5
168D								22.1	11.7		1.9						7.3			0.22				749			42	
161Db				3.1		0.17				3	0.6		1.1	1070				3				1.0		121		1.9		42.4
168Db								5.0	7.8		0.4						2.2			0.05				123			8	
58B																												
58C																												
58Bb								3.5	12.5		0.5						3.0			0.13				356			11	

REE Section 59

T.136N., R.103W., Sec.22, SE/NW/SW
Elevation at top 2,794 ft.

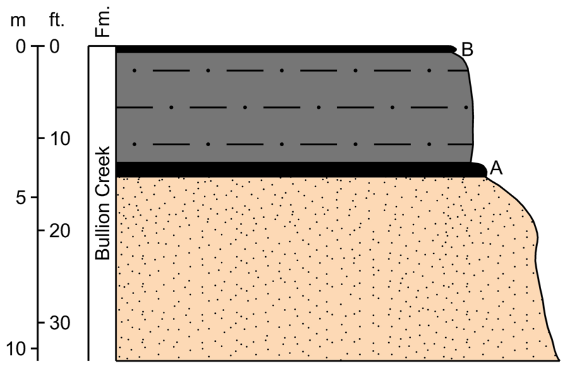


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
59D	38.3	7.6	5.24	1.51	6.4	1.75	19.3	0.76	20.0	4.9	4.9	15.7	1.16	0.75	4.83	56	189	389
59C	30.7	6.9	4.93	1.08	5.1	1.60	15.5	0.75	15.7	3.9	3.9	15.1	1.00	0.72	4.83	44	156	421
59B	22.0	3.7	2.18	0.87	3.7	0.75	7.5	0.33	13.8	3.2	3.5	9.6	0.62	0.32	2.16	18	92	245
59A	21.9	2.8	1.56	0.75	2.9	0.54	8.7	0.23	12.9	3.0	3.2	6.9	0.47	0.23	1.54	14	82	175

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
59D																												
59C																											86	164
59B																												
59A																												

REE Section 60

T.136N., R.103W., Sec.22, SE/NW/SW
Elevation at top 2,676 ft.

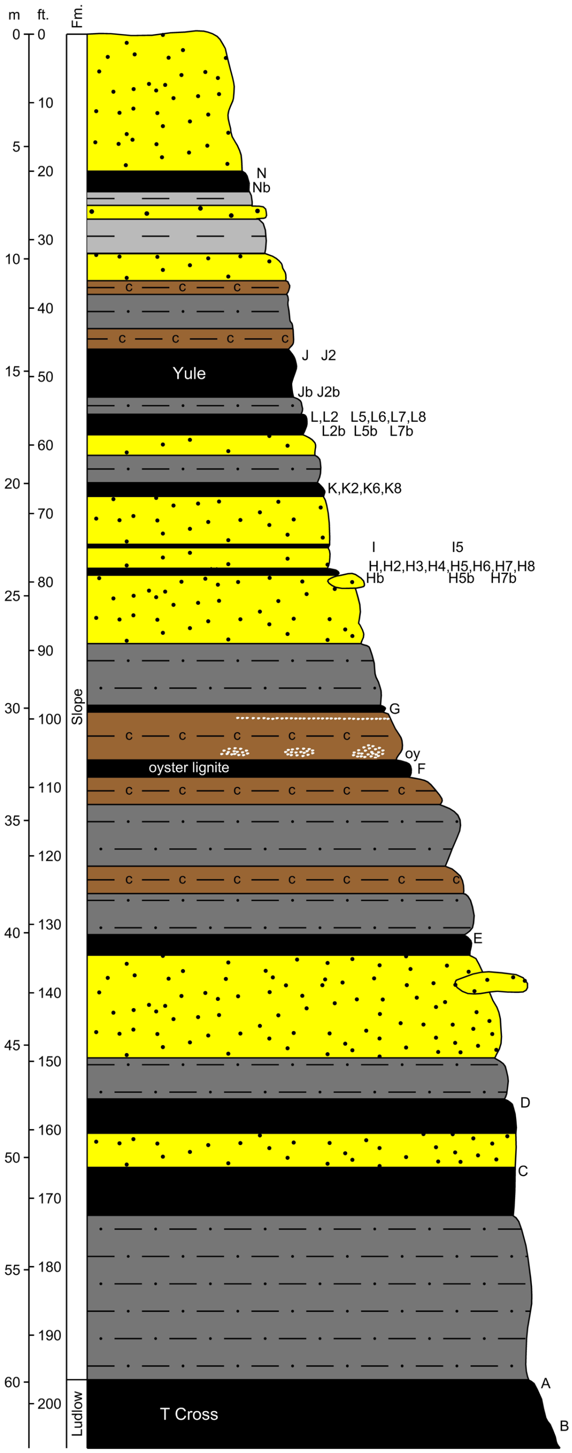


SAMPLE ID	LAB ANALYSIS (in µg/g)															TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
60B	31.0	5.2	3.19	1.02	4.7	1.09	13.5	0.44	17.4	4.2	4.2	11.0	0.82	0.44	2.87	31	132	313
60A	9.6	2.1	1.31	0.49	1.9	0.44	4.0	0.20	6.1	1.4	1.6	6.6	0.32	0.19	1.30	12	50	126

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
60B																												
60A																											55	102

REE Section 61

T.135N., R.105W., Sec.10, SW/SW to SE/SW
Elevation at top 2,868 ft.

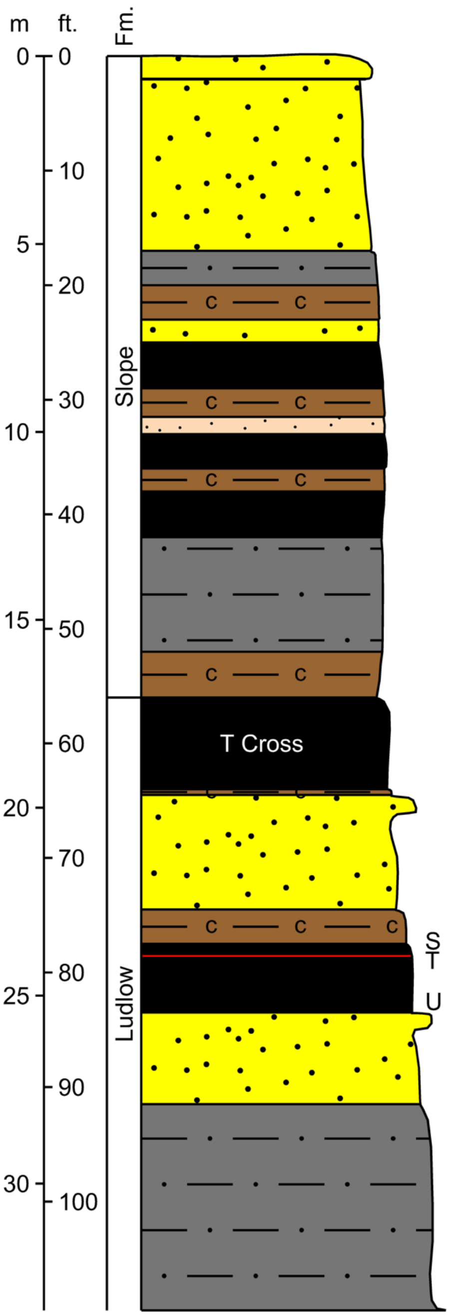


SAMPLE ID	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	TOTAL REE Whole Coal	TOTAL REE Ash
	LAB ANALYSIS (in µg/g)																	
61N	42.2	2.7	1.6	0.91	3.3	0.54	21.8	0.26	20.3	5.2	4.1	10.9	0.47	0.24	1.7	11.5	128	200
61Nb	71.8	5.9	3.46	1.67	6.5	1.17	38.6	0.45	33.4	8.5	6.9	13.7	0.99	0.48	3.11	28.8	*225*	479
61J	22.5	3.3	2.35	0.61	2.8	0.77	12.9	0.38	10.2	2.6	2.3	10.3	0.50	0.35	2.35	25	99	398
61J2	28.0		2.65		3.2		19.0		10.8			8.5				23.7	*~111*	*~360*
61Jb	133	13.7	7.03	3.83	16.5	2.57	48.2	0.89	72.8	17.2	16.5	18.5	2.52	0.97	5.99	59.2	419	1021
61J2b	177	17.5	8.38	5.30	21.8	3.14	68.7	1.03	102	23.7	23.6	24.8	3.29	1.11	6.87	56.0	544	1435
61L	117	12.0	5.93	3.49	15.0	2.16	38.3	0.72	70.1	16.7	16.3	20.7	2.22	0.78	4.94	47.4	374	1334
61L2	104	11	5.47	3.16	13.6	2.00	32.6	0.66	61	14.4	14.4	15.8	2.04	0.73	4.71	44.2	330	1016
61L5	39.3	4.2	2.39	1.12	4.7	0.81	16.5	0.33	22.9	5.4	5.4	10.4	0.71	0.34	2.25	18	135	388
61L6	52.5	5.5	2.77	1.64	6.8	1.00	18.3	0.35	33.4	7.7	7.9	11.1	0.99	0.37	2.46	20.4	173	616
61L7	65.9	6.8	3.66	1.88	7.7	1.27	23.2	0.48	36.6	8.5	8.9	12.9	1.19	0.5	3.37	27.2	210	787
61L8	50	6.2	3.61	1.43	6.7	1.24	18.8	0.45	28.9	6.8	6.4	5.6	1.03	0.48	3.1	31.7	172	631
61L2b	37.4	3.5	2.1	0.89	3.6	0.71	17.7	0.29	16.1	4.1	3.5	8.1	0.58	0.3	1.98	18.5	119	660
61L5b	42.7	3.3	1.97	0.93	3.6	0.65	21	0.28	18.9	4.9	3.9	9.3	0.56	0.28	1.93	15.7	130	437
61L7b	38	2.4	1.21	0.85	3	0.43	18.1	0.15	17.4	4.4	3.6	6.6	0.43	0.17	1.06	9.8	108	257
61K	60.2	6.5	3.81	1.94	7.1	1.29	24.2	0.52	32.3	7.8	7.0	12.0	1.09	0.53	3.40	36.1	206	677
61K2	30.8	4.3	3.01	1.75	4.3	1.45	15.9	0.98	15.4	4.4	4	10.2	1.31	0.98	2.86	23.9	126	478
61K6	10.3	2.1	1.6	0.51	1.8	0.55	6.5	0.31	5.1	1.3	1.3	6.9	0.38	0.3	1.58	16.7	57	361
61K8	61.5	5.8	3.23	1.8	6.6	1.12	26.8	0.39	31.3	7.7	7	12	1	0.43	2.73	30.7	200	847
61I	79.9	5.8	2.91	2.32	7.4	1.06	27.0	0.40	43.5	10.3	9.0	14.6	1.07	0.41	2.71	24	232	628
61I5	72.4	5.2	2.85	2.04	6.5	0.98	30.2	0.39	36.4	9.2	7.6	13.2	0.94	0.41	2.72	22.8	214	364
61H	118	10.4	5.26	3.68	12.2	1.93	34.7	0.64	65.6	15.8	14.0	19.4	1.88	0.71	4.49	47	356	1451
61H2	105	10.7	5.71	3.74	13.2	2.02	28.3	0.71	67.2	15.8	14.2	15.5	1.94	0.77	4.80	50.6	340	2272
61H3	110	10	5.4	3.46	12.2	1.9	29.3	0.65	67.2	15.9	13.7	17.6	1.77	0.72	4.56	49.6	344	1540
61H4	109	9.3	4.98	3.18	11.3	1.76	32	0.59	61.2	15	12.5	16.6	1.64	0.65	4.26	44.5	328	779
61H5	88.6	7.9	4.29	2.79	9.4	1.5	28	0.53	48.8	11.8	10.5	13.1	1.39	0.58	3.76	36.8	270	1754
61H6	54.9	4.4	2.35	1.65	5.5	0.82	17.4	0.29	30.2	7.2	6.4	10.9	0.79	0.32	2.07	20.5	166	980
61H7	30	1.8	0.99	0.83	2.6	0.34	12.5	0.13	15.7	3.8	3.3	7.2	0.34	0.13	0.92	8.3	89	273
61H8	56.6	3.6	1.89	1.46	4.7	0.67	22.9	0.23	27.7	6.9	5.8	10.4	0.67	0.25	1.67	16.5	162	916
61Hb	84.5	8.2	4.91	2.59	9.3	1.64	27.6	0.69	44.9	10.7	9.9	10.8	1.41	0.68	4.57	40.7	263	2112
61H5b	79.7	6.7	3.85	2.41	8.2	1.31	26.8	0.52	43.6	10.5	9.3	17.4	1.18	0.52	3.5	32.1	248	851
61H7b	43.1	3.1	1.99	1.08	3.6	0.64	20.1	0.3	19.9	5.1	3.9	12.2	0.53	0.28	1.94	17.5	135	304
61G	62.6	4.5	2.51	1.30	5.2	0.88	25.4	0.34	29.7	7.5	5.8	8.8	0.79	0.35	2.28	23	181	181
61oy	18.9	1.6	0.89	0.53	2	0.30	8	0.12	10.3	2.4	2.3	3.9	0.28	0.13	0.83	7	59	234
61F	45.3	3.0	1.53	0.93	3.7	0.57	29.6	0.20	19.5	5.1	3.7	7.3	0.53	0.20	1.31	16	138	660
61E	44.0	2.7	1.53	0.93	3.4	0.53	18.4	0.23	20.5	5.2	3.9	9.7	0.49	0.23	1.51	14	127	195
61D	15.7	2.7	2.00	0.52	2.3	0.65	9.8	0.31	7.4	1.8	1.7	12.2	0.41	0.29	1.96	23	83	347
61C	39.4	1.9	1.15	0.64	2.4	0.39	19.1	0.19	17.2	4.7	3.1	7.3	0.34	0.18	1.21	10	109	131
61A	49.1	7.7	3.81	2.65	9.9	1.42	10.1	0.48	50.7	10.2	11.9	12.9	1.45	0.52	3.36	33	209	669
61B	8.5	1.0	0.56	0.27	1.0	0.20	5.0	0.07	4.0	1.0	1.1	2.7	0.17	0.08	0.50	6	32	201

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
61N																											7	43.3
61Nb	2.47	27.1	5310	3.4	0.45	1.74	34	9.5	13.0	8	2.7	0.05	28.8	8650	71	8.7	6.5	17	992	0.57	0.16	12.0	1.2	1830	2.6	7.3		
61J																											25	87.9
61J2	0.96	2.8	382			0.11		77.9		3			49.6		578	1.3		3	407						1.0	3.0		
61Jb	5.13	33.2	1140	3.1	0.27	3.00	40	14.5	13.4	7	2.4	0.04	21.6	5190	90	12.8	11.3	34	402	0.41	<0.10	5.9	1.0	1210	3.4	14.7	56	86.5
61J2b	6.36	49.6	1580			1.56		13.6		4			15.5		123	16.5		21	548						1.6	18.3	57	91.3
61L	3.73	15.9	1020	1.9	0.21	1.52	40	13.1	8.3	5	2.2	0.06	11.6	3710	85	15.7	8.9	18	168	0.29	<0.10	9.1	0.7	854	2.0	30.4	45	106
61L2	3.77		1570	2.0		1.30	27		7.5	5	2.1		14.6	3360		16.3	8.9		305	0.42				911	1.3	17.7	43	55.5
61L5																												
61L6																											108	123
61L7	4.91		488	1.7		1.35	29		9.0	5	2.3		8.1	5750		12.6	10.9		205	0.35				828	2.7	23.2	27	86.3
61L8																												
61L2b																												
61L5b																												
61L7b	1.48		1650	1.3		1.42	24		6.1	3	1.2		5.4	4000		4.6	6.1		746	0.21				642	2.8	2.7		
61K	0.79	11.7	992	4.4		1.43	42	15.8	8.0	8	2.7		8.2	7510		3.6	7.0		210	0.18				736	1.5	3.1		
61K2																												
61K6	0.65		596	4.6		0.17	8		5.0	13	0.9		5.0	4340		1.0	4.1		444	0.05				140	1.6	1.8		
61K8																												
61I																											105	215
61I5	0.49		856	1.8		7.04	56		14.8	5	2.7		28.6	4060		3.1	10.8		374	0.69				2570	1.4	5.6		
61H																											71	123
61H2	0.52	14.5	809	3.1	<0.10	0.18	71	10.9	6.1	4	2.2	0.03	2.9	2840	82	8.1	7.2	2	43	0.05	<0.10	6.8	<0.2	218	3.9	6.4	131	187
61H3																											94	123
61H4	0.33		1010	3.4		1.04	123		6.9	6	3.0		6.4	3200		1.9	6.8		221	0.24				799	1.3	6.1		
61H5	0.11		431	2.8		0.32	56		5.0	3	1.9		4.5	2640		0.5	4.9		219	0.06				219	1.7	6.5		
61H6																												
61H7	0.17		537	0.8		0.80	108		4.3	3	3.3		5.3	1970		1.4	5.6		245	0.21				996	0.9	2.6	32	
61H8																											99	107
61Hb																												
61H5b	0.43	2.7	177	2.1	0.17	2.71	64	13.1	8.9	10	2.1	0.05	12.6	4690	102	1.9	8.3	22	215	0.36	<0.10	7.3	0.7	1300	2.7	7.7	98	134
61H7b	0.38		1310	2.3		4.12	52		11.7	15	2.5		12.2	3690		1.5	9.1		321	0.45				1730	2.0	3.2	164	
61G	0.60		531	2.1		3.92	36		19.1	2	3.4		47.2	3560		1.7	12.6		224	1.19				2730	1.3	7.6	42	137
61oy	2.02		1070	0.5		0.64	13		4.0	9	1.1		4.0	1510		6.1	4.7		335	0.11				366	3.1	2.2		
61F																											137	196
61E	0.77		932	1.9		7.50	43		15.5	5	3.6		30.5	4590		3.5	11.3		228	0.80				2520	1.7	3.2		
61D																											38	185
61C																												
61A																											30	210
61B																												

REE Section 61 Base

T.135N., R.105W., Sec.15, NW/NW
Elevation at top 2,702 ft.

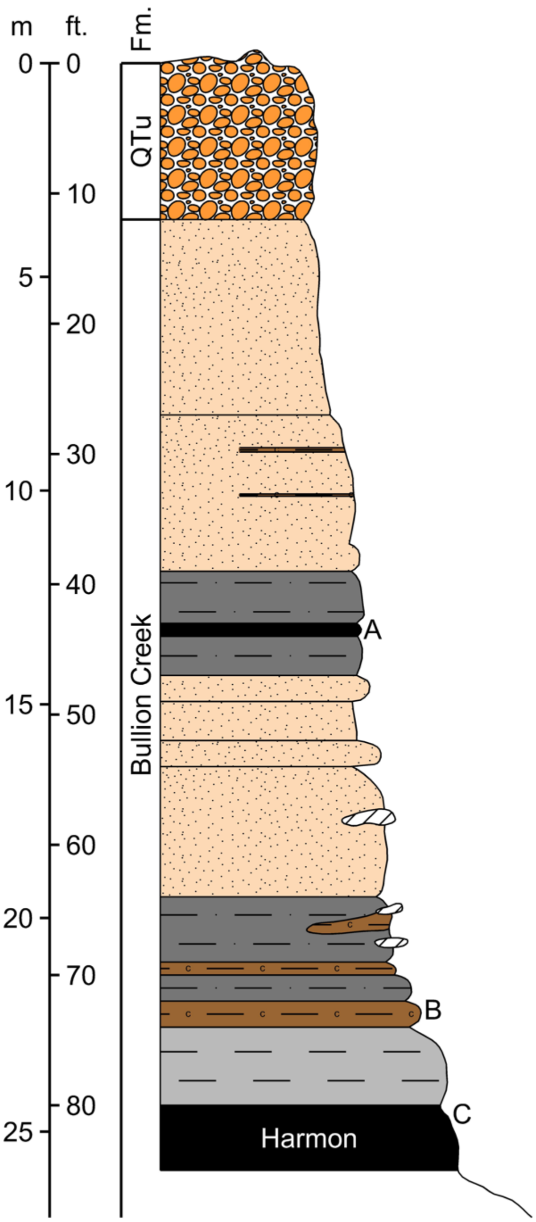


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
61S	12	2	1.53	0.4	1.5	0.47	6.6	0.25	5.4	1.4	1.3	9.4	0.28	0.23	1.62	13.5	58	159
61T	107	2.2	0.86	0.97	3.7	0.35	57.3	0.08	34.7	10.7	5.5	2	0.48	0.11	0.64	8.3	235	290
61U	24.6	1.2	0.74	0.35	1.3	0.25	9.9	0.1	7.8	2.2	1.5	3.1	0.21	0.11	0.7	6.2	60	187

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
61S																												
61T	1.11		210	0.7		0.34	2		31.2	3	1.6		126.0	2700		0.7	9.3		73	1.70				2450	2.3	4.3		
61U	1.35		452	2.6		0.25	6		13.5	2	6.9		43.2	6750		1.5	12.7		246	0.91				1690	1.5	5.1		

REE Section 67

T.136N., R.102W., Sec.8, NE1/4
Elevation at top 2,656 ft.

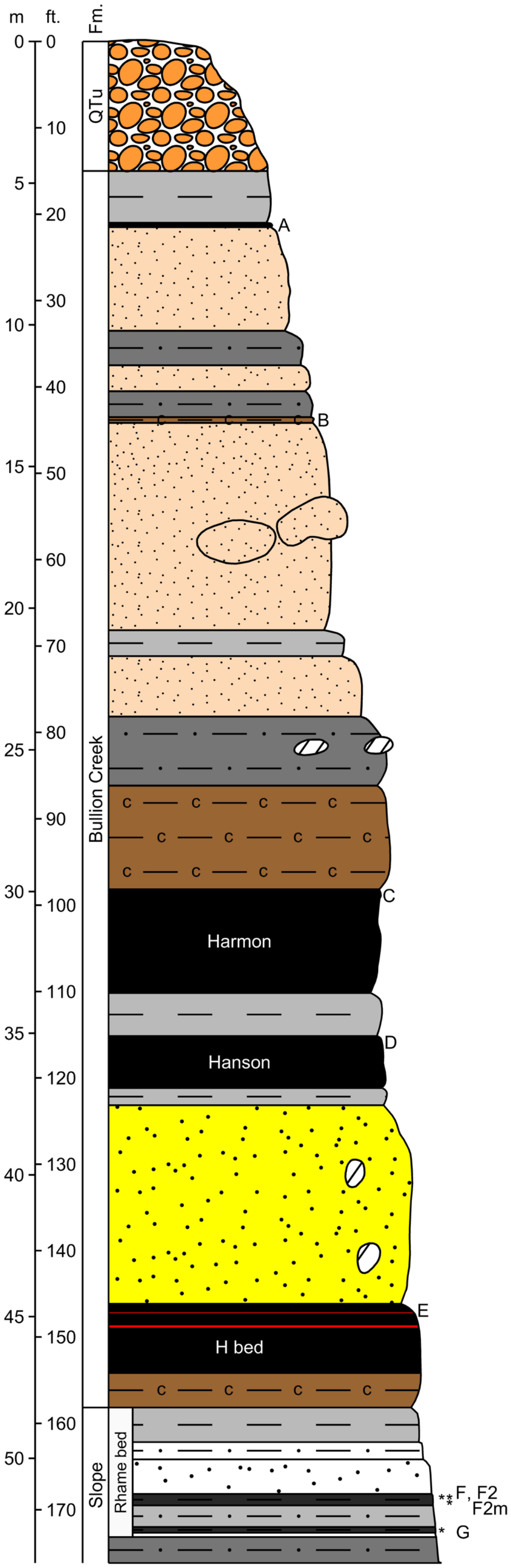


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
67A	26.2	8.0	5.38	1.18	5.9	1.77	13.5	0.80	14.2	3.4	4.0	23.2	1.15	0.77	5.03	44	158	276
67B	70.6	4.9	2.78	1.26	5.8	0.93	33.9	0.39	31.9	8.5	6.3	12.9	0.82	0.37	2.67	26	210	241
67C	23.3	4.4	2.82	0.74	3.7	0.94	10.0	0.39	11.7	2.9	2.9	7.8	0.68	0.39	2.53	26	101	431

SAMPLE ID	LAB ANALYSIS (in µg/g)																												
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
67A																													
67B																													
67C																													

REE Section 68

T.136N., R.102W., Sec.8, NW
Elevation at top 2,667 ft.

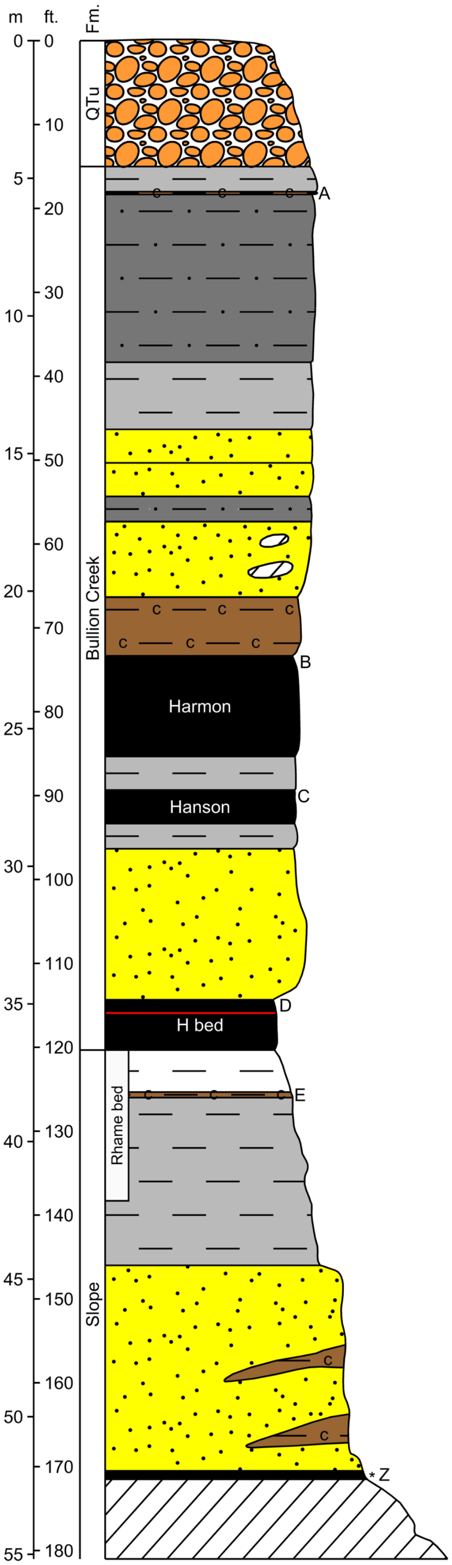


SAMPLE ID	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	TOTAL REE Whole Coal	TOTAL REE Ash
	LAB ANALYSIS (in µg/g)																	
68A	42.4	11.4	7.97	1.67	8.5	2.57	19.0	1.20	23.9	5.7	6.4	26.5	1.64	1.15	7.44	65	232	511
68B	27.3	6.0	4.16	0.96	4.5	1.33	14.9	0.64	13.1	3.3	3.3	18.6	0.85	0.60	4.00	33	137	277
68C	14.6	2.6	1.65	0.46	2.3	0.56	6.9	0.23	7.1	1.8	1.8	5.0	0.41	0.23	1.46	17	64	239
68D	39.6	6.9	4.11	1.24	6.1	1.42	20.1	0.56	19.2	4.9	4.6	15.7	1.09	0.57	3.60	38	168	502
68E	76.9	4.2	2.04	1.63	5.9	0.73	33.9	0.27	38.5	10.1	7.9	12.9	0.82	0.27	1.81	16	214	640
68F	205	19.0	9.27	5.65	23.4	3.48	90.6	1.07	110	26.7	25.3	19.9	3.46	1.24	7.65	86	638	824
68F2	170	14.4	7.30	4.25	18.3	2.67	74.3	0.85	86.6	21.1	19.1	17.2	2.63	0.97	6.04	65.1	511	641
68F2m	134	10.7	5.73	2.91	12.7	2.02	62.9	0.72	62.7	16.1	13.2	18.5	1.86	0.79	5.04	54.6	404	449
68G	71.9		2.49		5.3		37.7		32.0			15.1				22.2	*~211*	*~226*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
68A																												
68B																												
68C																												
68D																												
68E																												
68F																												
68F2								18.2		192						17.0												
68F2m								17.2		23						7.8												
68G						11.4			25.8	3			52.2				14.4			1.07				3530				

REE Section 69

T.136N., R.102W., Sec.8, NW
Elevation at top 2,654 ft.

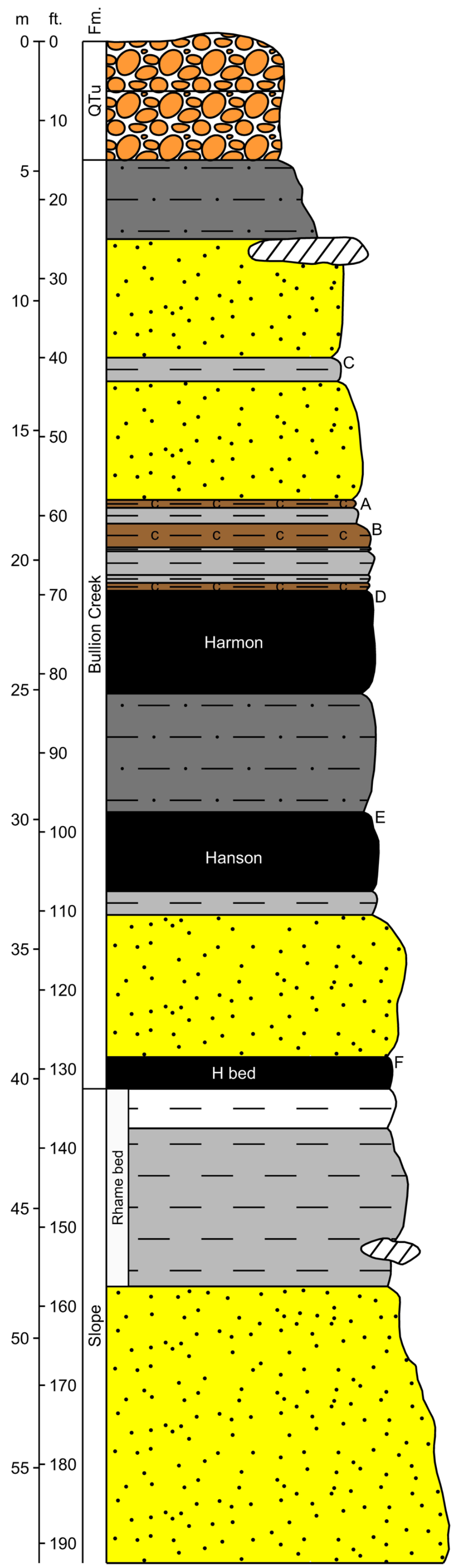


SAMPLE ID	LAB ANALYSIS (in µg/g)															TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
69A	71.9	13.2	9.29	2.01	10.1	2.97	33.9	1.37	34.9	8.9	8.2	29.1	1.88	1.32	8.57	81	319	399
69B	17.1	3.1	1.95	0.59	2.7	0.66	7.9	0.27	8.5	2.1	2.0	4.7	0.47	0.27	1.72	20	74	258
69C	27.4	10.2	5.91	2.03	9.5	2.10	9.6	0.80	24.8	4.8	7.7	13.3	1.66	0.83	5.16	53	179	698
69D	10.1	1.3	0.78	0.30	1.3	0.25	4.1	0.10	5.7	1.4	1.3	4.8	0.19	0.09	0.76	6	38	86
69E	59.4	3.0	1.78	0.88	3.8	0.55	29.8	0.24	26.9	7.1	4.9	14.3	0.50	0.24	1.82	16	171	206
69Z	46.2	4.6	2.46		5.1		24.7		21.7			6.0				26.9	*~154*	*~464*

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
69A																												
69B																												
69C																												
69D																												
69E																												
69Z						1.32	37		15.7	14			6.2	1860		14.5	7.2									10.1	48	

REE Section 70

T.136N., R.102W., Sec.8, NW
Elevation at top 2,674 ft.

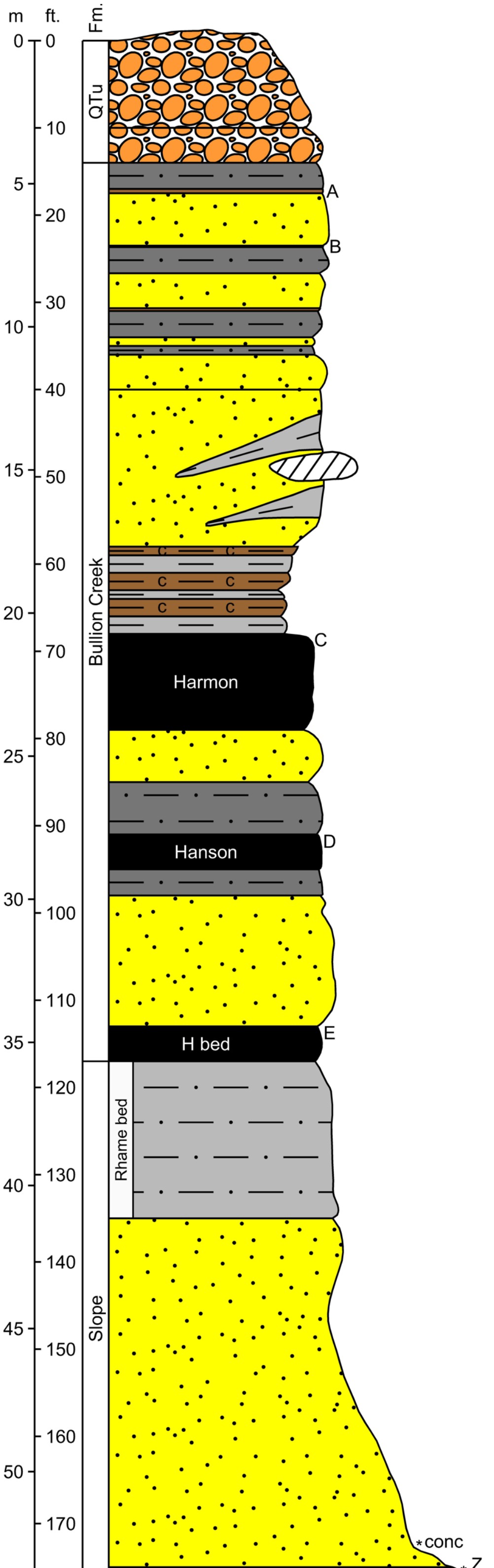


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
70C	53.6	3.0	1.77	0.86	3.9	0.55	25.7	0.22	24.2	6.4	4.6	8.5	0.51	0.22	1.66	16	152	169
70A	51.0	3.0	1.80	0.85	3.5	0.56	24.6	0.26	23.1	6.1	4.4	10.9	0.48	0.24	1.86	16	149	175
70B	62.6	4.1	2.43	1.05	5.0	0.79	30.5	0.31	29.0	7.5	5.5	11.9	0.69	0.31	2.32	23	187	227
70D	33.1	3.0	1.83	0.70	3.3	0.59	14.7	0.27	15.9	4.1	3.4	8.6	0.50	0.25	1.82	16	108	232
70E	12.7	2.4	1.60	0.42	2.1	0.53	5.7	0.25	6.7	1.6	1.6	6.5	0.36	0.23	1.55	15	59	275
70F	12.0	2.5	1.61	0.34	1.9	0.50	6.3	0.23	6.0	1.5	1.5	7.6	0.34	0.22	1.64	13	57	150

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
70C																												
70A																												
70B																												
70D																												
70E																												
70F																												

REE Section 71

T.136N., R.102W., Sec.5, NW
Elevation at top 2,657 ft.

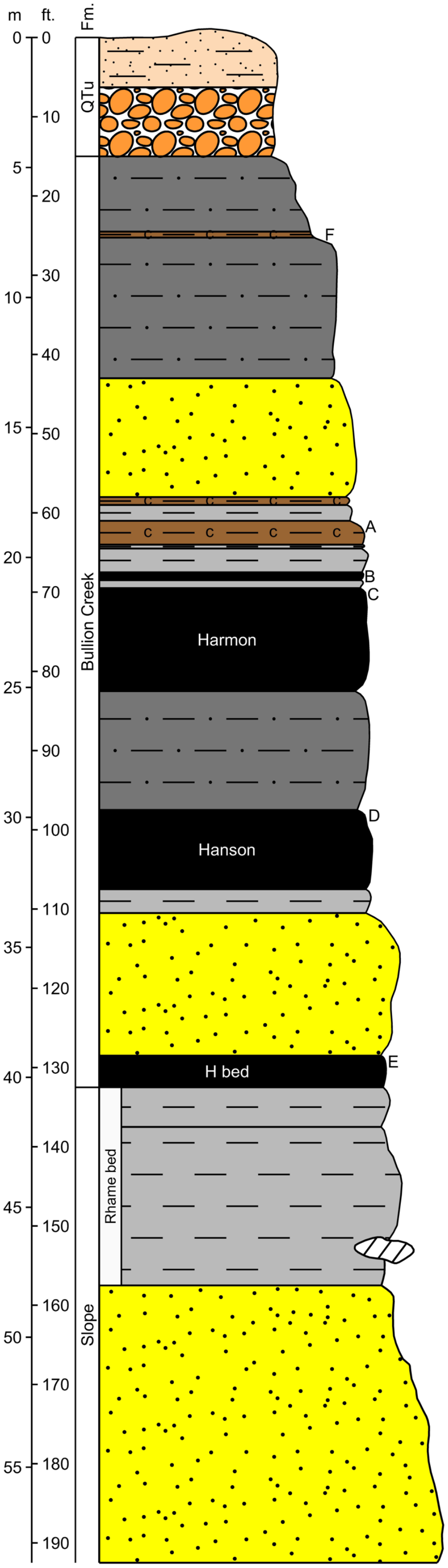


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
71A	49.0	10.0	7.07	1.51	7.7	2.23	24.8	1.08	25.8	6.4	6.2	23.7	1.41	1.00	6.91	59	234	346
71B	44.1	4.3	3.02	0.89	4.0	0.93	22.1	0.44	20.1	5.2	4.0	11.1	0.62	0.41	3.00	29	153	195
71C	21.9	2.0	1.27	0.50	2.1	0.42	10.0	0.21	10.2	2.6	2.2	7.5	0.34	0.19	1.28	11	74	177
71D	9.6	1.7	0.99	0.39	1.7	0.33	3.4	0.16	6.0	1.4	1.6	6.9	0.27	0.14	1.00	8	44	243
71E	17.6	1.1	0.59	0.40	1.4	0.20	7.4	0.09	9.0	2.2	1.9	7.2	0.19	0.08	0.57	4	54	147
71conc	25.4		0.61		1.7		12.9		11.3			2.5				5.4	*~68*	*~86*
71Z	43.1		1.77		4.0		22.0		22.4			8.5				12.7	*~132*	*~410*
71Zb	52.0		1.91		3.3		27.6		21.9			10.5				15.1	*~149*	*~203*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
71A																												
71B																												
71C																												
71D																												
71E																												
71conc	22.7	246	211	0.5		1.69	146	13.7	5.8	2	0.9		10.8	1910	146	12.7	5.0	32	31	0.43		3.2		1200	367	0.9	17	27.9
71Z						2.33	80		14.4	15			9.4	3670		16.4	10.0									9.2	177	
71Zb						11.2	54		26.7	9			35.7	6720		3.6	13.8									6.3	82	

REE Section 72

T.136N., R.102W., Sec.8, NW
Elevation at top 2,668 ft.

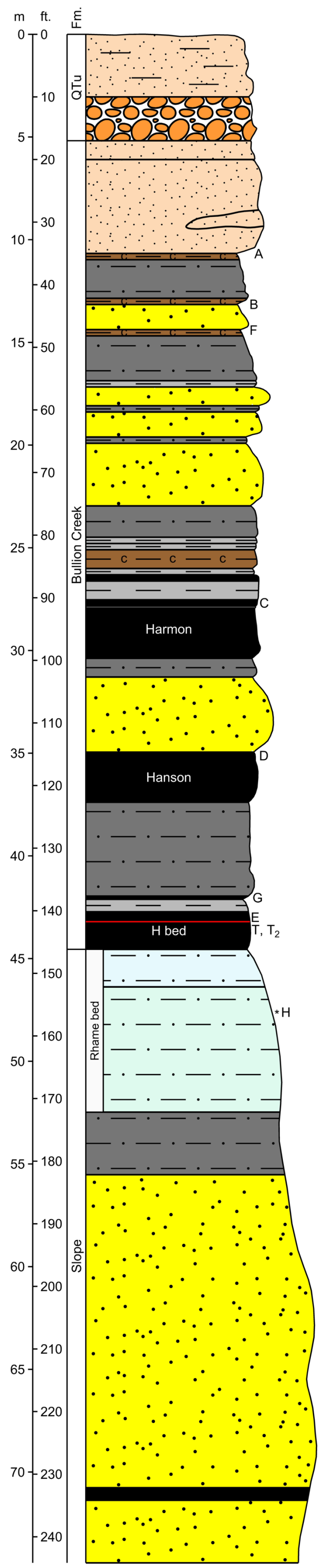


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
72F	49.7	5.6	3.85	1.08	5.2	1.24	24.7	0.60	23.4	6.0	4.9	13.9	0.86	0.57	3.72	36	181	264
72A	59.0	4.3	2.46	1.01	4.5	0.81	28.6	0.39	26.2	6.9	5.2	12.7	0.69	0.38	2.47	22	178	205
72B	61.6	4.0	2.44	1.05	4.8	0.80	29.5	0.36	27.6	7.2	5.4	12.2	0.70	0.36	2.32	22	182	219
72C	43.5	4.6	2.81	1.00	4.7	0.95	18.7	0.41	20.9	5.3	4.6	9.6	0.78	0.40	2.65	24	145	264
72D	25.6	5.5	3.36	1.02	5.1	1.13	11.4	0.45	14.5	3.4	3.8	11.6	0.86	0.46	2.92	33	124	478
72E	21.3	4.2	2.66	0.66	3.3	0.88	11.0	0.39	9.9	2.5	2.6	13.3	0.62	0.38	2.53	24	100	405

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
72F																												
72A																												
72B																												
72C																												
72D																												
72E																												

REE Section 73

T.136N., R.102W., Sec.5, SW
Elevation at top 2,678 ft.

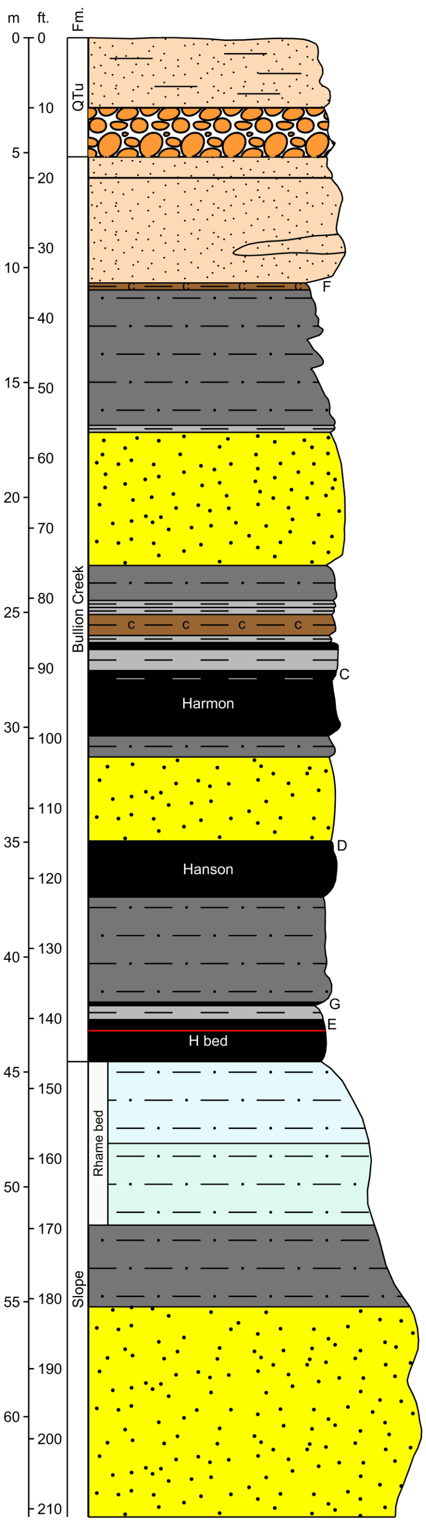


SAMPLE ID	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	TOTAL REE Whole Coal	TOTAL REE Ash
	LAB ANALYSIS (in µg/g)																	
73A	19.7	5.5	3.92	0.78	3.9	1.24	9.7	0.60	10.8	2.5	2.9	14.1	0.77	0.57	3.80	32	113	222
73B	45.7	4.2	2.95	0.94	4.0	0.96	22.8	0.53	20.5	5.4	4.1	12.4	0.70	0.49	2.93	26	155	202
73F	58.0	3.6	2.31	1.00	4.1	0.75	28.7	0.35	25.3	6.8	4.8	12.0	0.60	0.35	2.35	20	171	187
73C	31.6	3.0	1.91	0.65	3.0	0.62	14.8	0.31	14.6	3.7	3.1	9.7	0.47	0.28	1.93	16	106	230
73D	11.5	2.4	1.63	0.43	1.9	0.51	5.0	0.26	6.6	1.6	1.6	7.6	0.35	0.24	1.63	14	57	368
73G	43.8	3.6	2.17	0.90	3.8	0.70	20.0	0.35	19.5	5.1	4.0	13.1	0.59	0.32	2.19	16	136	485
73E	18.9	3.2	2.20	0.51	2.6	0.70	9.5	0.35	8.5	2.1	2.1	9.7	0.47	0.33	2.20	19	82	357
73T	150	3.5	1.34	0.76	6.0	0.52	68.9	0.13	52.8	15.8	8.8	1.6	0.75	0.16	0.98	13	325	408
$73T_2$	116		1.37		5.2		57.4		42.1			1.9				11.3	*~262*	*~378*
73H	108	8.3	3.90	2.93	11.3	1.46	48.3	0.48	57.9	13.8	13.3	17.9	1.67	0.53	3.40	26.3	319	439

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
73A																												
73B																												
73F																												
73C																												
73D																												
73G																												
73E																												
73T																												
$73T_2$	1.35								44.5		2.6		101				3.5			2.39		47.8	9.7	1320				59.2
73H						8.16	140		25.6	114			27.7	4830		31.7	22.6									17.9	365	

REE Section 74

T.136N., R.102W., Sec.5, SW
Elevation at top 2,667 ft.

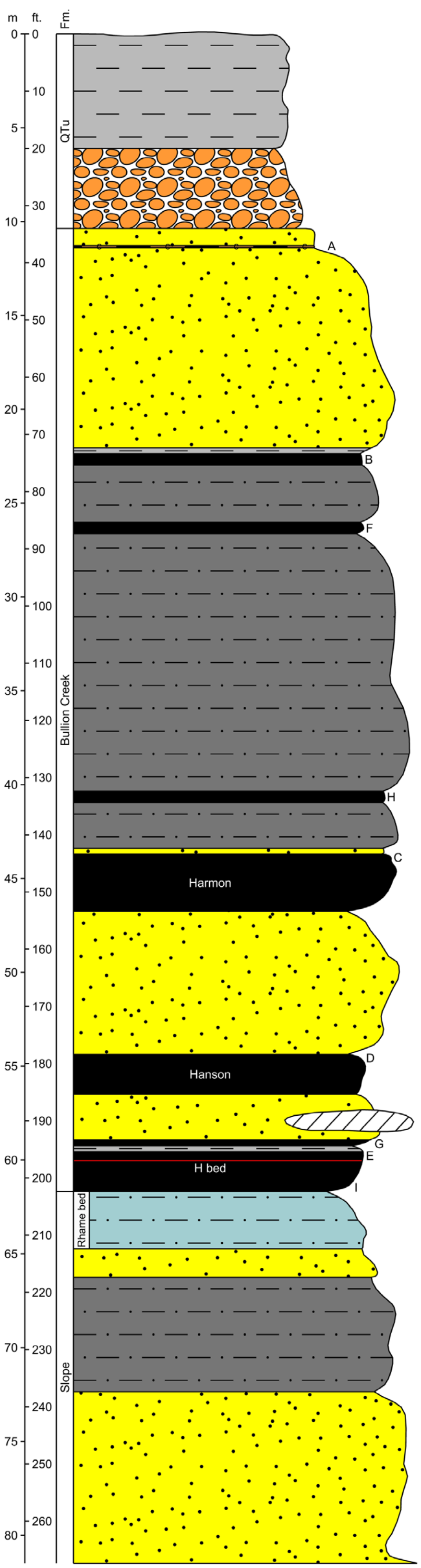


SAMPLE ID	LAB ANALYSIS (in µg/g)															TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
74F	53.4	5.4	3.50	1.13	5.0	1.14	25.8	0.56	23.6	6.2	4.9	15.8	0.85	0.53	3.42	29	180	248
74C	46.9	2.5	1.47	0.70	3.1	0.47	21.5	0.23	20.5	5.5	3.9	8.1	0.43	0.22	1.52	13	130	184
74D	26.7	5.9	3.68	1.10	5.1	1.21	10.6	0.54	17.1	3.9	4.4	9.4	0.90	0.53	3.47	34	129	696
74G	50.2	3.2	1.72	0.95	3.9	0.60	23.8	0.24	20.5	5.5	4.2	6.8	0.57	0.24	1.57	15	139	376
74E	44.6	4.1	2.56	0.71	3.7	0.85	26.6	0.37	15.2	4.3	3.1	9.1	0.63	0.36	2.38	26	145	512

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
74F																												
74C																												
74D																												
74G																												
74E																												

REE Section 75

T.136N., R.102W., Sec.5, SW
Elevation at top 2,709 ft.

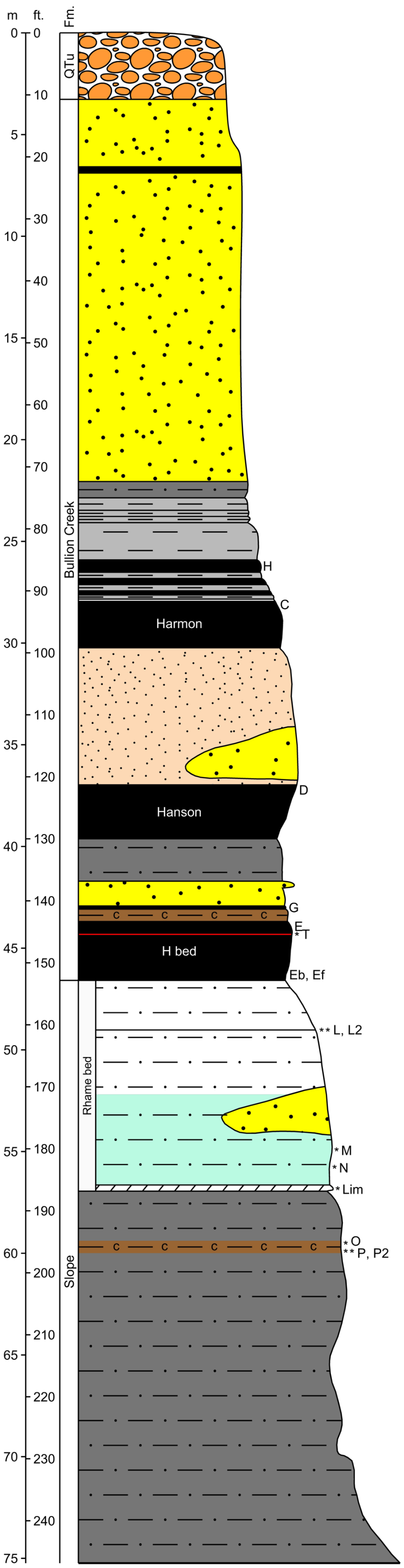


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
75A	71.8	4.2	2.47	1.11	4.9	0.81	34.1	0.39	31.1	8.2	5.9	12.5	0.73	0.38	2.65	22	203	213
75B	56.1	4.3	2.67	1.04	4.6	0.87	26.6	0.41	24.9	6.6	4.9	13.2	0.70	0.39	2.70	23	173	232
75F	12.8	2.6	1.82	0.43	2.1	0.58	6.2	0.25	6.8	1.6	1.7	4.9	0.37	0.25	1.56	20	64	204
75H	33.7	2.9	1.82	0.68	3.2	0.59	15.1	0.27	15.6	4.0	3.3	8.0	0.48	0.25	1.74	18	110	247
75C	20.4	3.5	2.32	0.51	2.6	0.76	13.4	0.34	7.9	2.1	1.9	8.5	0.49	0.33	2.20	23	90	540
75D	7.7	1.1	0.73	0.27	1.0	0.24	3.7	0.13	3.9	1.0	0.9	5.0	0.16	0.11	0.78	6	33	146
75G	20.0	2.2	1.30	0.62	2.4	0.42	8.2	0.21	11.9	2.8	2.7	8.7	0.37	0.19	1.32	10	73	271
75E	18.4	3.6	2.33	0.59	3.0	0.76	8.7	0.35	9.1	2.2	2.4	9.2	0.53	0.34	2.29	23	87	317
75I	12.1	1.7	1.07	0.28	1.4	0.36	6.4	0.15	5.1	1.4	1.2	3.0	0.25	0.15	0.95	11	47	275

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
75A																												
75B																												
75F																												
75H																												
75C																												
75D																												
75G																												
75E																												
75I																												

REE Section 76

T.136N., R.102W., Sec.5, SW
Elevation at top 2,678 ft.

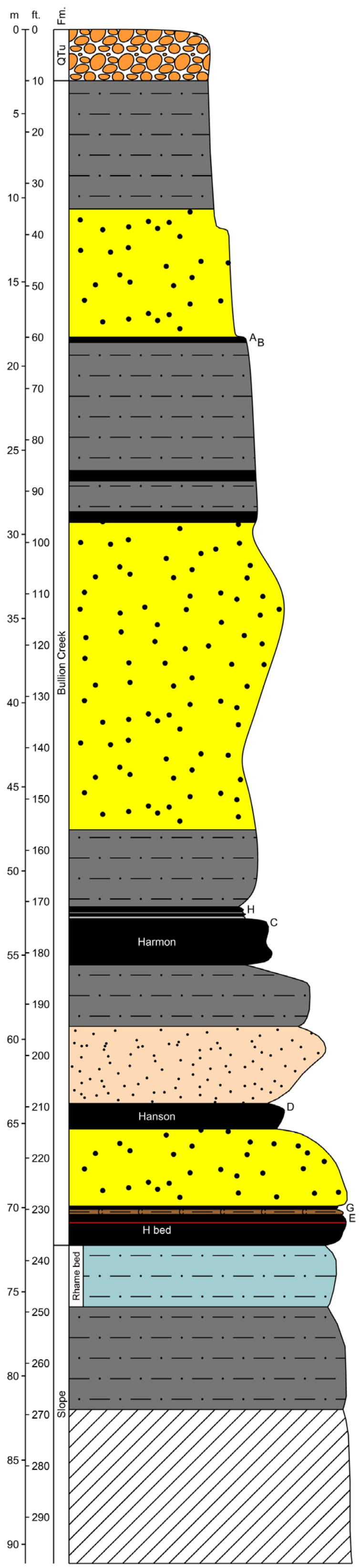


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
76H	29.9	3.1	1.96	0.63	3.1	0.64	13.5	0.29	13.9	3.6	2.9	7.1	0.49	0.28	1.85	18	101	268
76C	9.0	1.0	0.59	0.20	0.9	0.20	4.3	0.09	4.2	1.1	0.9	3.0	0.16	0.09	0.56	6	32	171
76D	11.6	2.9	1.95	0.46	2.2	0.63	5.3	0.29	6.3	1.5	1.6	6.0	0.41	0.28	1.84	18	61	597
76G	57.3	3.8	2.11	1.19	4.6	0.70	25.2	0.33	26.6	6.7	5.5	9.9	0.68	0.30	2.14	15	162	496
76E	50.9	3.6	2.18	0.72	3.7	0.73	25.4	0.30	17.4	5.0	3.3	6.7	0.59	0.31	1.95	21	144	652
76T	103		1.19		4.3		50.4		36.2			1.6				10.0	*~229*	*~337*
76Eb	28.1		1.62		2.3		15.1		11.9			5.6				13.1	*~89*	*~207*
76Ef	50.7		1.25		2.6		25.8		20.8			4.6				10.2	*~130*	*~154*
76L	68.2		2.68		5.4		34.2		30.5			12.2				20.8	*~199*	*~213*
76L2	83.0		3.00		6.6		42.2		35.9			11.2				25.9	*~237*	*~260*
76M	53.8		1.89		3.7		27.6		23.3			10.8				17.5	*~156*	*~165*
76N	69.8		2.81		5.7		35.9		31.8			14.6				25.1	*~212*	*~221*
76lim	39.5		2.99		4.6		21.7		18.3			10.7				29.6	*~148*	*~179*
76O	209	12.8	5.69	4.43	18.6	2.19	92.7	0.67	101	25.1	21.4	19.8	2.63	0.73	4.61	43.4	566	711
76P	96.8		3.35		8.3		47.6		44.4			15.9				25.9	*~278*	*~372*
76P2	82.9		3.03		7.5		38.8		40.0			14.8				24.3	*~243*	*~258*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
76H																												
76C																												
76D																												
76G																												
76E																												
76T	0.76								44.5		2.9		115				3.7			2.77		47.8	10.1	1310				55.7
76Eb						0.62	22		12.3	9			14.8	1360		3.7	10.8									4.3	33	
76Ef	1.73	35.5	488	0.6		2.51	19	0.7	9.2	5	2.8		14.8	1190	36	3.1	16.2	32	119	1.18		6.2		3520	3.0	2.9	32	98.8
76L						11.6	67		22.1	6			44.7	7310		4.7	15.5									11.6	104	
76L2						8.54	56		18.6	5			57.7	6520		2.5	14.1									7.1	82	
76M	1.69	4.7	996	2.0		9.22	54	6.0	17.4	3	2.7		46.4	9080	190	1.1	15.7	135	94	1.15		10.4		3360	3.6	2.5	80	90.5
76N	1.47	11.8	583	2.4		12.9	72	14.5	23.6	3	3.3		50.3	9710	102	0.8	16.4	155	83	1.22		12.1		3510	2.3	2.5	102	110
76lim						1.49	32		54.5	2			23.5	12200		0.7	7.8									6.5	57	
76O						11.1	95		26.4	7			70.0	6030		6.3	14.2									13.9	159	
76P						11.8	76		27.8	20			76.0	6240		7.1	14.3									10.6	112	
76P2						10.8	71		28.0	3			54.3	7330		3.0	15.6									6.8	113	

REE Section 77

T.136N., R.102W., Sec.5, NW
Elevation at top 2,730 ft.

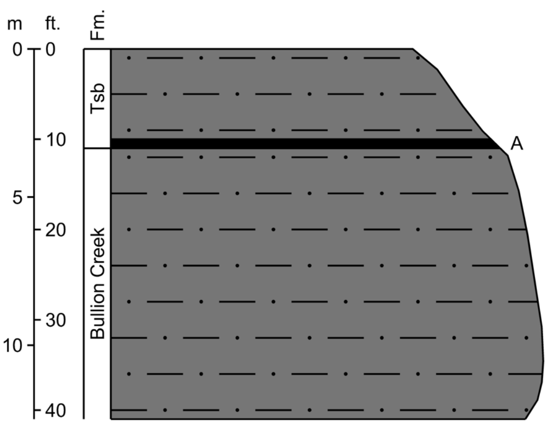


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
77A	66.6	9.2	6.14	1.74	8.4	1.99	35.6	0.92	33.4	8.2	7.4	19.1	1.41	0.89	5.82	58	265	347
77B	30.7	6.9	4.27	1.21	6.1	1.44	17.6	0.57	18.3	4.2	4.7	15.5	1.05	0.59	3.73	42	159	443
77H	38.1	4.3	2.78	0.84	4.1	0.92	18.1	0.40	18.0	4.6	3.8	8.5	0.67	0.40	2.58	30	138	340
77C	15.9	1.6	1.00	0.35	1.5	0.33	7.4	0.14	7.0	1.8	1.4	4.2	0.26	0.14	0.93	10	54	207
77D	16.5	3.7	2.36	0.68	3.2	0.77	6.5	0.37	9.9	2.2	2.6	7.6	0.57	0.34	2.30	18	78	482
77G	55.7	9.1	4.81	2.65	10.5	1.69	15.7	0.69	47.6	10.1	11.3	23.8	1.57	0.69	4.57	36	236	959
77E	75.8	5.9	3.75	1.16	5.6	1.22	32.3	0.54	27.2	7.4	5.4	9.9	0.93	0.53	3.45	35	216	631

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
77A																												
77B																												
77H																												
77C																												
77D																												
77G																												
77E																												

REE Section 78

T.136N., R.102W., Sec.5, NW
Elevation at top 2,841 ft.

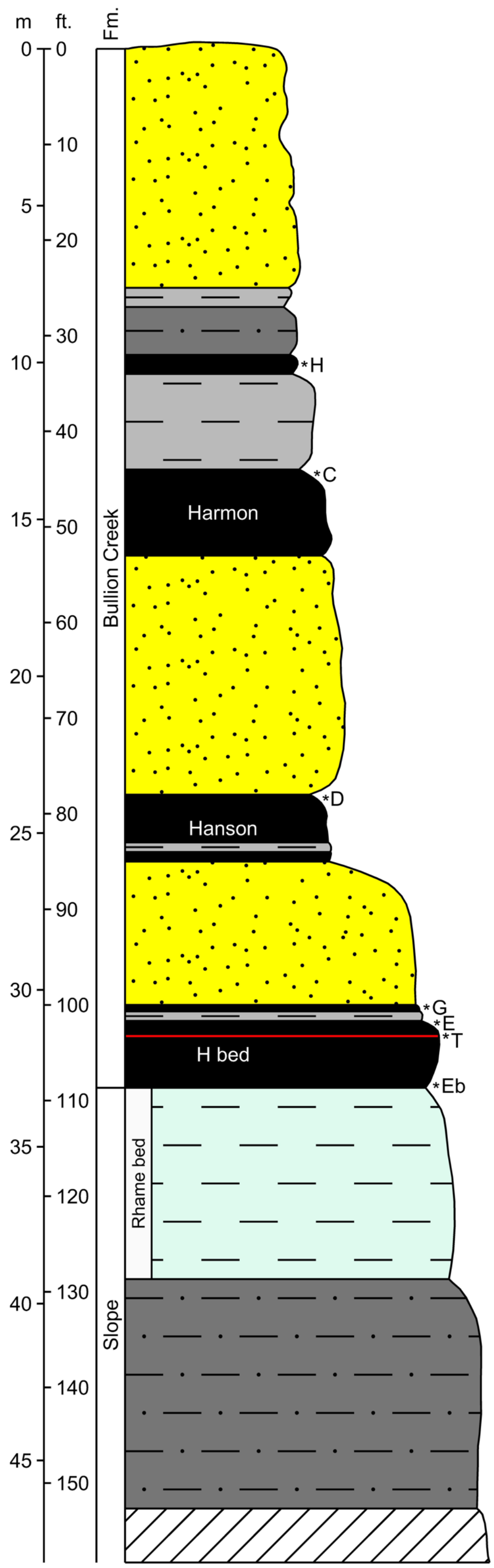


SAMPLE ID	LAB ANALYSIS (in µg/g)															TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
78A	23.3	2.9	1.44	1.16	3.6	0.52	7.0	0.21	16.9	3.7	4.1	5.7	0.52	0.20	1.37	9	82	181

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
78A																												

REE Section 79

T.136N., R.102W., Sec.5, NW
Elevation at top 2,627 ft.

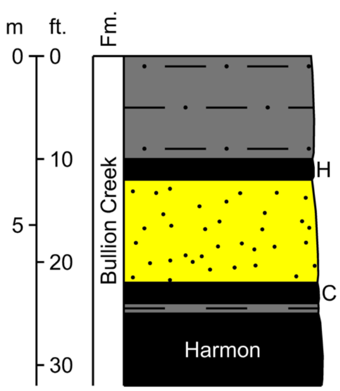


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
79H	17.3	1.4	0.86	0.40	1.6	0.28	8.1	0.13	8.2	2.1	1.8	3.9	0.24	0.12	0.83	7	54	144
79C	37.7	3.7	2.09	0.76	3.6	0.73	18.3	0.27	15.2	4.1	3.3	7.3	0.60	0.28	1.79	21	121	569
79D	10.6	1.2	0.69	0.39	1.3	0.23	3.9	0.11	5.9	1.4	1.5	5.0	0.20	0.10	0.72	5	38	96
79G	28.2	3.7	2.01	1.16	4.5	0.69	8.2	0.29	22.5	4.9	5.1	10.0	0.66	0.29	1.96	15	109	582
79E	46.1	5.2	3.27	0.95	4.7	1.08	22.2	0.47	18.5	4.9	4.1	9.5	0.79	0.47	3.07	30	155	488
79T	107		1.13		4.8		51.3		39.9			1.4				9.6	*~239*	*~303*
79Eb	13.9		1.66		2.0		8.0		5.9			3.3				17.2	*~61*	*~300*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
79H																												
79C																												
79D																												
79G																												
79E																												
79T	0.70								50.7		1.5		102				2.6			1.63		48.4	7.1	987				22.5
79Eb						0.90	8		2.9	17			8.0	2300		3.1	4.4									7.3	9	

REEE Section 80

T.136N., R.102W., Sec.5, NW
Elevation at top 2,592 ft.

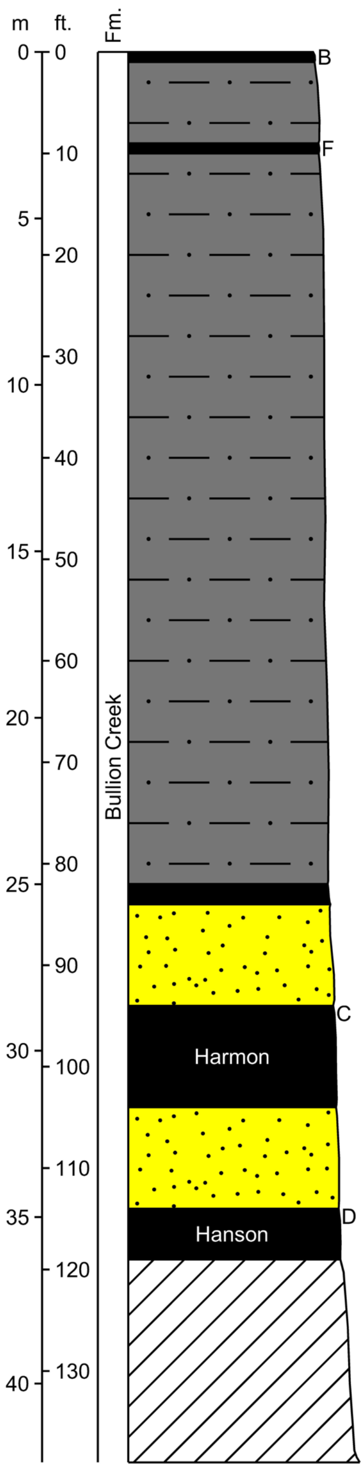


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
80H	25.3	2.6	1.64	0.56	2.6	0.54	12.5	0.23	11.8	3.0	2.5	5.3	0.40	0.23	1.45	18	89	231
80C	15.1	3.3	2.22	0.54	2.5	0.71	6.9	0.32	7.7	1.9	1.8	9.4	0.46	0.32	2.11	21	76	323

SAMPLE ID	LAB ANALYSIS (in µg/g)																												
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
80H																												
80C																												

REE Section 81

T.136N., R.102W., Sec.5, NW
Elevation at top 2,578 ft.

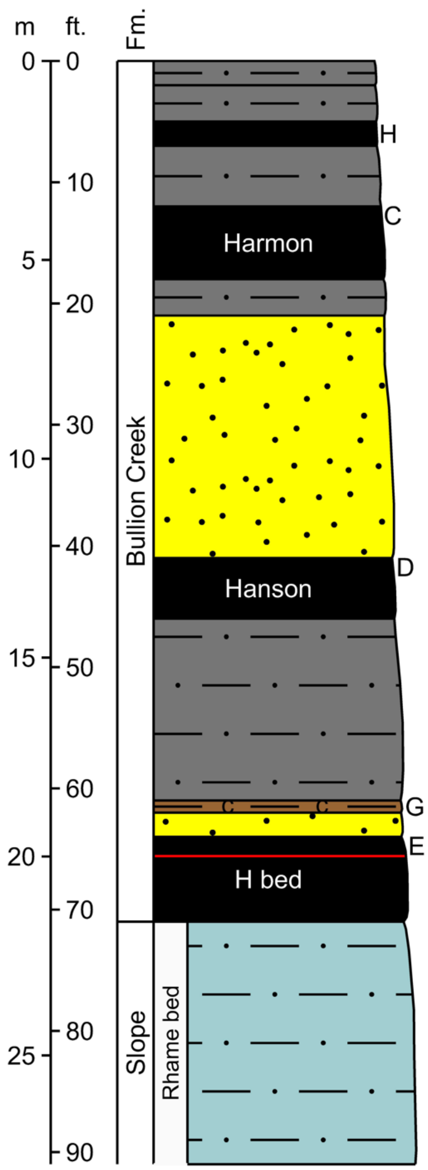


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
81B	46.7	3.2	1.93	0.91	3.6	0.65	22.2	0.31	21.0	5.5	4.3	11.0	0.53	0.29	2.03	15	*139*	196
81F	22.5	2.6	1.72	0.51	2.5	0.57	10.4	0.23	10.7	2.8	2.2	4.3	0.41	0.23	1.49	20	83	325
81C	26.9	4.9	3.32	0.82	3.8	1.07	13.6	0.50	12.0	3.1	2.9	13.9	0.69	0.48	3.19	32	123	485
81D	20.5	5.1	3.96	0.80	3.6	1.20	9.5	0.68	10.9	2.7	2.8	18.9	0.69	0.60	4.16	33	119	627

SAMPLE ID	LAB ANALYSIS (in µg/g)																												
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
81B																												
81F																												
81C																												
81D																												

REE Section 82

T.136N., R.102W., Sec.5, NW
Elevation at top 2,567 ft.

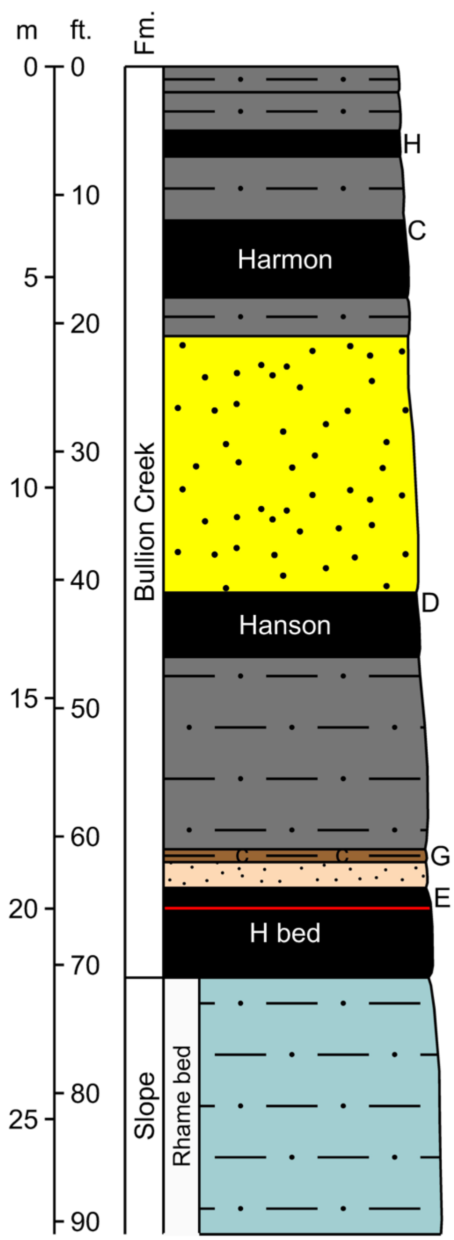


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
82H	42.0	3.7	2.15	0.94	4.1	0.72	17.9	0.31	20.7	5.2	4.4	9.3	0.62	0.31	2.04	18	132	229
82C	31.9	4.5	2.41	0.94	4.3	0.87	15.6	0.28	14.6	3.8	3.7	9.6	0.74	0.32	1.95	24	120	459
82D	35.9	6.1	3.65	1.30	5.8	1.24	17.1	0.52	21.0	5.0	5.1	14.0	0.98	0.50	3.35	30	152	672
82G	77.2	5.3	2.75	1.70	6.3	0.95	34.5	0.41	37.9	9.8	8.0	17.0	0.95	0.40	2.75	21	227	256
82E	64.4	6.7	3.21	2.40	8.8	1.16	17.8	0.43	47.5	10.8	11.3	20.0	1.24	0.44	2.90	24	223	582

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
82H																												
82C																												
82D																												
82G																												
82E																												

REE Section 83

T.136N., R.102W., Sec.5, NW
Elevation at top 2,563 ft.

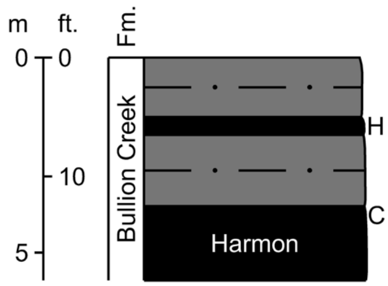


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
83H	38.7	3.2	1.85	0.88	3.7	0.62	16.5	0.28	19.3	4.8	4.1	7.3	0.54	0.27	1.83	16	120	231
83C	81.1	9.3	4.96	2.06	9.5	1.79	37.2	0.64	38.6	9.8	8.5	16.0	1.55	0.67	4.25	49	275	1032
83D	29.2	4.7	2.87	1.01	4.4	0.95	9.0	0.45	15.9	3.6	4.2	8.5	0.75	0.42	2.87	21	110	639
83G	63.8	3.4	1.83	1.13	4.0	0.62	25.4	0.28	25.2	6.6	4.9	12.0	0.61	0.27	1.87	14	166	181
83E	36.0	3.6	1.87	1.20	4.4	0.66	11.6	0.27	23.4	5.5	5.3	11.4	0.63	0.26	1.76	14	122	322

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
83H																												
83C																												
83D																												
83G																												
83E																												

REE Section 84

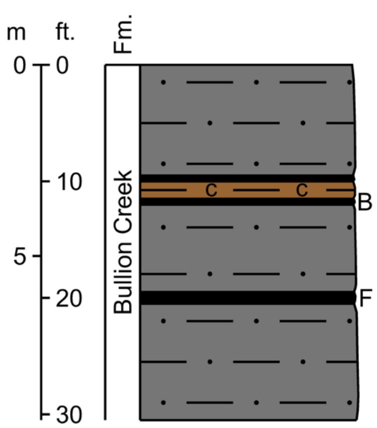
T.136N., R.102W., Sec.5, NW
Elevation at top 2,577 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
84H	53.8	4.1	2.36	1.06	4.6	0.79	23.5	0.36	25.0	6.4	5.1	9.0	0.69	0.33	2.29	21	160	267
84C	20.0	4.1	2.67	0.71	3.2	0.88	9.4	0.39	9.6	2.4	2.4	9.7	0.59	0.38	2.52	27	96	327

REE Section 85

T.136N., R.102W., Sec.5, NW
Elevation at top 2,650 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
85B	50.5	3.8	2.36	0.91	4.1	0.75	23.5	0.35	22.9	5.9	4.6	11.6	0.63	0.34	2.29	20	155	222
85F	40.8	3.6	2.22	1.10	4.0	0.74	18.4	0.31	19.6	5.0	4.0	7.3	0.60	0.30	1.99	22	132	255

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
84H																												
84C																												

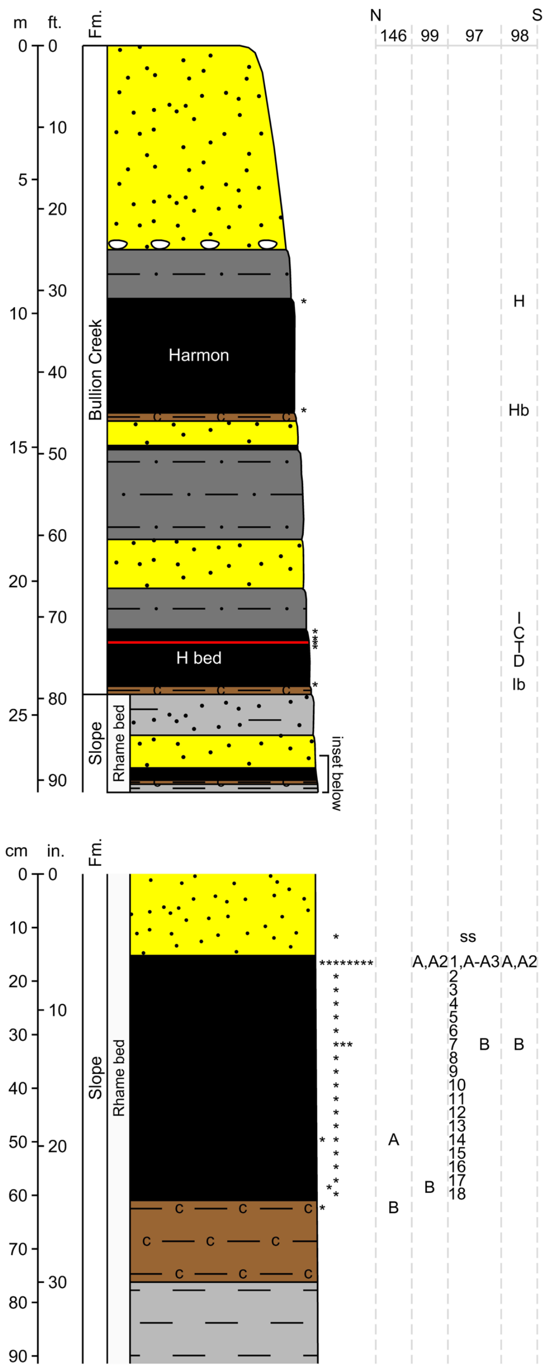
SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
85B																												
85F																												

REE Section 97

T.136N., R.102W., Sec.16, NE/SW/NE

Elevation at top 2,616 ft.

Includes directly adjacent sections 98, 99, and 146

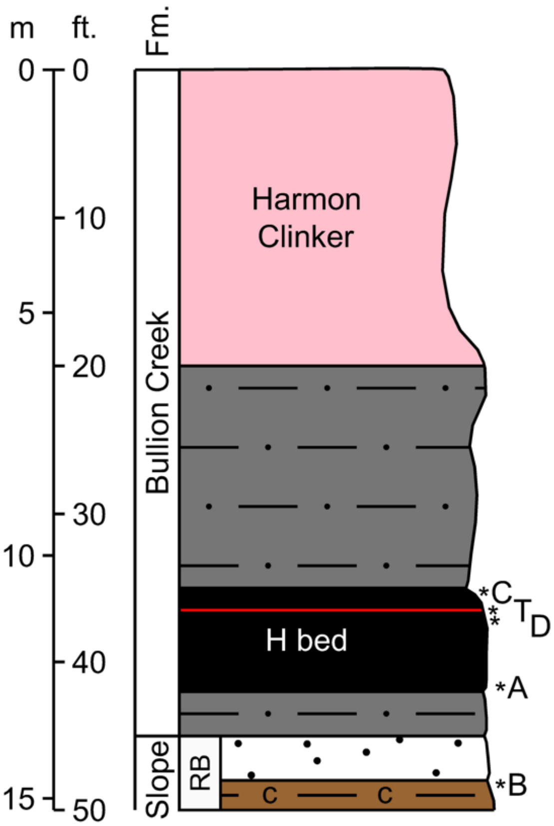


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
98H	7.9		1.35		1.7		3.7		4.5			4.5				13.9	*~45*	*~236*
98Hb	57.5	11.5	6.75	2.34	10.9	2.36	23.3	0.80	39.2	8.5	9.4	16.6	1.87	0.92	5.55	71.4	269	1312
98I	22.1		3.22		3.4		11.3		10.4			11.9				32.1	*~111*	*~452*
98C	31.3	3.4	2.00	0.58	3.3	0.67	14.6	0.28	14.2	3.7	3.2	4.2	0.54	0.28	1.87	19.7	104	351
98T	67.4	2.3	1.12	0.43	3.1	0.38	29.5	0.13	24.6	7.3	4.3	2.0	0.41	0.15	1.01	10.5	155	252
98D	26.3	2.3	1.37	0.3	2.2	0.44	11.8	0.19	10.8	3.0	2.3	2.5	0.35	0.19	1.31	12.5	78	219
98Ib	35.6		2.17		3.1		19.5		14.9			15.6				20.0	*~126*	*~255*
97ss	47.2	1.9	1.14	0.61	2.6	0.33	22.8	0.14	19.1	5.2	3.4	6.7	0.30	0.12	1.21	9.9	123	127
99A	88.7	5.4	2.52	1.85	7.0	0.90	39.3	0.31	41.5	10.5	8.6	16	0.99	0.33	2.18	21.3	247	755
99A2	175	9.7	4.08	3.36	13.7	1.52	85.5	0.40	78.9	20.4	15.7	21.4	1.82	0.46	3.23	37.5	473	762
97-1	157	8.4	3.67	3.00	11.4	1.39	75.5	0.44	66.9	18.1	13.3	19.9	1.59	0.50	3.06	32.5	417	549
97A	355	26.1	9.22	10.2	39.7	3.97	168	0.77	198	50.1	44	32.3	5.44	1.1	6.28	76.6	1027	1719
97A3	395	23.0	9.1	8.32	33.3	3.75	200	0.80	177	45.9	37.2	28.7	4.71	1.06	6.18	92.3	1066	4020
98A	275	18.5	7.26	7.9	28.0	2.88	99.0	0.71	160	37.0	36.1	38.2	3.72	0.89	5.42	59.5	780	2833
98A2	562	41.2	15.6	15.0	59.9	6.59	244	1.26	302	73.9	67.1	41	8.39	1.82	10.4	148	1598	5642
97-2	326	17.7	6.36	6.97	26.6	2.66	154	0.60	144	37.6	30.5	27.6	3.63	0.76	4.49	58.0	847	1275
97-3	435	25.3	9.04	9.78	36.9	3.83	201	0.82	196	51.2	43.1	38.3	5.17	1.08	6.26	82.3	1145	2317
97-4	358	20.6	8.50	7.86	28.4	3.32	149	0.87	166	43.3	35.5	43.5	4.02	1.08	6.50	70.6	947	3415
97-5	269	15.0	6.41	5.95	21.1	2.46	111	0.66	131	32.7	27.2	35.7	2.94	0.81	4.87	56.5	723	2719
97-6	230	12.5	5.43	4.90	17.8	2.08	97.3	0.56	111	28.0	22.9	27.9	2.42	0.69	4.12	50.2	618	2250
97-7	173	10.3	4.83	4.04	14.8	1.81	74.2	0.52	90.7	22.5	18.7	22.3	2.04	0.61	3.75	41.0	485	1626
97B	178	14.1	6.73	4.46	18.6	2.55	92.6	0.69	97.7	24.6	19.6	16.1	2.63	0.88	5.19	54.4	539	1939
98B	116	8.0	3.91	2.84	10.9	1.40	47.5	0.49	61.6	14.9	12.6	16.3	1.47	0.52	3.48	29.9	332	531
97-8	169	10.5	4.98	3.92	14.7	1.87	73.5	0.54	87.3	21.8	17.9	22.1	2.03	0.65	3.96	45.7	480	2201
97-9	183	11.7	5.59	4.32	16.4	2.07	79.0	0.60	95.7	23.5	19.8	23.6	2.26	0.72	4.37	50.0	523	2581
97-10	186	12.3	6.03	4.30	17.0	2.25	81.8	0.65	94.9	23.6	19.7	21.8	2.32	0.77	4.75	54.3	532	2640
97-11	185	13.3	6.80	4.09	17.0	2.51	79.7	0.76	90.6	22.8	18.2	19.0	2.42	0.89	5.42	60.7	529	3392
97-12	170	12.8	6.72	3.63	15.6	2.43	71.1	0.77	80.2	20.3	15.7	17.0	2.26	0.89	5.40	55.8	481	4028
97-13	191	15.4	8.00	4.14	18.4	2.93	79.8	0.89	89.0	22.9	17.6	17.1	2.68	1.05	6.29	65.0	542	3197
146A	141	12.2	7.12	2.62	12.8	2.49	66.5	0.88	58.8	15.7	11.2	14.3	2.03	0.94	5.95	60.7	415	1364
97-14	158	13.4	7.20	3.42	15.5	2.58	66.8	0.82	73.8	19.0	14.4	15.7	2.31	0.94	5.76	58.0	458	2395
97-15	158	13.5	7.18	3.63	16.0	2.57	61.9	0.83	76.8	19.5	15.2	16.2	2.37	0.95	5.82	53.4	454	2550
97-16	154	13.0	6.75	3.72	15.9	2.43	60.6	0.80	78.0	19.6	15.8	17.4	2.32	0.89	5.60	49.4	446	2014
97-17	109	9.3	5.14	2.70	11.2	1.80	42.6	0.68	56.2	13.9	11.8	16.8	1.64	0.71	4.65	38.0	326	923
99B	69.6	5.6	3.18	1.39	6.2	1.09	32.5	0.41	30.9	8.0	6.2	11.1	0.93	0.43	2.85	26.3	207	913
97-18	92.6	5.2	2.81	1.68	7.0	0.95	42.0	0.38	42.7	11.1	8.1	14.2	0.94	0.40	2.65	24.1	257	376
146B	77.8	4.1	2.48	1.16	5.2	0.80	38.0	0.35	32.9	8.8	5.9	11.6	0.71	0.34	2.36	21.4	214	267

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
98H	2.25		1010	2.3		0.40	5	2.9	4.7	35	0.5		3.2	10900		9.0	3.8			0.09				313	5.6	2.4	14	18.2
98Hb								48.0	10.8		1.9						5.9			0.16				416			27	
98I	1.44		521	7.2		0.35	15	5.3	7.4	1	2.5		28.1	4050		7.7	4.7			0.42				1020	0.7	10.2	43	110
98C																												
98T																												
98D																												
98Ib	2.42		577	1.9		6.64	63	1.7	17.4	2	2.9		52.5	11000		2.9	9.6			0.71				2320	1.4	6.5	92	99.4
97ss																												
99A																												
99A2	3.13		554	2.3		9.57	104	6.8	24.4	7.0	3.8		57.0	4560		13.1	12.0		219	0.97				2890	2.2	11.2	166	141
97-1	2.37		703	3.2		11.0	155	8.7	28.0	5	4.7		60.7	3620		9.2	14.9		113	1.27				4110	2.5	7.7	223	199
97A																												
97A3	3.47		568	8.5		1.37	183	25.1	12.3	11	4.3		35.4	5760		14.0	8.5			0.45				1220	1.4	13.6	327	199
98A	4.64		558	2.2		0.26	403	11.0	9.1	16	8.9		18.5	705		23.7	9.9		233	0.50				1380	2.4	25.4	379	401
98A2	3.47		209	9.0		1.72	317	31.3	15.4	17	6.6		30.0	2040		17.6	9.0			0.53				1440	1.9	25.7	477	311
97-2								9.8		9						9.9												
97-3	3.42	17.0	358	4.5	0.82	5.21	227	11.5	22.4	13	4.3	0.09	50.9	2250	31	13.2	9.8	55	101	0.77	0.21	49.3	1.8	2400	1.4	18.5	362	183
97-4								16.0		13						27.4												
97-5								17.4		13						32.2												
97-6								16.6		12						34.4												
97-7	9.46		1270	2.1		0.48	117		8.9	10	3.6		13.8	1120		28.3	7.0		503	0.31				801	3.4	15.2	262	104
97B																												
98B																												
97-8																												
97-9																												
97-10																												
97-11																												
97-12	3.07		258	1.4		0.07	39		9.7	15	1.5		4.8	818		13.6	2.5		197	0.10				177	6.9	9.7	56	37.0
97-13																												
146A																												
97-14																												
97-15																												
97-16																												
97-17	4.82	80.8	1130	1.4	0.19	2.73	43	17.6	16.1	14	2.4	0.03	11.8	2040	40	14.4	12.5	46	324	0.47	<0.10	5.8	1.1	1240	3.9	9.5	54	133
99B																												
97-18	2.49		463	1.8		7.48	58		21.0	5	3.6		28.3	4480		6.3	14.0		52	1.02				3090	2.5	6.9	70	159
146B																												

REE Section 101

T.136N., R.102W., Sec.16, NW 1/4
Elevation at top 2,564 ft.

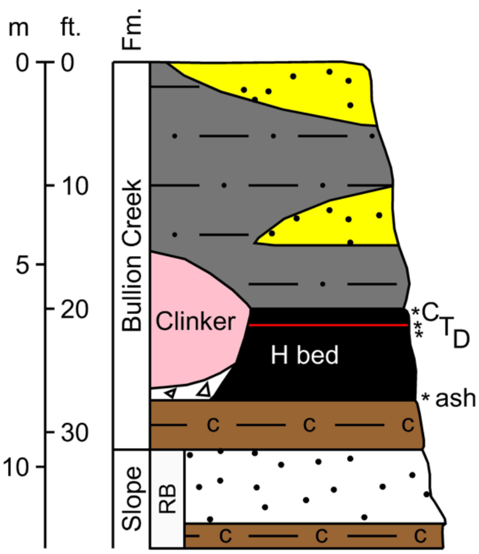


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
101C	60.7	4.2	2.36	0.53	4.3	0.79	26.1	0.32	23.5	6.7	4.9	3.9	0.68	0.33	2.22	24	166	685
101T	48.0	1.2	0.47	0.19	1.9	0.13	22.7	<0.02	17.1	5.0	2.8	1.5	0.18	<0.02	0.38	4.9	106	134
101D	57.2	3.0	1.58	0.33	3.4	0.51	25.8	0.19	21.4	6.2	4.0	2.5	0.48	0.19	1.45	15.1	143	321
101A	37.7		2.26		3.1		21.3		14.5			9.0				23.7	*~127*	*~262*
101B	57.3		1.83		4.0		26.3		26.3			14.3				14.0	*~163*	*~186*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
101C																												
101T																												
101D																												
101A	3.22		2150	2.6		2.80	30	33.0	17.0	10	2.4		40.5	10700		5.2	11.1			0.77				2110	3.1	6.8	47	93.8
101B	3.56		390	1.6		6.22	95	7.9	18.1	5	3.8		34.8	4410		7.4	13.3			1.04				3220	2.1	6.1	141	188

REE Section 102

T.136N., R.102W., Sec.16, NE/NW/SE
Elevation at top 2,570 ft.

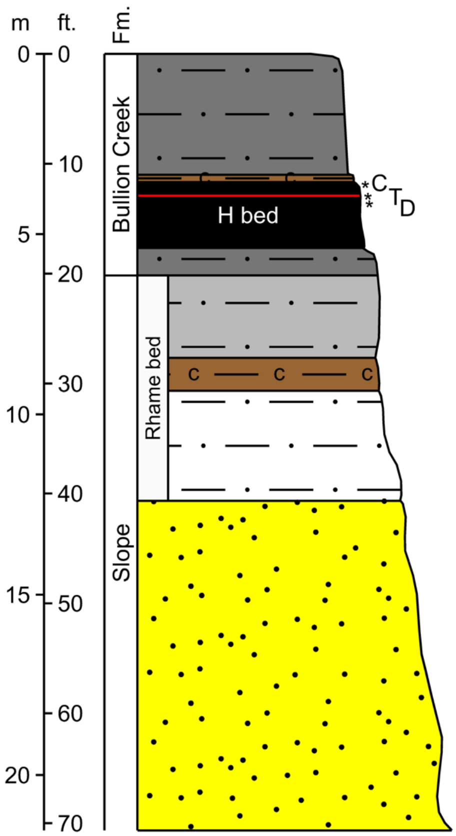


SAMPLE ID	LAB ANALYSIS (in µg/g)															TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
102C	50.2	4.0	2.38	0.51	3.9	0.80	21.6	0.33	19.4	5.5	4.1	3.8	0.64	0.33	2.19	25.6	145	522
102T	37.0	1.3	0.62	0.27	1.9	0.22	17.1	0.08	14.1	4.1	2.5	1.5	0.25	0.08	0.54	6.4	88	115
102D	43.0	2.9	1.62	0.37	3.0	0.56	18.0	0.22	16.4	4.7	3.3	2.4	0.47	0.23	1.50	17.3	116	401
102ash	53.2	3.6	2.42	0.68	3.5	0.78	30.1	0.39	18.4	5.4	3.3	11.8	0.58	0.37	2.45	24.4	161	173

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
102C																												
102T																												
102D																												
102ash																												

REE Section 103

T.136N., R.102W., Sec.16, SE/NW/SE
Elevation at top 2,562 ft.

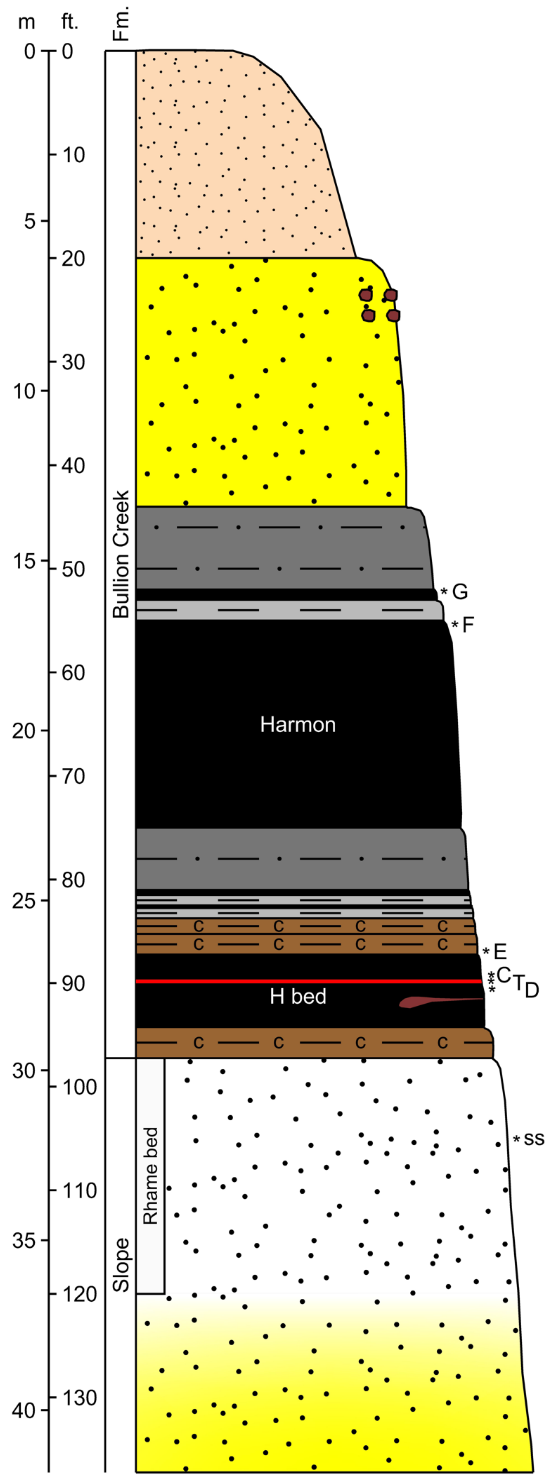


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
103C	47.9	3.5	2.07	0.47	3.6	0.69	20.2	0.28	18.2	5.2	3.7	2.7	0.57	0.28	1.91	20.9	132	586
103T	44.0	1.5	0.70	0.28	2.2	0.25	20.3	0.09	16.4	4.9	2.9	1.6	0.29	0.09	0.60	6.7	103	145
103D	52.4	3.0	1.69	0.39	3.4	0.58	21.3	0.23	19.9	5.8	3.9	2.4	0.52	0.24	1.57	16.9	134	581

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
103C																												
103T																												
103D																												

REE Section 118

T.136N., R.102W., Sec.18, SW/NE/NW
Elevation at top 2,621 ft.

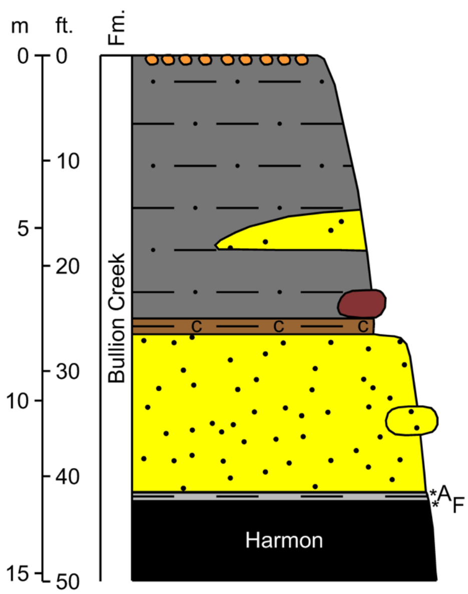


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
118G	26.1	3.8	2.23	0.84	3.9	0.76	11.7	0.29	13.6	3.3	3.4	5.2	0.62	0.30	1.94	22.7	101	362
118F	51.4	5.0	2.80	0.99	5.0	0.96	24.4	0.37	21.8	5.8	4.5	11.7	0.83	0.38	2.49	24.6	163	451
118E	95.5	6.0	2.69	2.33	8.4	0.98	38.5	0.35	51.2	12.6	11.3	19.9	1.13	0.36	2.38	22.0	276	978
118C	40.5	3.9	2.29	0.71	4.0	0.78	19.9	0.32	18.1	4.8	3.9	3.6	0.63	0.32	2.07	22.4	128	362
118T	49.6	2.5	1.39	0.57	3.1	0.48	24.1	0.19	19.2	5.4	3.6	3.0	0.45	0.19	1.23	14.2	129	197
118D	67.6	6.0	3.66	0.86	6.1	1.22	31.5	0.50	27.9	7.6	5.8	4.1	0.97	0.50	3.25	38.6	206	634
118ss	60.7	2.4	1.41	0.79	3.3	0.44	29.4	0.21	23.9	6.7	4.3	7.2	0.43	0.19	1.47	12.2	155	160

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
118G								4.7		3						7.5												
118F								31.4		3						7.0												
118E	11.5		427	1.1		1.46	139	9.5	13.7	14	6.2		7.8	2440		28.4	18.1			0.44				1120	6.1	12.6	203	272
118C								5.0		1						7.2												
118T								3.7		1						5.4												
118D								7.7		1						7.8												
118ss																												

REE Section 119

T.136N., R.102W., Sec.24, SE/SW/NW
Elevation at top 2,565 ft.



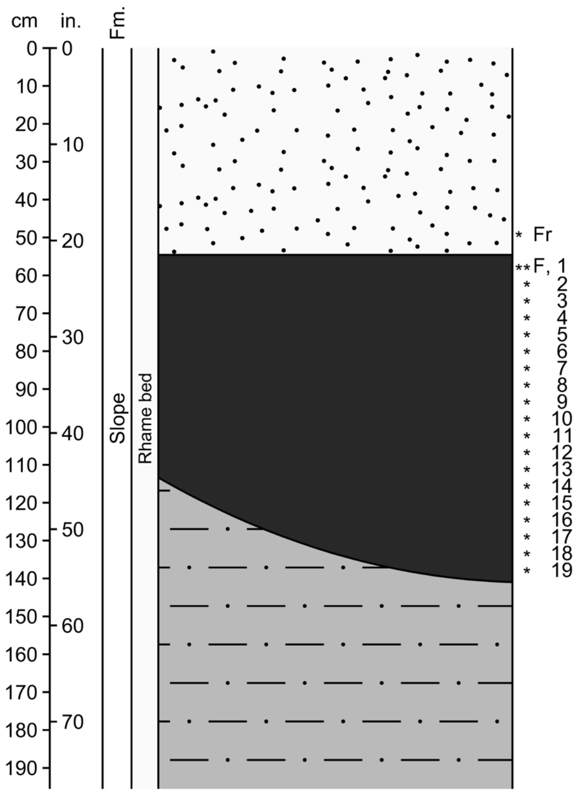
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
119A	19.4	2.9	1.99	0.53	2.4	0.61	9.0	0.33	9.7	2.4	2.2	9.8	0.42	0.30	2.03	16.4	80	341
119F	8.9	2.1	1.44	0.34	1.6	0.45	4.1	0.23	4.8	1.1	1.2	7.2	0.29	0.21	1.43	12.9	48	319

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
119A								4.2		34						10.1												
119F								1.9		21						7.0												

REE Section 123

T.136N., R.102W., Sec.8, SW/NW/NE

Elevation at top 2,493 ft.

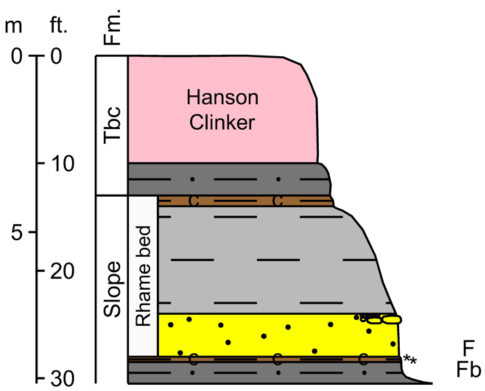


SAMPLE ID	LAB ANALYSIS (in µg/g)															TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
123Fr	88.4		2.90		7.0		41.7		41.0			10.9				25.5	*~248*	*~263*
123F	197	17.9	8.94	5.39	22.3	3.24	86.2	1.02	105	25.3	24.2	18.2	3.27	1.18	7.24	82.9	609	829
123-1	288	18.3	8.07	6.55	26.3	3.06	121	0.80	141	35.1	30.7	17.6	3.62	0.98	6.25	71.8	779	851
123-2	275	23.4	12.1	6.85	29.2	4.33	118	1.36	137	33.3	30.6	21.3	4.27	1.56	10.0	112	820	952
123-3	182	16.8	9.43	4.37	19.4	3.22	82.2	1.12	89.1	22.2	19.4	19.4	2.86	1.24	8.21	89.1	570	645
123-4	151	13.5	7.79	3.44	15.8	2.63	70.0	0.95	71.6	17.9	15.5	18.3	2.31	1.02	6.75	73.4	472	531
123-5	127	10.9	6.34	2.73	12.6	2.15	59.2	0.78	58.7	14.8	12.3	18.0	1.83	0.84	5.62	60.7	394	434
123-6	111	9.4	5.48	2.36	10.6	1.86	53.0	0.74	50.5	12.9	10.5	17.5	1.61	0.77	4.97	51.7	345	384
123-7	108	9.4	5.51	2.37	10.6	1.85	52.0	0.72	50.6	12.8	10.6	18.2	1.60	0.76	4.91	50.5	340	378
123-8	111	9.2	5.40	2.33	10.4	1.82	53.2	0.71	50.5	13.1	10.5	18.6	1.60	0.76	4.91	50.0	344	378
123-9	101	8.5	5.06	2.15	9.4	1.69	48.1	0.68	46.3	11.8	9.6	18.7	1.43	0.72	4.57	45.5	315	349
123-10	100	8.5	5.06	2.13	9.4	1.67	48.3	0.69	45.9	11.8	9.6	19.3	1.42	0.71	4.60	46.1	315	349
123-11	97.8	8.2	4.92	2.02	9.0	1.64	47.0	0.67	44.2	11.4	9.2	18.4	1.38	0.69	4.49	44.1	305	337
123-12	98.7	8.1	4.89	1.99	9.0	1.61	47.1	0.67	44.2	11.5	9.2	19.0	1.37	0.69	4.43	43.8	306	338
123-13	102	8.2	4.82	2.05	9.1	1.62	48.3	0.66	45.7	11.8	9.5	19.4	1.39	0.68	4.48	44.4	314	347
123-14	107	8.1	4.68	2.11	9.2	1.57	50.5	0.64	47.9	12.4	9.7	19.5	1.41	0.67	4.30	43.7	323	355
123-15	106	8.1	4.67	2.12	9.3	1.57	50.3	0.63	47.4	12.5	9.7	19.3	1.39	0.65	4.29	42.4	320	351
123-16	100	7.9	4.73	2.00	8.9	1.58	48.4	0.64	45.1	11.7	9.3	18.8	1.37	0.67	4.39	43.2	309	340
123-17	109	8.2	4.71	2.15	9.7	1.60	51.2	0.63	49.1	12.7	10.1	19.3	1.43	0.64	4.34	42.6	327	359
123-18	103	8.0	4.70	2.02	9.2	1.59	48.8	0.64	45.7	12.0	9.5	19.4	1.38	0.65	4.32	42.8	314	344
123-19	98.8	7.9	4.60	1.96	8.8	1.53	47.4	0.62	44.6	11.6	9.2	18.8	1.32	0.63	4.30	41.4	303	331

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
123Fr						6.24			17.7	3			30.7				13.9			1.05				3030				
123F								20.1		193						22.0												
123-1	2.33	15.8	598	3.9		12.9	99	16.3	26.3	30	3.4		47.1	5850		4.7	15.0		114	1.13				3730	2.6	22.0	141	141
123-2	0.88	56.7	1070	1.1	0.10	0.55	10	21.9	6.0	44	1.2	<0.02	7.0	3430	205	10.5	4.8	8	376	0.38	<0.10	3.2	0.6	1140	3.1	24.0	17	42.8
123-3		53.7						18.5		41						10.0										16.4		
123-4		60.0						17.6		54						9.6										12.5		
123-5	3.31	36.1	521	4.1		14.6	96	15.9	29.8	39	3.4		56.3	5820		7.0	16.1		115	1.20				4220	2.8	10.6	130	140
123-6		42.2						15.4		37						6.8										8.6		
123-7		62.5						15.7		44						8.1										8.2		
123-8		40.6						16.2		23						6.8										8.4		
123-9																												
123-10	3.21		600	4.8		13.8	96		31.1	23	3.8		68.3	6760		6.9	16.4		154	1.24				4190	2.8	8.1	139	141
123-11																												
123-12																												
123-13																												
123-14																												
123-15	2.40		438	4.4		14.5	92		31.2	5	3.6		73.6	7180		7.5	15.4		89	1.16				4110	2.7	8.6	134	127
123-16																												
123-17																												
123-18																												
123-19	2.14		424	5.2		14.8	94		30.3	3	3.9		66.9	7470		4.5	15.0		131	1.14				3650	2.4	7.8	139	124

REE Section 124

T.136N., R.102W., Sec.8, SW/NW/NE
Elevation at top 2,523 ft.

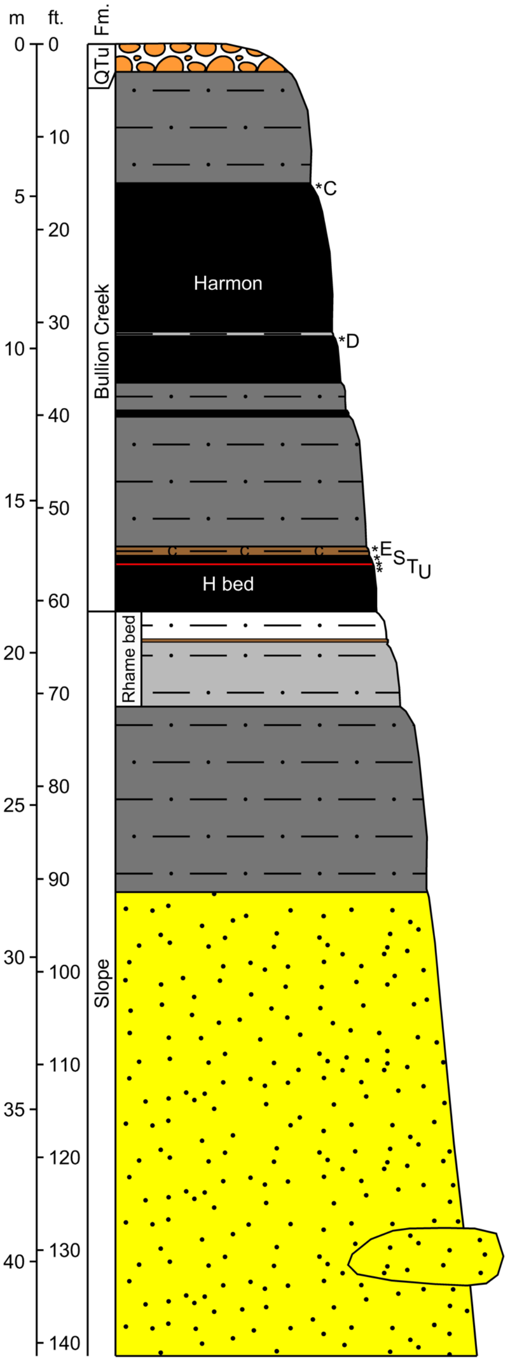


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
124F	82.3	6.8	3.77	1.94	8.3	1.29	36.2	0.53	42.7	10.5	8.9	15.5	1.20	0.53	3.44	33.7	258	285
124Fb	79.6	6.2	3.54	1.73	7.5	1.21	34.4	0.47	39.5	9.8	8.2	12.7	1.09	0.49	3.17	31.1	241	259

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
124F								7.5		6						6.3												
124Fb								5.7		4						3.2												

REE Section 125

T.136N., R.102W., Sec.9, NW/SW/SW
Elevation at top 2,598 ft.

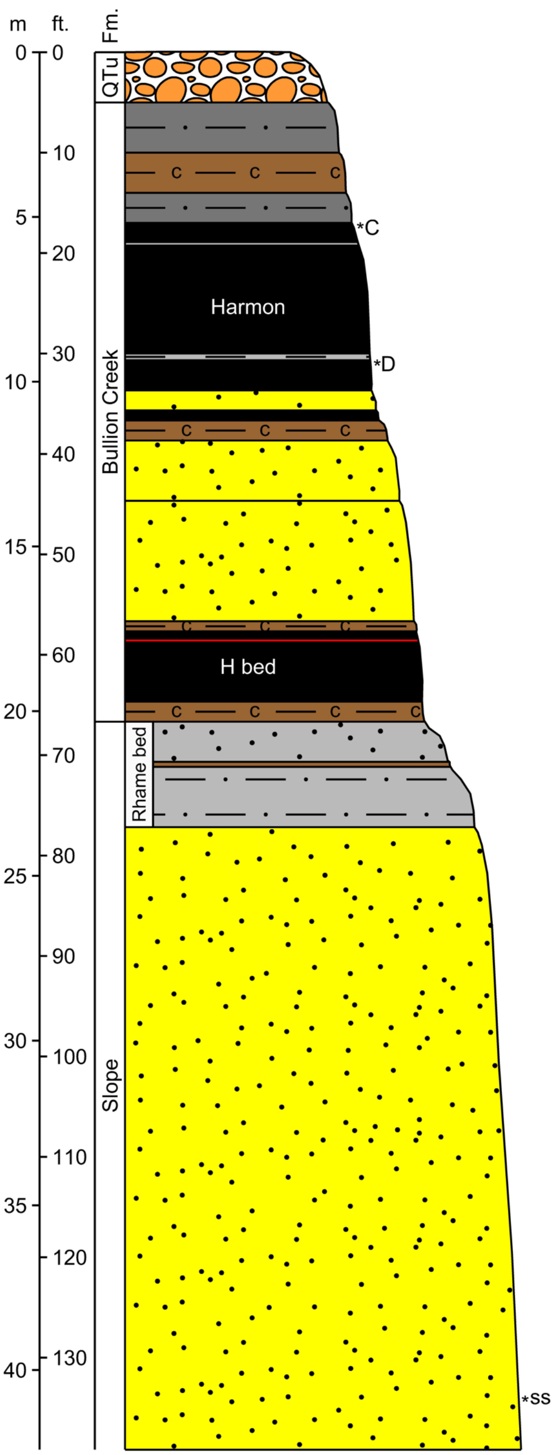


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
125C	9.2	2.9	1.84	0.44	2.2	0.60	4.1	0.26	5.3	1.2	1.6	7.2	0.42	0.26	1.72	17.6	57	305
125D	20.7	2.2	1.24	0.49	2.3	0.42	8.6	0.17	9.8	2.5	2.2	5.5	0.36	0.17	1.14	9.1	67	492
125E	20.8	3.4	2.50	0.53	2.8	0.78	11.0	0.38	9.9	2.5	2.3	9.4	0.49	0.36	2.44	24.2	94	273
125S	27.3	3.1	1.97	0.43	2.9	0.64	12.6	0.29	12.0	3.2	2.8	3.6	0.49	0.28	1.86	19.8	93	335
125T	82.9	2.3	1.01	0.40	3.4	0.36	36.1	0.12	29.5	8.9	4.9	2.0	0.45	0.13	0.85	9.4	183	235
125U	18.9	1.5	0.88	0.17	1.4	0.29	7.6	0.13	6.3	1.7	1.4	1.7	0.23	0.13	0.86	8.1	51	301

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
125C								3.8		7						4.0												
125D								4.4		1						18.0												
125E								11.5		12						13.6												
125S								3.1		2						6.1												
125T								1.0		1						2.9												
125U								1.1		2						5.4												

REE Section 126

T.136N., R.102W., Sec.9, NE/NW/SW
Elevation at top 2,606 ft.

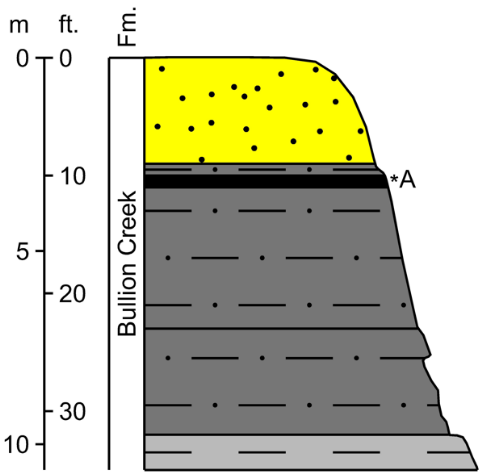


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
126C	7.2	2.5	1.60	0.35	1.8	0.53	2.8	0.23	4.4	1.0	1.3	6.0	0.35	0.23	1.49	14.7	46	292
126D	18.1	2.2	1.28	0.46	2.2	0.43	7.6	0.18	9.0	2.3	2.1	6.1	0.36	0.18	1.20	10.1	64	413
126ss	36.3	2.3	1.44	0.69	2.8	0.45	17.8	0.20	15.8	4.2	3.1	6.6	0.39	0.19	1.41	12.6	106	114

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
126C								2.1		18						4.9												
126D								5.6		2						15.4												
126ss																												

REE Section 127

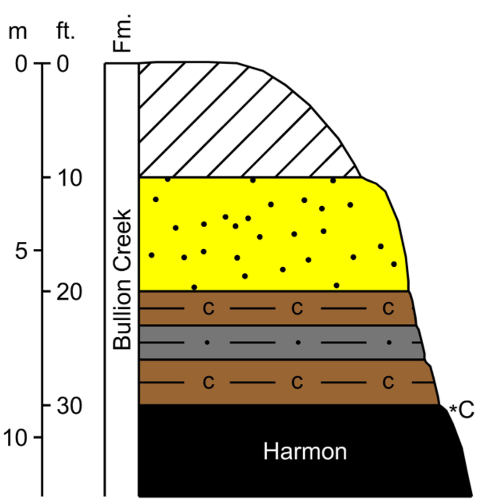
T.136N., R.102W., Sec.5, NW
Elevation at top 2,632 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
127A	26.1	6.0	3.81	0.96	4.8	1.26	13.3	0.54	13.7	3.3	3.6	14.5	0.87	0.53	3.49	35.5	132	282

REE Section 128

T.136N., R.102W., Sec.9, NW/NE/NW
Elevation at top 2,594 ft.



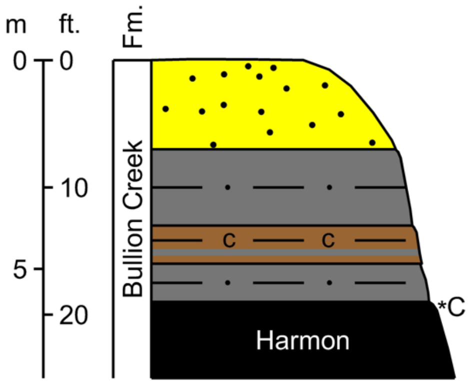
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
128C	11.4	3.3	2.12	0.50	2.6	0.69	5.1	0.31	6.6	1.5	1.9	8.0	0.47	0.30	1.99	19.8	67	220

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
127A								7.9		6						9.7												

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
128C								2.5		5						5.7												

REE Section 129

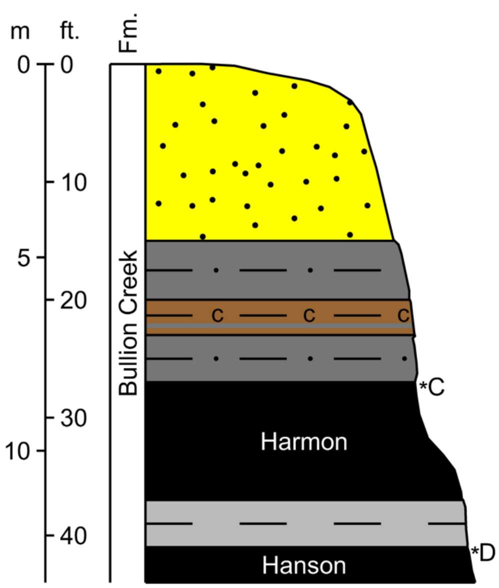
T.136N., R.102W., Sec.9, NE/NE/NW
Elevation at top 2,580 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
129C	12.8	3.8	2.52	0.53	2.9	0.81	5.7	0.36	7.2	1.7	2.0	8.0	0.54	0.35	2.31	24.7	76	464

REE Section 130

T.136N., R.102W., Sec.5, SE/SW/SE
Elevation at top 2,598 ft.



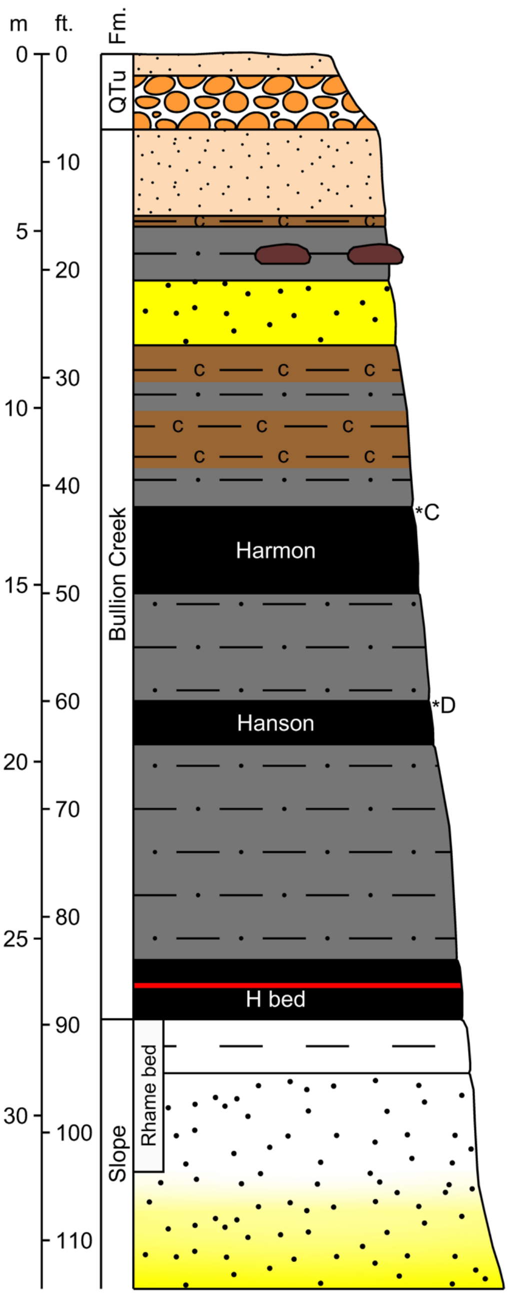
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
130C	11.1	1.8	1.06	0.39	1.7	0.35	4.6	0.17	6.4	1.5	1.7	5.8	0.28	0.15	1.07	8.4	46	131
130D	56.3	11.5	7.28	1.81	9.8	2.42	29.3	1.03	26.7	6.6	6.3	23.1	1.70	1.00	6.47	73.0	264	1917

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
129C								4.0		10						4.0												

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
130C								2.2		6						7.1												
130D	3.58		989	7.6		0.12	10	58.6	14.2	4	0.9		5.1	5040		7.4	6.7		338	0.12				368	1.3	9.0	24	38.1

REE Section 131

T.136N., R.102W., Sec.4, NW/SE/SE
Elevation at top 2,621 ft.

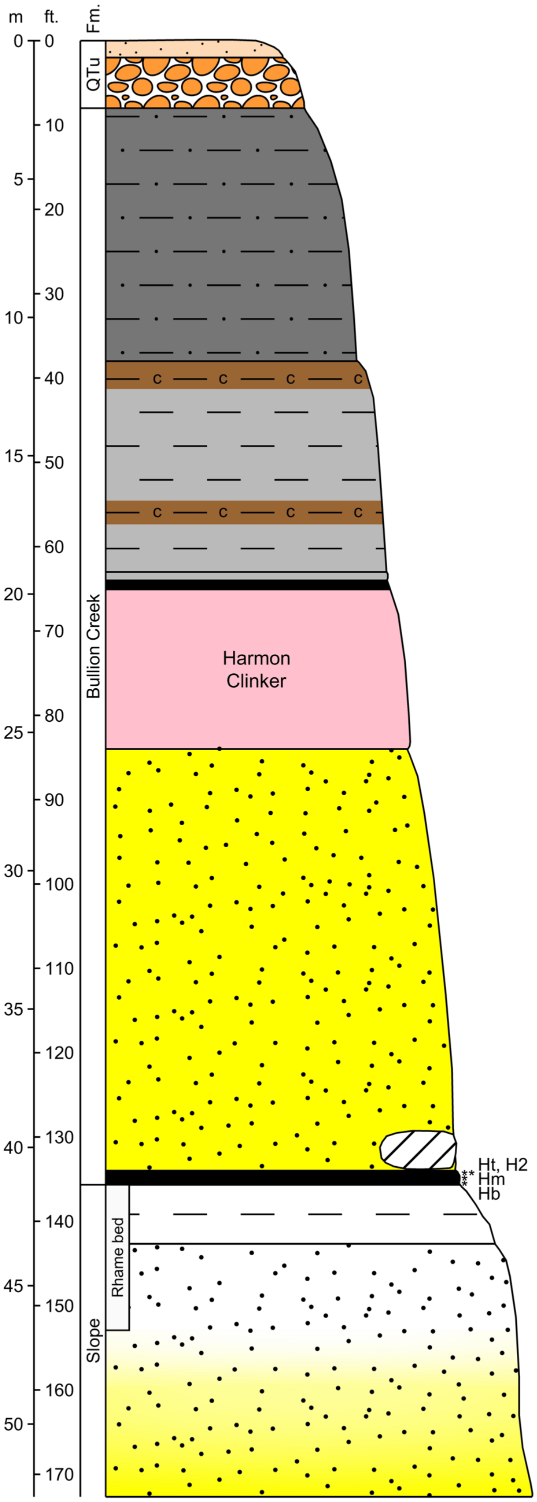


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
131C	8.9	1.8	1.06	0.36	1.6	0.35	3.1	0.17	5.3	1.2	1.4	4.6	0.27	0.15	1.05	8.7	40	278
131D	21.3	4.4	2.92	0.81	3.9	0.93	9.0	0.45	12.4	2.9	3.1	9.1	0.65	0.41	2.73	29.8	105	468

SAMPLE ID	LAB ANALYSIS (in μg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
131C								3.3		7						4.8												
131D								5.5		16						8.3												

REE Section 132

T.136N., R.102W., Sec.3, SE/NE/SW
Elevation at top 2,635 ft.

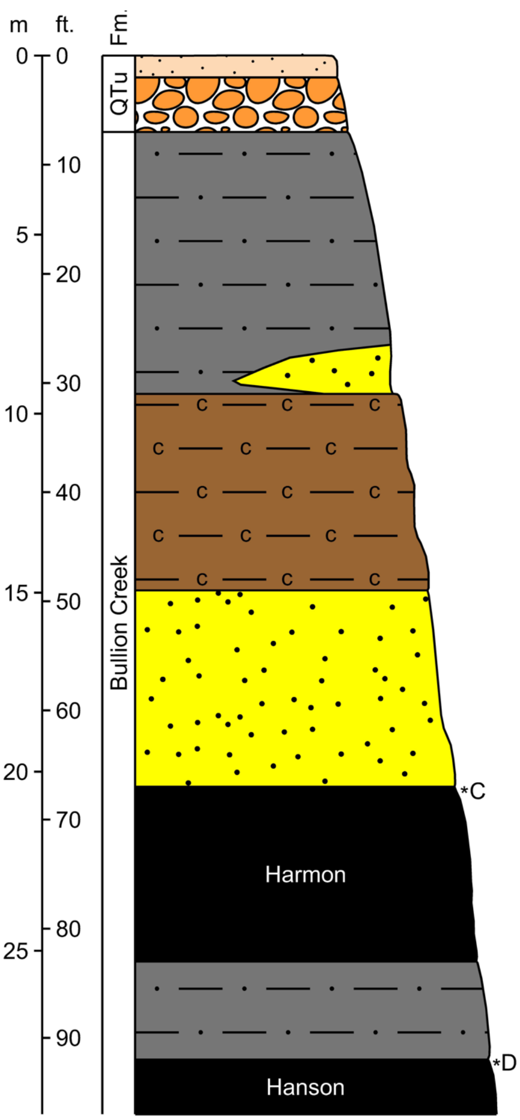


SAMPLE ID	LAB ANALYSIS (in µg/g)															TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
132Ht	15.8	4.4	3.31	0.67	2.9	1.01	8.7	0.55	7.9	2.0	2.1	25.0	0.58	0.49	3.38	32.1	111	332
132H2	9.7	2.6	1.86	0.44	1.9	0.60	5.1	0.30	5.1	1.2	1.3	12.3	0.36	0.27	1.83	19.4	64	213
132Hm	10.5	2.6	1.92	0.44	1.9	0.60	5.4	0.29	5.3	1.3	1.4	12.7	0.36	0.27	1.81	20.2	67	258
132Hb	9.7	2.3	1.50	0.37	1.8	0.51	4.8	0.19	4.9	1.2	1.3	4.3	0.33	0.20	1.21	16.2	51	271

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
132Ht								12.2		12						2.3												
132H2								4.3		23						4.0												
132Hm	2.98		1060	7.1		0.17	12	7.9	36.3	109	1.6		7.4	12800		6.3	7.5		520	0.20				474	10.0	7.8	39	149
132Hb								10.6		16						1.9												

REE Section 133

T.136N., R.102W., Sec.3, SW/NE/SW
Elevation at top 2,640 ft.



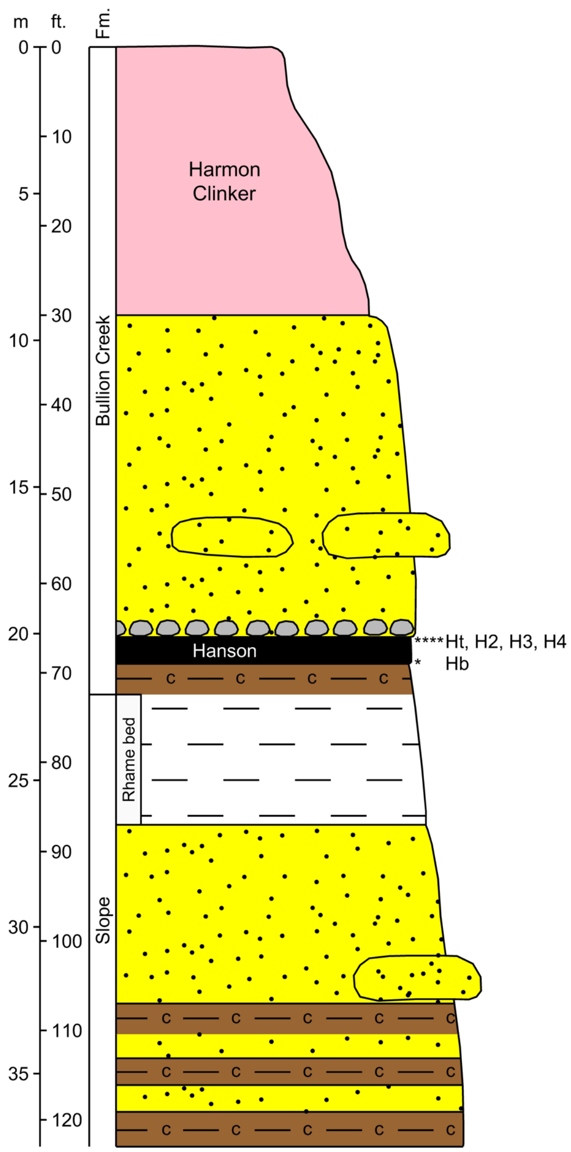
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
133C	6.3	1.4	0.91	0.27	1.2	0.29	2.6	0.14	3.7	0.9	1.0	3.9	0.21	0.13	0.90	7.6	31	158
133D	93.6	12.1	7.22	2.71	12.5	2.41	41.3	1.03	48.6	11.6	10.8	24.5	1.94	0.99	6.49	66.6	344	1128

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
133C	4.54	27.6	1240	2.5	<0.10	0.14	5	3.9	5.0	5	2.1	<0.02	3.7	3680	70	5.3	9.1	2	393	0.08	<0.10	1.1	0.2	233	1.0	3.8	25	241
133D	10.9	44.8	570	5.1	0.22	2.35	93	38.8	15.0	13	4.2	0.03	10.1	5190	165	12.6	20.0	27	363	0.34	<0.10	15.1	0.8	1110	2.6	16.4	287	235

REE Section 134

T.136N., R.102W., Sec.3, SE/NE/SW

Elevation at top 2,590 ft.

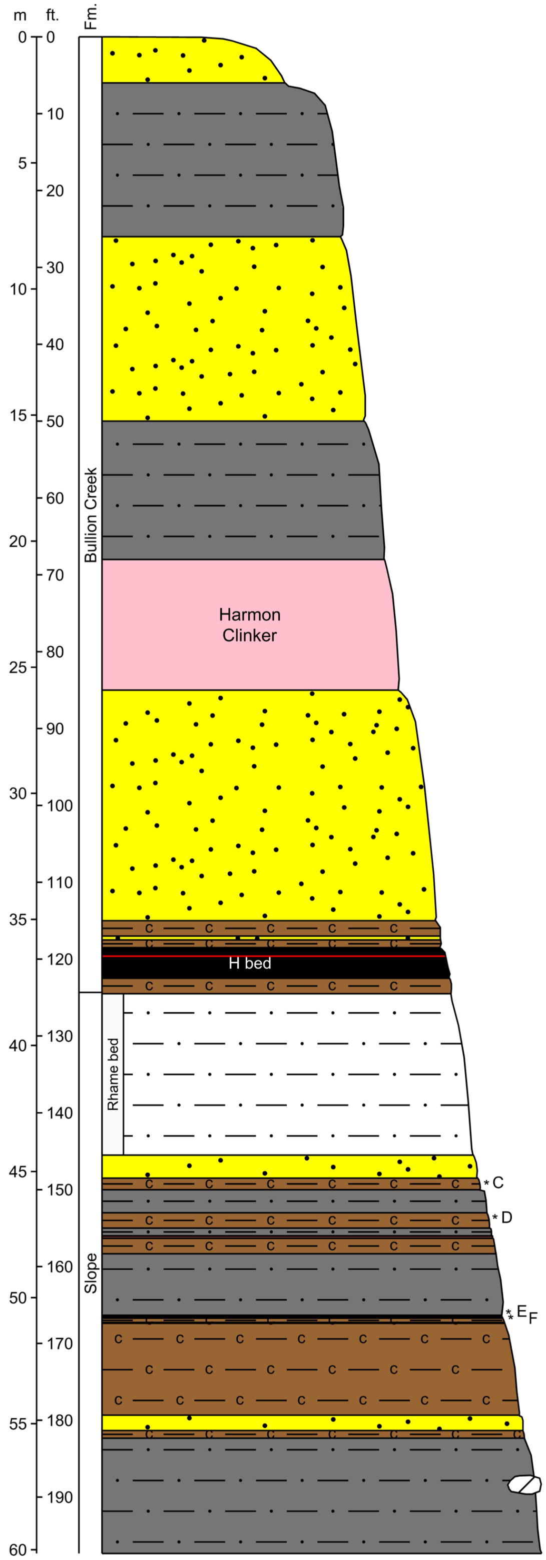


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
134Ht	15.2	2.8	1.95	0.46	2.2	0.62	8.5	0.30	7.3	1.8	1.8	6.6	0.40	0.28	1.83	20.2	72	231
134H2	14.4	3.9	2.85	0.67	2.8	0.90	7.9	0.46	7.8	1.9	2.1	18.3	0.55	0.42	2.84	29.6	97	301
134H3	39.5	4.8	2.92	1.07	4.3	0.99	22.1	0.42	17.9	4.8	3.8	15.0	0.74	0.41	2.70	30.3	152	347
134H4	29.0	5.2	3.50	1.03	4.2	1.13	15.9	0.51	14.3	3.6	3.2	13.9	0.76	0.49	3.19	37.8	138	336
134Hb	13.2	1.0	0.50	0.17	0.9	0.18	7.2	0.06	4.5	1.4	0.8	2.6	0.16	0.06	0.40	5.9	39	122

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
134Ht								7.1		10						1.7												
134H2								9.4		14						1.2												
134H3								18.6		23						12.9												
134H4								16.5		19						1.6												
134Hb	0.30	2.2	1530	0.7	0.15	0.03	6	1.2	3.8	1	0.9	<0.02	9.1	4420	45	1.2	3.9	1	481	0.45	<0.10	4.8	0.9	952	1.6	2.1	6	30.5

REE Section 135

T.136N., R.102W., Sec.3, SE/NE/NW
Elevation at top 2,570 ft.

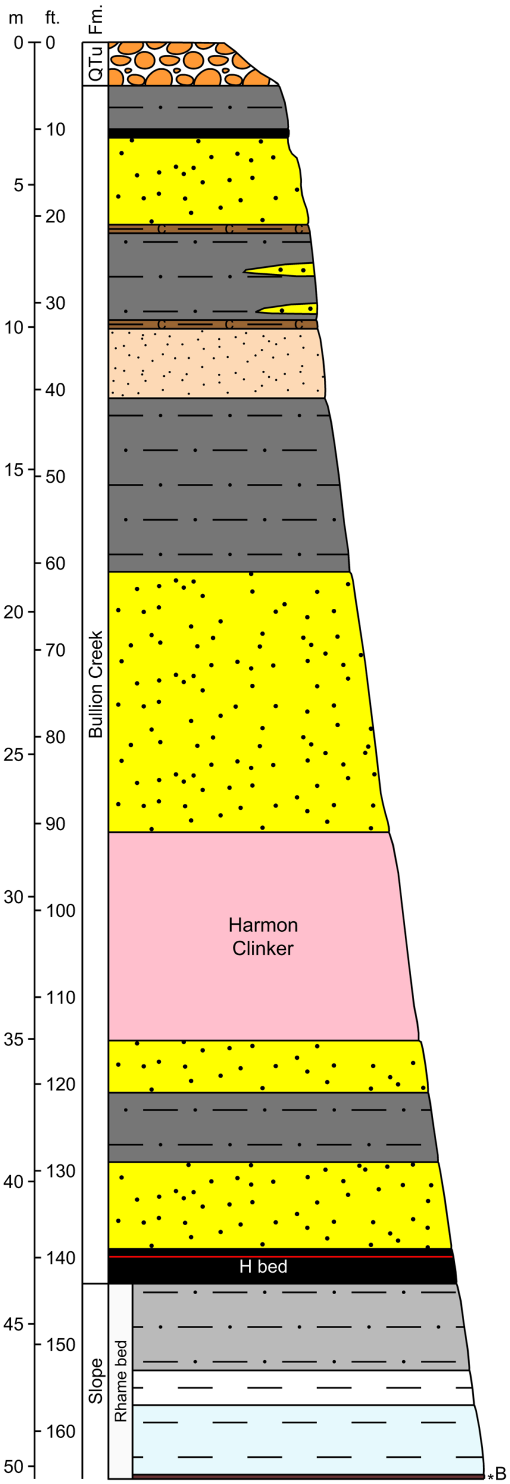


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
135C	64.9		2.32		4.7		36.5		27.9			9.5				19.5	*~187*	*~197*
135D	80.3		2.19		5.3		41.2		34.2			10.8				18.9	*~218*	*~230*
135E	110	8.8	4.89	2.46	10.6	1.69	50.8	0.64	50.5	12.7	10.9	18.3	1.56	0.67	4.23	42.7	331	535
135F	96.0		2.53		6.5		47.6		40.8			13.4				23.0	*~260*	*~276*

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
135C									17.5	7																3.2		
135D									20.4	7																3.8		
135E	10.10	64.4		6.0		4.91	68	30.7	31.5	55			49.9	5790		10.0	16.5			0.68				2240	3.7	16.6	170	342.0
135F									23.5	9																6.0		

REE Section 136

T.136N., R.102W., Sec.3, SW/NE/NW
Elevation at top 2,622 ft.



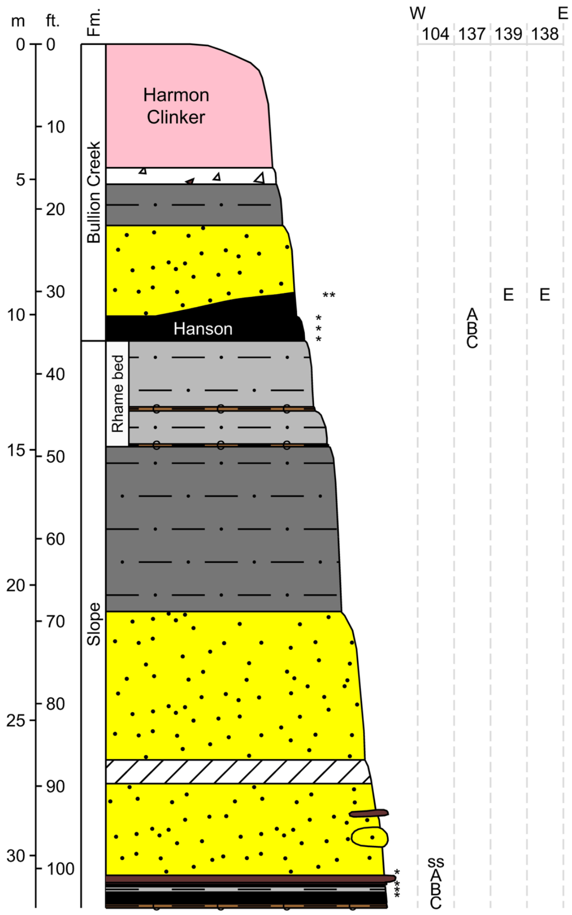
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
136B	88.2		3.80		7.3		46.9		39.7			15.6				33.6	*~268*	*~282*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
136B									27.6	8																5.3		

REE Section 137

T.136N., R.102W., Sec.16, NW/NE/NE
Elevation at top 2,568 ft.

Includes nearby sections 104, 138, and 139

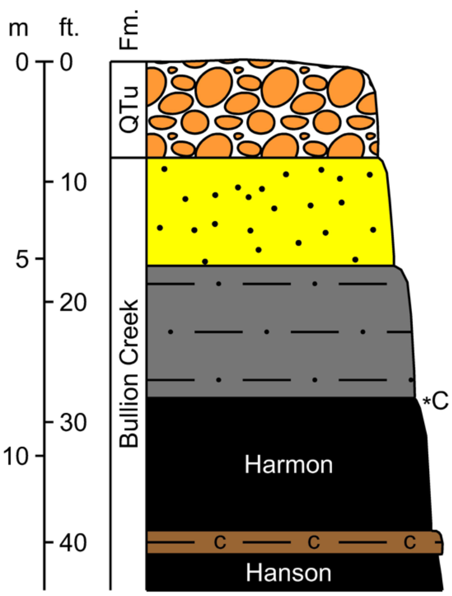


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
139E	34.6		3.52		4.4		21.2		14.8			12.5				34.1	*~145*	*~337*
138E	38.7		2.10		2.9		21.1		15.5			9.3				18.7	*~123*	*~248*
137A	40.5		3.86		3.4		24.2		15.6			21.6				34.2	*~163*	*~221*
137B	15.6		0.87		1.2		8.9		5.9			3.2				10.2	*~52*	*~255*
137C	94.3		3.64		8.3		46.1		42.0			11.1				33.9	*~275*	*~702*
104ss	48.1	3.2	1.82	1.06	4.0	0.62	24.6	0.25	22.2	5.8	4.4	10.6	0.56	0.25	1.65	17.7	147	157
104A	73.1	5.7	3.47	1.49	6.2	1.13	36.1	0.50	34.0	9.2	6.5	16.2	0.94	0.48	3.28	31.3	230	284
104B	51	4.3	2.32	1.31	4.9	0.80	21.4	0.31	25.0	6.5	5.4	12	0.74	0.31	2.07	20.8	160	339
104C	27	2.3	1.50	0.60	2.3	0.49	14.6	0.23	11.2	3.1	2.2	9.1	0.36	0.21	1.45	13.7	90	214

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
139E	4.01		1630	7.7		1.54	23	4.5	9.5	7	3.1		41.1	6250		8.5	5.2			0.47				1270	0.9	10.5	74	149
138E	2.29		833	1.2		1.91	40	12.7	15.2	3	2.8		41.1	5600		2.5	14.4			1.05				3470	2.8	5.5	44	100
137A	2.14		1380	14.3		0.50	80	8.1	23.2	3	5.5		29.5	10600		10.4	50.9			4.31				10000	9.8	8.6	170	323
137B	0.44		1200	1.9		0.15	11	6.9	6.4	1	1.1		14.5	10600		1.8	7.6			0.62				1310	2.9	3.2	18	43.9
137C	18.9		1530	4.1		1.31	16	3.1	10.6	21	6.1		24.1	5390		45.8	11.0			0.31				758	2.5	21.7	81	328
104ss																												
104A	4.15	27.6	478	3.4	0.43	7.74	93	7.9	27.7	21	5.8	0.05	53.9	8710	317	6.5	14.9	67	233	0.94	0.16	9.8	1.9	3500	2.4	11.7	173	400
104B																												
104C																												

REE Section 140

T.136N., R.102W., Sec.8, SE/NE/SE
Elevation at top 2,590 ft.

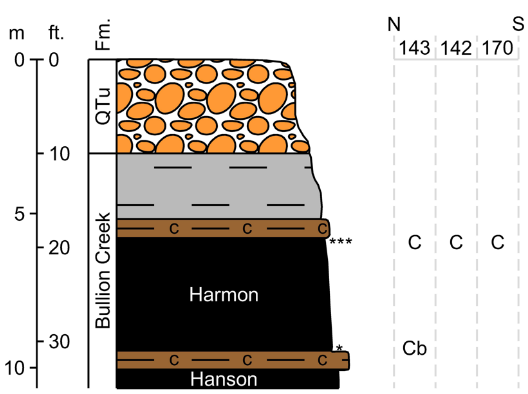


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
140C	21.1	5.7	3.55	0.89	4.4	1.19	9.6	0.51	11.9	2.7	3.3	14.6	0.84	0.51	3.37	32.3	116	360

REE Section 142

T.136N., R.102W., Sec.8, NE/SW/SW
Elevation at top 2,608 ft.

Includes adjacent sections 143 and 170



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
143C	15.6	2.3	1.47	0.44	2.3	0.49	7.2	0.19	7.7	1.9	1.8	2.8	0.37	0.20	1.24	15.9	62	384
142C	27.8	4.1	2.52	0.79	3.7	0.85	12.1	0.35	13.6	3.4	3.1	6.2	0.64	0.36	2.36	23.6	105	538
170C	19.0	1.8	1.14	0.45	2.0	0.37	8.9	0.15	8.8	2.2	1.8	3.5	0.30	0.16	1.05	11.9	64	220
143Cb	40.3	3.3	1.72	0.87	3.8	0.62	16.7	0.21	18.9	4.9	4.0	9.9	0.60	0.23	1.47	13.1	121	317

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
140C																												

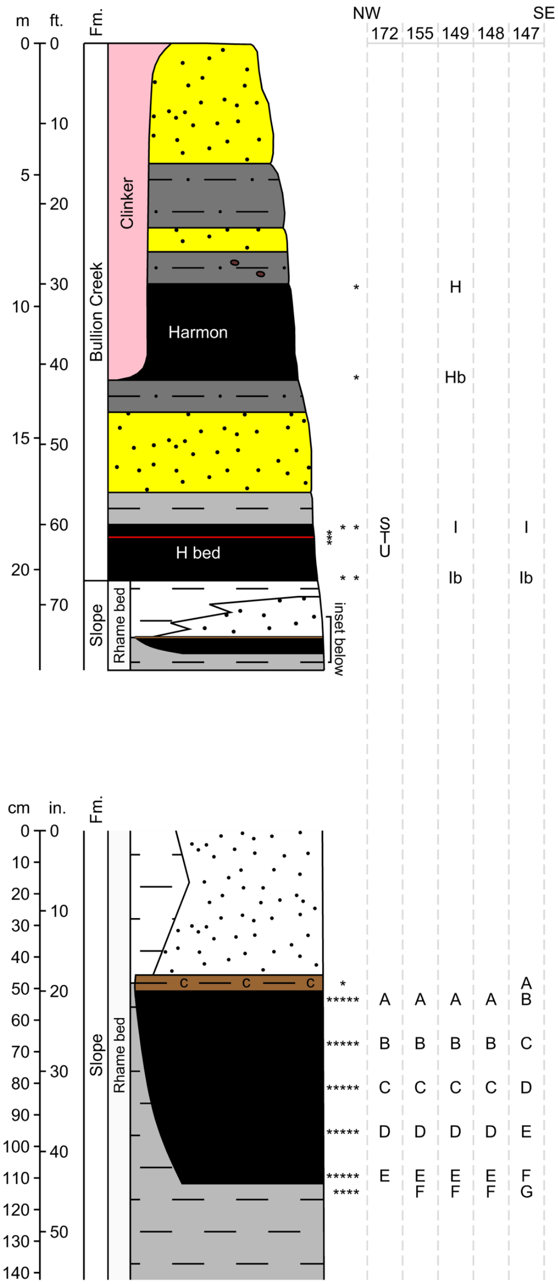
SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
143C	0.42		372	2.1		0.30	5		5.8	3	0.8		6.3	6530		2.3	4.1		327	0.17				455	1.9	2.6	8	25.8
142C																												
170C																												
143Cb	5.20		1750	0.9		2.69	58		10.1	2	2.1		20.3	4660		12.8	7.9		785	0.30				870	1.3	7.5	96	71.2

REE Section 149

T.136N., R.102W., Sec.16, NE/SW/NE

Elevation at top 2,595 ft.

Includes directly adjacent sections 147, 148, 155, and 172



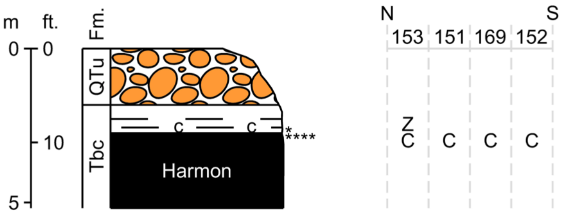
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
149H	20.9	5.3	3.37	0.83	4.2	1.10	9.8	0.45	11.2	2.6	3.0	9.3	0.77	0.46	3.03	33.6	110	320
149Hb	26.8	8.3	5.01	1.50	7.9	1.73	12.2	0.63	17.2	3.6	5.2	12.2	1.31	0.68	4.19	55.4	164	805
149I	42.9	4.7	3.11	0.80	4.2	1.03	21.5	0.45	17.9	4.8	3.6	12.8	0.73	0.45	2.80	31.4	153	467
147I	10.3		1.81		1.9		5.1		5.6			8.4				14.0	*~56*	*~211*
172S	42.7	4.1	2.52	0.53	3.9	0.83	21.8	0.35	16.9	4.7	3.7	4.1	0.65	0.35	2.38	26	136	595
172T	64.3	1.8	0.74	0.31	2.8	0.22	29.1	0.03	23.1	6.9	4.0	1.8	0.30	0.03	0.60	7.4	143	185
172U	99.4	4.4	2.31	0.54	5.1	0.78	41.8	0.30	33.3	9.9	6.3	3.6	0.76	0.31	2.07	22.9	234	817
149Ib	18.2	2.6	1.55	0.45	2.2	0.53	10.1	0.23	7.9	2.0	1.8	9.7	0.41	0.23	1.45	16.2	76	276
147Ib	18.5		1.91		2.4		10.2		8.0			10.3				18.8	*~81*	*~175*
147A	69.0	3.1	1.90	1.04	4.2	0.61	33.4	0.31	30.1	8.1	5.6	13.7	0.57	0.29	2.01	15.5	189	209
172A	80.0	6.0	3.16	1.68	6.9	1.10	38.7	0.43	36.1	9.4	7.6	19.6	1.05	0.45	2.92	26.2	241	275
155A	81.9	5.6	2.74	1.49	6.3	1.00	39.2	0.36	33.6	9.3	6.9	16.9	1.00	0.38	2.45	26.0	235	324
149A	90.7	5.1	2.67	1.78	6.8	0.96	46.5	0.38	39.0	10.5	7.8	16.4	0.96	0.39	2.52	23.5	256	310
148A	107	6.4	2.91	2.40	9.2	1.10	51.4	0.38	50.7	12.9	11.0	19.0	1.26	0.40	2.62	25.1	304	432
147B	216	13.0	5.20	5.30	20.0	2.10	96.5	0.61	109	27.4	24.4	30.6	2.70	0.67	4.24	42.0	600	1066
172B	166	12.7	5.60	4.16	16.4	2.12	75.0	0.63	81.2	20.4	18.3	25.5	2.43	0.71	4.50	46.4	482	613
155B	100	6.3	3.29	1.72	7.2	1.17	49.1	0.42	39.4	11.0	7.8	18.4	1.14	0.45	2.83	31.9	282	337
149B	125	6.5	3.14	2.19	9.0	1.17	63.1	0.41	52.6	14.4	10.4	16.8	1.24	0.43	2.76	29.2	338	429
148B	135	8.1	3.78	2.88	11.5	1.43	66.7	0.47	62.4	16.1	13.0	19.3	1.58	0.51	3.31	33.5	380	466
147C	167	9.5	4.28	3.45	13.8	1.65	81.5	0.59	76.3	19.6	15.6	19.8	1.96	0.62	3.66	35.9	455	586
172C	164	11.6	5.54	3.94	15.2	2.05	72.6	0.64	80.0	20.3	17.5	19.8	2.22	0.72	4.54	46.6	467	616
155C	196	11.5	5.04	3.77	15.0	1.97	94.3	0.51	82.3	22.4	16.6	22.7	2.20	0.63	3.69	50.7	529	810
149C	116	7.7	4.22	2.01	9.1	1.50	57.4	0.52	49.1	13.2	9.1	13.3	1.34	0.57	3.58	38.5	327	950
148C	235	16.3	8.61	4.57	20.5	3.18	115	1.02	104	27.6	20.3	17.6	2.91	1.15	7.00	80.6	665	1913
147D	178	11.2	5.64	3.51	15.0	2.03	81.4	0.70	83.3	21.6	16.3	18.8	2.11	0.75	4.79	43.9	489	1129
172D	131	8.7	4.28	2.86	11.7	1.55	59.0	0.47	62.8	16.0	13.1	16.2	1.65	0.54	3.56	36.5	370	444
155D	196	12.5	6.22	3.70	15.4	2.29	89.5	0.67	85.1	22.7	16.7	20.4	2.26	0.79	4.67	59.7	539	1348
149D	68.2	3.5	1.97	1.09	4.6	0.67	33.0	0.27	29.6	7.7	5.4	9.7	0.63	0.27	1.90	17.7	186	271
148D	111	10.6	6.76	2.28	10.8	2.25	55.8	0.86	49.4	12.9	9.8	11.2	1.69	0.92	5.74	66.2	358	1642
147E	87.1	8.3	5.05	1.92	8.7	1.69	37.7	0.68	41.6	10.7	8.4	13.2	1.37	0.70	4.56	38.0	270	1165
172E	82.6	5.2	2.94	1.54	6.6	0.94	39.2	0.36	37.9	9.9	7.4	13.5	0.90	0.37	2.63	24.8	237	262
155E	81.5	4.7	2.60	1.43	6.0	0.93	38.2	0.34	36.9	9.5	6.9	11.4	0.83	0.36	2.29	23.3	227	306
149E	57.1	2.4	1.48	0.75	3.3	0.45	28.6	0.21	24.4	6.6	4.3	9.1	0.41	0.20	1.55	13.0	154	182
148E	76.3	4.7	2.91	1.26	5.6	0.96	36.4	0.43	33.9	8.8	6.4	10.9	0.81	0.43	2.91	25.6	218	308
147F	61.9	3.9	2.44	1.04	4.5	0.79	30.4	0.35	26.6	7.0	4.9	9.7	0.66	0.36	2.32	21.1	178	274
155F	53.2	2.9	1.84	0.86	3.5	0.59	26.0	0.28	23.1	6.1	4.2	9.9	0.50	0.28	1.85	16.3	151	175
149F	57.5	2.7	1.70	0.79	3.5	0.53	28.7	0.24	24.5	6.6	4.4	10.7	0.45	0.22	1.75	14.6	159	187
148F	63.0	3.3	2.28	0.90	4.0	0.69	31.6	0.35	26.8	7.2	4.8	11.6	0.58	0.33	2.25	19.4	179	203
147G	60.6	2.9	1.89	0.84	3.6	0.60	30.3	0.30	25.1	6.9	4.5	11.4	0.50	0.28	1.96	16.8	168	194

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
149H	1.08	28.5	788	3.1	0.24	0.08	10	18.5	5.5	2	2.3	0.03	12.7	7020	82	3.6	10.6	1	391	0.99	0.12	10.1	1.4	2740	3.2	3.6	12	81.1
149Hb																												
149I	3.91	18.7	867	5.7	0.25	0.48	22	6.6	8.3	5	3.6	0.03	30.3	3350	74	12.4	6.2	6	394	0.58	<0.10	7.6	0.8	1390	1.2	14.0	72	179
147I				2.5		0.56				13	2.0		12.3	8130				7				3.0		448		7.8		87.3
172S																												
172T																												
172U																												
149Ib																												
147Ib				0.9		0.14				2	2.8		19.4	6790				2				21.0		4430		4.8		99.0
147A		16.3						9.1		3						2.9												
172A																												
155A																												
149A		15.0						18.2		4						8.9												
148A		33.6						12.5		8						13.1												
147B	5.96	26.4	918	2.0		6.80	152	30.1	28.0	13	5.0		51.9	3730		17.3	14.5		299	0.77				2200	2.8	18.0	234	214
172B	2.45		427	3.8		12.6	138		29.7	5	3.8		59.1	5870		10.4	13.5		97	1.08				3590	2.3	10.3	197	140
155B																												
149B	2.16	10.4	753	2.8		13.1	96	12.5	28.9	5	3.3		64.0	4380		8.7	13.7		126	1.07				3710	2.6	6.3	135	116
148B		8.9						12.2		4						8.1												
147C																												
172C																												
155C																												
149C	7.27		696	2.7		1.14	33		12.3	11	2.1		21.1	1280		19.2	5.4		519	0.28				753	3.6	13.3	87	59.4
148C	4.32	32.0	204	4.2		2.58	52	26.4	14.1	9	2.3		32.9	1770		31.8	5.7		203	0.39				1150	2.6	14.2	111	72.2
147D																												
172D																												
155D	5.49		797	4.7		2.30	74		14.9	14	2.7		28.9	2770		20.2	8.8		307	0.44				1180	4.9	15.9	124	77.6
149D																												
148D	3.29		152	4.3		0.73	27		9.5	8	1.3		14.0	978		20.8	3.2		161	0.18				435	4.8	9.0	48	35.6
147E																												
172E																												
155E																												
149E																												
148E																												
147F																												
155F																												
149F																												
148F																												
147G																												

REE Section 151

T.136N., R.102W., Sec.7, NE/SE/SE
Elevation at top 2,605 ft.

Includes adjacent sections 152, 153 and 169



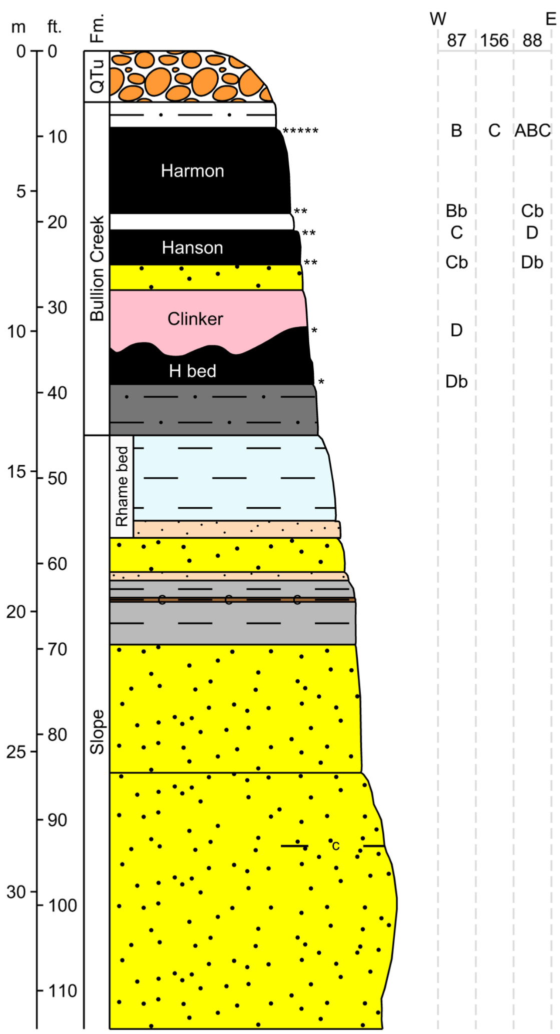
LAB ANALYSIS (in µg/g)

SAMPLE ID	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	TOTAL REE Whole Coal	TOTAL REE Ash
153Z	61.5	2.9	1.82	0.76	3.5	0.52	30.4	0.26	25.7	7.0	4.5	13.3	0.43	0.23	2.02	15.1	170	181
153C	58.2	5.2	3.05	0.93	5.2	1.08	42.4	0.37	20.0	5.8	3.9	7.1	0.83	0.41	2.53	32.3	189	1039
151C	41.7	5.9	3.39	1.06	5.7	1.20	21.8	0.45	19.2	4.8	4.5	9.3	0.96	0.47	2.99	33.9	157	373
169C	69.5	10.5	5.74	2.05	10.7	2.06	28.3	0.71	36.8	9.0	8.8	13.6	1.76	0.77	4.87	54.6	260	600
152C	36.2	6.2	3.64	1.10	5.9	1.28	16.9	0.48	18.4	4.5	4.5	8.5	0.99	0.50	3.17	35.3	148	660

REE Section 156

T.136N., R.102W., Sec.7, NE/SE/SE
Elevation at top 2,593 ft.

Includes directly adjacent lateral sections 87 and 88



LAB ANALYSIS (in µg/g)

SAMPLE ID	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	TOTAL REE Whole Coal	TOTAL REE Ash
87B	51.0	10.1	5.48	2.36	10.4	1.97	14.3	0.75	40.8	8.9	10.9	18.4	1.73	0.79	5.09	44.3	227	521
156C	64.1	7.6	4.31	1.39	7.7	1.51	36.7	0.54	26.1	7.0	5.7	11.8	1.26	0.58	3.65	42.1	222	642
88A	74.9	11.2	6.01	2.46	11.9	2.14	24.7	0.79	46.1	10.8	11.4	16.2	1.93	0.85	5.44	47.2	274	547
88B	53.1	9.6	5.54	1.70	9.1	1.93	22.3	0.71	28.7	6.8	7.0	12.85	1.56	0.78	4.95	45.4	209	577
88C	70.0	10.1	5.53	2.03	10.5	1.98	32.8	0.69	36.5	8.9	8.7	12.3	1.70	0.76	4.79	44.2	251	783
87Bb	14.7		1.72		2.9		6.6		9.0			5.2				17.8	*~69*	*~395*
88Cb	13.9		2.52		3.5		7.0		8.4			11.9				20.9	*~82*	*~723*
87C	75.8	8.9	4.68	2.15	9.82	1.70	39.8	0.59	41.8	10.6	9.3	15.2	1.58	0.65	4.14	34.7	261	1262
88D	61.9		3.50		6.7		30.5		27.8			15.0				28.4	*~202*	*~727*
87Cb	24.0		2.26		3.7		11.1		13.8			6.8				24.2	*~101*	*~319*
88Db	9.0		2.02		1.8		4.5		4.9			13.3				17.1	*~62*	*~742*
87D	99.6	6.28	3.04	2.21	8.52	1.11	44.6	0.39	49.7	12.5	10.7	18.5	1.2	0.42	2.74	22	283	446
87Db	46.6		2.96		4.5		22.4		21.1			10.4				25.1	*~154*	*~277*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
153Z	2.06		640	2.2		10.5	65		22.1	3	3.3		42.5	10500		1.7	15.2		79	1.23				3780	2.4	3.5	90	112
153C	1.53	10.2	1400	3.1		0.11	6	34.7	8.2	3	1.4		8.3	4570		5.7	4.3		895	0.32				857	3.0	4.5	10	49.4
151C		11.2						31.4		2						3.0												
169C																												
152C		6.8						27.3		2						3.8												

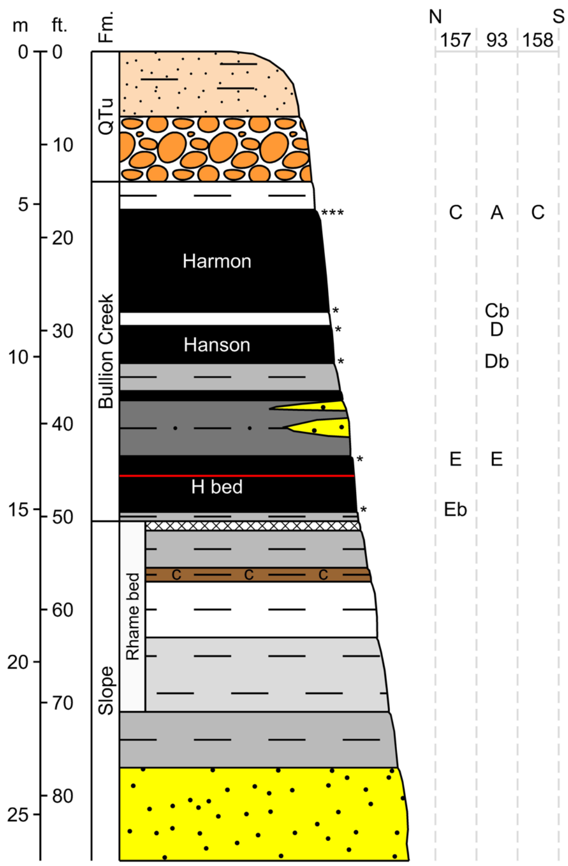
SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
87B																												
156C																												
88A																												
88B																												
88C																												
87Bb								4.5	4.4		0.9						2.8			0.15				342			6	
88Cb				2.1		0.13				2	1.8		11.7	6050				1				4.6		635		6.4		64.3
87C																												
88D				2.0		0.12				2	1.3		7.0	3920				2				4.2		280		15.1		46.7
87Cb								15.4	4.7		1.5						2.9			0.18				475			19	
87Db								6.4	9.0		3.8						16.3			1.22				2980			51	
87D	9.89		371	2.1		5.40	129		21.9	6	5.6		41.2	4410		17.2	10.4		263	0.83				3160	1.6	20.2	270	253
87Db								6.4	9.0		3.8						16.3			1.22				2980			51	

REE Section 157

T.136N., R.102W., Sec.7, NE/SE/SE

Elevation at top 2,601 ft.

Includes directly adjacent lateral sections 93 and 158



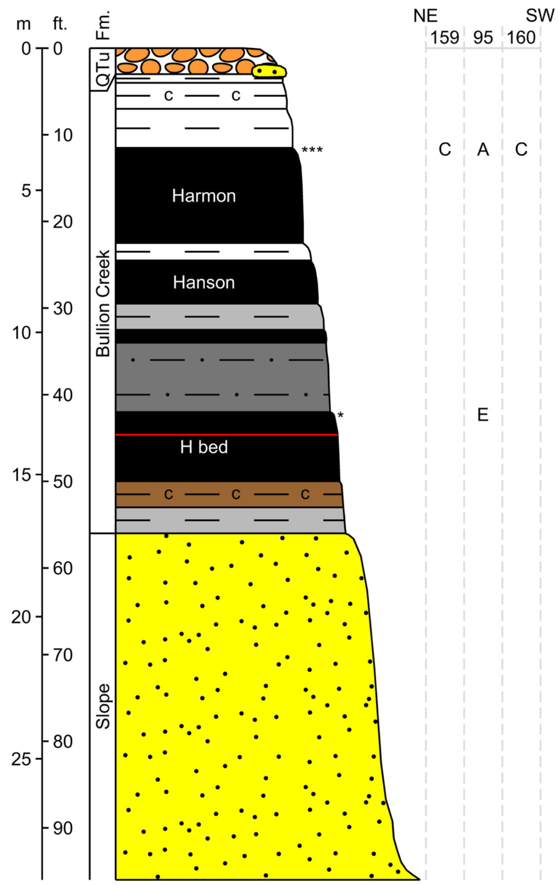
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
157C	17.0	3.7	2.45	0.54	3.0	0.81	11.1	0.32	8.0	1.9	2.1	4.4	0.53	0.33	2.12	26.8	85	725
93A	116	18.2	8.91	4.42	21.2	3.32	45.1	1.04	81.0	19.0	20.1	22.1	3.26	1.19	7.41	66.8	439	1555
158C	70.4	10.7	5.82	2.05	11.3	2.12	31.2	0.69	38.1	9.1	8.7	12.4	1.82	0.76	4.73	61.7	272	774
93Cb	15.6	3.6	2.08	0.60	3.2	0.72	7.4	0.27	8.6	2.0	2.4	8.9	0.55	0.29	1.85	18.9	77	332
93D	49.2	5.7	2.97	1.30	6.2	1.07	23.3	0.36	23.2	5.8	5.4	10.9	0.99	0.40	2.48	25.4	165	694
93Db	57.8	10.1	5.80	2.22	10.3	2.02	21.2	0.75	36.7	8.4	8.6	19.3	1.67	0.79	4.96	52.0	243	1087
157E	87.2	8.5	4.67	2.36	9.8	1.60	32.4	0.62	48.9	12.1	10.6	25.5	1.45	0.63	4.25	39.9	290	700
93E	36.2		1.09		2.5		18.7		16.8			8.6				9.3	*~105*	*~225*
157Eb	34.0	4.0	2.46	0.79	3.7	0.80	15.5	0.33	15.9	4.1	3.6	9.3	0.61	0.32	2.33	22.0	120	253

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
157C	0.89	7.5	426	2.4	0.11	0.05	3	9.9	4.5	2	0.8	<0.02	7.1	7830	137	3.9	2.3	1	404	0.15	<0.10	1.7	0.4	331	2.2	3.5	6	30.9
93A	2.76	99.6	1310	2.8	0.30	0.93	29	24.6	14.0	5	3.3	0.05	15.4	3000	141	8.5	13.4	14	216	0.60	<0.10	7.9	1.5	1460	3.1	15.5	33	136
158C		22.9						15.9		5						3.4										4.8		
93Cb	3.72	31.3	1160	1.9	0.19	0.82	12	17.6	8.9	3	1.6	0.02	13.4	6240	336	2.4	4.8	9	663	0.35	<0.10	3.7	0.9	819	1.2	4.9	19	55.2
93D	7.63		1300	2.6		0.29	18		7.3	2	1.2		3.9	8170		19.0	7.1		538	0.14				433	1.0	8.6	36	39.9
93Db	2.07	10.4	879	3.5	<0.10	0.73	32	15.9	16.5	4	2.1	0.02	3.8	4980	137	4.3	7.6	11	330	0.19	<0.10	3.0	0.4	505	3.8	6.9	44	143
157E	4.92		1950	3.7		3.32	118		18.8	5	7.5		21.6	3770		14.2	12.5		268	0.77				2270	1.5	11.8	213	322
93E				0.9		5.15				7	4.1		19.8	4620				44				13.1		2030		8.1		184
157Eb	1.08		661	1.9		0.25	29		7.0	7	3.0		12.2	2240		2.6	14.0		244	1.07				2820	1.8	3.9	49	132

REE Section 159

T.136N., R.102W., Sec.7, NE/SE/SE
Elevation at top 2,604 ft.

Includes directly adjacent lateral sections 95 and 160

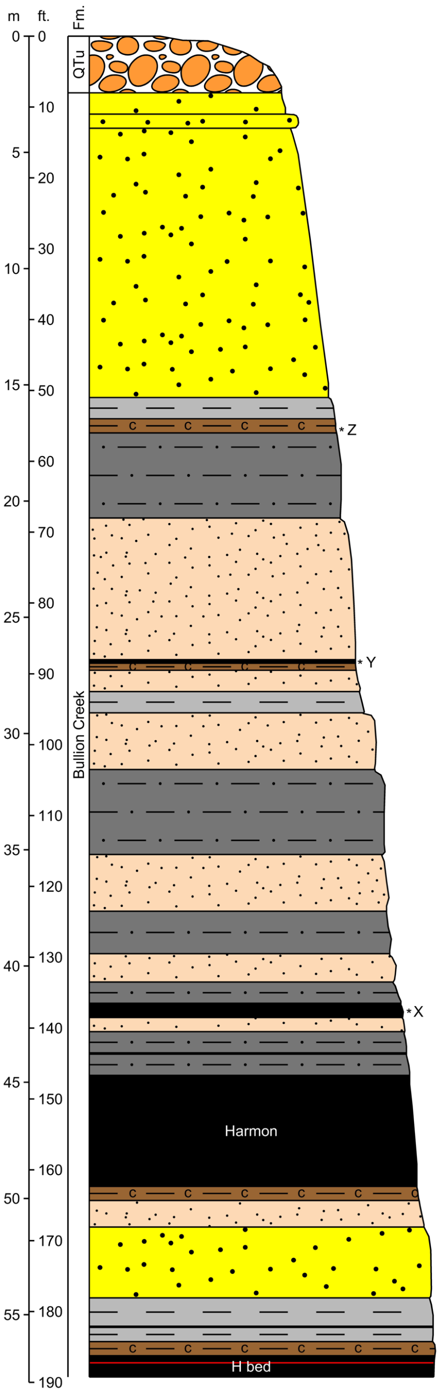


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
159C	51.0	5.4	2.91	1.17	5.7	1.03	23.9	0.37	23.2	6.0	5.1	10.4	0.91	0.40	2.55	25.9	166	365
95A	92.5	10.0	4.99	2.53	11.5	1.84	42.7	0.62	53	13.4	11.8	14.6	1.81	0.69	4.38	32.8	299	811
160C	22.8	4.5	2.68	0.75	4.0	0.92	11.9	0.36	11.7	2.8	3.0	10.1	0.71	0.38	2.37	24.8	104	376
95E	68.6		4.30		7.9		27.7		38.5			24.4				33.7	*~239*	*~629*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
159C 95A 160C	3.44		1160	1.3		1.16	34		20.6	5	3.6		9.6	7420		9.3	16.6		379	0.29				658	7.5	13.1	57	148
95E				2.8		5.13				5	7.3		18.9	2470				28				17.4		2090		10.1		374

REE Section 162

T.137N., R.102W., Sec.36, NE1/4
Elevation at top 2,620 ft.

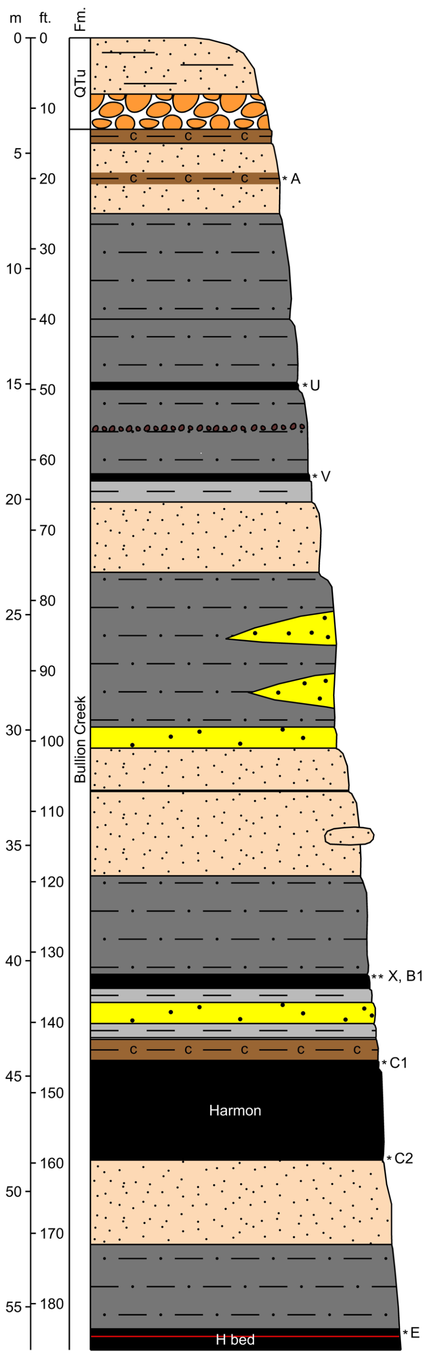


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
162Z	55.0	6.4	3.91	1.33	6.3	1.28	24.2	0.51	25.7	6.5	5.7	11.7	1.01	0.50	3.45	35.9	189	478
162Y	92.9	11.1	6.35	2.50	11.5	2.19	41.3	0.83	47.0	11.4	10.8	19.1	1.85	0.86	5.67	53.7	319	672
162X	34.6	3.9	2.41	0.82	3.9	0.80	16.5	0.34	16.6	4.2	3.6	7.9	0.63	0.33	2.26	23.1	122	233

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
162Z																												
162Y	12.2		805	7.6		2.93	45		17.1	19	3.3		25.6	6130		27	13.2		398	0.44				1390	4.8	28.4	92	203
162X																												

REE Section 163

T.137N., R.102W., Sec.36, SW/NE
Elevation at top 2,618 ft.

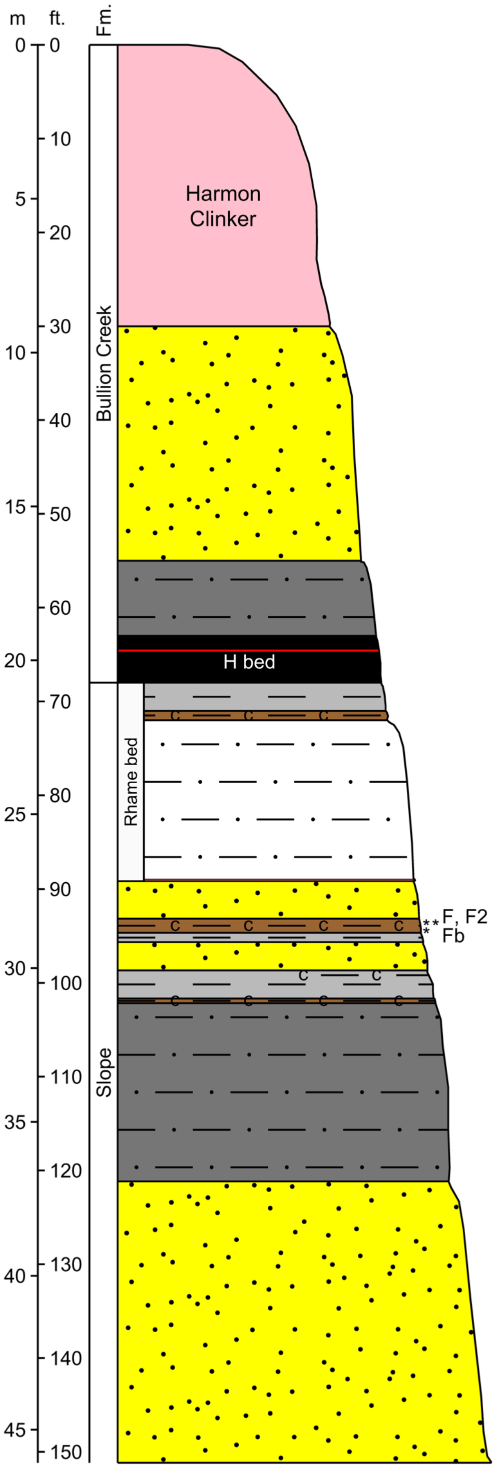


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
163A	80.4	8.8	5.28	2.05	9.6	1.75	35.4	0.67	45.1	11.0	9.4	18.9	1.45	0.68	4.61	51.5	287	355
163U	52.0		2.58		4.2		25.4		23.2			11.9				20.7	*~160*	*~225*
163V	17.5	2.6	1.58	0.58	2.8	0.53	6.6	0.20	10.7	2.5	2.4	3.1	0.43	0.21	1.34	16.6	70	293
163X	16.0		1.52		2.3		8.0		8.2			4.2				15.1	*~65*	*~223*
163B1	52.2		4.04		7.8		21.5		29.0			12.6				38.5	*~197*	*~495*
163C1	50.5		3.66		6.2		21.7		24.8			11.8				33.2	*~178*	*~714*
163C2	9.3		0.49		0.9		4.4		4.5			1.7				4.7	*~30*	*~162*
163E	105	8.9	5.21	1.97	9.2	1.78	44.1	0.72	43.5	11.6	9.1	16.6	1.49	0.75	4.88	46.1	311	1047

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
163A																												
163U				3.3		8.97				7	2.9		38.8	7470				106				10		2280		9		108
163V																												
163X				2.8		1.01				10	1.3		10.2	6360				12				4.5		880		5.7		42.6
163B1				4.1		2.17				4	3.1		21	3130				28				12.8		1220		8.1		142
163C1				3.7		0.26				2	1.1		13.6	3210				4				11.7		583		6.7		43
163C2				0.5		0.13				<1	0.5		4.1	3170				2				1.2		229		1.0		16.7
163E				8.1		0.81				5	4.3		22.8	1820				11				6.4		1210		10.1		189

REE Section 166

T.136N., R.102W., Sec.8, SE/NE/NW
Elevation at top 2,568 ft.

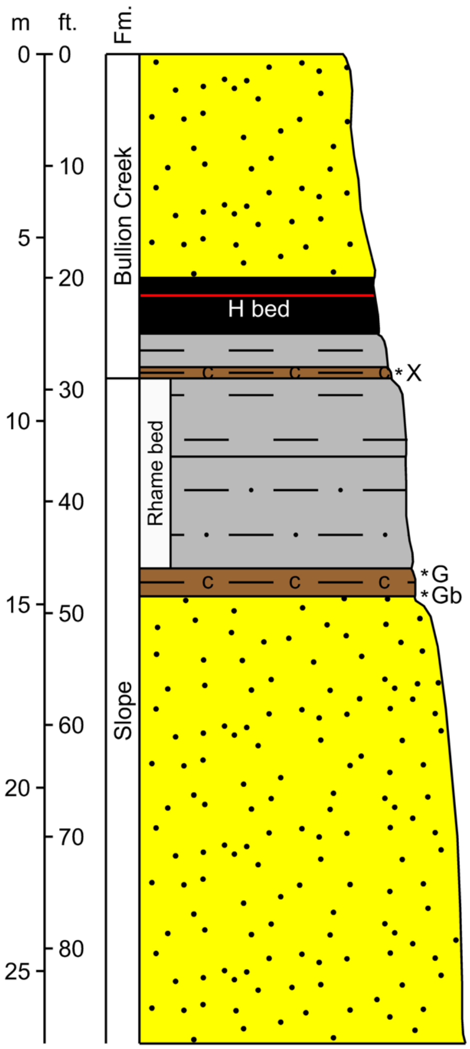


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
166F	98.6	11.0	5.76	3.55	14.0	2.03	39.3	0.73	57.2	13.1	14.4	23.2	2.03	0.75	5.06	47.4	338	455
166F2	123	8.6	5.12	2.47	10.4	1.74	60.3	0.72	53.9	14.1	11.1	17.1	1.52	0.72	4.64	46.5	362	604
166Fb	44.8	2.6	1.80	0.73	3.1	0.54	22.1	0.28	19.5	5.2	3.7	11.4	0.42	0.24	1.94	15.4	134	142

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
166F	6.67		10300	5.7		7.98	111		26.4	38	5.2		54.0	5360		12.3	16.2		134	0.95				2840	3.4	19.5	171	354
166F2						4.85			33.9	43			46.2				15.8			0.59				1830				
166Fb																												

REE Section 167

T.136N., R.102W., Sec.8, NE/NE/NW
Elevation at top 2,535 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
167X	63.8		1.97		4.3		32.1		28.7			18.9				15.5	*~186*	*~230*
167G	132	10.1	5.9	2.75	12.3	2.03	63.5	0.76	59.5	14.8	12.3	12.4	1.78	0.83	5.28	58.1	394	424
167Gb	66.7		3.15		5.8		35.0		30.1			8.9				31.3	*~207*	*~224*

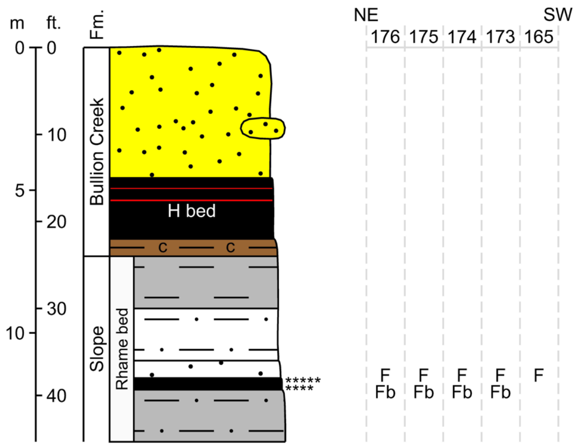
SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
167X				1.5		12.0			27.5	13			34	5920				126				22.3		3330		16.8		
167G				3.8		9.87			22.7	10			46.9	7930				124				13.5		3130		6.3		
167Gb				2.7		5.86			17.8	4			33.4	5250				94				10.8		2570		4		

REE Section 173

T.136N., R.102W., Sec.8, SW/NW/NE

Elevation at top 2,518 ft.

Includes directly adjacent sections 165, 174, 175 & 176



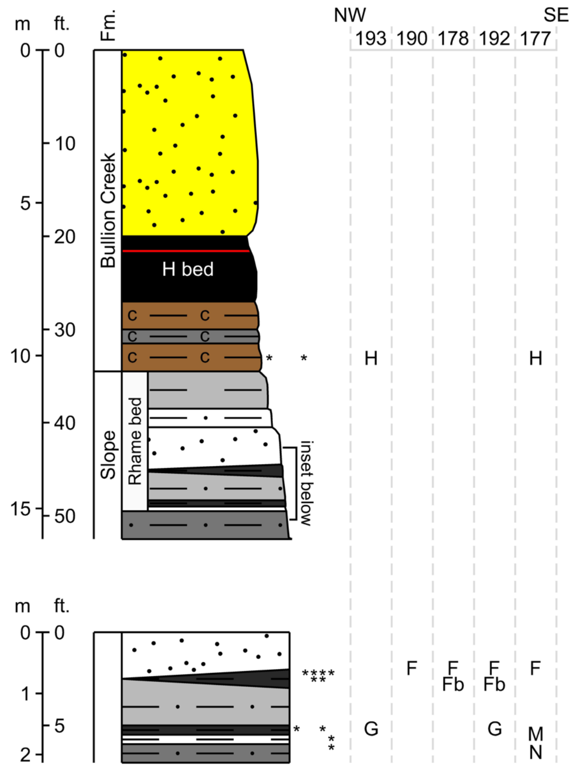
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
176F	98.7	9.9	5.98	2.26	10.7	2	50.9	0.77	46.4	11.6	10	19	1.63	0.83	5.44	56.1	332	362
175F	130	12.8	7.64	3.01	13.9	2.61	64	0.95	61.2	15.3	13.3	20.5	2.15	1.05	6.71	72.2	427	467
174F	116	12.4	7.84	2.65	12.4	2.61	59.6	1	54.9	13.7	11.7	19.1	1.97	1.06	6.91	75.8	400	433
173F	76	8.1	5.39	1.76	8.3	1.74	40.6	0.76	36.3	9.1	7.6	19.1	1.31	0.75	5.05	51.5	273	312
165F	120	9.5	5.26	2.60	11.6	1.82	58.5	0.66	56.1	14.1	11.7	18.1	1.69	0.72	4.67	48.5	366	399
176Fb	82.2	6.1	3.61	1.55	6.9	1.23	41.2	0.51	36.2	9.5	7.3	16.4	1.04	0.52	3.55	32.4	250	268
175Fb	86.1	5.9	3.62	1.57	7	1.21	43.9	0.51	37.4	9.7	7.4	16.6	1.03	0.52	3.48	33	259	277
174Fb	78.2	5.7	3.64	1.39	6.3	1.17	40.5	0.51	34.1	9	6.6	16.3	0.92	0.51	3.48	34.2	243	258
173Fb	86.6	6.6	3.96	1.69	7.5	1.33	44.6	0.55	39.9	10.1	7.7	18.3	1.12	0.55	3.68	38.4	273	296

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
176F	3.39		6700	6.0		12.9	96		33.6	4	3.7		66.9	7640		7.4	16.1		195	1.29				4240	2.9	11.6	148	141
175F	3.15		552	6.1		13.5	102		34.7	5	3.9		71.0	7380		7.9	16.1		176	1.31				4270	2.9	15.1	157	152
174F	1.78		331	6.9		12.2	103		36.6	4	3.9		75.3	8460		5.3	15.6		105	1.28				4380	3.0	9.4	156	145
173F	2.97		392	4.4		12.8	92		31.8	4	3.5		67.0	7110		8.1	15.8		149	1.22				4170	2.9	8.5	138	133
165F	2.41		440	5.0		12.3	93		30.9	4	3.6		73.0	7250		5.0	15.1		124	1.15				4170	2.7	14.5	135	135
176Fb																												
175Fb	2.53		600	4.0		14.2	85		29.2	4	3.7		59.6	7030		5.4	16.0		112	1.32				3930	2.6	6.7	129	126
174Fb																												
173Fb	1.91		679	4.4		14.4	88		28.9	3	3.3		64.5	8060		3.9	14.5		119	1.15				3600	2.4	6.9	130	116

REE Section 177

T.136N., R.102W., Sec.8, SW/NW/NE
Elevation at top 2,480 ft.

Includes directly adjacent sections 193, 190, 178 & 192

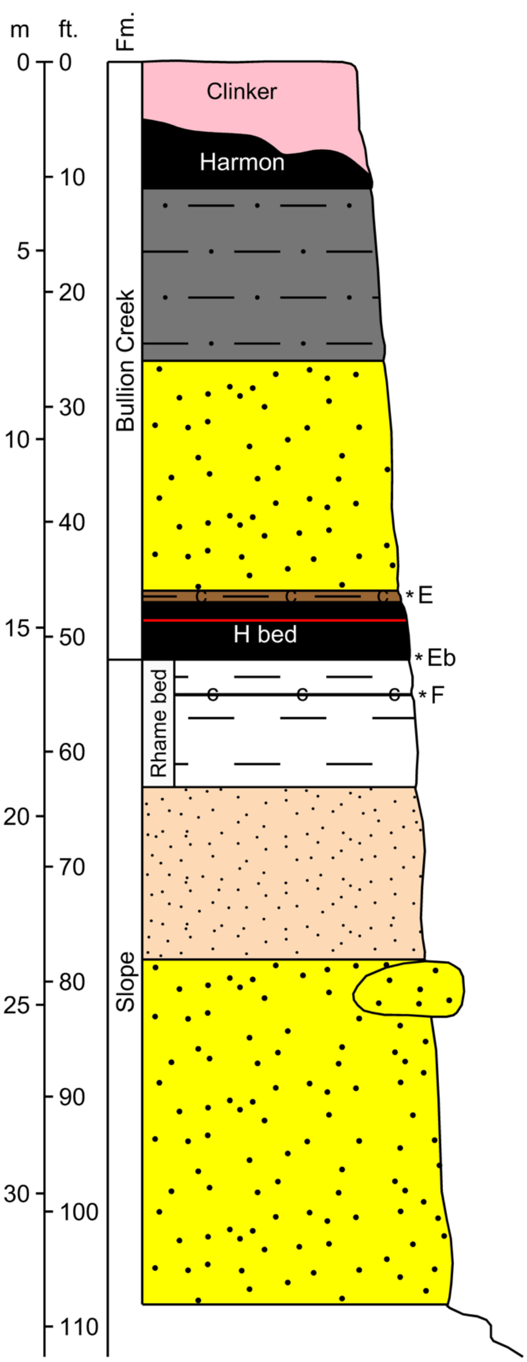


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
193H	64		2.18		4.4		32.6		27.4			14.9				19.0	*~186*	*~196*
177H	69.6		2.39		5.4		33.1		32.7			15.0				18.7	*~201*	*~243*
190F	93.3	5.1	2.65	1.78	7.0	0.95	43.5	0.36	43.3	11.2	9.0	13.3	0.98	0.38	2.50	22.4	258	272
178F	116	7.3	3.55	2.51	9.8	1.29	51.6	0.43	55.3	14.1	12	12.8	1.4	0.47	3.11	30.3	322	339
192F	236	16.1	7.22	5.40	22.1	2.77	102	0.76	117	29.3	25.9	14.8	3.18	0.93	5.76	63.3	653	708
177F	241	16.1	7.42	5.23	21.6	2.8	105	0.78	109	27.6	24	15.5	3.04	0.94	5.95	67.2	653	710
178Fb	98.2	6.3	3.33	1.98	7.9	1.18	44.4	0.43	45	11.7	9.8	12.2	1.17	0.46	3.06	28.4	276	288
192Fb	77.1	5.1	2.89	1.36	5.9	0.99	38.8	0.41	33.6	8.8	6.6	13.3	0.87	0.42	2.86	25.7	225	236
193G	100	6.4	3.47	1.96	8	1.20	47.5	0.47	46.2	12.0	9.6	15.8	1.16	0.49	3.27	29.6	287	307
192G	79.7		3.34		7.2		40.0		36.7			17.2				29.8	*~245*	*~260*
177M	78.4		2.70		5.7		40.5		34.6			15.8				24.5	*~229*	*~240*
177N	78.0		2.69		6.0		39.7		35.3			15.1				24.4	*~228*	*~240*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
193H				2.6		14.1			27.4	3			47.5	6700				162				14.3		4050		2.7		
177H	5.35		1010	1.9		10.3	74	9.7	21.7	13	4.3		31.6	5230		7.9	14.5			1.09				3280	2.1	8.1	135	189
190F						10.1			22.2	4			37.6				16.3			1.22				3460				
178F	1.22		823	3.1		9.78	58		20.1	4	2.6		44.1	4830		1.7	13.0		91	1.06				3270	2.4	5.0	80	98.0
192F						10.4			22.4	7			47.0				15.9			1.21				3490				
177F	1.64		495	5.0		11.0	79		23.4	7	3.1		48.7	5350		3.3	14.1		119	1.17				3440	2.3	8.7	113	123
178Fb																												
192Fb						9.87			22.6	3			50.3				16.7			1.23				3650				
193G				3.6		11.7			29.6	4			56.2	7040				115				15		4000		4.4		
192G						12.8			27.1	3			57.1				15.4			1.13				3830				
177M						12.4			22.2	3			47.3				15.3			1.12				3660				
177N						12.0			23.7	3			47.5				16.4			1.25				4070				

REE Section 179

T.136N., R.102W., Sec.9, SE/SE/SE
Elevation at top 2,536 ft.



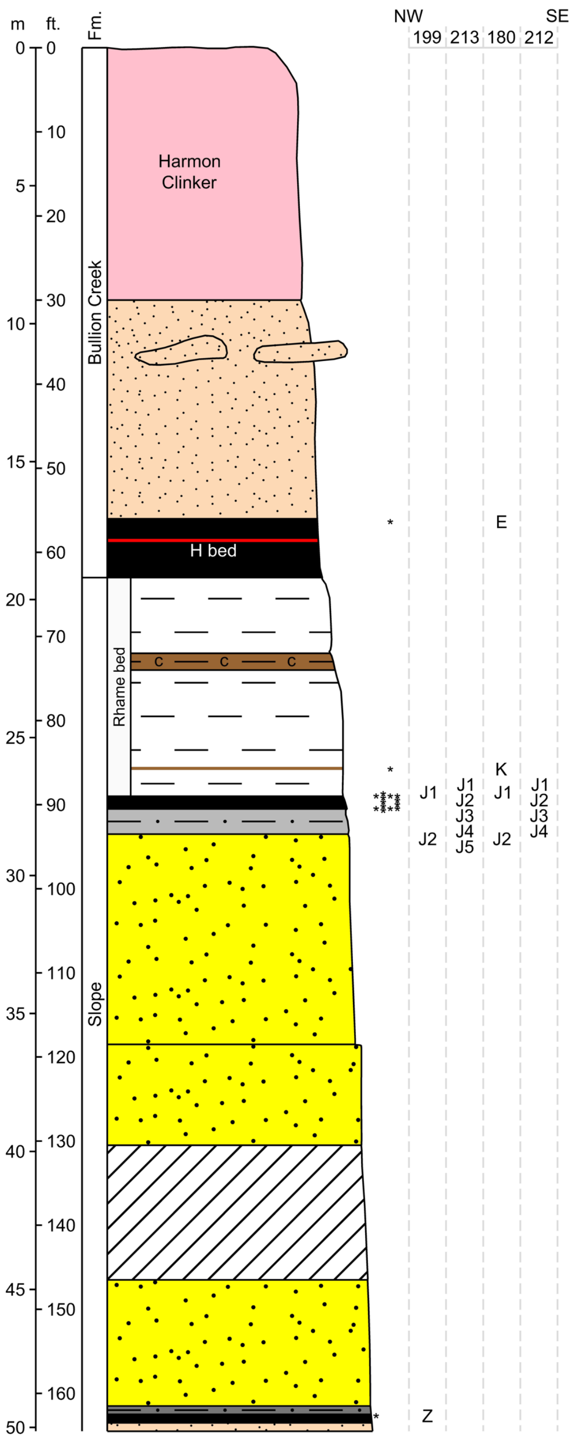
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
179E	58.9		1.51		3.5		30.3		24.2			11.0				12.8	*~159*	*~184*
179Eb	34.1		1.76		2.6		18.3		14.2			9.2				16.3	*~109*	*~263*
179F	60.8	3.5	2.13	1.07	4.2	0.68	29.6	0.33	27.0	7.1	5.4	15.6	0.62	0.31	2.21	17.4	178	204

SAMPLE ID	LAB ANALYSIS (in μg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
179E	1.68		515	2.5		9.03	55	3.7	30.0	5	3.0		82.8	8060		2.9	16.7			1.90				3140	2.5	9.3	86	99.2
179Eb	2.74		387	0.9		2.1	29	3.2	14.9	5	2.3		20.2	3030		2.6	12.2			0.92				2960	3.2	8.3	40	83.3
179F	4.94		1610	2.1		10.1	98	32.8	20.8	4	4.2		38.3	6180		6.2	15.7			1.21				3740	2.4	10.6	176	202

REE Section 180

T.136N., R.102W., Sec.22, NW/NW
Elevation at top 2,570 ft.

Includes directly adjacent sections 199, 212, and 213

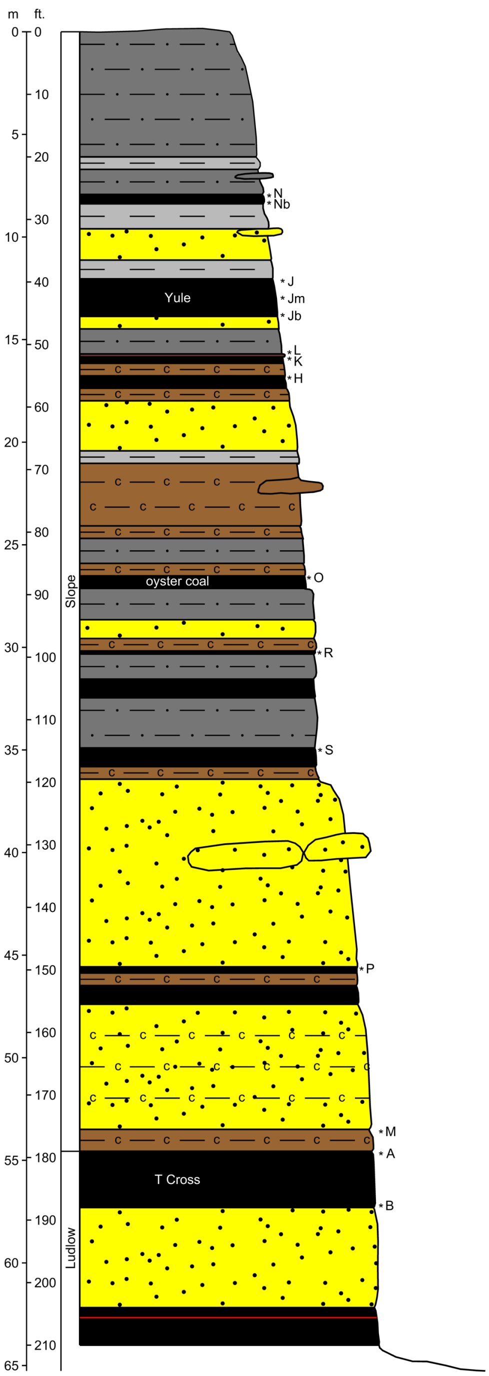


SAMPLE ID	LAB ANALYSIS (in µg/g) Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	TOTAL REE Whole Coal	Ash
180E	25.6	2.3	1.53	0.48	2.2	0.50	13.6	0.22	10.7	2.8	2.1	6.5	0.36	0.22	1.45	14.4	85	195
180K	78.0	8.6	5.01	2.46	10.4	1.74	38.6	0.67	45.0	10.2	10.5	16.7	1.50	0.72	4.61	46.6	281	412
213J1	132	13.2	6.78	3.7	16.1	2.48	63.4	0.80	71.6	17.0	16.2	18.6	2.43	0.91	5.66	64.5	435	496
212J1	66.6		4.12		8.9		33.3		39.6			11.0				37.6	*~237*	*~387*
199J1	57.7	6.1	3.70	1.52	6.5	1.24	30.3	0.56	30.3	7.4	6.8	18.0	1.02	0.55	3.80	28.4	204	223
180J1	169	13.2	7.56	3.33	16.4	2.66	92.9	0.89	76.2	19.6	14.8	18.1	2.30	1.01	6.16	86.1	530	726
213J2	331	36.2	18.6	9.36	44.1	6.91	149	2.06	180	42.9	40.4	24.3	6.65	2.44	14.5	184	1092	1530
212J2	58.1		6.21		9.6		28.2		34.6			13.7				52.8	*~243*	*~805*
213J3	377	39.7	23.8	7.53	43.4	8.45	193	2.70	160	40.4	31.0	18.7	6.76	3.09	18.1	278	1252	2225
212J3	17.9		4.99		4.3		8.2		10.4			7.8				40.8	*~116*	*~683*
213J4	351	54.1	34.8	9.19	53.3	11.9	181	4.24	162	39.5	35.5	18.5	8.70	4.62	27.8	346	1342	4567
212J4	37.9		3.82		4.7		18.4		19.3			11.1				30.2	*~148*	*~300*
199J2	190	35.6	18.2	10.1	40.8	6.50	60.2	2.38	153	31.5	42.1	22.9	6.29	2.53	17.2	127	766	1132
180J2	114	18.7	12.2	3.48	18.7	4.10	51.4	1.63	62.8	14.5	14.0	13.8	2.98	1.69	10.5	124	468	1211
213J5	193	34.8	21.8	6.55	34.4	7.45	82.8	2.82	104	24.2	25.4	22.1	5.63	3.01	18.7	195	782	1282
199Z	39.5		5.92		6.8		19.0		22.1			14.4				49.3	*~188*	*~637*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
180E	11.60		1150	2.5		0.97	24	2.3	14.8	3	4.4		57.6	3750		19.8	6.4			0.70				1710	1.0	11.4	68	184
180K	1.30		230	7.4		9.02	133	26.0	23.2	6	3.7		74.9	8160		8.1	12.3			0.86				2790	2.2	6.7	179	159
213J1				5.4		15.3			31.3	7			66.8	7740				117				20.8		4130		12.2		
212J1				5.7		7.86			22.0	12			63.6	6460				63				11.9		2880		6.4		
199J1				3.6		13.1				2	3.9		39.5	8310				111				18.0		4190		7.4		129
180J1	4.24		464	8.6		10.9	76	10.1	26.5	14	3.8		68.5	6540		17.3	12.5			1.01				3210	2.6	8.9	141	157
213J2				14		10.9			29.8	25			57.8	7200				85				16.9		2880		26.2		
212J2				10.5		1.77			12.5	15			26.9	6020				17				5.5		806		12.2		
213J3				22.6		5.74			20.6	27			56.3	6720				39				14.8		1740		23.7		
212J3				11.5		0.64			7.9	7			13.5	8030				7				3.1		464		9.3		
213J4	6.73		703	30.7	0.22	0.86	45	89.2	16.9	28	2.1	0.03	23.4	8660	52	63.5	4.4	9	83	0.20	0.12	6.4	0.4	418	11.2	29.6	141	70.2
212J4				4.8		5.10			15.1	8			30.9	5520				69				7.5		1550		6.7		
199J2				14.8		7.41				25	4.1		37.4	6230				85				11.5		2070		28.4		213
180J2	3.57		688	11.7		3.78	39	26.1	15.2	14	2.0		28.8	4090		19.4	7.4			0.35				1050	3.6	8.0	83	97.7
213J5				15.5		4.61			22.0	37			70.7	7970				60				15.6		1480		25.2		
199Z				11.5		2.10				12	3.6		14.1	7670				19				10.7		1620		12.3		170

REE Section 181

T.135N., R.105W., Sec.10, NE/NE/SW
Elevation at top 2,834 ft.

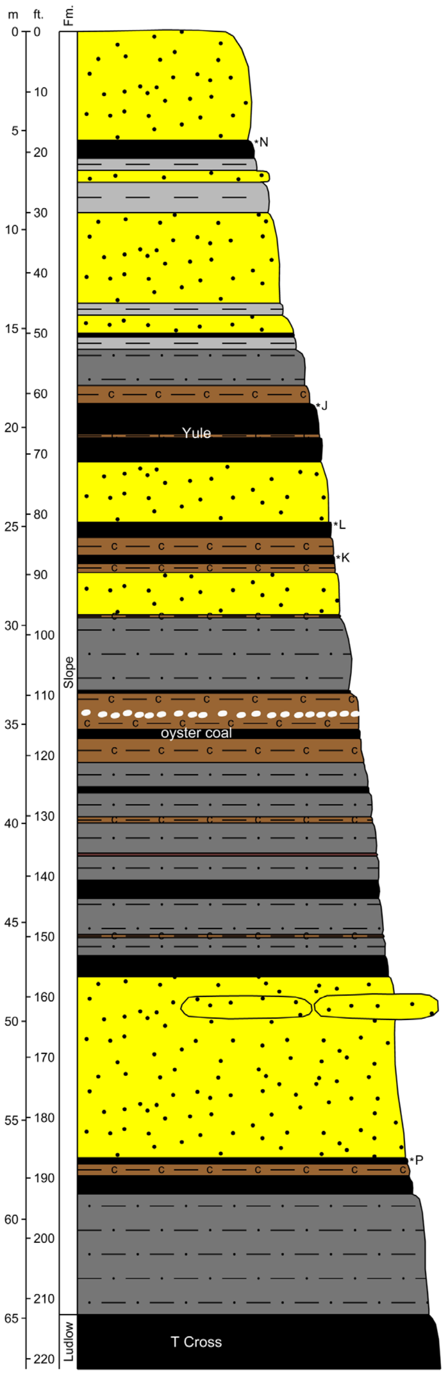


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
181N	64.1		2.05		4.4		34.4		28.4			12.8				16.8	*~184*	*~207*
181Nb	53.6		2.49		4.5		28.5		25.2			13.2				19.7	*~168*	*~391*
181J	46.9		3.61		4.9		27.8		19.4			11.3				34.7	*~172*	*~618*
181Jm	13.0		0.81		1.4		6.5		6.6			3.4				6.9	*~45*	*~253*
181Jb	29.6		1.52		2.6		15.8		12.5			5.8				15.6	*~95*	*~290*
181L	51.7		2.56		4.0		33.1		21.7			8.7				24.6	*~166*	*~337*
181K	19.7		1.89		2.6		10.7		9.9			7.8				18.2	*~82*	*~388*
181H	50.6		2.00		4.5		22.6		24.7			9.2				18.1	*~151*	*~511*
181O	31.8		1.90		4.2		11.5		20.2			5.4				16.8	*~109*	*~327*
181R	107	9.0	5.28	2.54	10.4	1.84	44.8	0.71	49.4	12.2	10.0	13.2	1.60	0.71	4.52	45.9	319	787
181S	16.6		2.63		2.9		8.6		9.0			11.5				25.9	*~91*	*~340*
181P	38.7		2.87		3.7		21.5		17.8			13.4				22.7	*~139*	*~328*
181M	90.2	3.6	2.12	1.27	4.7	0.71	46.5	0.3	31	8.6	5.9	12.6	0.64	0.31	2.07	17.3	228	262
181A	16.8	1.2	0.72	0.44	1.6	0.24	7.7	0.1	9.1	2.2	1.9	3	0.22	0.1	0.69	6.5	53	170
181B	84.3	4	2.31	1.4	5.4	0.78	39.1	0.33	33.8	9	6.4	12.2	0.72	0.33	2.26	19.6	222	292

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
181N	0.77	14.4	457	2.3				9.9		3			36.5	8430	97	3.0			165			11.8			1.7			
181Nb	2.08	9.8	141	3.2				6.8		9			33.1	3930	45	8.8			267			12.5			2.0		95	68.8
181J	1.00	5.6	172			0.60		31.5		4			26.6		326	1.5		6	211						1.0	4.1	145	222
181Jm	1.46	6.4	1080			0.39		4.4		1			8.6		120	7.3		6	457						1.7	4.2	121	
181Jb	0.98	24.1	1070			0.26		9.4		1			3.7		116	5.4		5	1190						1.7	2.4	26	
181L			2200				38			3									677							12.5		
181K			1190				11			5									502							2.9		
181H			635				37			4									453							5.8		
181O			1010				33			6									432							2.5	24	56.0
181R			1200				30			17									748							5.0	423	845
181S			600				19			7									282							5.5	61	91.7
181P	2.52	26.7	337	6.7		2.35	55	35.0	25	18	3.2		19.7	15500	356	4.2	9.7	18	407	0.44		7.7			2.2	19.7		
181M																												
181A																												
181B																												

REE Section 182

T.135N., R.105W., Sec.10, NE/NE/SW
Elevation at top 2,864 ft.

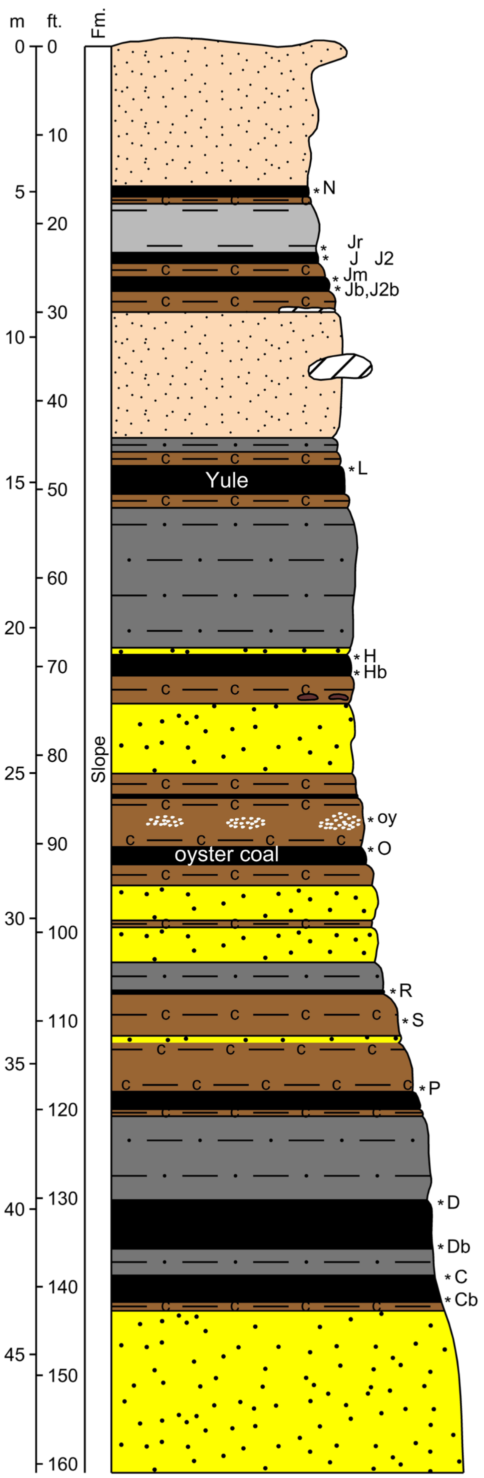


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
182N	96.4	7.2	3.9	2.63	9.1	1.35	38	0.55	51.9	12.5	11	11.7	1.27	0.56	3.74	28.4	280	773
182J	61.5	5.2	3.3	1.15	5.4	1.11	34.9	0.45	24.2	6.4	4.8	10.2	0.85	0.47	2.99	36.3	199	700
182L	10.3	1.7	1.24	0.38	1.4	0.39	5.6	0.19	5.1	1.2	1.2	7.2	0.25	0.19	1.27	12	50	195
182K	25.6	1.7	0.96	0.7	2.2	0.33	10.4	0.13	14	3.3	2.9	7.7	0.31	0.14	0.92	8	79	527
182P	32.1	3.6	2.72	0.94	3.1	0.82	18.5	0.45	14	3.7	2.9	16.6	0.51	0.42	2.89	22	125	300

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
182N	3.76	29.8	1920	2.3	0.36	2.36	29	12.5	11.0	5	1.9	0.03	14.7	3820	95	14.2	6.8	23	365	0.37	0.10	6.2	0.7	1040	5.8	8.2		
182J	0.46		521	1.3		0.42	16		8.7	3	1.3		18.6	2650		1.4	5.6		245	0.54				979	1.1	3.0		
182L																												
182K																												
182P	2.39		11500	7.4		2.35	197		40.1	41	7.0		17.9	20900		4.2	17.6		469	0.44				2100	2.9	17.2		

REE Section 183

T.135N., R.105W., Sec.9, NE/SE
Elevation at top 2,843 ft.

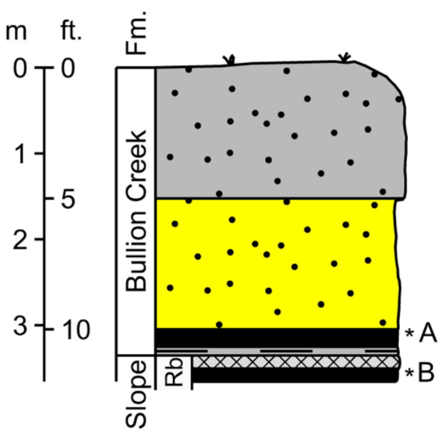


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
183N	39.6		2.56		3.5		21.0		15.8			9.2				25.9	*~135*	*~225*
183Jr	61.8		2.17		4.2		35.5		26.4			15.2				17.2	*~183*	*~198*
183J	93.9		3.56		7.3		48.5		40.8			16.9				29.6	*~274*	*~318*
183J2	32.6	2.7	1.57	0.83	3.1	0.54	12.4	0.2	17.1	4.3	3.4	6.1	0.46	0.22	1.42	15.1	102	315
183Jm	99.9	7.2	4.04	2.01	8.1	1.39	51.5	0.53	43.4	11.3	8.6	17.3	1.27	0.56	3.65	36.6	297	439
183Jb	56.2		2.49		5.1		27.9		28.3			11.9				19.2	*~174*	*~326*
183J2b	22.4	2.4	1.61	0.58	2.3	0.52	10.9	0.23	10.4	2.7	2.1	7.5	0.38	0.23	1.51	15.3	81	429
183L	29.3		1.88		3.6		14.6		15.6			6.7				15.1	*~102*	*~284*
183H	50.9		2.30		5.3		20.1		28.6			12.0				18.0	*~159*	*~457*
183Hb	71.8		3.23		7.4		32.1		38.2			11.0				23.3	*~218*	*~484*
183oy	44.5		2.36		4.1		24.2		20.9			11.7				20.0	*~146*	*~187*
183O	38.1		2.07		4.7		14.6		22.0			5.3				17.9	*~124*	*~457*
183R	37.9		3.11		3.9		19.7		17.9			11.7				22.7	*~136*	*~299*
183S	37.5	4.5	3.04	0.93	4.3	0.98	17.4	0.43	16.1	4.0	3.3	7.3	0.71	0.43	2.76	26.3	130	2193
183P	85.4		4.25		9.1		29.0		41.2			10.5				33.0	*~250*	*~858*
183D	9.3		1.39		1.6		4.3		5.2			8.3				12.6	*~50*	*~217*
183Db	71.7		2.94		5.6		33.8		30.8			13				22.8	*~207*	*~433*
183C	13.8		1.91		1.9		7.2		7.2			7.8				15.0	*~64*	*~250*
183Cb	4.0		1.15		1.4		1.8		2.9			4.2				11.0	*~32*	*~329*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
183N	1.17	6.7	1050	5.0				4.7		5			48.4	23900	559	2.1			612			18.8			2.0			
183Jr		0.87	439	1.8		10.9	84	7.5	24.7	2	4.2		60.7	9890	127	2.6	15.5	103	715	1.19		11.2			2.3	5		
183J	1.37	9.5	326			8.66		8.0		3			89.9		134	4.5		63	296						2.7	7.2		
183J2																												
183Jm	0.82	7.4	351			4.86		8.9		3			108		94	3.5		29	269						2.7	7.2	80	66.1
183Jb	3.02	30.8	209			7.14		4.9		4			52.1		54	13.0		71	106						2.5	14.0	69	142
183J2b		30.8																										
183L			503				9			3									587							2.7		
183H			844				102			11									276							3.5		
183Hb			5020				46			9									1260							3.1	43	
183oy	0.46	19.1	511	1.1		4.37	56	14.8	11.6	1	2.1		21.7	10200	474	1.4	8.4	59	477	0.71		5.7			1.0	2.5		
183O			1920				20			9									595							1.8		
183R			1000				42			25									481							9.1		
183S			43				17			68									34							2.2		
183P	1.25	15.1	1100	3.0		1.55	20	9.6	10.4	10	2.6		13.0	6360	54	7.4	10.2	14	410	0.25		3.3			3.2	4.3		
183D	1.59	8.9	1150	5.8		0.56	15	4.2	7.3	7	1.7		4.4	11500	318	4.0	6.6	7	452	0.14		1.5			1.4	3.6	155	
183Db			273				46			4									244							6.6	110	
183C			2020				18			4									273							10.3	74	
183Cb			262				3			1									256							1.3	142	125

REE Section 185

T.129N., R.96W., Sec.17, NW
Elevation at top 2,827 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
185A	51.8	3.6	2.43	0.84	3.7	0.77	28.2	0.37	20	5.6	3.7	9.8	0.60	0.36	2.40	23.3	157	209
185B	43.5	4.3	3.02	0.69	3.5	0.94	24.4	0.50	16.2	4.6	3.2	11.1	0.65	0.47	3.19	25.6	146	179

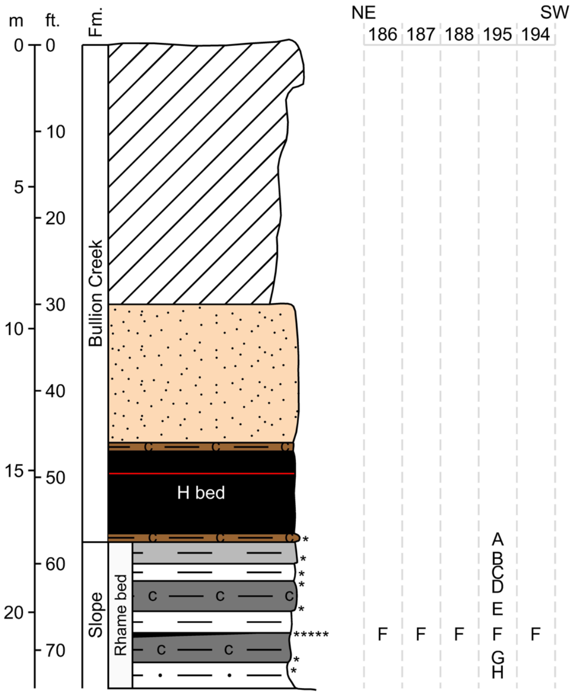
SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
185A	2.6		5360	3.4		0.71	57		27.5	8			36.3	3140		22.4	18.8		360	1.6				4290	13.2	20.3	56	166
185B																												

REE Section 186

T.136N., R.102W., Sec.8, NW/SE/NE

Elevation at top 2,567 ft.

Includes directly adjacent sections 187, 188, 194 & 195

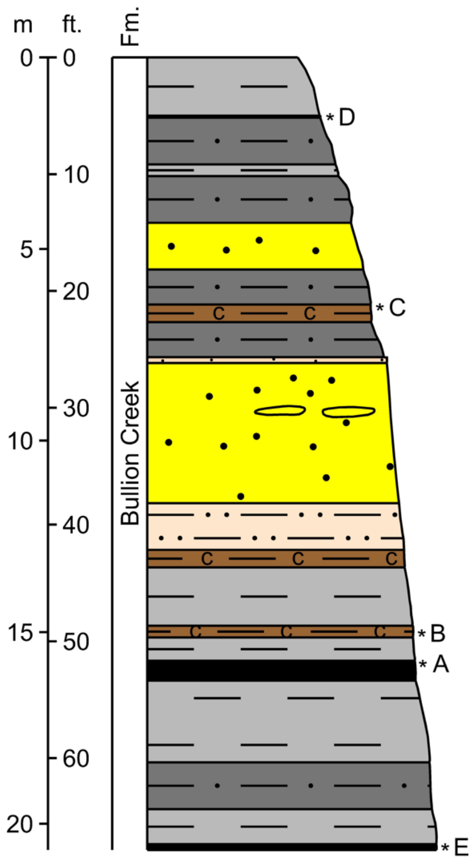


SAMPLE ID	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	TOTAL REE Whole Coal	TOTAL REE Ash
	LAB ANALYSIS (in µg/g)																	
195A	92.3		4.04		8.4		45.8		45.9			28.6				31.3	*~293*	*~339*
195B	47.6		1.71		2.8		24.3		20.0			16.4				13.7	*~141*	*~149*
195C	64.7		2.12		4.2		32.2		27.7			15.2				18.2	*~185*	*~193*
195D	68.3		2.11		4.3		36.0		28.6			13.1				20.0	*~194*	*~202*
195E	37.9		1.47		2.4		19.8		16.0			11.1				12.2	*~113*	*~118*
186F	139	9.8	4.88	3.05	12.5	1.78	64.3	0.58	67.6	16.9	14.6	16.6	1.82	0.66	4.24	43.4	402	432
187F	100	6.1	3.15	1.99	7.9	1.12	47.6	0.42	46.7	12.0	9.9	14.2	1.15	0.44	2.93	27.9	284	299
188F	50.9	2.6	1.76	0.72	3.1	0.55	26.3	0.29	21.5	5.8	3.9	12.0	0.45	0.27	1.94	14.6	147	152
195F	58.7	2.8	1.84	0.80	3.4	0.57	29.6	0.30	24.5	6.6	4.5	12.2	0.48	0.28	1.99	15.3	164	171
194F	52.4	2.6	1.76	0.75	3.3	0.55	27.2	0.30	22.1	5.9	4.0	11.9	0.46	0.28	1.89	15.1	150	158
195G	53.2		2.12		3.3		29.2		21.8			15.4				17.9	*~160*	*~169*
195H	54.1		1.93		3.2		28.8		22.4			13.3				16.0	*~157*	*~163*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
195A						10.5			40.9	30			32.5				16.6			0.96				3100				
195B						11.7			24.0	3			36.7				17.4			1.28				3850				
195C						9.81			23.9	3			36.7				19.6			1.44				4000				
195D						11.6			22.7	3			38.6				17.9			1.36				3940				
195E						7.58			19.3	2			30.7				13.6			1.04				3090				
186F						11.0			29.0	4			67.7				17.5			1.26				4010				
187F						10.1			23.4	4			53.3				18.4			1.36				3980				
188F						10.0			20.6	3			39.3				17.0			1.26				3870				
195F						11.1			21.2	3			42.0				17.6			1.31				4060				
194F						10.2			20.6	3			39.6				17.7			1.29				3940				
195G						14.5			27.1	3			47.9				16.2			1.20				3950				
195H						11.1			22.7	3			42.4				17.5			1.31				4120				

REE Section 197

T.136N., R.102W., Sec.14, SE1/4
Elevation at top 2,655 ft.

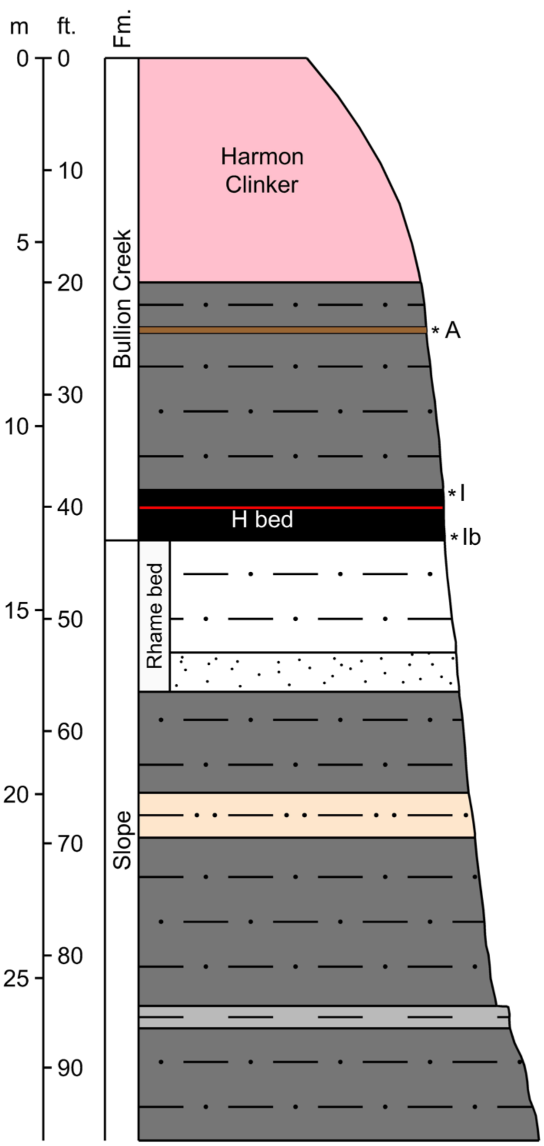


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
197D	25.5		1.74		2.9		12.1		14.1			7.8				12.5	*~89*	*~175*
197C	44.0		1.89		3.4		21.8		19.8			8.1				15.6	*~131*	*~190*
197B	65.6		3.76		6.4		30.8		30.9			15.6				28.4	*~210*	*~297*
197A	18.7		1.79		3.0		7.9		11.6			6.9				13.5	*~76*	*~225*
197E	41.6		5.30		6.7		19.1		22.1			15.8				40.0	*~180*	*~411*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
197D				2.6		3.57				12	7.1		11.9	9210				47				5.5		1170		18.6		465
197C				2.2		6.47				8	2.5		27.0	6520				91				7.9		2100		5.6		108
197B				2.6		7.47				9	4.8		93.9	13700				86				12.5		2640		9.1		235
197A				1.8		1.88				5	2.8		10.8	4150				27				6.6		828		11.6		123
197E				3.9		2.74				18	3.4		26.1	8740				36				7.9		1150		58.5		221

REE Section 198

T.136N., R.102W., Sec.22, NW1/4
Elevation at top 2,567 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
198A	50.6		3.58		4.5		27.4		23.8			17.1				27.9	*~178*	*~198*
198I	73.8		3.61		7.7		28.1		38.8			8.9				27.6	*~221*	*~538*
198Ib	85.1	8.9	5.08	1.57	8.3	1.78	42.5	0.63	32.4	8.8	6.6	11.3	1.47	0.68	4.27	43.2	263	901

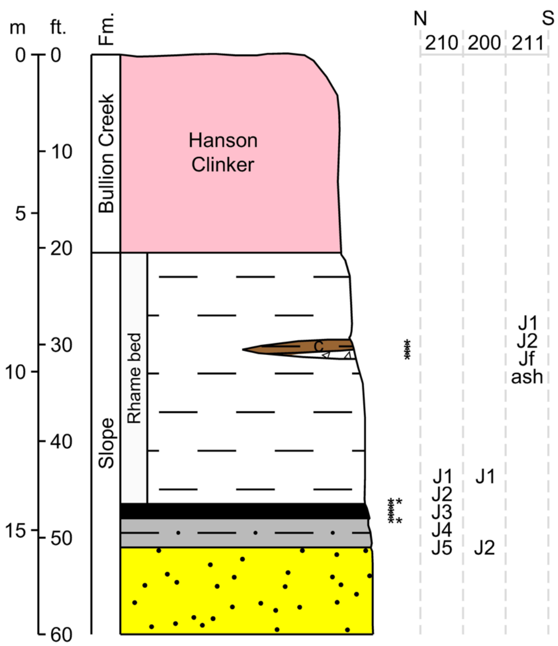
SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
198A				4.0		9.86				12	5.1		42.8	18100				125				11.4		2860		8.6		300
198I				3.4		1.15				6	3.0		23.0	5440				11				8.9		1540		13.3		120
198Ib				2.7		1.05				6	2.0		22.1	6380				12				5.2		977		10.9		78.5

REE Section 200

T.136N., R.102W., Sec.22, NW/NW

Elevation at top 2,570 ft.

Includes directly adjacent sections 210, and 211



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
211J1	126	7.2	4.26	2.15	9.5	1.40	64.9	0.60	55.0	14.4	10.7	18.0	1.32	0.60	4.08	38.7	359	418
211J2	59	11.3	7.72	1.76	10.1	2.48	38.2	1.10	34.1	8.4	8.4	17.7	1.73	1.10	7.27	90.7	301	436
211Jf	66.7		3.87		6.3		32.9		28.5			9.7				36.6	*~213*	*~142*
211ash	37.3		2.78		3.6		26.8		18.0			6.4				25.6	*~138*	*~250*
210J1	98.5	8.5	4.85	2.23	10	1.67	49.8	0.61	47.9	11.8	10.0	17.9	1.48	0.66	4.31	45.7	316	370
200J1	111	9.4	5.07	2.64	11.1	1.76	56.0	0.66	55.1	13.7	11.9	19.7	1.66	0.70	4.71	40.6	346	377
210J2	96.3	7.5	4.33	2.02	9.1	1.49	50.1	0.56	46.6	11.6	9.4	14.8	1.32	0.59	3.85	41.4	301	344
210J3	271	25.8	13.7	7.28	33	4.96	116	1.61	153	35.4	33.1	23.9	4.68	1.79	11.3	125	862	1446
210J4	343	36.3	19.3	9.84	45.2	6.87	134	2.41	200	45.0	45.0	22.2	6.54	2.54	16.1	156	1090	2437
210J5	281	29.7	16.1	7.91	37.1	5.67	109	1.99	161	36.6	36.1	24.1	5.33	2.12	13.4	129	896	1738
200J2	264	35.0	20.2	7.71	35.0	7.01	123	2.51	145	34.7	32.9	31.1	5.70	2.82	18.3	151	916	1061

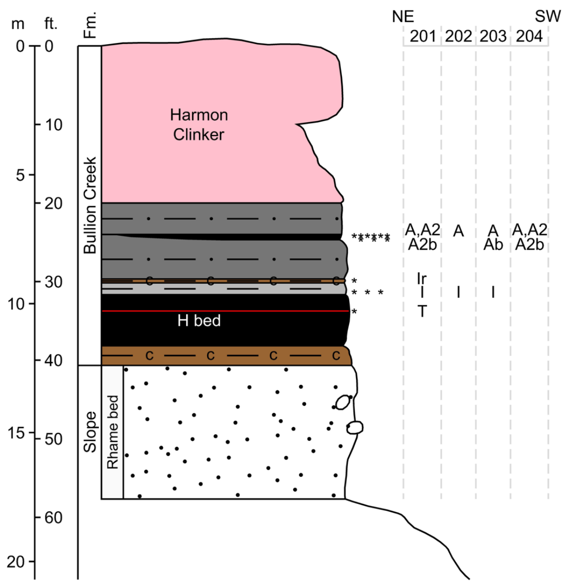
SAMPLE ID	LAB ANALYSIS (in μg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
211J1				5.2		9.93			40.7	6			129	8600				72				17.7		4550		12.3		
211J2				14.7		1.42			35.8	11			265	12200				14				19.1		3460		39.6		
211Jf				8.1		2.91			43.0	11			302	15000				28				41		2680		9.2		
211ash				1.2		0.46			23.6	4			64.4	3540				6				27.7		13100		5.1		
210J1	2.17		570	4.5	0.89	11.9	91	12.2	29.1	4	3.8	0.11	65.3	8810	92	8.3	16.1	100	196	1.29	0.18	22.1	3.1	3630	3.0	13.7	149	145
200J1				3.7		13.4				4	4.4		46.0	7360				107				28.8		4340		12.8		154
210J2				3.8		11.8			28.0	4			69.6	7930				97				13.7		3790		8.7		
210J3				8.3		5.21			24.9	35			51.5	6550				45				21.6		2040		31.9		
210J4	8.69		1040	9.5	0.34	3.23	80	51.9	25.1	43	3.0	0.06	37.8	6200	64	59.6	8.3	31	187	0.45	0.11	10.7	1.1	1140	9.8	45.2	142	125
210J5				7.6		3.90			21.4	42			48.8	6460				49				17.8		1280		37.7		
200J2				12.8		10.6				33	6.1		30.2	6120				78				24.0		3510		51.1		239

REE Section 201

T.136N., R.102W., Sec.21, SE/SW

Elevation at top 2,617 ft.

Includes nearby lateral sections 202, 203, and 204

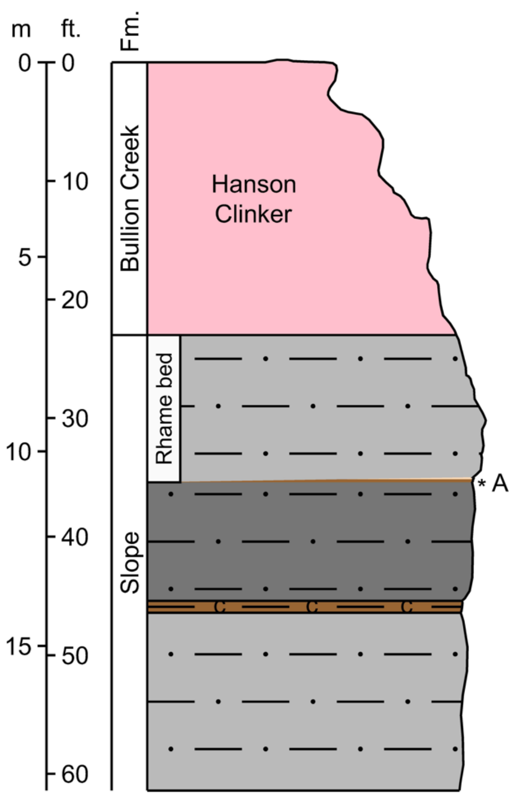


SAMPLE ID	LAB ANALYSIS (in µg/g)															TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
201A	97.7	37.0	18.6	10.1	43.3	6.86	20.3	2.34	147	24.1	42.6	39.9	6.65	2.50	16.0	137	*652*	2345
201A2	172	32.8	17.4	8.5	37.4	6.15	46.2	2.20	147	30.8	36.5	34.9	5.83	2.34	15.1	125	720	1449
202A	173	48.8	27.3	11.6	51.1	9.58	45.6	3.82	171	32.2	46.0	31.7	8.29	3.79	24.9	168	857	2587
203A	97.8	6.4	3.54	1.97	8	1.21	47.7	0.49	48.5	12.5	10.0	17.5	1.16	0.51	3.42	27.7	288	344
204A	212	18.5	9.72	5.42	22.7	3.44	86.3	1.22	112	27.2	24.6	26.6	3.33	1.31	8.52	79.9	643	1578
204A2	427	42.8	22	11.8	51.2	7.95	148	2.73	230	55.1	52.3	44.3	7.76	2.95	19.0	152	1277	4963
201A2b	90.6	14	7.2	4.15	17.6	2.58	27.3	0.96	77.4	16.1	19.2	27.6	2.57	0.99	6.53	55.0	370	617
203Ab	113	6.9	3.15	2.43	9.7	1.16	58.7	0.39	54.9	14.1	11.5	18.3	1.33	0.42	2.75	27.1	326	396
204A2b	359	37	19.4	10.4	44.4	6.88	118	2.54	201	47.3	46.4	45.5	6.75	2.64	17.4	120	1085	3889
201Ir	94.9	6.3	3.05	2.11	8.8	1.11	49.1	0.37	46.2	11.6	9.9	19.7	1.21	0.41	2.64	28.4	286	333
201I	92.9	10.8	6.02	2.89	12.2	2.09	36.8	0.78	56.4	12.9	13.1	19.9	1.86	0.82	5.37	49.2	324	504
202I	86.0		4.01		8.1		39.3		41.8			14.0				32.3	*~261*	*~449*
203I	134	10.3	5.55	2.69	11.9	1.96	58.3	0.71	59.9	15.3	12.5	12.8	1.81	0.77	4.92	47.4	381	998
201T	20		0.41		1		9.8		7.6			1.8				4.1	*~50*	*~60*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
201A				6.1		1.88				8	3.7		14.4	8990				17				11.7		633		23.2		225
201A2				5.6		6.10			27.8	14			24.9	4700				63				12.9		1690		18.1		
202A				7.1		2.06				6	2.6		14.1	10400				23				13.6		784		25.2		175
203A				2.7		13.0			26.1	4			84.1	8970				108				21.6		3810		16.5		
204A				5.9		3.76				8	3.1		12.6	4160				41				16.6		1340		20.5		105
204A2	3.49		1350	6.8	0.27	1.78	171	47.4	29.6	13	5.5	0.10	18.5	3140	33	16.0	13.2	17	112	0.38	<0.1	22.7	0.6	818	3.9	39.1	173	221
201A2b				3.2		7.35			19.8	12			20.5	4790				96				20		2100		17.6		
203Ab				2.7		6.09			33.7	4			125	5680				49				22.9		4280		16.9		
204A2b				5.6		2.25			27.4	12			9.8	2530				24				11.3		654		27.3		
201Ir				2.4		9.06			35.3	4			153	5230				63				23.9		4510		10.7		
201I				4.2		6.32				4	5.4		71.9	4610				43				27.3		3150		23.7		190
202I				3.5		2.43				3	4.2		69.6	8620				19				18.6		2660		14.4		153
203I				5.3		0.40				6	4.0		30.5	6550				5				11.4		1490		15.0		161
201T				1.1		1.12			59.0	2			193	3350				17				16		1230		1.8		

REE Section 206

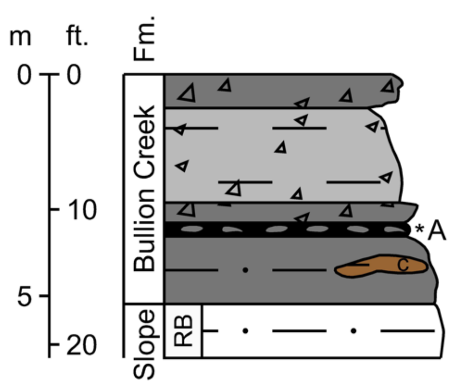
T.136N., R.102W., Sec.16, NW/SW/NW
Elevation at top 2,573 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
206A	52		1.62		3.6		25.7		23.2			12.6				13.1	*~149*	*~155*

REE Section 207

T.136N., R.102W., Sec.17, NE/SE
Elevation at top 2,558 ft.



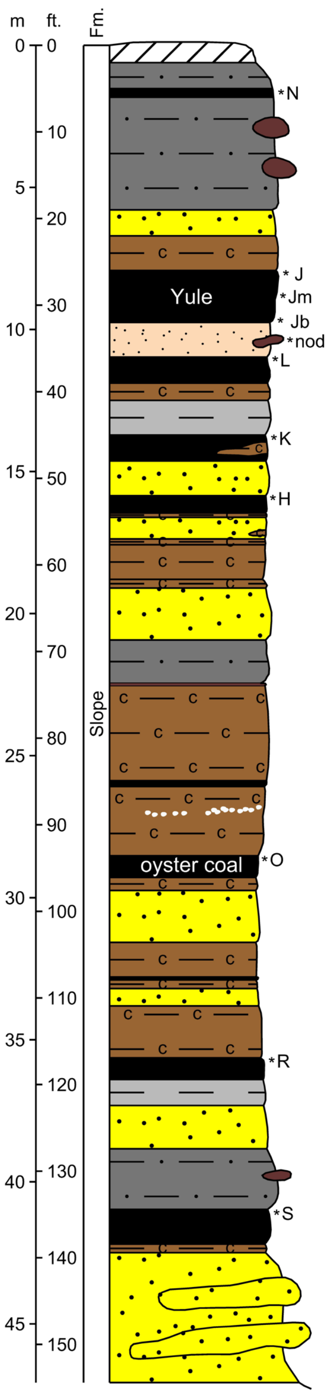
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
207A	42.3		2.01		3.2		25.4		15.4			7.3				22.2	*~133*	*~207*

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
206A				1.4		7.68			18.6	4			24.9	3440				139				18.8		3710		3.5		

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
207A				2.1		0.85			19.1	12			136	19400				13				9.9		2060		5.4		

REE Section 216

T.135N., R.105W., Sec.10
Elevation at top 2,813 ft.

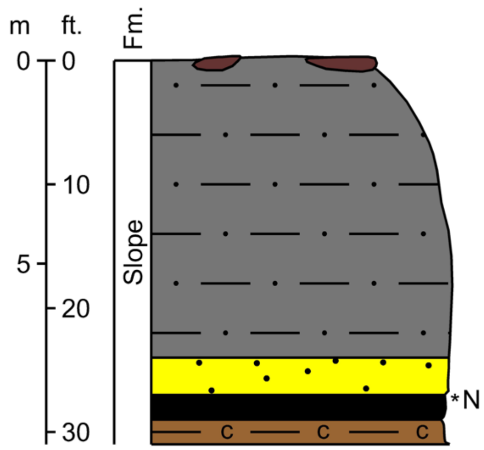


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
216N	64.8		2.90		6.3		29.9		33.7			10.1				22.4	*~197*	*~314*
216J	23.1		2.15		2.6		13.4		9.8			7.7				19.7	*~91*	*~378*
216Jm	47.5		1.70		3.3		26.9		19.3			7.2				14.8	*~136*	*~307*
216Jb	48.9		3.41		6.8		18.3		31.3			15.4				24.0	*~176*	*~647*
216nod	14.8		0.75		1.4		10.0		6.3			2.9				9.5	*~52*	*~69*
216L	22.4		3.00		3.7		11.3		13.3			11.0				23.3	*~105*	*~395*
216K	21.3		1.66		2.5		9.8		10.9			7.3				15.0	*~80*	*~306*
216H	52.9	4.7	2.48	1.79	5.9	0.87	15.4	0.33	32.7	7.5	7.0	11.7	0.88	0.34	2.23	19.1	166	1006
216O	137	12.3	6.37	3.90	15.6	2.28	44.8	0.78	80.2	18.8	17.3	8.7	2.29	0.84	5.27	51.2	408	1239
216R	49.3		2.10		5.0		16.6		26.6			11.1				15.2	*~147*	*~432*
216S	19.1		2.31		2.7		10.5		9.5			13.9				22.1	*~93*	*~253*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
216N	4.00	90.7	644	2.2				7.8		18			15.7	6310	80	21.0			295			8.5			3.0		29	30.0
216J	0.82	6.7	382			0.56		9.1		3			22.5		729	1.9		6	511						1.2	5.3		
216Jm	0.80	4.1	647			2.92		2.5		2			42.9		281	2.5		26	470						1.8	3.3		
216Jb	3.60	26.4	1370			1.31		6.9		3			7.0		44	11.3		19	245						2.1	12.4		
216nod				1.7		1.28	18		3.5	1				6590	9460	0.2	2.2							601		0.5		
216L			1540				29			2									228							15.3	115	
216K			900				38			6									456							2.7	170	
216H			802				91			3									108							3.2	154	
216O			1280				24			8									320							3.4	75	105
216R			1980				30			9									373							5.3	59	220
216S			880				29			5									547							5.2	67	206

REE Section 217

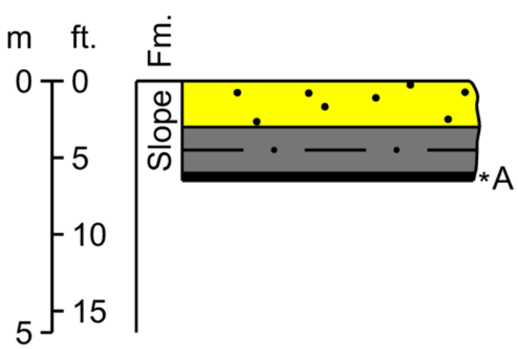
T.135N., R.109W., Sec.5
Elevation at top 2,847 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
217N	20.7		1.66		2.2		11.5		10.2			11.5				13.8	*~82*	*~178*

REE Section 218

T.135N., R.105W., Sec.9, ??
Elevation at top 2,860 ft.



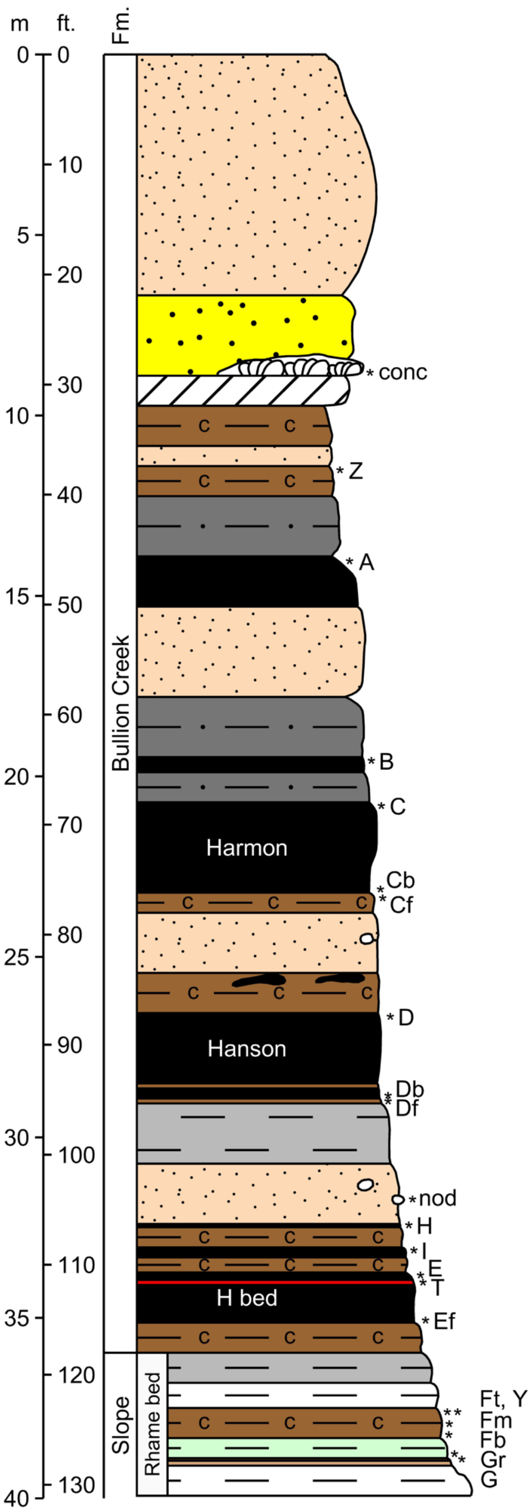
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
218A	90.1	8.0	5.27	1.93	8.1	1.74	49.4	0.79	40.1	10.3	7.7	20.5	1.31	0.75	4.88	47.3	298	401

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
217N	2.47	60.4	1040	2.8				2.3		15			7.9	5390	87	8.5			325			4.9			3.4		80	145

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
218A	2.29	8.7	270	7.2				7.5		7			89.7	9740	40	16.8			174			20.1			4.1		202	399

REE Section 219

T.136N., R.102W., Sec.6, NW 1/4
Elevation at top 2,604 ft.

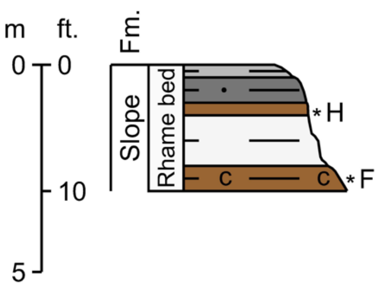


SAMPLE ID	LAB ANALYSIS (in µg/g)															TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
219conc	14.5		0.70		1.3		7.6		6.8			3.8				6.1	*~47*	*~69*
219Z	48.7		2.20		4.0		25.1		22.2			10.8				18.4	*~150*	*~184*
219A	36.9		2.17		3.4		18.6		16.7			8.1				18.4	*~120*	*~243*
219B	19.6		2.23		3.3		8.1		12.0			8.0				17.3	*~84*	*~285*
219C	64.0		4.17		8.5		29.8		32.3			10.8				37.4	*~221*	*~539*
219Cb	83.2		5.07		11.2		30.0		49.4			19.3				33.4	*~276*	*~791*
219Cf	51.9		1.46		3.3		26.1		22.5			9.0				12.7	*~143*	*~150*
219D	16.1		1.73		2.6		7.0		9.3			5.6				13.9	*~67*	*~318*
219Db	5.0		1.20		1.4		2.3		3.2			1.9				10.5	*~31*	*~419*
219Df	70.3		2.07		4.6		35.5		30.2			13.1				17.8	*~196*	*~214*
219nod	24.1		0.93		1.8		13.1		11.0			4.2				7.3	*~71*	*~90*
219H	82.5		3.84		7.3		42.4		36.7			17.2				29.7	*~252*	*~378*
219I	41.4		2.53		5.5		16.7		27.1			17.3				17.7	*~150*	*~310*
219E	38.8		3.65		5.0		20.4		16.3			8.8				33.0	*~148*	*~536*
219T	65.0		1.77		4.0		28.9		26.3			2.8				13.8	*~162*	*~260*
219Ef	70.0		2.46		4.3		36.2		29.5			14.3				19.1	*~198*	*~224*
219Ft	61.0		2.30		4.3		32.3		25.8			14.9				16.7	*~178*	*~192*
219Y	69.6		3.32		5.9		38.7		32.2			14.0				27.9	*~219*	*~246*
219Fm	57.3		2.05		3.6		32.4		23.9			15.9				14.9	*~168*	*~182*
219Fb	45.7		1.90		2.9		25.9		19.0			15.7				14.5	*~141*	*~151*
219Gr	69.1		2.24		4.2		35.4		28.4			17.0				18.2	*~196*	*~206*
219G	60.1		2.22		4.2		30.1		26.6			13.3				17.2	*~174*	*~183*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
219conc				0.8		2.81	18		5.3	1				10600		0.2	4.0							949		1.0	29	30.0
219Z				2.6		9.26	57		19.1	5				22800		1.7	13.9							2840		2.9	75	105
219A				4.5		4.32	32		15.8	6				7610		3.9	13.4							1740		4.2	59	220
219B				2.9		1.48	18		12.7	7				2820		16.0	12.8							840		12.0	67	206
219C				2.5		0.79	28		12.5	2				4190		8.7	15.7							3080		9.2	80	145
219Cb				3.0		2.42	73		24.7	4				4240		2.9	39.3							1590		6.6	202	399
219Cf	1.47	5.2	580	1.3		7.72	45	4.1	17.8	3	2.6		31.5	7820	115	0.9	15.9	109	65	1.21		8.6		3070	2.3	2.5	69	83.4
219D				2.8		0.78	10		8.0	3				6240		11.1	6.3							345		7.8	28	31.4
219Db				2.4		0.05	2		2.0	<1				4810		3.2	0.7							79		1.5	3	7.5
219Df	0.96	6.2	558	2.2		14.5	66	7.1	22.2	3	3.0		49.6	14300	182	0.7	14.5	162	109	1.11		12.4		3730	1.9	2.8	92	95.2
219nod				0.6		3.22	41		6.6	1				5410	151	12.2	6.6							1430		1.2	32	40.9
219H				2.9		9.87	76		26.1	10				6530		14.1	19.7							3050		9.8	160	304
219I				1.7		4.00	78		20.7	7				3260		14.5	13.0							2000		11.7	172	229
219E				7.2		0.47	19		7.2	1				7160		1.4	6.3							1010		3.0	30	59.6
219T	0.68								41.7		2.6		79.6				3.5			2.03		43.9	8.1	1170				54.0
219Ef	2.19	3.8	907	1.4		11.2	59	2.0	25.5	4	3.8		27.0	6580	51	2.7	20.3	100	91	1.55		11.7		5310	3.3	10.5	94	140
219Ft				2.8		12.4	83		29.6	2				6530		2.3	17.3							4120		2.7	129	123
219Y				3.0		11.0	83		23.8	2				8130		3.0	15.2							3710		3.7	124	126
219Fm				2.3		13.2	83		28.1	2				7070		2.5	16.1							3990		3.8	147	122
219Fb				2.6		13.1	86		28.1	2				6730		2.5	17.1							4260		2.9	142	127
219Gr	1.72	3.0	1010	2.3		16.4	79	4.5	27.3	3	3.9		46.1	7710	47	2.4	15.7	148	95	1.14		14		3720	2.2	4.6	135	125
219G				2.4		11.6	65		22.1	2				5960		2.1	16.5							3800		3.0	106	119

REE Section 221

T.136N., R.102W., Sec.7, NE
Elevation at top 2,505 ft.

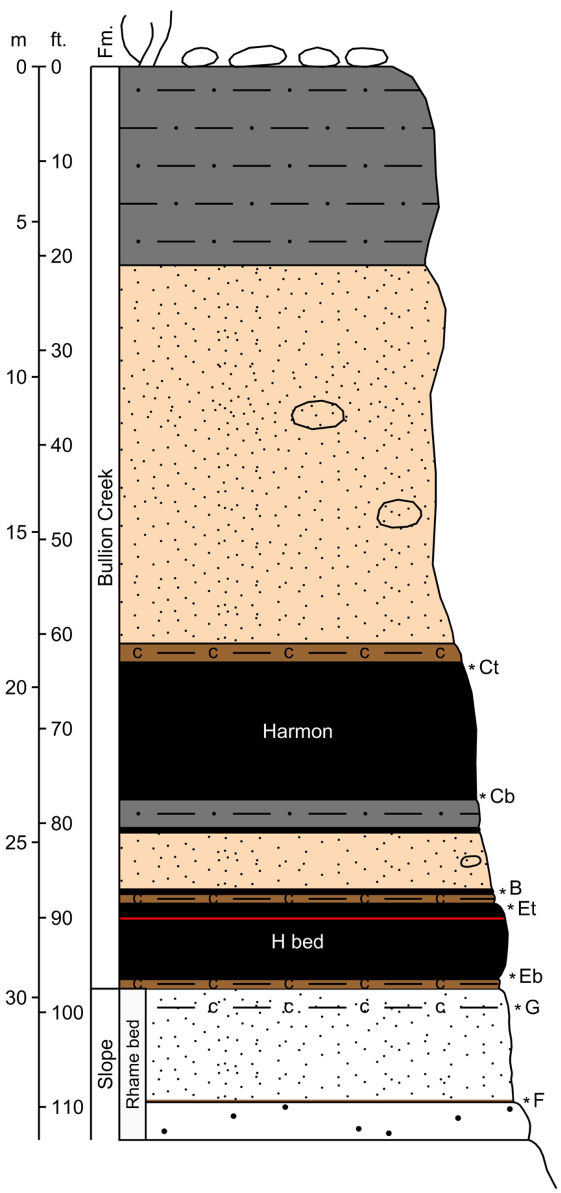


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
221H	65.7		2.19		4.7		33.2		28.8			13.1				17.1	*~187*	*~196*
221F	95.7	8.4	4.97	2.18	9.9	1.74	50.3	0.67	47.2	11.2	9.8	13.4	1.45	0.69	4.45	43.9	306	326

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
221H						9.38	65		22.3	3			34.5	5030		3.1	16.6									4.0	99	
221F						9.05	67		20.5	4			46.0	10100		1.6	16.2									4.0	89	

REE Section 238

T.136N., R.102W., Sec.28, NW/SE
Elevation at top 2,645 ft.

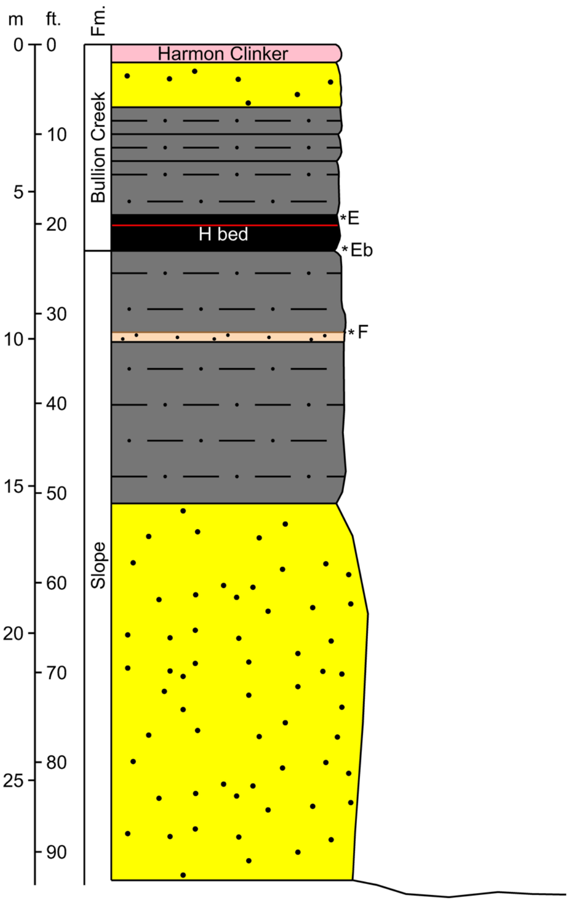


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
238Ct	21		3.72		5.3		9.3		13.8			9.5				34.0	*~118*	*~624*
238Cb	10.8		0.37		0.7		5.9		4.7			2.4				3.4	*~32*	*~169*
238B	142	9.5	5.02	2.98	12.6	1.77	73.1	0.67	66.2	16.6	13.5	19	1.79	0.66	4.39	41.1	411	584
238Et	131	10.0	5.32	3.12	11.9	1.86	56	0.70	65.8	16.4	14.1	22	1.85	0.73	4.61	40.0	385	982
238Eb	12.3		0.82		1.5		6.4		5.5			3.4				8.0	*~44*	*~224*
238G	46.1		1.65		2.8		23.3		19.2			7.6				12.5	*~128*	*~137*
238F	58.4		1.89		3.7		28		25.1			9.7				13.2	*~158*	*~170*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
238Ct				6.3					5.7	3			3.1	2980		2.7	5.3			0.25				817		5.5	20	52.1
238Cb				0.5					4.4	1			6.0	5440		1.7	3.1			0.25				807		1.5	15	24.0
238B				3.6					33.0	8			144.0	8170		28.3	16.1			0.97				2720		26.5	174	234.0
238Et				3.4					16.1	5			18.0	6280		18.3	9.7			0.50				1580		24.6	231	251.0
238Eb				0.7					7.9	3			21.6	10400		5.4	1.9			0.15				337		2.3	14	32.3
238G				1.0		4.07	38		16.8	2			31.7	2930		1.1	12.3									3.1	55	121.0
238F				1.3		3.31	60		16.7	3			25.3	3130		3.9	12.1									4.4	77	129.0

REE Section 239

T.136N., R.102W., Sec.22, NE/NW/NE
Elevation at top 2,562 ft.

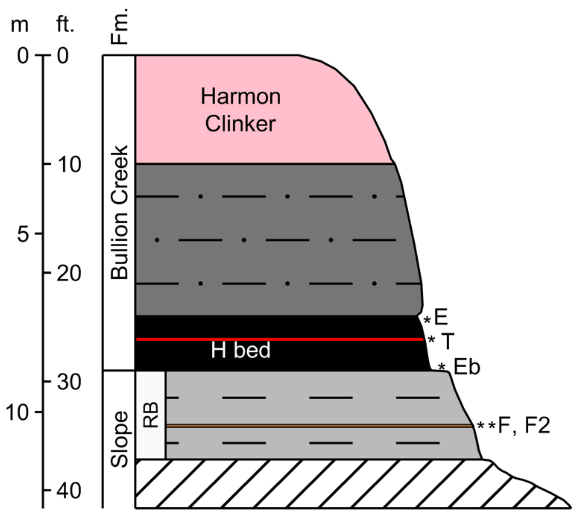


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
239E	35.5		1.93		3.7		13.9		19.9			11.3				12.5	*~115*	*~212*
239Eb	74.1		4.85		7.5		39.7		30.8			13.5				44.4	*~249*	*~630*
239F	68.6		2.20		4.6		37.4		30.3			15.4				16.5	*~197*	*~212*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
239E				1.6					16.3	11			44.4	4900		29.9	13.4			1.22				2570		11.5	70	528.0
239Eb				4.3					18.9	13			27.2	8040		2.9	9.5			0.61				1800		6.4	42	134.0
239F				2.2		9.04	83		22.8	5			38.7	7870		3.1	14.3									5.8	157	157.0

REE Section 240

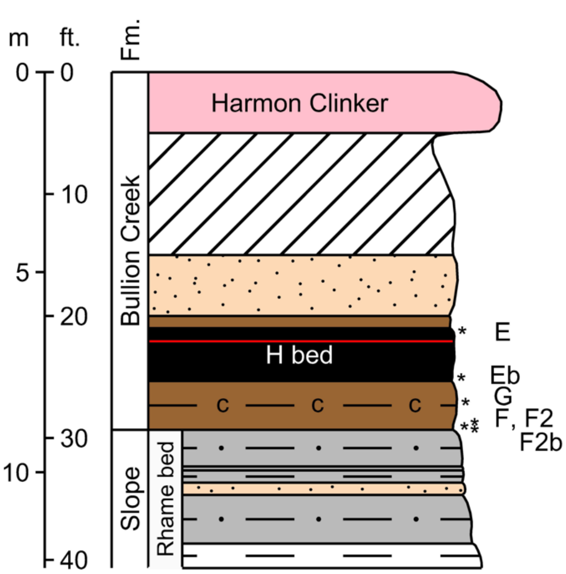
T.136N., R.102W., Sec.22, NE/SW/NE
Elevation at top 2,558 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
240E	18.5		2.30		2.8		10		9.6			7.8				18.0	*~82*	*~232*
240T	28.8		0.29		1.2		15.3		10.5			1.4				2.3	*~66*	*~77*
240Eb	44.8		1.62		3.2		21.7		20.6			9.6				11.4	*~128*	*~200*
240F	76.9		3.14		6.3		34.3		38.5			20.3				20.9	*~229*	*~269*
240F2	70.2		2.33		4.8		33.4		32.3			18.8				16.3	*~201*	*~221*

REE Section 241

T.136N., R.102W., Sec.22, SE/NW/NE
Elevation at top 2,562 ft.



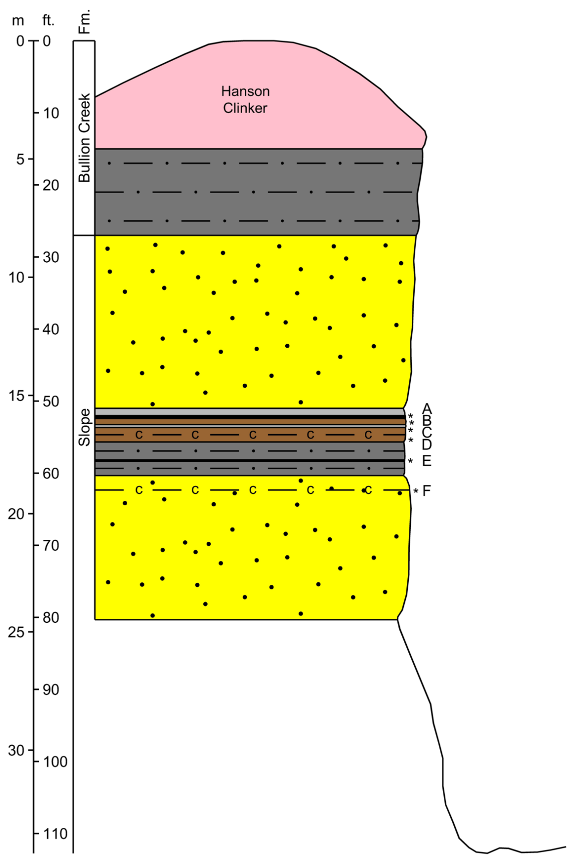
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
241E	127	12.3	7.38	2.64	13	2.52	56.8	1.04	59.6	14.9	12.3	13.6	2.08	1.03	6.67	60.2	393	768
241Eb	67.1		2.93		5.2		32.4		29.4			19.4				22.9	*~204*	*~281*
241G	63.7		2.88		5.5		29		31.5			34.4				19.0	*~211*	*~265*
241F	55.2		2.22		4.5		25.9		27.4			23.8				15.1	*~175*	*~228*
241F2	82.7		3.06		6.3		39.5		37.7			22				21.7	*~242*	*~284*
241F2b	76.1		2.31		5.1		36.0		33.2			14.4				17.3	*~209*	*~220*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
240E				5.4					13.2	7			9.8	13100		25.3	11.4			0.27				554		13.5	47	112.0
240T	0.96	1.9	250	0.8	0.55	0.4	4	0.4	59.9	2	2.9	0.02	147.0	2890	14	1.3	6.4	14	49	2.83	<0.1	11	6.1	1250	1.1	1.7	8	31.6
240Eb				0.9					16.3	7			16.3	4260		23.7	13.3			0.93				2870		10.6	80	129.0
240F				1.8		12	129		25.7	26			35.5	5440		12.3	16.5									21.3	264	328.0
240F2				1.8		13.5	99		25.7	21			35.1	5390		9.6	17.3									17.0	158	228.0

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
241E				5.5					24.0	6			41.2	5090		18.1	13.0			1.33				3150		17.5	76	283.0
241Eb				1.7					27.7	7			28.4	6040		5.2	16.7			1.21				3990		10.1	114	153.0
241G				1.8		11.1	181		22.7	4			34.2	6270		5.6	12.0									22.1	196	227.0
241F				1.6		10.2	136		23.3	18			29.6	5780		21.2	16.4									27.6	249	343.0
241F2				2.3		13.5	159		33.8	30			29.4	6080		28.3	19.0									23.6	290	376.0
241F2b				1.5			52		17.2	8	3.3			3640		6.7	17.1							4020		8.4	88	120

REE Section 242

T.136N., R.102W., Sec.22, NW/NW/SW
Elevation at top 2,558 ft.

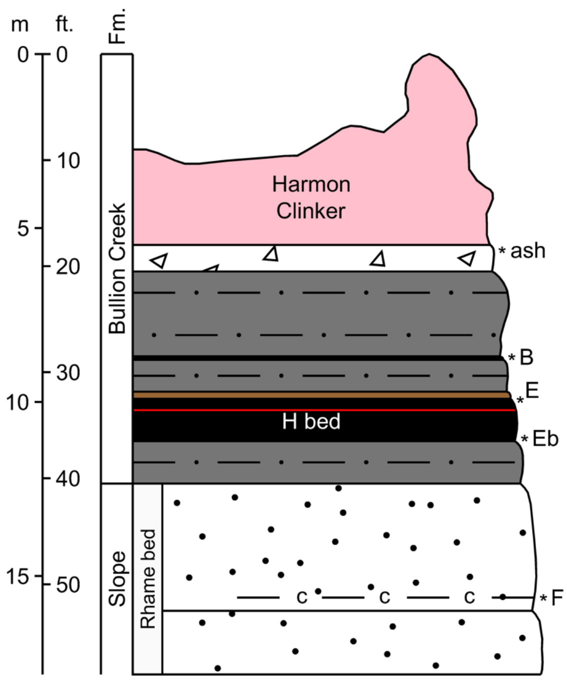


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
242A	78.1		3.47		6.5		36.3		36.1			20.8				26.4	*~238*	*~268*
242B	76.1		2.79		5.8		37.7		34.1			16.1				22.8	*~222*	*~251*
242C	75.4		2.39		5.5		37.3		33			13.6				20.9	*~213*	*~239*
242D	63.5		2.29		4.5		31.3		26.6			12.7				20.9	*~183*	*~219*
242E	65.2		3.77		6.4		31.8		30.9			10.9				34.2	*~212*	*~244*
242F	55.3		2.44		6.3		20.3		34.4			7.6				19.7	*~171*	*~191*

SAMPLE ID	LAB ANALYSIS (in µg/g)																										
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
242A				5.4		11.3	82		31.5	14			55.3	11000		2.7	14.1									10.1	130	193.0
242B				4.3		11.4	75		27.4	6			55.8	10400		1.8	14.1									5.5	108	126.0
242C				3.2		11.3	68		27.4	3			59.3	9400		1.5	14.9									3.6	98	107.0
242D				4.9		9.22	61		25.9	4			68.2	9830		2.0	11.8									4.1	105	91.9
242E				4.3		6.73	58		21.2	5			40.5	10900		4.7	10.9									12.4	107	184.0
242F				1.4		2.29	118		13.2	21			12.7	2280		5.1	9.6									2.4	93	280.0

REE Section 243

T.136N., R.102W., Sec.22, NW/SW/SW
Elevation at top 2,563 ft.

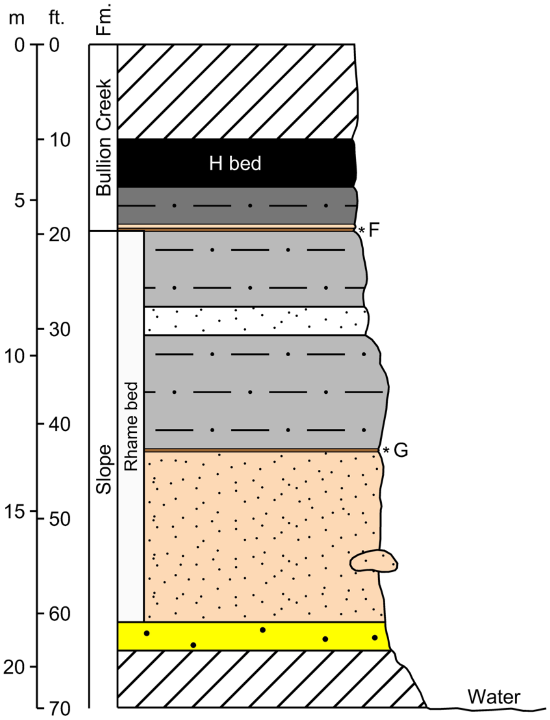


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
243ash	75.2		2.64		4.8		48.4		27.1			13.1				24.3	*~219*	*~253*
243B	35.3		6.22		9.2		18.4		22.2			12.9				59.2	*~200*	*~776*
243E	30.6		5.18		5.6		15.9		15.7			8.3				56.5	*~164*	*~329*
243Eb	27.6		1.73		2.9		16.6		11.9			5.1				19.2	*~98*	*~218*
243F	58		2.87		7.9		27.7		32.7			10.6				20.9	*~190*	*~203*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
243ash	2.70	40.9	5940	2.2	<0.1	0.66	33	4.9	22.1	3	5.0	0.1	143.0	32800	1790	2.4	19.4	13	2850	1.57	0.52	22.3	3.5	4380	5.9	7.5	131	166.0
243B				7.3					10.7	7			5.5	6600		26.0	9.1			0.26				828		13.6	84	234.0
243E				8.3					14.2	2			52.9	4790		16.7	11.1			0.93				2290		16.5	47	94.5
243Eb				3.2					14.4	4			56.8	20600		16.3	4.4			0.34				1020		4.6	20	38.0
243F				1.7		3.02	78		16.1	4			22.0	4400		7.9	9.3									3.6	132	166.0

REE Section 244

T.136N., R.102W., Sec.23, SW/NW/NW
Elevation at top 2,552 ft.

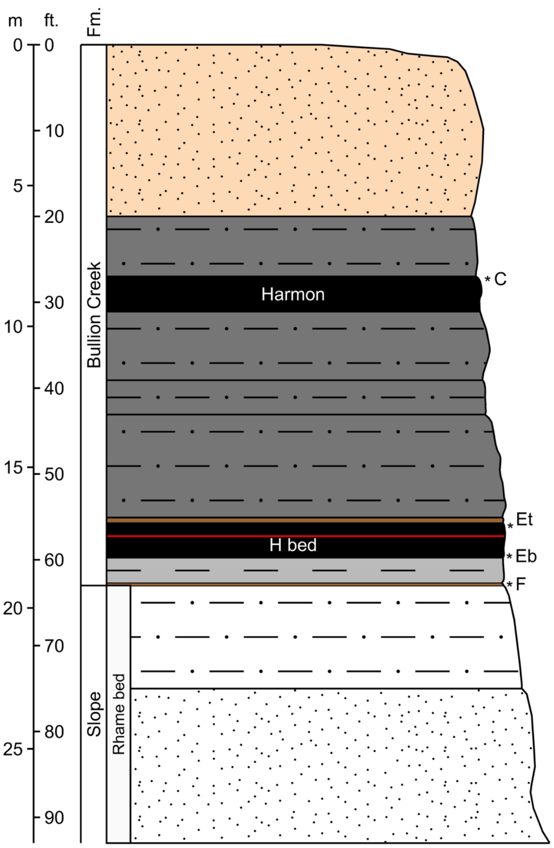


SAMPLE ID	LAB ANALYSIS (in µg/g)															TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
244F	95.2		2.74		6.9		45.7		45			15.5				19.4	262	289
244G	84.1		3.17		7.3		45.1		38.1			11.5				29.8	251	271

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
244F				1.7		8.98	110		23.5	11			24.2	3710		6.4	18.7									9.9	146	202.0
244G				4.0		9.01	61		26.0	3			97.5	7050		5.0	14.2									6.6	100	112.0

REE Section 245

T.136N., R.102W., Sec.23, SE/NW/SW
Elevation at top 2,575 ft.

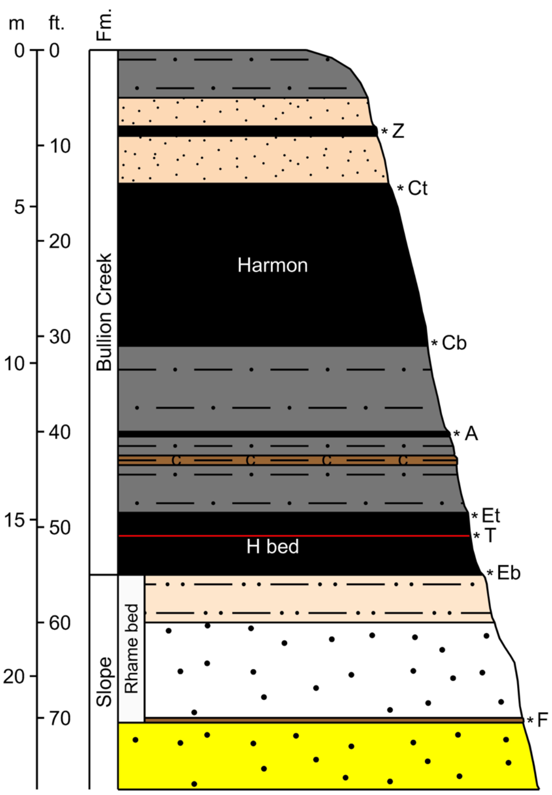


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
245C	52.1		5.59		8.3		22.8		27.3			11				43.5	*~206*	*~686*
245Et	93.7		3.95		7.3		42.4		40.8			14.6				31.4	*~268*	*~481*
245Eb	54.5		3.82		5.7		30.7		23.9			14.2				34.9	*~194*	*~545*
245F	109	7.2	3.36	2.45	9.5	1.23	46.5	0.45	54.3	13.6	12.2	30.2	1.42	0.45	2.96	23.3	318	433

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
245C				4.9					10.1	10			12.1	5010		7.6	4.6			0.26				901		12.2	21	57.4
245Et				4.0					19.1	8			44.5	5590		8.4	8.2			0.88				2330		14.5	71	161.0
245Eb				3.9					16.0	5			23.3	7470		3.0	9.6			0.72				2120		3.7	52	98.9
245F				1.6		10.5	255		29.1	25			37.2	5970		39.9	16.5									38.6	414	613.0

REE Section 246

T.136N., R.102W., Sec.33, NE1/4
Elevation at top 2,624 ft.

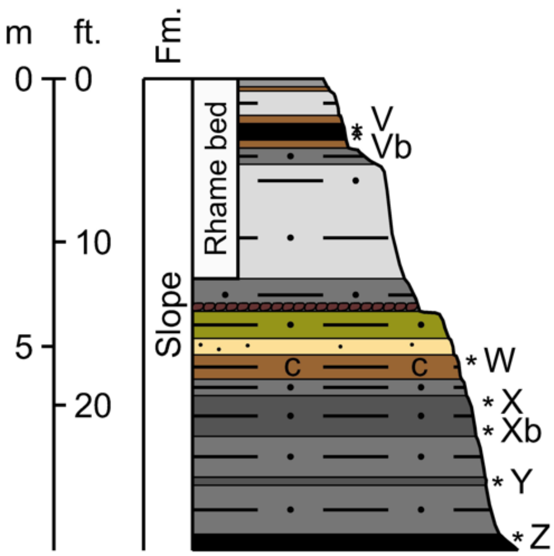


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
246Z	16.5		3.54		4.4		8.1		10.1			9.4				33.3	*~104*	*~286*
246Ct	58.5		5.48		10		22.6		36			13.1				43.0	*~228*	*~687*
246Cb	9.7		0.51		1		5.1		4.6			1.3				4.5	*~31*	*~261*
246A	69.4	11.8	8.21	2.26	10.6	2.65	35.6	1.22	35.9	8.5	8.3	15.6	1.82	1.15	7.33	84.8	305	940
246Et	47.9		2.55		4.8		24.2		24.5			16.2				19.2	*~160*	*~207*
246T	27.6		0.55		1.4		13.9		10.2			1.4				5.2	*~67*	*~85*
246Eb	25.3		2.18		2.7		14.6		10.7			5.1				18.6	*~92*	*~197*
246F	109		1.92		6.6		51.1		47.4			10.8				15.1	*~272*	*~287*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
246Z				7.3					11.2	4			7.5	18100		7.6	5.8			0.17				677		11.4	19	88.7
246Ct				3.7					9.7	3			7.8	6560		7.7	9.0			0.33				1080		11.0	48	141.0
246Cb				0.5					1.7	<1			3.0	5300		1.5	1.0			0.07				228		1.2	6	13.7
246A				7.3					16.7	18			13.3	11100		10.2	15.5			0.35				1060		9.4	91	321.0
246Et				1.9					27.1	9			36.4	6370		13.7	13.8			1.21				3720		12.6	146	247.0
246T	1.05	4.1	685	1.0	0.74	0.34	5	4.4	60.6	2	2.1	0.05	129.0	3080	25	3.8	4.1	14	97	2.40	0.17	21.8	10	1480	1.3	3.2	9	38.0
246Eb				1.0					11.0	6			26.0	11200		9.8	11.1			0.75				2340		6.1	34	119.0
246F				1.3		3.24	52		21.7	3			23.1	4240		17.5	12.6									3.6	106	92.0

REE Section 280

T.137N., R.86W., Sec.14, NE/NE/SE
Elevation at top 2,035 ft.

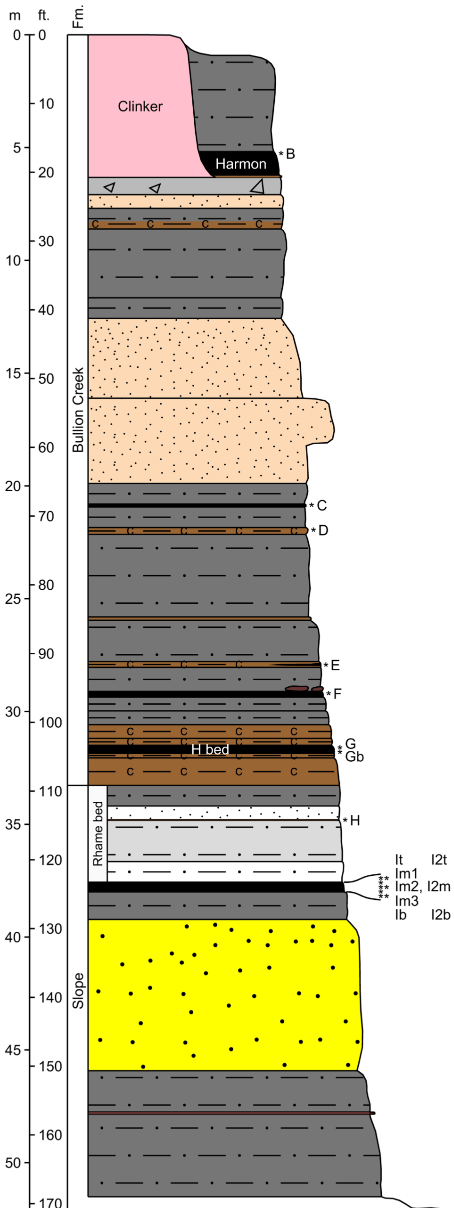


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
280V	70.2		4.84		8.7		30.0		37.1			17.9				41.6	*~247*	*~430*
280Vb	116	9.4	5.09	2.85	11.6	1.77	49.9	0.67	57.2	14.3	12.8	19.7	1.70	0.69	4.47	42.3	350	520
280W	80.2		2.89		6.5		39.0		38.3			15.3				23.2	*~234*	*~260*
280X	112	6.3	3.43	2.17	8.3	1.19	52.7	0.46	48.2	12.6	9.9	20.5	1.17	0.48	3.09	29.1	312	337
280Xb	103	7.1	3.63	2.17	9.1	1.31	50.3	0.46	45.4	11.6	9.4	13.9	1.31	0.50	3.16	32.2	*~295*	*~318*
280Y	95.1		3.36		7.2		51.9		36.3			16.4				32.7	*~276*	*~308*
280Z	159	11.8	5.12	3.85	14.8	1.99	70.8	0.52	71.8	18.8	16.4	18.9	2.22	0.65	3.81	45.4	446	529

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
280V								16.6	18																17.0			
280Vb	24.1		3.7		5.64	93	13.9	26.3	15			47.1	3780		7.1	12.9			0.88				3460	1.7	16.3	150	215	
280W								25.1	8																4.8			
280X	21.5		2.6		9.74	127	14.9	32.2	10			49.4	8370		3.6	15.8			1.1				5060	2.1	4.4	198	128	
280Xb	30.6		2.3		5.9	74	12.3	22.4	10			39.2	4680		2.7	13.4			0.96				3970	1.8	5.4	126	133	
280Y								30.3	9																4.9			
280Z	9.5		3.3		3.72	87	17.2	21.0	13			27.1	2920		3.4	14.3			1.05				3820	2.2	4.6	133	130	

REE Section 284

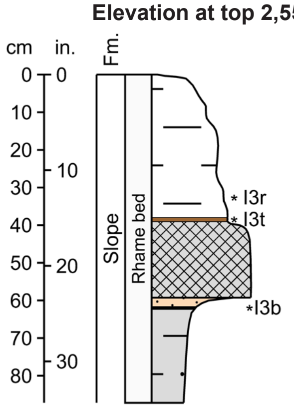
T.137N., R.103W., Sec.32, NW/SW/SE
Elevation at top 2,660 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
284B	31.9		2.32		3.5		15.6		14.0			6.8				23.4	*~113*	*~430*
284C	39.2		4.50		5.4		19.7		19.9			21.4				36.8	*~172*	*~261*
284D	49.3		3.37		5.2		25.9		23.9			15.6				29.2	*~176*	*~294*
284E	61.4		4.35		6.8		28.8		30.4			25.7				35.3	*~223*	*~462*
284F	53.5		4.19		6.3		31.1		23.7			15.4				40.0	*~202*	*~675*
284G	45.6		2.10		3.7		23.7		19.1			6.7				21.6	*~140*	*~332*
284Gb	33.8		3.48		4.4		18.0		14.8			8.5				33.0	*~136*	*~401*
284H	81.7		2.69		6.0		38.9		38.9			20.6				19.8	*~236*	*~265*
284It	686	39.5	19.5	12.50	53.7	7.22	316	2.08	307	78.0	62.1	24.9	7.57	2.54	15.00	195	1829	3280
284I2t	1090	54.1	23.2	19.50	81.4	9.07	526	2.20	483	124.0	98.2	26.2	11.10	2.83	16.40	225	2792	5068
284Im1	651	44.2	24.3	12.20	55.3	8.62	299	2.69	298	75.0	60.6	29.4	8.06	3.15	18.80	248	1838	3999
284Im2	224	23.1	13.9	5.41	25.2	4.74	103	1.76	109	26.1	24.2	28.9	3.87	1.90	11.90	141	748	2048
284I2m	207	16.2	9.32	4.17	20.1	3.26	116	1.17	97.8	23.8	19.5	21.4	2.90	1.25	7.68	99.8	651	1829
284Im3	222	18.9	11.2	4.91	22.6	3.83	102	1.41	109	26.1	23.0	25.5	3.32	1.51	9.43	112	697	1583
284Ib	226	14.3	7.79	4.45	19.9	2.73	109	1.01	108	27.0	21.7	22.0	2.66	1.05	6.78	78.4	653	978
284I2b	100	9.5	5.76	2.35	10.9	1.95	51.3	0.79	51.8	12.3	10.6	20.1	1.62	0.80	5.14	53.3	338	647

REE Section 284 East

T.137N., R.103W., Sec.32, NW/SW/SE
Elevation at top 2,557 ft.



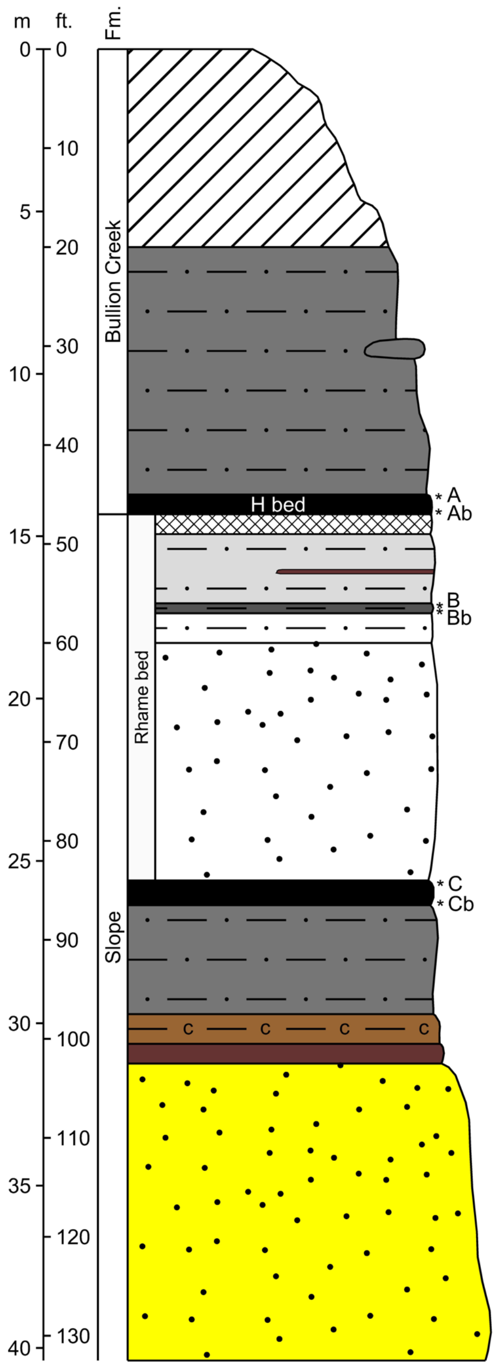
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
284I3r	121	6.4	3.39	2.12	8.8	1.19	60.2	0.45	54.7	14.1	10.9	14.9	1.24	0.47	3.06	30.0	*333*	363
284I3t	336	21.0	10.2	6.89	28.0	3.72	135	1.09	157	39.4	34.2	11.0	4.03	1.31	8.10	91.4	888	1005
284I3b	200	17.1	9.15	5.04	21.6	3.21	86.3	1.11	109	25.8	23.6	23.8	3.08	1.21	7.57	83.1	621	1018

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
284B								10.1	8																5.2			
284C								33.6	13																24.1			
284D								22.7	9																17.8			
284E								26.9	15																19.1			
284F								23.1	6																12.1			
284G								11.9	7																4.7			
284Gb								25.6	14																6.3			
284H								30.1	10																11.2			
284lt	36.0	1670	10.0	0.24	2.87	68	43.4	37.0	45	3.3	0.03	41.4	4110	97	11.9	9.1	32	411	0.8	0.05	8.2	1.3	2020	1.4	26.1	175	156	
284l2t	29.2	1390	14.9	0.58	3.46	90	32.4	18.3	21	2.8	0.05	58.8	2950	41	5.7	9.4	41	343	0.78	0.05	11.1	1.8	2060	1.5	20.8	158	123	
284lm1	30.9	1250	9.1	0.14	2.71	60	23.2	18.7	24	4.7	0.04	47.6	4060	49	27.7	10	30	382	0.9	0.1	11.8	2.0	2020	1.8	20.9	232	256	
284lm2	22.0	1580	9.3	0.39	1.23	34	17	25.3	29	4.4	0.03	36.4	3300	35	29.9	11.5	11	386	0.87	0.16	9.4	1.4	2160	2.1	9.7	85	232	
284l2m	17.1	1000	12.4		1.08	33	33.2	24.3	33	3.1	0.04	34.3	2420	37	14.1	13.7	11	358	0.94	0.1	11.5	1.5	1920	3.4	8.0	65	145	
284lm3	16.9	1520	8.0	0.29	1.61	35	12.5	17.7	19	4.1	0.04	40.8	3450	36	27.1	12	15	316	0.98	0.11	10.5	1.6	2350	2	10.5	71	202	
284lb	7.4	1040	7.2	0.71	8.25	55	7	37.6	24	5.00	0.07	49.3	5020	58	14.5	21.8	65	255	2.16	0.1	18.9	4.4	4450	3.9	11.5	102	204	
284l2b	45.2		6.3		4.85	81	20.7	29.9	18			52.5	3370		27.8	15			0.89				1890	3.1	13.7	156	270	

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
284l3r	9.1		3.1		9.54	70	10.9	23.2	4			54.8	5900		1.6	15.3			1.09				3640	2.1	5.3	113	113	
284l3t	9.3	363	2.3	0.33	0.9	33	6.3	6.7	8	2.6	0.02	17.1	604	15	3.2	11.3	11	92	0.94	0.03	7.8	1.1	2670	3.4	8.1	56	105	
284l3b	27.7	1010	6.5	0.44	1.16	90	10	10.2	11	3.7	0.07	33.2	1050	20	5	12.7	17	225	1.04	0.06	19	1.7	2860	6.6	22.2	153	205	

REE Section 285

T.136N., R.104W., Sec.17, NE/NE/NE
Elevation at top 2,700 ft.

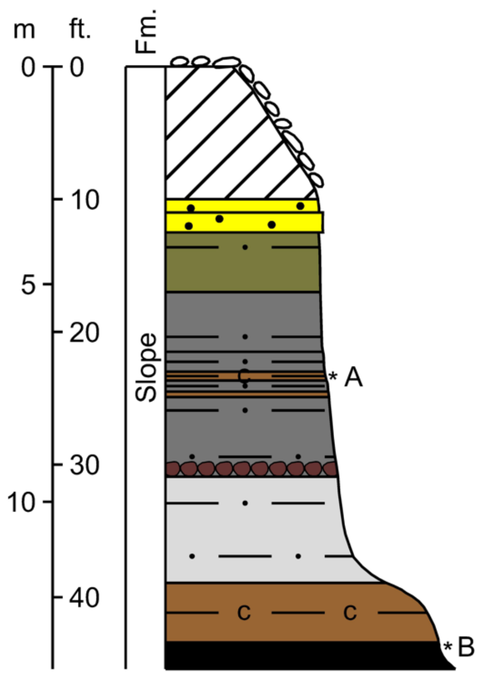


SAMPLE ID	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	TOTAL REE: Whole Coal	TOTAL REE: Ash
	LAB ANALYSIS (in µg/g)																	
285A	12.2		0.75		1.4		5.5		6.7			5.5				6.8	*~45*	*~126*
285Ab	16.2		2.10		2.4		8.9		7.6			6.2				21.5	*~76*	*~167*
285B	35.9		2.16		3.2		20.6		15.7			7.0				19.4	*~119*	*~126*
285Bb	26.3		2.39		2.4		16.1		10.7			9.5				20.9	*~101*	*~108*
285C	66.2		3.63		5.9		34.6		29.5			16.1				32.1	*~215*	*~274*
285Cb	51.4		2.14		3.8		29.0		22.5			15.1				18.8	*~161*	*~195*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
285A								3.0	12																5.8			
285Ab								21.4	25																11.2			
285B								24.7	4																5			
285Bb								37.2	4																5.2			
285C								30.2	8																5.0			
285Cb								27.5	9																7.1			

REE Section 286

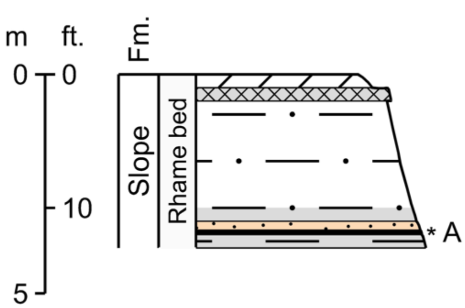
T.131N., R.104W., Sec.36, SW1/4
Elevation at top 3,210 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
286A	32.3		1.78		2.0		19.5		12.7			13.0				14.8	*~108*	*~124*
286B	154	9.1	4.46	3.08	12.0	1.64	67.1	0.52	67.0	17.1	13.5	11.6	1.70	0.59	3.68	40.6	408	668

REE Section 287

T.129N., R.92W., Sec.16, SE/SE
Elevation at top 2,600 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
287A	171	11.9	6.26	3.33	14.5	2.26	85.2	0.77	75.5	19.6	15.2	19.2	2.16	0.84	5.24	63.0	496	566

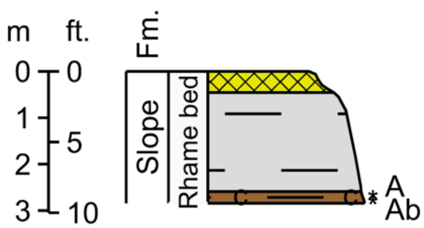
SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
286A								26.3	6																3.0			
286B	19.4		2.6		3.85	53	18.1	20.8	21			21.5	4760		23.4	11.1			0.65				2210	2.6	3.8	109	206	

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
287A	20.4		4.9		11.6	97	7.4	34.6	17			219	7900		8.9	21.6			1.47				4030	2.9	13.8	209	194	

REE Section 288

T.131N., R.95W., Sec.16, SW/SW/NE

Elevation at top 2,605 ft.

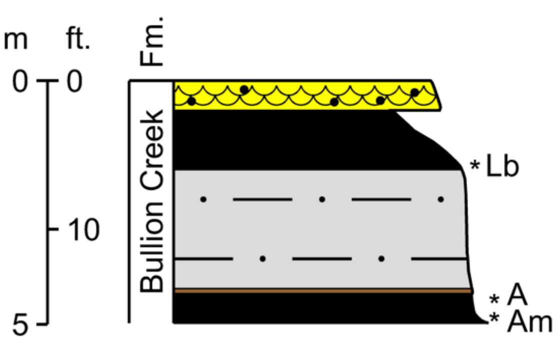


SAMPLE ID	LAB ANALYSIS (in µg/g)															TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
288A	68.2		2.31		4.7		35.8		30.5			17.6				18.6	*~200*	*~216*
288Ab	62.5		2.08		4.3		34.0		27.5			16.5				16.7	*~184*	*~200*

REE Section 289

T.130N., R.96W., Sec.16, NE1/4

Elevation at top 2,820 ft.



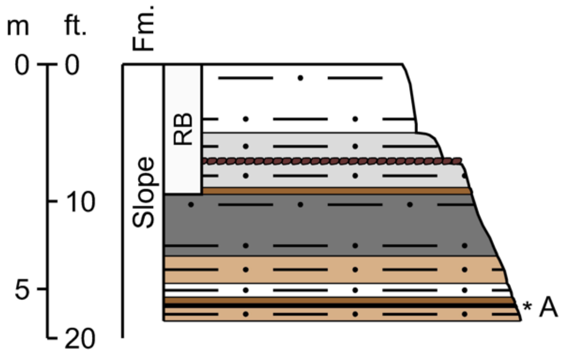
SAMPLE ID	LAB ANALYSIS (in µg/g)															TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
289Lb	31.8		3.15		4.4		16.6		16.1			11.6				32.2	*~135*	*~281*
289A	30.0		2.94		4.7		11.9		17.5			9.4				25.2	*~121*	*~397*
289Am	12.6		0.91		1.7		5.9		6.3			2.4				13.5	*~50*	*~350*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
288A								30.1	6																6.8			
288Ab								29.1	6																6.4			

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
289Lb								12.8	7																10.4			
289A								8.4	4																11.0			
289Am								4.1	1																2.1			

REE Section 290

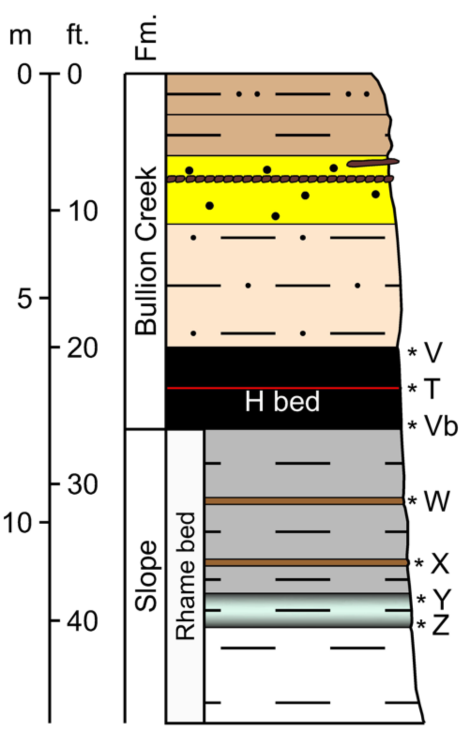
T.130N., R.101W., Sec.36, NW/NW
Elevation at top 2,960 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
290A	154	10.8	5.33	4.48	15.3	1.90	67.2	0.71	85.7	20.1	19.6	27.0	2.09	0.74	4.88	40.7	461	662

REE Section 294

T.135N., R.104W., Sec.15, NE/NW/NW
Elevation at top 2,792 ft.



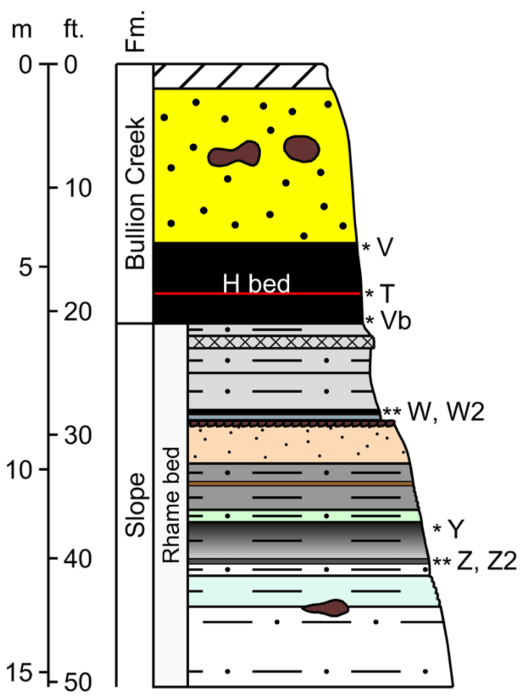
SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
294V	37.1		2.36		4.2		18.1		17.1			6.2				22.6	*~126*	*~393*
294T	15.5		0.22		0.6		8.2		5.1			1.4				2.0	*~36*	*~45*
294Vb	59.0		2.31		3.5		31.6		24.3			12.2				20.4	*~172*	*~218*
294W	104	8.1	4.41	2.13	9.3	1.55	53.1	0.59	47.3	12.4	9.8	21.6	1.40	0.60	3.91	40.4	321	400
294X	78.4		2.44		5.5		39.4		34.2			14.6				20.7	*~221*	*~237*
294Y	156	8.7	4.15	2.81	11.9	1.55	77.8	0.52	69.3	18.5	13.6	17.3	1.67	0.56	3.50	38.5	426	461
294Z	55.3		1.88		3.6		29.0		23.5			13.3				16.2	*~161*	*~170*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
290A	57.7		2.8		9.85	163	10.4	32.2	24			31.3	7370		13.6	17.9			0.99				3390	3.6	20.1	271	373	

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
294V								8.5	8																9.6			
294T								65.5	3																0.9			
294Vb								32.2	8																6.4			
294W	22.9		4.8		13.1	116	51.9	31.0	25			54.9	8240		9.2	14.9			0.98				3410	2.3	8.9	232	282	
294X								25.0	8																7.1			
294Y	10.1		3.9		11.9	88	8.2	33.0	13			85.4	6720		2.8	19.3			1.45				4690	3.4	10.1	144	142	
294Z								25.1	6																3.7			

REE Section 295

T.135N., R.104W., Sec.6, NW/NE
Elevation at top 2,810 ft.

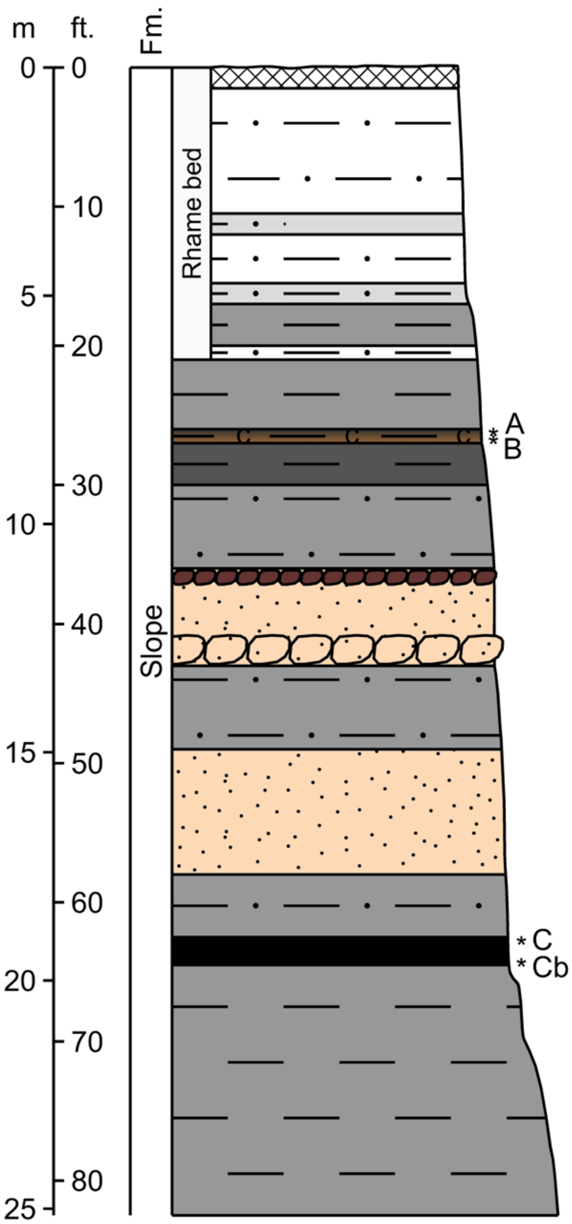


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
295V	22.6		3.08		3.4		12.9		10.8			14.7				28.0	*~112*	*~344*
295T	12.2		0.20		0.5		6.5		4.1			1.3				1.7	*~29*	*~36*
295Vb	31.8		1.93		2.7		17.9		12.7			7.2				16.8	*~104*	*~157*
295W	140	13.0	6.74	3.30	16.1	2.44	67.7	0.76	72.2	17.6	14.4	16.1	2.27	0.83	4.97	72.2	451	628
295W2	86.0		3.70		7.9		39.2		42.7			22.1				27.0	*~263*	*~312*
295Y	103	6.8	3.61	1.89	8.2	1.24	55.7	0.52	46.4	12.4	9.2	20.7	1.19	0.51	3.33	32.5	307	337
295Z	76.9		2.34		5.5		38.3		34.0			13.5				20.1	*~216*	*~228*
295Z2	54.6		2.02		3.5		29.4		22.9			14.6				16.1	*~161*	*~183*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
295V								24.7	6																10.6			
295T								57.3	3																1.5			
295Vb								8.9	5																5.9			
295W	87.1		4.4		12.0	143	38.2	32.3	57			38.7	9180		30.7	18.7			0.85				2920	2.3	29.3	289	585	
295W2								28.0	27																10.0			
295Y	10		4.7		16.4	101	8.9	36.5	10			90.9	9810		4.8	17.6			1.34				4320	3.3	8.7	172	168	
295Z								24.1	7																6.8			
295Z2								29.3	11																7.6			

REE Section 300

T.136N., R.106W., Sec.34, NE/NW
Elevation at top 3,100 ft.

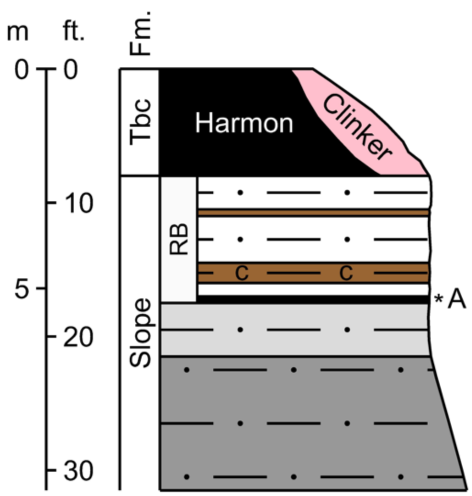


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
300A	439	24.6	11	9.82	35.9	4.08	159	1.26	218	53.8	48.8	30.5	4.95	1.44	8.94	92.2	1143	1462
300B	134	10.4	5.78	3.13	12.5	1.99	58	0.77	67.7	16.7	15.0	21	1.85	0.81	5.27	49.4	404	456
300C	67.2		2.2		4.8		34.5		29.4			14.6				19.9	*~195*	*~214*
300Cb	96		3.44		7.3		47.6		42.8			16.3				31.6	*~279*	*~425*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
300A	159	318	3.1	0.54	9.19	125	10.8	27.2	31	6.4	0.13	40.3	4730	40	73.7	14.3	125	581	0.93	0.19	17.4	2.4	2540	5.6	28.4	286	342	
300B	82.1		2.7	0.89	11.1	92	8	24.9	24			45.5	6420		37.1	15.9			1.14				3770	3.8	10.9	161	244	
300C								23.2	3																4.5			
300Cb								23.1	13																7.2			

REE Section 301

T.137N., R.102W., Sec.6, NE/NW
Elevation at top 2,450 ft.

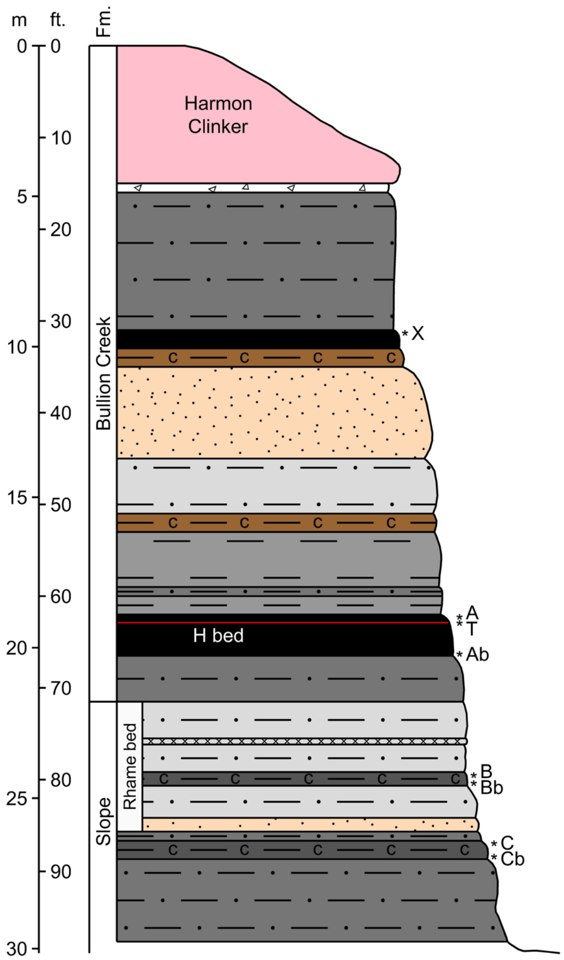


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
301A	101	12.2	6.55	3.08	14.2	2.32	31.4	0.86	58.9	13.5	13.4	33	2.16	0.89	5.76	57.8	357	1044

SAMPLE ID	LAB ANALYSIS (in µg/g)																													
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
301A	78.8		3.8	0.35	2.77	71	20.9	21.6	12			16.5	3270		39	18.6			0.38				1100	4.1	27.6	224	185	

REE Section 302

T.136N., R.103W., Sec.35, SW/NW/SE
Elevation at top 2,634 ft.

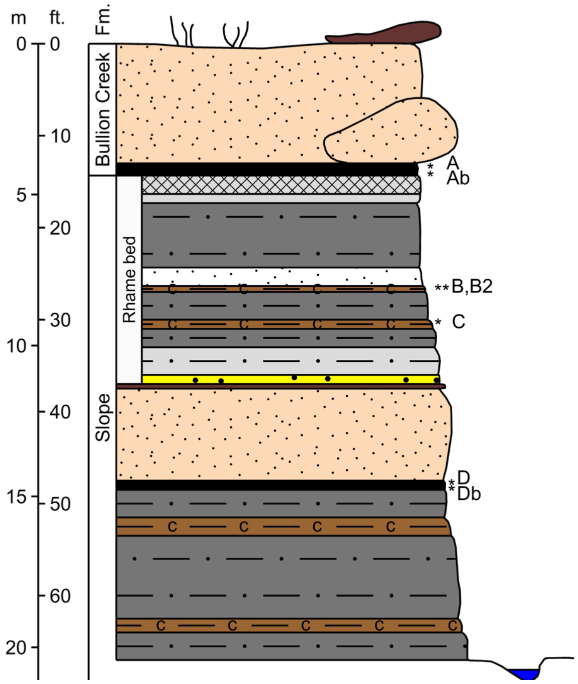


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
302X	35.8		2.6		4.1		19		17.2			9.7				33.1	*~140*	*~235*
302A	99.9		3.78		9.3		42.5		50			8.1				30.9	*~284*	*~679*
302T	31.9		0.86		2		16.5		12.2			1.6				9	*~84*	*~107*
302Ab	46.2		2.2		3.6		25.7		17.1			19.2				22	*~153*	*~430*
302B	128	11.6	5.23	3.72	14.1	1.95	48.1	0.62	66.5	16.7	17.4	31.3	2.18	0.68	4.22	48.2	401	530
302Bb	54		1.94		3.4		32.7		21.4			18.1				16.9	*~166*	*~184*
302C	99.7	10.9	7.04	2.43	10.8	2.32	50.2	0.96	48.6	12.0	10.9	21.3	1.75	0.99	6.48	65.9	352	398
302Cb	58.5		2.62		4.6		33.1		25.4			15.7				24.3	*~186*	*~204*

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
302X								13.3	3																8.6			
302A								6.7	11																8.1			
302T								59.5	2																2.1			
302Ab								20.6	12																8.7			
302B	7.7		6.0		6.82	131	8.7	23.6	4			69.6	6060		5.4	13.6			0.97				3260	2.3	13.2	212	179	
302Bb								29.7	3																6.6			
302C	12		4.1		14.7	110	13.8	31.6	4			49.4	5460		5	20.9			1.53				5380	3.4	6.9	173	208	
302Cb								26.6	4																3.3			

REE Section 303

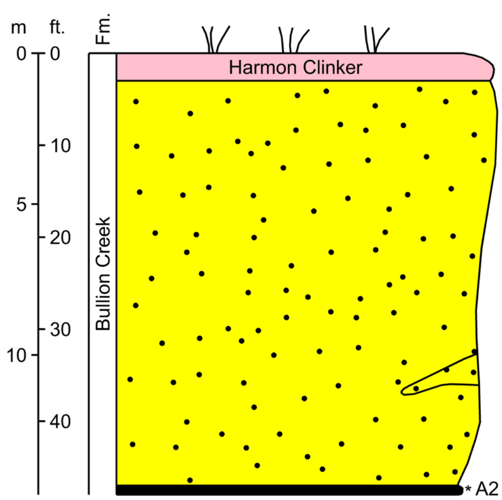
T.135N., R.102W., Sec.18, SW/SW/SE
Elevation at top 2,668 ft.



SAMPLE ID	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	TOTAL REE Whole Coal	TOTAL REE Ash
	LAB ANALYSIS (in µg/g)																	
303A	24.1		4.04		4.3		12		12.9			18.1				38.3	*~134*	*~311*
303Ab	21.9		3.38		3.4		10		10.1			12.4				31	*~109*	*~175*
303B	369	24.4	10.8	8.50	34.2	4.14	158	1.22	180	44.4	39.5	28.8	4.82	1.40	8.62	91.7	1010	1380
303B2	443	25.3	10.4	10.00	40.3	4.11	187	1.07	228	55.7	51.0	26.6	5.40	1.30	7.81	86.4	1183	2220
303C	64.4		3.11		5		33.2		27.4			15.8				27.1	*~200*	*~274*
303D	25.5		1.96		3.2		11.8		13.6			11.6				17	*~98*	*~295*
303Db	54.2		1.85		3.3		29.5		22.3			16.4				15.7	*~160*	*~195*

REE Section 303-North

T.135N., R.102W., Sec.18, SE/NE/SW
Elevation at top 2,694 ft.



SAMPLE ID	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	TOTAL REE Whole Coal	TOTAL REE Ash
	LAB ANALYSIS (in µg/g)																	
303A2	27.2		2.78		3.3		14.7		12.1			21.1				27.5	*~124*	*~310*

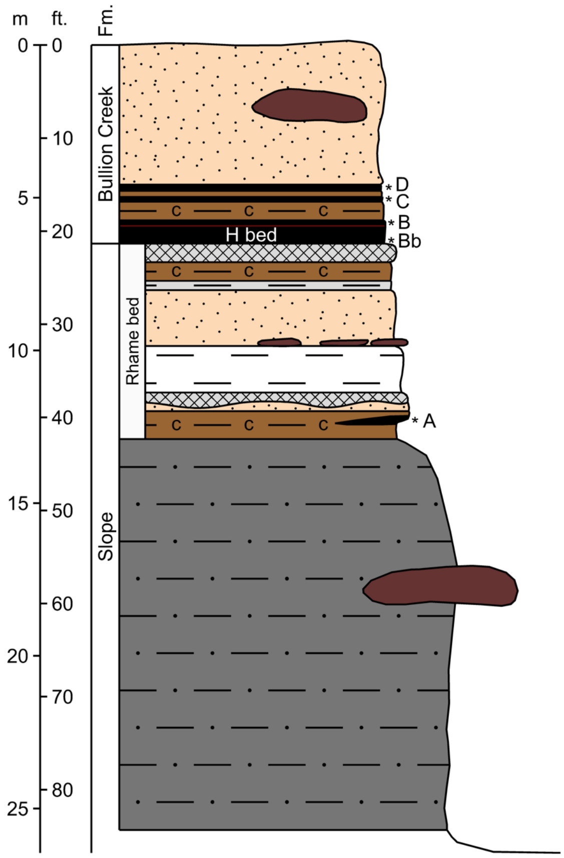
SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
303A								80.9	40																56.2			
303Ab								18.9	12																11.0			
303B	51.8	989	5.4		2.44	109	11.2	18.9	14	6.8	0.08	24.9	1960	16	4.3	25.4	31	184	1.96	0.09	18.5	2.7	5140	3.8	18.6	184	347	
303B2	38.6	861	4.3		2.12	110	9.5	14.1	12	6.1	0.05	33.4	2470	38	7	14.5	20	285	1.29	0.13	20.7	2.0	3220	2.3	20.6	185	323	
303C								22.3	10																8.7			
303D								15.7	28																9.9			
303Db								22.8	7																5.4			

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
303A2								34.5	20																19.0			

REE Section 304

T.137N., R.103W., Sec.32, NW/NE/SW

Elevation at top 2,590 ft.

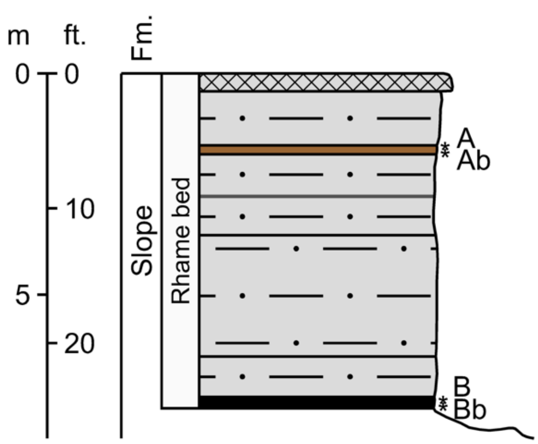


SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
304D	117	10.9	5.93	3.28	13.5	2.06	38	0.81	63.9	14.9	14.6	25.8	2.00	0.81	5.32	46.5	365	924
304C	76.2		3.98		8.6		30.5		40			16.1				32.9	*~244*	*~430*
304B	128	11.3	6.29	3.10	13.1	2.17	45.9	0.83	63.2	15.6	14.2	19.6	1.99	0.87	5.56	54.7	386	1009
304Bb	46.4		2.54		3.8		23.8		18.9			11.2				23.5	*~149*	*~230*
304A	420	17.6	7.76	6.82	27.9	2.99	184	0.82	185	47.8	34.4	16.4	3.64	0.98	5.83	75	1037	1428

REE Section 305

T.133N., R.104W., Sec.36, SE/NW

Elevation at top 3,145 ft.



SAMPLE ID	LAB ANALYSIS (in µg/g)																TOTAL REE	
	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Whole Coal	Ash
305A	99.3		1.93		5.9		44.6		42.4			14.7				16.5	*~253*	*~288*
305Ab	408	17.1	7.11	7.08	26.9	2.76	172	0.74	176	46.3	35.0	35.8	3.65	0.88	5.35	60.1	1005	1343
305B	113	14.4	9.06	3.17	15.1	3.08	49.5	1.19	56.7	13.6	12.5	14.3	2.40	1.22	7.43	110	427	1154
305Bb	91.8	14.2	9.93	2.83	13.6	3.24	43.6	1.51	47.3	11.3	11.0	16.9	2.24	1.39	8.80	114	394	1646

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
304D	89.6		2.8		0.87	60	14.1	12.9	4			9.7	5190		33.6	12.9			0.2				589	5.3	25.4	65	147	
304C								12.9	12																15.9			
304B	15.8		4.8	0.32	0.49	40	16.5	12.4	5			33.8	4540		16.4	25.9			0.87				1640	2.7	13.5	86	226	
304Bb								24.0	15																6.5			
304A	24.1	1060	7.3	0.24	1.9	73	25.6	14.9	16	4.0	0.04	37.8	2800	63	6.3	13.9	25	166	1.13	0.05	12.5	2.0	2870	6.7	9.5	177	210	

SAMPLE ID	LAB ANALYSIS (in µg/g)																											
	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
305A								21.2	6																5.3			
305Ab	107	135	2.7		5.43	238	12.5	27.8	35	8.1	0.11	41.8	3840	34	14.6	12.5	51	142	0.79	0.07	43.1	1.9	2260	2.1	27.3	252	439	
305B	71.6		16.1		1.65	60	31.3	11.3	15			11.1	4280		14.7	8.7			0.35				1120	2.8	9.7	88	192	
305Bb	43.2		18.7		0.85	62	44	13.8	7			9.6	4590		17.2	6.1			0.19				560	4.3	16.0	89	99.5	

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

* Denotes duplicate sample analysis

Results initially reported in Kruger and others (2017)

Results initially reported in Murphy and others (2018)

Results initially reported in Kruger and others (2022)

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
42A		66.5	3.0	2.08	0.77	3.5	0.64	35.7	0.36	27.3	7.6	4.5		0.48	0.33	2.31	17																												
42B		32.2	5.4	3.21	0.97	5.0	1.11	14.5	0.42	17.0	4.2	4.1		0.86	0.45	2.84	24																												
42D	27.85%	7.1	1.0	0.60	0.19	1.1	0.22	3.2	0.07	3.9	0.9	0.9		0.17	0.08	0.49	7																												
42E		11.0	1.2	0.78	0.19	1.2	0.26	5.0	0.12	5.5	1.4	1.2		0.20	0.11	0.74	9																												
42F	10.44%	10.0	0.8	0.48	0.11	0.8	0.16	5.6	0.07	4.2	1.1	0.8		0.13	0.07	0.44	5																												
42H		8.4	0.7	0.42	0.10	0.7	0.14	4.0	0.06	3.8	1.0	0.8		0.12	0.06	0.39	3																												
42J	19.79%	5.8	0.5	0.29	0.08	0.5	0.10	3.0	0.04	2.5	0.7	0.5		0.08	0.04	0.25	3																												
42L		13.7	1.7	1.06	0.43	1.7	0.36	6.6	0.15	7.0	1.7	1.6		0.29	0.15	0.98	11																												
42M		40.7	2.4	1.55	0.62	2.7	0.49	21.2	0.25	17.9	4.8	3.3		0.41	0.24	1.60	13																												
42N		72.9	4.5	2.58	1.16	5.3	0.85	35.1	0.38	32.4	8.6	6.3		0.76	0.38	2.48	21																												
42O		58.8	3.6	2.20	0.90	4.1	0.71	29.1	0.35	25.6	6.8	4.8		0.59	0.33	2.24	19																												
53A (ash)	93.06%	81.1	5	2.85	1.38	5.4	1	54.7	0.39	29	8.3	5.2	11.2	0.82	0.4	2.62	27	2.59	20.2	6650	1.8	0.18	0.32	37	5.2	19.3	2	3.7	0.10	121	23300	972	6.4	35.5	6	2840	3.28	0.22	31.8	6.3	10500	6.9	7.6	61	133
53B	91.31%	98.4	4.7	2.40	1.48	6.2	0.88	53.4	0.34	39.9	10.9	7.3	13.5	0.87	0.35	2.28	21																												
53C	84.49%	64.1	4.6	2.83	1.13	5.0	0.94	31.4	0.44	28.7	7.7	5.6	13.1	0.79	0.42	2.89	23																												
53D	35.55%	18.2	4.2	3.66	0.62	2.7	1.08	9.4	0.65	8.9	2.2	2.1	13.9	0.54	0.57	4.01	30																												
53E	88.39%	55.4	4.7	2.93	1.14	5.0	0.99	28.4	0.44	26.3	6.7	5.1	11.4	0.76	0.42	2.75	27																												
54A		206	17.9	7.69	7.55	26.1	3.04	72.9	0.88	136	30.3	32.9		3.66	1.04	6.35	51																												
54A2	28.01%	269	21.0	8.3	8.51	32.4	3.40	109	0.74	165	37.3	38.4	30.0	4.32	0.99	5.93	67.9	5.61		725	3.6		0.25	241	13.2	9.4	13	6.0		17.3	2180		20.8	8.6			0.36				841	2.8	19.3	335	274
54B		158	16.0	6.61	6.81	24.7	2.70	60.9	0.73	114	23.9	28.9		3.32	0.86	5.31	46																												
54BB		9.0	0.8	0.42	0.21	0.8	0.15	3.6	0.05	3.8	1.0	0.8		0.13	0.06	0.36	4																												
54C		65.2	9.2	5.45	2.96	10.9	1.86	22.7	0.87	48.4	10.1	12.4		1.63	0.84	5.79	29																												
54CC		11.6	0.7	0.38	0.19	0.7	0.14	7.9	0.04	3.7	1.1	0.7		0.12	0.05	0.31	4																												
54D		78.1	4.7	2.61	1.28	5.4	0.88	37.9	0.37	33.5	9.0	6.4		0.81	0.37	2.47	22																												
54DD		11.8	0.6	0.33	0.17	0.7	0.12	7.2	0.04	3.8	1.2	0.7		0.11	0.05	0.27	3																												
54F		10.8	2.5	1.68	0.34	2.0	0.54	5.3	0.26	5.9	1.4	1.7		0.36	0.25	1.68	14																												
54FF		26.6	1.2	0.67	0.27	1.4	0.23	14.8	0.08	10.0	2.9	1.5		0.22	0.10	0.56	5																												
54G		37.0	3.9	2.46	0.47	3.5	0.80	16.6	0.34	16.9	4.6	3.7		0.62	0.35	2.27	21																												
54HH		11.8	1.0	0.56	0.23	1.1	0.19	5.0	0.08	5.7	1.5	1.2		0.17	0.09	0.53	5																												
54I		23.6	1.7	1.01	0.29	1.7	0.34	13.6	0.14	8.7	2.5	1.6		0.28	0.14	0.89	9																												
54J		13.3	0.8	0.41	0.16	0.8	0.15	8.0	0.04	4.3	1.3	0.8		0.13	0.05	0.31	4																												
54JJ		13.5	0.7	0.45	0.23	0.9	0.14	7.0	0.07	5.7	1.5	1.0		0.12	0.07	0.46	4																												
54L		5.7	0.4	0.18	0.07	0.3	0.07	3.3	0.02	1.9	0.6	0.3		0.06	0.02	0.14	2																												
54O		10.8	0.7	0.38	0.16	0.8	0.14	6.4	0.04	3.9	1.1	0.7		0.12	0.05	0.31	4																												
54Q		10.6	1.0	0.46	0.22	1.1	0.18	6.1	0.05	4.4	1.2	0.9		0.17	0.06	0.33	7																												
54R		16.6	4.5	2.79	0.76	3.8	0.95	7.3	0.37	9.9	2.2	2.7		0.69	0.38	2.39	28																												
54S		11.4	1.4	0.82	0.29	1.4	0.29	7.7	0.10	5.0	1.2	1.1		0.22	0.11	0.66	11																												
54T		7.7	0.7	0.43	0.16	0.8	0.15	3.8	0.05	3.6	0.9	0.7		0.12	0.06	0.33	6																												
54U		8.8	0.7	0.39	0.18	0.7	0.14	5.0	0.05	3.8	1.0	0.7		0.11	0.06	0.34	5																												
54X		16.1	0.8	0.43	0.18	0.8	0.15	11.5	0.06	4.8	1.5	0.8		0.13	0.06	0.38	4																												
54Z		17.9	0.8	0.44	0.19	0.8	0.15	14.1	0.06	4.6	1.5	0.8		0.13	0.07	0.40	4																												
55-1		36.2	1.5	0.99	0.52	2.0	0.32	18.0	0.18	15.6	4.2	2.7		0.27	0.16	1.16	8																												

* Denotes duplicate sample analysis
Results initially reported in Kruger and others (2017)
Results initially reported in Murphy and others (2018)
Results initially reported in Kruger and others (2022)

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
55-2	63.51%	139	8.3	3.35	3.03	12.0	1.34	69.1	0.37	64.7	16.7	13.5		1.67	0.41	2.67	29																												
55-4	28.72%	94.7	8.2	4.60	2.04	8.9	1.66	42.7	0.58	45.0	11.9	9.0	13.9	1.41	0.63	3.95	38																												
55-6	83.07%	62.6	3.3	2.04	0.91	3.9	0.64	31.5	0.32	27.2	7.3	4.9		0.56	0.30	2.11	16																												
55-7	66.83%	47.8	11.7	8.34	1.71	8.3	2.71	25.4	1.22	24.7	6.1	6.0	28.4	1.63	1.20	7.75	69																												
56A	85.48%	121	8.2	4.23	2.58	9.9	1.53	58.7	0.58	55.4	14.6	11.3	16.5	1.49	0.60	4.00	33																												
56B	50.76%	76.5	5.5	2.88	1.74	6.6	1.01	33.2	0.41	38.4	9.8	8.3	19.9	1.00	0.41	2.75	20																												
56C	82.30%	32.1	0.9	0.40	0.22	1.3	0.14	16.3	0.05	11.2	3.4	1.9	1.6	0.17	0.05	0.34	4																												
56E	28.05%	105	7.8	3.61	2.42	9.8	1.35	41.6	0.46	52.3	13.3	11.2	18.1	1.46	0.49	3.17	23																												
56F	34.33%	151	18.8	9.65	4.00	20.6	3.60	64.2	1.15	77.6	19.2	17.4	16.8	3.30	1.28	7.78	77																												
56FII (F2)	30.34%	165	20.6	10.1	4.80	23.6	3.87	68.4	1.20	91.2	22.5	20.9	17.7	3.80	1.35	7.97	92																												
56G	13.11%	32.8	2.6	1.59	0.51	2.7	0.57	20.7	0.19	12.1	3.7	2.1	2.1	0.43	0.22	1.24	20																												
57B	33.04%	31.6	2.4	1.15	0.89	3.3	0.43	14.3	0.15	18.3	4.4	4.0	9.9	0.45	0.16	0.99	10																												
57Bb	25.89%	17.1	2.4	1.60	0.39	2.0	0.53	9.0	0.23	7.4	2.0	1.6	6.1	0.37	0.23	1.46	15.2	1.45		702	1.3		0.44	19		16.2	22	2.6		21.2	3640		1.7	9.3		232	0.46				1320	2.7	2.7	45	104
57E	15.77%	49.4	3.7	1.82	1.23	4.8	0.66	18.2	0.26	25.7	6.6	5.5	10.8	0.72	0.26	1.71	12																												
57Eb	9.79%	7.0	2.8	2.06	0.37	1.8	0.64	3.4	0.32	4.1	0.9	1.1	13.8	0.36	0.3	2.02	17.9	1.66	10.1	280	2.9	<0.10	0.2	18	4.4	11.7	4	1.8	<0.02	2.2	5620	148	2.4	5.4	3	292	0.07	<0.10	1.8	0.2	189	2.7	1.9	42	107
57F	26.25%	101	8.5	4.33	2.10	9.6	1.60	47.2	0.53	44.6	12.0	9.2	9.1	1.54	0.60	3.60	39																												
57Fb	13.76%	8.8	2.1	1.3	0.37	1.8	0.45	4.2	0.19	5	1.2	1.40	7.6	0.34	0.19	1.20	10.6	2.3		452	0.9		1.0	29		8.4	2	1.4		8.7	5500		0.8	6.9		282	0.27				749	0.8	3.6	55	43.7
58B	51.16%	94.3	6.5	3.10	2.51	8.7	1.15	40.8	0.41	50.7	12.9	11.0	21.9	1.24	0.44	2.81	26																												
58Bb	17.64%	9.9		0.82		1.2		4.6		3.8			2.3				8.2								3.5	12.5		0.5						3.0			0.13				356			11	
58C	73.00%	73.5	2.7	1.30	0.46	3.6	0.48	32.0	0.16	27.7	8.3	4.8	2.2	0.51	0.18	1.12	14																												
58E	15.78%	9.9	0.6	0.29	0.28	0.9	0.10	3.6	0.05	6.2	1.5	1.4	8.5	0.12	0.05	0.33	2																												
58F	37.08%	107	12.2	5.84	3.12	14.2	2.20	41.3	0.71	59.5	14.7	14.1	18.9	2.26	0.79	4.80	48																												
58Fb	16.59%	13.1		1.84		2.6		6.4		7.4			9.7				16.0								7.5	11.6		1.7						7.6			0.27				757			50	
58G	47.32%	31.1	5.5	3.62	1.27	4.9	1.23	14.4	0.52	16.3	4.0	4.0	9.1	0.86	0.52	3.28	39																												
59A	46.59%	21.9	2.8	1.56	0.75	2.9	0.54	8.7	0.23	12.9	3.0	3.2	6.9	0.47	0.23	1.54	14																												
59B	37.64%	22.0	3.7	2.18	0.87	3.7	0.75	7.5	0.33	13.8	3.2	3.5	9.6	0.62	0.32	2.16	18																												
59C	36.99%	30.7	6.9	4.93	1.08	5.1	1.60	15.5	0.75	15.7	3.9	3.9	15.1	1.00	0.72	4.83	44																												
59D	48.61%	38.3	7.6	5.24	1.51	6.4	1.75	19.3	0.76	20.0	4.9	4.9	15.7	1.16	0.75	4.83	56																												
60A	39.33%	9.6	2.1	1.31	0.49	1.9	0.44	4.0	0.20	6.1	1.4	1.6	6.6	0.32	0.19	1.30	12																												
60B	42.19%	31.0	5.2	3.19	1.02	4.7	1.09	13.5	0.44	17.4	4.2	4.2	11.0	0.82	0.44	2.87	31																												
61A	31.27%	49.1	7.7	3.81	2.65	9.9	1.42	10.1	0.48	50.7	10.2	11.9	12.9	1.45	0.52	3.36	33																												
61B	16.00%	8.5	1.0	0.56	0.27	1.0	0.20	5.0	0.07	4.0	1.0	1.1	2.7	0.17	0.08	0.50	6																												
61C	83.36%	39.4	1.9	1.15	0.64	2.4	0.39	19.1	0.19	17.2	4.7	3.1	7.3	0.34	0.18	1.21	10																												
61D	23.84%	15.7	2.7	2.00	0.52	2.3	0.65	9.8	0.31	7.4	1.8	1.7	12.2	0.41	0.29	1.96	23																												
61E	60.89%	44.0	2.7	1.53	0.93	3.4	0.53	18.4	0.23	20.5	5.2	3.9	9.7	0.49	0.23	1.51	14	0.77		932	1.9		7.50	43		15.5	5	3.6		30.5	4590		3.5	11.3		228	0.80				2520	1.7	3.2	86	164
61F	20.98%	45.3	3.0	1.53	0.93	3.7	0.57	29.6	0.20	19.5	5.1	3.7	7.3	0.53	0.20	1.31	16																												
61G	77.33%	62.6	4.5	2.51	1.30	5.2	0.88	25.4	0.34	29.7	7.5	5.8	8.8	0.79	0.35	2.28	23	0.60		531	2.1		3.92	36		19.1	2	3.4		47.2	3560		1.7	12.6		224	1.19				2730	1.3	7.6	55	102
61H	24.51%	118	10.4	5.26	3.68	12.2	1.93	34.7	0.64	65.6	15.8	14.0	19.4	1.88	0.71	4.49	47																												
61Hb	12.46%	84.5	8.2	4.91	2.59	9.3	1.64	27.6	0.69	44.9	10.7	9.9	10.8	1.41	0.68	4.57	40.7																												
61H2	14.97%	105	10.7	5.71	3.74	13.2	2.02	28.3	0.71	67.2	15.8	14.2	15.5	1.94	0.77	4.80	50.6	0.52	14.5	809	3.1	<0.10	0.18	71	10.9	6.1	4	2.2	0.03	2.9	2840	82	8.1	7.2	2	43	0.05	<0.10	6.8	<0.2	218	3.9	6.4	38	185
61H3	22.34%	110	10	5.4	3.46	12.2	1.9	29.3	0.65	67.2	15.9	13.7	17.6	1.77	0.72	4.56	49.6																												

* Denotes duplicate sample analysis

Results initially reported in Kruger and others (2017)

Results initially reported in Murphy and others (2018)

Results initially reported in Kruger and others (2022)

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium
61H4	42.16%	109	9.3	4.98	3.18	11.3	1.76	32	0.59	61.2	15	12.5	16.6	1.64	0.65	4.26	44.5
61H5	15.38%	88.6	7.9	4.29	2.79	9.4	1.5	28	0.53	48.8	11.8	10.5	13.1	1.39	0.58	3.76	36.8
61H5b	29.09%	79.7	6.7	3.85	2.41	8.2	1.31	26.8	0.52	43.6	10.5	9.3	17.4	1.18	0.52	3.5	32.1
61H6	16.90%	54.9	4.4	2.35	1.65	5.5	0.82	17.4	0.29	30.2	7.2	6.4	10.9	0.79	0.32	2.07	20.5
61H7	32.60%	30	1.8	0.99	0.83	2.6	0.34	12.5	0.13	15.7	3.8	3.3	7.2	0.34	0.13	0.92	8.3
61H7b	44.51%	43.1	3.1	1.99	1.08	3.6	0.64	20.1	0.3	19.9	5.1	3.9	12.2	0.53	0.28	1.94	17.5
61H8	17.69%	56.6	3.6	1.89	1.46	4.7	0.67	22.9	0.23	27.7	6.9	5.8	10.4	0.67	0.25	1.67	16.5
61I	37.00%	79.9	5.8	2.91	2.32	7.4	1.06	27.0	0.40	43.5	10.3	9.0	14.6	1.07	0.41	2.71	24
61I5	58.74%	72.4	5.2	2.85	2.04	6.5	0.98	30.2	0.39	36.4	9.2	7.6	13.2	0.94	0.41	2.72	22.8
61J	24.93%	22.5	3.3	2.35	0.61	2.8	0.77	12.9	0.38	10.2	2.6	2.3	10.3	0.50	0.35	2.35	25
61J2	30.83%	28.0		2.65		3.2		19.0		10.8			8.5				23.7
61J2b	37.92%	177	17.5	8.38	5.30	21.8	3.14	68.7	1.03	102	23.7	23.6	24.8	3.29	1.11	6.87	56.0
61Jb	41.07%	133	13.7	7.03	3.83	16.5	2.57	48.2	0.89	72.8	17.2	16.5	18.5	2.52	0.97	5.99	59.2
61K	30.39%	60.2	6.5	3.81	1.94	7.1	1.29	24.2	0.52	32.3	7.8	7.0	12.0	1.09	0.53	3.40	36.1
61K2	26.26%	30.8	4.3	3.01	1.75	4.3	1.45	15.9	0.98	15.4	4.4	4	10.2	1.31	0.98	2.86	23.9
61K6	15.84%	10.3	2.1	1.6	0.51	1.8	0.55	6.5	0.31	5.1	1.3	1.3	6.9	0.38	0.3	1.58	16.7
61K8	23.62%	61.5	5.8	3.23	1.8	6.6	1.12	26.8	0.39	31.3	7.7	7	12	1	0.43	2.73	30.7
61L	28.01%	117	12.0	5.93	3.49	15.0	2.16	38.3	0.72	70.1	16.7	16.3	20.7	2.22	0.78	4.94	47.4
61L2	32.46%	104	11	5.47	3.16	13.6	2	32.6	0.66	61	14.4	14.4	15.8	2.04	0.73	4.71	44.2
61L2b	18.08%	37.4	3.5	2.1	0.89	3.6	0.71	17.7	0.29	16.1	4.1	3.5	8.1	0.58	0.3	1.98	18.5
61L5	34.71%	39.3	4.2	2.39	1.12	4.7	0.81	16.5	0.33	22.9	5.4	5.4	10.4	0.71	0.34	2.25	18
61L5b	29.75%	42.7	3.3	1.97	0.93	3.6	0.65	21	0.28	18.9	4.9	3.9	9.3	0.56	0.28	1.93	15.7
61L6	28.10%	52.5	5.5	2.77	1.64	6.8	1	18.3	0.35	33.4	7.7	7.9	11.1	0.99	0.37	2.46	20.4
61L7	26.69%	65.9	6.8	3.66	1.88	7.7	1.27	23.2	0.48	36.6	8.5	8.9	12.9	1.19	0.5	3.37	27.2
61L7b	41.95%	38	2.4	1.21	0.85	3	0.43	18.1	0.15	17.4	4.4	3.6	6.6	0.43	0.17	1.06	9.8
61L8	27.34%	50	6.2	3.61	1.43	6.7	1.24	18.8	0.45	28.9	6.8	6.4	5.6	1.03	0.48	3.1	31.7
61M	86.88%	90.2	3.6	2.12	1.27	4.7	0.71	46.5	0.3	31	8.6	5.9	12.6	0.64	0.31	2.07	17.3
61N	63.89%	42.2	2.7	1.6	0.91	3.3	0.54	21.8	0.26	20.3	5.2	4.1	10.9	0.47	0.24	1.7	11.5
61Nb	47.03%	71.8	5.9	3.46	1.67	6.5	1.17	38.6	0.45	33.4	8.5	6.9	13.7	0.99	0.48	3.11	28.8
61oy	25.44%	18.9	1.6	0.89	0.53	2	0.3	8	0.12	10.3	2.4	2.3	3.9	0.28	0.13	0.83	7
61S	36.37%	12	2	1.53	0.4	1.5	0.47	6.6	0.25	5.4	1.4	1.3	9.4	0.28	0.23	1.62	13.5
61T	81.08%	107	2.2	0.86	0.97	3.7	0.35	57.3	0.08	34.7	10.7	5.5	2	0.48	0.11	0.64	8.3
61U	32.24%	24.6	1.2	0.74	0.35	1.3	0.25	9.9	0.1	7.8	2.2	1.5	3.1	0.21	0.11	0.7	6.2
67A	57.42%	26.2	8.0	5.38	1.18	5.9	1.77	13.5	0.80	14.2	3.4	4.0	23.2	1.15	0.77	5.03	44
67B	87.15%	70.6	4.9	2.78	1.26	5.8	0.93	33.9	0.39	31.9	8.5	6.3	12.9	0.82	0.37	2.67	26
67C	23.48%	23.3	4.4	2.82	0.74	3.7	0.94	10.0	0.39	11.7	2.9	2.9	7.8	0.68	0.39	2.53	26
68A	45.49%	42.4	11.4	7.97	1.67	8.5	2.57	19.0	1.20	23.9	5.7	6.4	26.5	1.64	1.15	7.44	65
68B	49.29%	27.3	6.0	4.16	0.96	4.5	1.33	14.9	0.64	13.1	3.3	3.3	18.6	0.85	0.60	4.00	33
68C	26.82%	14.6	2.6	1.65	0.46	2.3	0.56	6.9	0.23	7.1	1.8	1.8	5.0	0.41	0.23	1.46	17
68D	33.40%	39.6	6.9	4.11	1.24	6.1	1.42	20.1	0.56	19.2	4.9	4.6	15.7	1.09	0.57	3.60	38
68E	33.42%	76.9	4.2	2.04	1.63	5.9	0.73	33.9	0.27	38.5	10.1	7.9	12.9	0.82	0.27	1.81	16

SAMPLE ID	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
61H4	0.33		1010	3.4		1.04	123		6.9	6	3.0		6.4	3200		1.9	6.8		221	0.24				799	1.3	6.1	137	196
61H5	0.11		431	2.8		0.32	56		5.0	3	1.9		4.5	2640		0.5	4.9		219	0.06				219	1.7	6.5	42	137
61H5b	0.43	2.7	177	2.1	0.17	2.71	64	13.1	8.9	10	2.1	0.05	12.6	4690	102	1.9	8.3	22	215	0.36	<0.10	7.3	0.7	1300	2.7	7.7	71	123
61H6																												
61H7	0.17		537	0.8		0.80	108		4.3	3	3.3		5.3	1970		1.4	5.6		245	0.21				996	0.9	2.6	131	187
61H7b	0.38		1310	2.3		4.12	52		11.7	15	2.5		12.2	3690		1.5	9.1		321	0.45				1730	2.0	3.2	94	123
61H8																												
61I																												
61I5	0.49		856	1.8		7.04	56		14.8	5	2.7		28.6	4060		3.1	10.8		374	0.69				2570	1.4	5.6	98	134
61J																												
61J2	0.96	2.8	382			0.11		77.9		3			49.6		578	1.3		3	407						1.0	3.0	32	
61J2b	6.36	49.6	1580			1.56		13.6		4			15.5		123	16.5		21	548						1.6	18.3	164	
61Jb	5.13	33.2	1140	3.1	0.27	3.00	40	14.5	13.4	7	2.4	0.04	21.6	5190	90	12.8	11.3	34	402	0.41	<0.10	5.9	1.0	1210	3.4	14.7	99	107
61K	0.79	11.7	992	4.4		1.43	42	15.8	8.0	8	2.7		8.2	7510		2.8	7.0		210	0.18				736	1.5	3.1	105	215
61K2																												
61K6	0.65		596	4.6		0.17	8		5.0	13	0.9		5.0	4340		1.0	4.1		444	0.05				140	1.6	1.8	25	87.9
61K8																												
61L	3.73	15.9	1020	1.9	0.21	1.52	40	13.1	8.3	5	2.2	0.06	11.6	3710	85	15.7	8.9	18	168	0.29	<0.10	9.1	0.7	854	2.0	30.4	57	91.3
61L2	3.77		1570	2.0		1.30	27		7.5	5	2.1		14.6	3360		16.3	8.9		305	0.42				911	1.3	17.7	56	86.5
61L2b																												
61L5																												
61L5b																												
61L6																												
61L7	4.91		488	1.7		1.35	29		9.0	5	2.3		8.1	5750		12.6	10.9		205	0.35				828	2.7	23.2	45	106
61L7b	1.48		1650	1.3		1.42	24		6.1	3	1.2		5.4	4000		4.6	6.1		746	0.21				642	2.8	2.7	43	55.5
61L8																												
61M																												
61N																												
61Nb	2.47	27.1	5310	3.4	0.45	1.74	34	9.5	13.0	8	2.7	0.05	28.8	8650	71	8.7	6.5	17	992	0.57	0.16	12.0	1.2	1830	2.6	7.3	108	123
61oy	2.02		1070	0.5		0.64	13		4.0	9	1.1		4.0	1510		6.1	4.7		335	0.11				366	3.1	2.2	27	86.3
61S																												
61T	1.11		210	0.7		0.34	2		31.2	3	1.6		126	2700		0.7	9.3		73	1.70				2450	2.3	4.3	7	43.3
61U	1.35		452	2.6		0.25	6		13.5	2	6.9		43.2	6750		1.5	12.7		246	0.91				1690	1.5	5.1	30	210
67A																												
67B																												
67C																												
68A																												
68B																												
68C																												
68D																												
68E																												

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

* Denotes duplicate sample analysis

Results initially reported in Kruger and others (2017)

Results initially reported in Murphy and others (2018)

Results initially reported in Kruger and others (2022)

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
68F	77.39%	205	19.0	9.27	5.65	23.4	3.48	90.6	1.07	110	26.7	25.3	19.9	3.46	1.24	7.65	86																											
68F2	79.67%	170	14.4	7.30	4.25	18.3	2.67	74.3	0.85	86.6	21.1	19.1	17.2	2.63	0.97	6.04	65.1								18.2		192						17.0												
68F2m	90.01%	134	10.7	5.73	2.91	12.7	2.02	62.9	0.72	62.7	16.1	13.2	18.5	1.86	0.79	5.04	54.6								17.2		23						7.8												
68G	93.48%	71.9		2.49		5.3		37.7		32.0			15.1				22.2						11.4			25.8	3			52.2				14.4			1.07				3530				
69A	79.85%	71.9	13.2	9.29	2.01	10.1	2.97	33.9	1.37	34.9	8.9	8.2	29.1	1.88	1.32	8.57	81																											
69B	28.69%	17.1	3.1	1.95	0.59	2.7	0.66	7.9	0.27	8.5	2.1	2.0	4.7	0.47	0.27	1.72	20																											
69C	25.61%	27.4	10.2	5.91	2.03	9.5	2.10	9.6	0.80	24.8	4.8	7.7	13.3	1.66	0.83	5.16	53																											
69D	44.73%	10.1	1.3	0.78	0.30	1.3	0.25	4.1	0.10	5.7	1.4	1.3	4.8	0.19	0.09	0.76	6																											
69E	83.11%	59.4	3.0	1.78	0.88	3.8	0.55	29.8	0.24	26.9	7.1	4.9	14.3	0.50	0.24	1.82	16																											
69Z	33.24%	46.2	4.6	2.46		5.1		24.7		21.7			6.0				26.9						1.32	37		15.7	14			6.2	1860		14.5	7.2									10.1	48	
70A	84.94%	51.0	3.0	1.80	0.85	3.5	0.56	24.6	0.26	23.1	6.1	4.4	10.9	0.48	0.24	1.86	16																											
70B	82.38%	62.6	4.1	2.43	1.05	5.0	0.79	30.5	0.31	29.0	7.5	5.5	11.9	0.69	0.31	2.32	23																											
70C	89.76%	53.6	3.0	1.77	0.86	3.9	0.55	25.7	0.22	24.2	6.4	4.6	8.5	0.51	0.22	1.66	16																											
70D	46.58%	33.1	3.0	1.83	0.70	3.3	0.59	14.7	0.27	15.9	4.1	3.4	8.6	0.50	0.25	1.82	16																											
70E	21.54%	12.7	2.4	1.60	0.42	2.1	0.53	5.7	0.25	6.7	1.6	1.6	6.5	0.36	0.23	1.55	15																											
70F	38.12%	12.0	2.5	1.61	0.34	1.9	0.50	6.3	0.23	6.0	1.5	1.5	7.6	0.34	0.22	1.64	13																											
71A	67.58%	49.0	10.0	7.07	1.51	7.7	2.23	24.8	1.08	25.8	6.4	6.2	23.7	1.41	1.00	6.91	59																											
71B	78.57%	44.1	4.3	3.02	0.89	4.0	0.93	22.1	0.44	20.1	5.2	4.0	11.1	0.62	0.41	3.00	29																											
71C	41.64%	21.9	2.0	1.27	0.50	2.1	0.42	10.0	0.21	10.2	2.6	2.2	7.5	0.34	0.19	1.28	11																											
71conc	78.81%	25.4		0.61		1.7		12.9		11.3			2.5				5.4	22.7	246	211	0.5		1.69	146	13.7	5.8	2	0.9		10.8	1910	146	12.7	5.0	32	31	0.43		3.2		1200	367	0.9	17	27.9
71D	17.93%	9.6	1.7	0.99	0.39	1.7	0.33	3.4	0.16	6.0	1.4	1.6	6.9	0.27	0.14	1.00	8																											
71E	36.68%	17.6	1.1	0.59	0.40	1.4	0.20	7.4	0.09	9.0	2.2	1.9	7.2	0.19	0.08	0.57	4																											
71Z	32.10%	43.1		1.77		4.0		22.0		22.4			8.5				12.7						2.33	80		14.4	15			9.4	3670		16.4	10.0									9.2	177	
71Zb	73.30%	52.0		1.91		3.3		27.6		21.9			10.5				15.1						11.2	54		26.7	9			35.7	6720		3.6	13.8									6.3	82	
72A	86.64%	59.0	4.3	2.46	1.01	4.5	0.81	28.6	0.39	26.2	6.9	5.2	12.7	0.69	0.38	2.47	22																											
72B	83.26%	61.6	4.0	2.44	1.05	4.8	0.80	29.5	0.36	27.6	7.2	5.4	12.2	0.70	0.36	2.32	22																											
72C	54.89%	43.5	4.6	2.81	1.00	4.7	0.95	18.7	0.41	20.9	5.3	4.6	9.6	0.78	0.40	2.65	24																											
72D	25.96%	25.6	5.5	3.36	1.02	5.1	1.13	11.4	0.45	14.5	3.4	3.8	11.6	0.86	0.46	2.92	33																											
72E	24.75%	21.3	4.2	2.66	0.66	3.3	0.88	11.0	0.39	9.9	2.5	2.6	13.3	0.62	0.38	2.53	24																											
72F	68.68%	49.7	5.6	3.85	1.08	5.2	1.24	24.7	0.60	23.4	6.0	4.9	13.9	0.86	0.57	3.72	36																											
73A	50.80%	19.7	5.5	3.92	0.78	3.9	1.24	9.7	0.60	10.8	2.5	2.9	14.1	0.77	0.57	3.80	32																											
73B	76.53%	45.7	4.2	2.95	0.94	4.0	0.96	22.8	0.53	20.5	5.4	4.1	12.4	0.70	0.49	2.93	26																											
73C	45.94%	31.6	3.0	1.91	0.65	3.0	0.62	14.8	0.31	14.6	3.7	3.1	9.7	0.47	0.28	1.93	16																											
73D	15.56%	11.5	2.4	1.63	0.43	1.9	0.51	5.0	0.26	6.6	1.6	1.6	7.6	0.35	0.24	1.63	14																											
73E	23.07%	18.9	3.2	2.20	0.51	2.6	0.70	9.5	0.35	8.5	2.1	2.1	9.7	0.47	0.33	2.20	19																											
73F	91.45%	58.0	3.6	2.31	1.00	4.1	0.75	28.7	0.35	25.3	6.8	4.8	12.0	0.60	0.35	2.35	20																											
73G	28.07%	43.8	3.6	2.17	0.90	3.8	0.70	20.0	0.35	19.5	5.1	4.0	13.1	0.59	0.32	2.19	16																											
73H	72.83%	108	8.3	3.90	2.93	11.3	1.46	48.3	0.48	57.9	13.8	13.3	17.9	1.67	0.53	3.40	26.3						8.16	140		25.6	114			27.7	4830		31.7	22.6									17.9	365	
73T	79.67%	150	3.5	1.34	0.76	6.0	0.52	68.9	0.13	52.8	15.8	8.8	1.6	0.75	0.16	0.98	13																											
73T2	69.31%	116		1.37		5.2		57.4		42.1			1.9				11.3	1.35								44.5		2.6		101				3.5			2.39		47.8	9.7	1320				59.2
74C	70.67%	46.9	2.5	1.47	0.70	3.1	0.47	21.5	0.23	20.5	5.5	3.9	8.1	0.43	0.22	1.52	13																											

* Denotes duplicate sample analysis

Results initially reported in Kruger and others (2017)

Results initially reported in Murphy and others (2018)

Results initially reported in Kruger and others (2022)

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
74D	18.47%	26.7	5.9	3.68	1.10	5.1	1.21	10.6	0.54	17.1	3.9	4.4	9.4	0.90	0.53	3.47	34																												
74E	28.23%	44.6	4.1	2.56	0.71	3.7	0.85	26.6	0.37	15.2	4.3	3.1	9.1	0.63	0.36	2.38	26																												
74F	72.67%	53.4	5.4	3.50	1.13	5.0	1.14	25.8	0.56	23.6	6.2	4.9	15.8	0.85	0.53	3.42	29																												
74G	36.97%	50.2	3.2	1.72	0.95	3.9	0.60	23.8	0.24	20.5	5.5	4.2	6.8	0.57	0.24	1.57	15																												
75A	95.42%	71.8	4.2	2.47	1.11	4.9	0.81	34.1	0.39	31.1	8.2	5.9	12.5	0.73	0.38	2.65	22																												
75B	74.56%	56.1	4.3	2.67	1.04	4.6	0.87	26.6	0.41	24.9	6.6	4.9	13.2	0.70	0.39	2.70	23																												
75C	16.71%	20.4	3.5	2.32	0.51	2.6	0.76	13.4	0.34	7.9	2.1	1.9	8.5	0.49	0.33	2.20	23																												
75D	22.41%	7.7	1.1	0.73	0.27	1.0	0.24	3.7	0.13	3.9	1.0	0.9	5.0	0.16	0.11	0.78	6																												
75E	27.38%	18.4	3.6	2.33	0.59	3.0	0.76	8.7	0.35	9.1	2.2	2.4	9.2	0.53	0.34	2.29	23																												
75F	31.35%	12.8	2.6	1.82	0.43	2.1	0.58	6.2	0.25	6.8	1.6	1.7	4.9	0.37	0.25	1.56	20																												
75G	27.06%	20.0	2.2	1.30	0.62	2.4	0.42	8.2	0.21	11.9	2.8	2.7	8.7	0.37	0.19	1.32	10																												
75H	44.38%	33.7	2.9	1.82	0.68	3.2	0.59	15.1	0.27	15.6	4.0	3.3	8.0	0.48	0.25	1.74	18																												
75I	16.91%	12.1	1.7	1.07	0.28	1.4	0.36	6.4	0.15	5.1	1.4	1.2	3.0	0.25	0.15	0.95	11																												
76C	18.88%	9.0	1.0	0.59	0.20	0.9	0.20	4.3	0.09	4.2	1.1	0.9	3.0	0.16	0.09	0.56	6																												
76D	10.26%	11.6	2.9	1.95	0.46	2.2	0.63	5.3	0.29	6.3	1.5	1.6	6.0	0.41	0.28	1.84	18																												
76E	22.05%	50.9	3.6	2.18	0.72	3.7	0.73	25.4	0.30	17.4	5.0	3.3	6.7	0.59	0.31	1.95	21																												
76Eb	42.95%	28.1		1.62		2.3		15.1		11.9			5.6				13.1						0.62	22		12.3	9			14.8	1360		3.7	10.8									4.3	33	
76Ef	84.23%	50.7		1.25		2.6		25.8		20.8			4.6				10.2	1.73	35.5	488	0.6		2.51	19	0.7	9.2	5	2.8		14.8	1190	36	3.1	16.2	32	119	1.18		6.2		3520	3.0	2.9	32	98.8
76G	32.67%	57.3	3.8	2.11	1.19	4.6	0.70	25.2	0.33	26.6	6.7	5.5	9.9	0.68	0.30	2.14	15																												
76H	37.78%	29.9	3.1	1.96	0.63	3.1	0.64	13.5	0.29	13.9	3.6	2.9	7.1	0.49	0.28	1.85	18																												
76L	93.12%	68.2		2.68		5.4		34.2		30.5			12.2				20.8						11.6	67		22.1	6			44.7	7310		4.7	15.5									11.6	104	
76L2	91.30%	83.0		3.00		6.6		42.2		35.9			11.2				25.9						8.54	56		18.6	5			57.7	6520		2.5	14.1									7.1	82	
76lim	82.33%	39.5		2.99		4.6		21.7		18.3			10.7				29.6						1.49	32		54.5	2			23.5	12200		0.7	7.8									6.5	57	
76M	94.98%	53.8		1.89		3.7		27.6		23.3			10.8				17.5	1.69	4.7	996	2.0		9.22	54	6.0	17.4	3	2.7		46.4	9080	190	1.1	15.7	135	94	1.15		10.4		3360	3.6	2.5	80	90.5
76N	95.94%	69.8		2.81		5.7		35.9		31.8			14.6				25.1	1.47	11.8	583	2.4		12.9	72	14.5	23.6	3	3.3		50.3	9710	102	0.8	16.4	155	83	1.22		12.1		3510	2.3	2.5	102	110
76O	79.59%	209	12.8	5.69	4.43	18.6	2.19	92.7	0.67	101	25.1	21.4	19.8	2.63	0.73	4.61	43.4						11.1	95		26.4	7			70.0	6030		6.3	14.2									13.9	159	
76P	74.62%	96.8		3.35		8.3		47.6		44.4			15.9				25.9						11.8	76		27.8	20			76.0	6240		7.1	14.3									10.6	112	
76P2	94.06%	82.9		3.03		7.5		38.8		40.0			14.8				24.3						10.8	71		28.0	3			54.3	7330		3.0	15.6									6.8	113	
76T	67.98%	103		1.19		4.3		50.4		36.2			1.6				10.0	0.76								44.5		2.9		115				3.7			2.77		47.8	10.1	1310				55.7
77A	76.31%	66.6	9.2	6.14	1.74	8.4	1.99	35.6	0.92	33.4	8.2	7.4	19.1	1.41	0.89	5.82	58																												
77B	35.86%	30.7	6.9	4.27	1.21	6.1	1.44	17.6	0.57	18.3	4.2	4.7	15.5	1.05	0.59	3.73	42																												
77C	26.06%	15.9	1.6	1.00	0.35	1.5	0.33	7.4	0.14	7.0	1.8	1.4	4.2	0.26	0.14	0.93	10																												
77D	16.10%	16.5	3.7	2.36	0.68	3.2	0.77	6.5	0.37	9.9	2.2	2.6	7.6	0.57	0.34	2.30	18																												
77E	34.24%	75.8	5.9	3.75	1.16	5.6	1.22	32.3	0.54	27.2	7.4	5.4	9.9	0.93	0.53	3.45	35																												
77G	24.66%	55.7	9.1	4.81	2.65	10.5	1.69	15.7	0.69	47.6	10.1	11.3	23.8	1.57	0.69	4.57	36																												
77H	40.61%	38.1	4.3	2.78	0.84	4.1	0.92	18.1	0.40	18.0	4.6	3.8	8.5	0.67	0.40	2.58	30																												
78A	45.09%	23.3	2.9	1.44	1.16	3.6	0.52	7.0	0.21	16.9	3.7	4.1	5.7	0.52	0.20	1.37	9																												
79C	21.22%	37.7	3.7	2.09	0.76	3.6	0.73	18.3	0.27	15.2	4.1	3.3	7.3	0.60	0.28	1.79	21																												
79D	39.83%	10.6	1.2	0.69	0.39	1.3	0.23	3.9	0.11	5.9	1.4	1.5	5.0	0.20	0.10	0.72	5																												
79E	31.82%	46.1	5.2	3.27	0.95	4.7	1.08	22.2	0.47	18.5	4.9	4.1	9.5	0.79	0.47	3.07	30																												
79Eb	20.38%	13.9		1.66		2.0		8.0		5.9			3.3				17.2						0.90	8		2.9	17			8.0	2300		3.1	4.4									7.3	9	

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

* Denotes duplicate sample analysis

Results initially reported in Kruger and others (2017)

Results initially reported in Murphy and others (2018)

Results initially reported in Kruger and others (2022)

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium
79G	18.76%	28.2	3.7	2.01	1.16	4.5	0.69	8.2	0.29	22.5	4.9	5.1	10.0	0.66	0.29	1.96	15
79H	37.68%	17.3	1.4	0.86	0.40	1.6	0.28	8.1	0.13	8.2	2.1	1.8	3.9	0.24	0.12	0.83	7
79T	79.01%	107		1.13		4.8		51.3		39.9			1.4				9.6
80C	23.62%	15.1	3.3	2.22	0.54	2.5	0.71	6.9	0.32	7.7	1.9	1.8	9.4	0.46	0.32	2.11	21
80H	38.38%	25.3	2.6	1.64	0.56	2.6	0.54	12.5	0.23	11.8	3.0	2.5	5.3	0.40	0.23	1.45	18
81B	70.99%	46.7	3.2	1.93	0.91	3.6	0.65	22.2	0.31	21.0	5.5	4.3	11.0	0.53	0.29	2.03	15
81C	25.40%	26.9	4.9	3.32	0.82	3.8	1.07	13.6	0.50	12.0	3.1	2.9	13.9	0.69	0.48	3.19	32
81D	18.99%	20.5	5.1	3.96	0.80	3.6	1.20	9.5	0.68	10.9	2.7	2.8	18.9	0.69	0.60	4.16	33
81F	25.59%	22.5	2.6	1.72	0.51	2.5	0.57	10.4	0.23	10.7	2.8	2.2	4.3	0.41	0.23	1.49	20
82C	26.04%	31.9	4.5	2.41	0.94	4.3	0.87	15.6	0.28	14.6	3.8	3.7	9.6	0.74	0.32	1.95	24
82D	22.55%	35.9	6.1	3.65	1.30	5.8	1.24	17.1	0.52	21.0	5.0	5.1	14.0	0.98	0.50	3.35	30
82E	38.33%	64.4	6.7	3.21	2.40	8.8	1.16	17.8	0.43	47.5	10.8	11.3	20.0	1.24	0.44	2.90	24
82G	88.64%	77.2	5.3	2.75	1.70	6.3	0.95	34.5	0.41	37.9	9.8	8.0	17.0	0.95	0.40	2.75	21
82H	57.81%	42.0	3.7	2.15	0.94	4.1	0.72	17.9	0.31	20.7	5.2	4.4	9.3	0.62	0.31	2.04	18
83C	26.64%	81.1	9.3	4.96	2.06	9.5	1.79	37.2	0.64	38.6	9.8	8.5	16.0	1.55	0.67	4.25	49
83D	17.19%	29.2	4.7	2.87	1.01	4.4	0.95	9.0	0.45	15.9	3.6	4.2	8.5	0.75	0.42	2.87	21
83E	37.84%	36.0	3.6	1.87	1.20	4.4	0.66	11.6	0.27	23.4	5.5	5.3	11.4	0.63	0.26	1.76	14
83G	91.66%	63.8	3.4	1.83	1.13	4.0	0.62	25.4	0.28	25.2	6.6	4.9	12.0	0.61	0.27	1.87	14
83H	51.89%	38.7	3.2	1.85	0.88	3.7	0.62	16.5	0.28	19.3	4.8	4.1	7.3	0.54	0.27	1.83	16
84C	29.34%	20.0	4.1	2.67	0.71	3.2	0.88	9.4	0.39	9.6	2.4	2.4	9.7	0.59	0.38	2.52	27
84H	60.07%	53.8	4.1	2.36	1.06	4.6	0.79	23.5	0.36	25.0	6.4	5.1	9.0	0.69	0.33	2.29	21
85B	69.61%	50.5	3.8	2.36	0.91	4.1	0.75	23.5	0.35	22.9	5.9	4.6	11.6	0.63	0.34	2.29	20
85F	51.75%	40.8	3.6	2.22	1.10	4.0	0.74	18.4	0.31	19.6	5.0	4.0	7.3	0.60	0.30	1.99	22
86C	44.50%	70.1	6.3	3.76	1.21	6.3	1.30	45.0	0.48	25.7	7.1	4.9	9.9	1.00	0.51	3.15	46
86D	15.57%	12.5	3.8	3.08	0.54	2.6	0.93	6.9	0.53	6.7	1.6	1.7	13.9	0.51	0.46	3.16	30
86H	50.47%	42.7	3.5	2.15	0.90	4.0	0.70	17.8	0.32	20.3	5.1	4.2	8.6	0.59	0.31	2.07	19
87B	43.60%	51.0	10.1	5.48	2.36	10.4	1.97	14.3	0.75	40.8	8.94	10.9	18.4	1.73	0.79	5.09	44.3
87Bb	17.56%	14.7		1.72		2.9		6.6		9.0			5.2				17.8
87C	20.71%	75.8	8.90	4.68	2.15	9.82	1.70	39.8	0.59	41.8	10.6	9.25	15.2	1.58	0.65	4.14	34.7
87Cb	31.74%	24.0		2.26		3.7		11.1		13.8			6.8				24.2
87D	63.55%	99.6	6.28	3.04	2.21	8.52	1.11	44.6	0.39	49.7	12.5	10.7	18.5	1.20	0.42	2.74	22.0
87Db	55.59%	46.6		2.96		4.5		22.4		21.1			10.4				25.1
88A	50.10%	74.9	11.2	6.01	2.46	11.9	2.14	24.7	0.79	46.1	10.8	11.4	16.2	1.93	0.85	5.44	47.2
88B	36.15%	52.1	9.44	5.48	1.67	8.99	1.90	21.8	0.70	28.2	6.71	6.92	12.8	1.54	0.77	4.88	44.8
88B*	36.57%	54.1	9.75	5.60	1.73	9.27	1.96	22.7	0.72	29.2	6.98	7.15	12.9	1.58	0.79	5.01	46.0
88C	32.11%	70.0	10.1	5.53	2.03	10.5	1.98	32.8	0.69	36.5	8.90	8.67	12.3	1.70	0.76	4.79	44.2
88Cb	11.38%	13.9		2.52		3.5		7.0		8.4			11.9				20.9
88D	27.79%	61.9		3.50		6.7		30.5		27.8			15.0				28.4
88Db	8.30%	9.0		2.02		1.8		4.5		4.9			13.3				17.1
89A	41.10%	98.5	13.7	7.31	2.74	14.4	2.67	42.2	0.89	50.7	12.5	12.1	13.5	2.38	1.00	6.23	62.4
89B	41.60%	120	12	6.51	3.47	14.2	2.28	49.8	0.82	69.1	16.6	14.9	24.3	2.13	0.88	5.64	58.9

SAMPLE ID	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
79G																												
79H																												
79T	0.70								50.7		1.5		102				2.6			1.63		48.4	7.1	987				22.5
80C																												
80H																												
81B																												
81C																												
81D																												
81F																												
82C																												
82D																												
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84C																												
84H																												
85B																												
85F																												
86C																												
86D																												
86H																												
87B																												
87Bb								4.5	4.4		0.9						2.8			0.15				342			6	
87C																												
87Cb								15.4	4.7		1.5						2.9			0.18				475			19	
87D	9.89		371	2.1		5.40	129		21.9	6	5.6		41.2	4410		17.2	10.4		263	0.83				3160	1.6	20.2	270	253
87Db								6.4	9.0		3.8						16.3			1.22				2980			51	
88A																												
88B																												
88B*																												
88C																												
88Cb				2.1		0.13				2	1.8		11.7	6050				1				4.6		635		6.4		64.3
88D				2.0		0.12				2	1.3		7.0	3920				2				4.2		280		15.1		46.7
88Db				3.4		0.24				4	2.5		2.0	4560				3				3.2		188		5.6		154
89A																												
89B								9.1	18.1		12.0						17.4			0.81				2330			247	

* Denotes duplicate sample analysis

Results initially reported in Kruger and others (2017)

Results initially reported in Murphy and others (2018)

Results initially reported in Kruger and others (2022)

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium
89Bb	30.90%	14.7		1.64		2.1		7.3		7.1			6.6				15.2
89Db	12.19%	8.8		1.62		1.7		4.1		5.2			7.6				16.1
90A	40.50%	134	14.5	7.12	3.41	16.4	2.70	52.3	0.84	67.0	16.7	15.7	15.9	2.63	0.96	5.98	55.9
90C	71.47%	88.7	7.34	3.69	2.06	9.00	1.33	35.5	0.47	45.3	11.4	10.0	15.8	1.36	0.52	3.35	27.1
90Cb	7.32%	6.5		1.35		1.7		3.0		4.0			6.9				11.3
90D	29.91%	62.7		1.94		5.5		27.4		30.8			10.8				13.6
90Db	6.92%	7.5		2.02		1.7		3.8		4.3			14.6				16.5
91A	35.50%	121	10.7	5.47	2.44	11.8	2.02	52.1	0.67	53.5	14.1	11.6	13.8	1.92	0.76	4.78	42.5
91B	31.53%	35.8	2.73	1.32	0.87	3.44	0.49	15.9	0.17	17.0	4.35	3.68	6.59	0.51	0.18	1.21	8.83
91E	38.88%	105	6.9	3.51	2.56	9.4	1.24	39.5	0.47	57.0	14.0	12.3	23.7	1.33	0.49	3.36	25.9
91Eb	32.23%	20.8		2.09		2.6		10.9		9.7			8.4				18.8
92A	38.55%	99.0	11.8	5.70	3.15	14.5	2.14	29.4	0.66	61.2	14.4	14.8	17.1	2.19	0.76	4.74	42.9
93A	28.23%	116	18.2	8.91	4.42	21.2	3.32	45.1	1.04	81.0	19.0	20.1	22.1	3.26	1.19	7.41	66.8
93Cb	23.21%	15.6	3.6	2.08	0.60	3.2	0.72	7.4	0.27	8.6	2.0	2.4	8.9	0.55	0.29	1.85	18.9
93D	23.74%	49.2	5.7	2.97	1.30	6.2	1.07	23.3	0.36	23.2	5.8	5.4	10.9	0.99	0.40	2.48	25.4
93Db	22.32%	57.8	10.1	5.80	2.22	10.3	2.02	21.2	0.75	36.7	8.4	8.6	19.3	1.67	0.79	4.96	52.0
93E	46.60%	36.2		1.09		2.5		18.7		16.8			8.6				9.3
94A	15.37%	63.9	7.84	4.15	1.71	8.41	1.50	32.9	0.51	34.0	8.70	7.49	9.03	1.36	0.58	3.61	31.0
94Ar	68.41%	69.8	4.5	2.42	1.20	5.3	0.82	31.3	0.32	31.0	8.2	6.2	15.9	0.79	0.33	2.32	19.7
94B	33.34%	30.9	5.74	3.63	0.80	4.65	1.23	18.0	0.49	13.2	3.33	3.14	8.80	0.87	0.52	3.38	33.4
95A	36.88%	92.5	10.0	4.99	2.53	11.5	1.84	42.7	0.62	53.0	13.4	11.8	14.6	1.81	0.69	4.38	32.8
95E	38.00%	68.6		4.30		7.9		27.7		38.5			24.4				33.7
96A	45.82%	62.4	7.55	4.25	1.39	7.55	1.50	32.8	0.51	26.5	6.88	5.67	13.1	1.25	0.58	3.62	39.0
96A*	44.81%	64.8	7.84	4.41	1.44	7.87	1.56	33.9	0.53	27.4	7.18	5.84	13.6	1.30	0.60	3.71	40.4
97-1	75.86%	157	8.4	3.67	3.00	11.4	1.39	75.5	0.44	66.9	18.1	13.3	19.9	1.59	0.50	3.06	32.5
97-10	20.17%	186	12.3	6.03	4.30	17.0	2.25	81.8	0.65	94.9	23.6	19.7	21.8	2.32	0.77	4.75	54.3
97-11	15.60%	185	13.3	6.80	4.09	17.0	2.51	79.7	0.76	90.6	22.8	18.2	19.0	2.42	0.89	5.42	60.7
97-12	11.93%	170	12.8	6.72	3.63	15.6	2.43	71.1	0.77	80.2	20.3	15.7	17.0	2.26	0.89	5.40	55.8
97-13	16.96%	191	15.4	8.00	4.14	18.4	2.93	79.8	0.89	89.0	22.9	17.6	17.1	2.68	1.05	6.29	65.0
97-14	19.11%	158	13.4	7.20	3.42	15.5	2.58	66.8	0.82	73.8	19.0	14.4	15.7	2.31	0.94	5.76	58.0
97-15	17.80%	158	13.5	7.18	3.63	16.0	2.57	61.9	0.83	76.8	19.5	15.2	16.2	2.37	0.95	5.82	53.4
97-16	22.15%	154	13.0	6.75	3.72	15.9	2.43	60.6	0.80	78.0	19.6	15.8	17.4	2.32	0.89	5.60	49.4
97-17	35.35%	109	9.3	5.14	2.70	11.2	1.80	42.6	0.68	56.2	13.9	11.8	16.8	1.64	0.71	4.65	38.0
97-18	68.38%	92.6	5.2	2.81	1.68	7.0	0.95	42.0	0.38	42.7	11.1	8.1	14.2	0.94	0.40	2.65	24.1
97-2	66.48%	326	17.7	6.36	6.97	26.6	2.66	154	0.60	144	37.6	30.5	27.6	3.63	0.76	4.49	58.0
97-3	49.43%	435	25.3	9.04	9.78	36.9	3.83	201	0.82	196	51.2	43.1	38.3	5.17	1.08	6.26	82.3
97-4	27.73%	358	20.6	8.50	7.86	28.4	3.32	149	0.87	166	43.3	35.5	43.5	4.02	1.08	6.50	70.6
97-5	26.60%	269	15.0	6.41	5.95	21.1	2.46	111	0.66	131	32.7	27.2	35.7	2.94	0.81	4.87	56.5
97-6	27.46%	230	12.5	5.43	4.90	17.8	2.08	97.3	0.56	111	28.0	22.9	27.9	2.42	0.69	4.12	50.2
97-7	29.84%	173	10.3	4.83	4.04	14.8	1.81	74.2	0.52	90.7	22.5	18.7	22.3	2.04	0.61	3.75	41.0
97-8	21.83%	169	10.5	4.98	3.92	14.7	1.87	73.5	0.54	87.3	21.8	17.9	22.1	2.03	0.65	3.96	45.7

SAMPLE ID	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
89Bb								5.8	11.3		2.0						13			0.92				2310			25	
89Db								12.4	7.3		0.6						2.5			0.07				197			11	
90A																												
90C																												
90Cb				1.1		0.43				3	0.7		5.2	2650				5				2.6		232		3.0		26.9
90D				0.4		1.09				2	2.4		8.7	1720				19				6.1		561		14.0		88.5
90Db				3.5		0.22				4	2.9		1.6	3490				3				2.8		181		5.5		169
91A																												
91B																												
91E				1.2		6.34				9	6.7		17.0	3240				33				17.5		2100		16.2		319
91Eb				2.6		0.28				19	3.1		14.4	3770				3				6.3		2160		3.3		179
92A	2.48		1510	1.4		1.05	39		7.1	3	2.7		14.0	2960		6.8	11.7		249	0.76				2040	3.7	11.8	41	113
93A	2.76	99.6	1310	2.8	0.30	0.93	29	24.6	14.0	5	3.3	0.05	15.4	3000	141	8.5	13.4	14	216	0.60	<0.10	7.9	1.5	1460	3.1	15.5	33	136
93Cb	3.72	31.3	1160	1.9	0.19	0.82	12	17.6	8.9	3	1.6	0.02	13.4	6240	336	2.4	4.8	9	663	0.35	<0.10	3.7	0.9	819	1.2	4.9	19	55.2
93D	7.63		1300	2.6		0.29	18		7.3	2	1.2		3.9	8170		19.0	7.1		538	0.14				433	1.0	8.6	36	39.9
93Db	2.07	10.4	879	3.5	<0.10	0.73	32	15.9	16.5	4	2.1	0.02	3.8	4980	137	4.3	7.6	11	330	0.19	<0.10	3.0	0.4	505	3.8	6.9	44	143
93E				0.9		5.15				7	4.1		19.8	4620				44				13.1		2030		8.1		184
94A	3.00		826	2.1		0.75	23		19.1	5	2.4		8.2	6860		5.0	11.3		351	0.32				729	6.4	13.6	16	91.6
94Ar																												
94B																												
95A	3.44		1160	1.3		1.16	34		20.6	5	3.6		9.6	7420		9.3	16.6		379	0.29				658	7.5	13.1	57	148
95E				2.8		5.13				5	7.3		18.9	2470				28				17.4		2090		10.1		374
96A	2.56		2050	2.8		1.27	17		15.5	3	2.5		18.8	6680		9.3	9.0		520	0.59				1450	3.4	10.0	25	96.5
96A*																												
97-1	2.37		703	3.2		11.0	155	8.7	28.0	5	4.7		60.7	3620		9.2	14.9		113	1.27				4110	2.5	7.7	223	199
97-10																												
97-11																												
97-12	3.07		258	1.4		0.07	39		9.7	15	1.5		4.8	818		13.6	2.5		197	0.10				177	6.9	9.7	56	37.0
97-13																												
97-14																												
97-15																												
97-16																												
97-17	4.82	80.8	1130	1.4	0.19	2.73	43	17.6	16.1	14	2.4	0.03	11.8	2040	40	14.4	12.5	46	324	0.47	<0.10	5.8	1.1	1240	3.9	9.5	54	133
97-18	2.49		463	1.8		7.48	58		21.0	5	3.6		28.3	4480		6.3	14.0		52	1.02				3090	2.5	6.9	70	159
97-2								9.8		9						9.9												
97-3	3.42	17.0	358	4.5	0.82	5.21	227	11.5	22.4	13	4.3	0.09	50.9	2250	31	13.2	9.8	55	101	0.77	0.21	49.3	1.8	2400	1.4	18.5	362	183
97-4								16.0		13						27.4												
97-5								17.4		13						32.2												
97-6								16.6		12						34.4												
97-7	9.46		1270	2.1		0.48	117		8.9	10	3.6		13.8	1120		28.3	7.0		503	0.31				801	3.4	15.2	262	104
97-8																												

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

* Denotes duplicate sample analysis

Results initially reported in Kruger and others (2017)

Results initially reported in Murphy and others (2018)

Results initially reported in Kruger and others (2022)

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium
97-9	20.25%	183	11.7	5.59	4.32	16.4	2.07	79.0	0.60	95.7	23.5	19.8	23.6	2.26	0.72	4.37	50.0
97A	59.74%	355	26.1	9.22	10.2	39.7	3.97	168	0.77	198	50.1	44.0	32.3	5.44	1.10	6.28	76.6
97A*	59.74%	346	25.5	8.91	9.92	38.1	3.96	189	0.76	192	48.2	42.7	29.9	5.31	1.08	6.21	74.3
97A2	46.05%	157	9.0	3.7	3.32	13.2	1.45	81.2	0.40	72.0	18.5	15.4	19.2	1.84	0.46	2.92	34.3
97A3	26.53%	395	23.0	9.1	8.32	33.3	3.75	200	0.80	177	45.9	37.2	28.7	4.71	1.06	6.18	92.3
97B	27.79%	178	14.1	6.73	4.46	18.6	2.55	92.6	0.69	97.7	24.6	19.6	16.1	2.63	0.88	5.19	54.4
97ss	96.40%	47.2	1.9	1.14	0.61	2.6	0.33	22.8	0.14	19.1	5.2	3.4	6.7	0.30	0.12	1.21	9.9
98A	27.54%	275	18.5	7.26	7.9	28.0	2.88	99.0	0.71	160	37.0	36.1	38.2	3.72	0.89	5.42	59.5
98A2	28.33%	562	41.2	15.6	15.0	59.9	6.59	244	1.26	302	73.9	67.1	41	8.39	1.82	10.4	148
98B	62.43%	116	8.0	3.91	2.84	10.9	1.40	47.5	0.49	61.6	14.9	12.6	16.3	1.47	0.52	3.48	29.9
98C	29.55%	31.3	3.4	2.00	0.58	3.3	0.67	14.6	0.28	14.2	3.7	3.2	4.2	0.54	0.28	1.87	19.7
98D	35.48%	26.3	2.3	1.37	0.3	2.2	0.44	11.8	0.19	10.8	3.0	2.3	2.5	0.35	0.19	1.31	12.5
98H	18.96%	7.9		1.35		1.7		3.7		4.5			4.5				13.9
98Hb	20.50%	57.5	11.5	6.75	2.34	10.9	2.36	23.3	0.80	39.2	8.5	9.4	16.6	1.87	0.92	5.55	71.4
98I	24.50%	22.1		3.22		3.4		11.3		10.4			11.9				32.1
98Ib	49.37%	35.6		2.17		3.1		19.5		14.9			15.6				20.0
98T	61.44%	67.4	2.3	1.12	0.43	3.1	0.38	29.5	0.13	24.6	7.3	4.3	2.0	0.41	0.15	1.01	10.5
99A	32.77%	88.7	5.4	2.52	1.85	7.0	0.90	39.3	0.31	41.5	10.5	8.6	16	0.99	0.33	2.18	21.3
99A2	62.07%	175.0	9.7	4.08	3.36	13.7	1.52	85.5	0.40	78.9	20.4	15.7	21.4	1.82	0.46	3.23	37.5
99B	22.63%	69.6	5.6	3.18	1.39	6.2	1.09	32.5	0.41	30.9	8.0	6.2	11.1	0.93	0.43	2.85	26.3
101A	48.33%	37.7		2.26		3.1		21.3		14.5			9				23.7
101B	87.43%	57.3		1.83		4.0		26.3		26.3			14.3				14
101C	24.18%	60.7	4.2	2.36	0.53	4.3	0.79	26.1	0.32	23.5	6.7	4.9	3.9	0.68	0.33	2.22	24
101D	44.70%	57.2	3.0	1.58	0.33	3.4	0.51	25.8	0.19	21.4	6.2	4.0	2.5	0.48	0.19	1.45	15.1
101T	79.73%	48.0	1.2	0.47	0.19	1.9	0.13	22.7	<0.02	17.1	5.0	2.8	1.5	0.18	<0.02	0.38	4.9
102ash	93.04%	53.2	3.6	2.42	0.68	3.5	0.78	30.1	0.39	18.4	5.4	3.3	11.8	0.58	0.37	2.45	24.4
102C	27.84%	50.2	4.0	2.38	0.51	3.9	0.80	21.6	0.33	19.4	5.5	4.1	3.8	0.64	0.33	2.19	25.6
102D	28.93%	43.0	2.9	1.62	0.37	3.0	0.56	18.0	0.22	16.4	4.7	3.3	2.4	0.47	0.23	1.50	17.3
102T	76.25%	37.0	1.3	0.62	0.27	1.9	0.22	17.1	0.08	14.1	4.1	2.5	1.5	0.25	0.08	0.54	6.4
103C	22.57%	47.9	3.5	2.07	0.47	3.6	0.69	20.2	0.28	18.2	5.2	3.7	2.7	0.57	0.28	1.91	20.9
103D	23.11%	52.4	3.0	1.69	0.39	3.4	0.58	21.3	0.23	19.9	5.8	3.9	2.4	0.52	0.24	1.57	16.9
103T	70.70%	44.0	1.5	0.70	0.28	2.2	0.25	20.3	0.09	16.4	4.9	2.9	1.6	0.29	0.09	0.60	6.7
104A	80.88%	73.1	5.7	3.47	1.49	6.2	1.13	36.1	0.50	34.0	9.2	6.5	16.2	0.94	0.48	3.28	31.3
104B	47.00%	51	4.3	2.32	1.31	4.9	0.80	21.4	0.31	25.0	6.5	5.4	12	0.74	0.31	2.07	20.8
104C	42.15%	27	2.3	1.50	0.60	2.3	0.49	14.6	0.23	11.2	3.1	2.2	9.1	0.36	0.21	1.45	13.7
104ss	93.65%	48.1	3.2	1.82	1.06	4.0	0.62	24.6	0.25	22.2	5.8	4.4	10.6	0.56	0.25	1.65	17.7
118C	35.41%	40.5	3.9	2.29	0.71	4.0	0.78	19.9	0.32	18.1	4.8	3.9	3.6	0.63	0.32	2.07	22.4
118D	32.51%	67.6	6.0	3.66	0.86	6.1	1.22	31.5	0.50	27.9	7.6	5.8	4.1	0.97	0.50	3.25	38.6
118E	28.18%	95.5	6.0	2.69	2.33	8.4	0.98	38.5	0.35	51.2	12.6	11.3	19.9	1.13	0.36	2.38	22.0
118F	36.14%	51.4	5.0	2.80	0.99	5.0	0.96	24.4	0.37	21.8	5.8	4.5	11.7	0.83	0.38	2.49	24.6
118G	27.82%	26.1	3.8	2.23	0.84	3.9	0.76	11.7	0.29	13.6	3.3	3.4	5.2	0.62	0.30	1.94	22.7

SAMPLE ID	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
97-9																												
97A																												
97A*																												
97A2	4.76		1360	2.5		5.20	192	15.3	24.4	12	6.3		40.5	3610		23.8	17.1			0.97				2450	2.5	15.7	283	321
97A3	3.47		568	8.5		1.37	183	25.1	12.3	11	4.3		35.4	5760		14.0	8.5			0.45				1220	1.4	13.6	327	199
97B																												
97ss																												
98A	4.64		558	2.2		0.26	403	11.0	9.1	16	8.9		18.5	705		23.7	9.9		233	0.50				1380	2.4	25.4	379	401
98A2	3.47		209	9.0		1.72	317	31.3	15.4	17	6.6		30.0	2040		17.6	9.0			0.53				1440	1.9	25.7	477	311
98B																												
98C																												
98D																												
98H	2.25		1010	2.3		0.40	5	2.9	4.7	35	0.5		3.2	10900		9.0	3.8			0.09				313	5.6	2.4	14	18.2
98Hb								48.0	10.8		1.9						5.9			0.16				416			27	
98I	1.44		521	7.2		0.35	15	5.3	7.4	1	2.5		28.1	4050		7.7	4.7			0.42				1020	0.7	10.2	43	110
98Ib	2.42		577	1.9		6.64	63	1.7	17.4	2	2.9		52.5	11000		2.9	9.6			0.71				2320	1.4	6.5	92	99.4
98T																												
99A																												
99A2	3.13		554	2.3		9.57	104	6.8	24.4	7.0	3.8		57.0	4560		13.1	12.0		219	0.97				2890	2.2	11.2	166	141
99B																												
101A	3.22		2150	2.6		2.8	30	33.0	17	10	2.4		40.5	10700		5.2	11.1			0.77				2110	3.1	6.8	47	94
101B	3.56		390	1.6		6.22	95	7.9	18.1	5	3.8		34.8	4410		7.4	13.3			1.04				3220	2.1	6.1	141	188
101C																												
101D																												
101T																												
102ash																												
102C																												
102D																												
102T																												
103C																												
103D																												
103T																												
104A	4.15	27.6	478	3.4	0.43	7.74	93	7.9	27.7	21	5.8	0.05	53.9	8710	317	6.5	14.9	67	233	0.94	0.16	9.8	1.9	3500	2.4	11.7	173	400
104B																												
104C																												
104ss																												
118C								5.0		1						7.2												
118D								7.7		1						7.8												
118E	11.5		427	1.1		1.46	139	9.5	13.7	14	6.2		7.8	2440		28.4	18.1			0.44				1120	6.1	12.6	203	272
118F								31.4		3						7.0												
118G								4.7		3						7.5												

* Denotes duplicate sample analysis
Results initially reported in Kruger and others (2017)
Results initially reported in Murphy and others (2018)
Results initially reported in Kruger and others (2022)

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
118ss	96.68%	60.7	2.4	1.41	0.79	3.3	0.44	29.4	0.21	23.9	6.7	4.3	7.2	0.43	0.19	1.47	12.2																												
118T	65.43%	49.6	2.5	1.39	0.57	3.1	0.48	24.1	0.19	19.2	5.4	3.6	3.0	0.45	0.19	1.23	14.2								3.7		1						5.4												
119A	23.61%	19.4	2.9	1.99	0.53	2.4	0.61	9.0	0.33	9.7	2.4	2.2	9.8	0.42	0.30	2.03	16.4								4.2		34						10.1												
119F	15.15%	8.9	2.1	1.44	0.34	1.6	0.45	4.1	0.23	4.8	1.1	1.2	7.2	0.29	0.21	1.43	12.9								1.9		21						7.0												
123-1	91.51%	288	18.3	8.07	6.55	26.3	3.06	121	0.80	141	35.1	30.7	17.6	3.62	0.98	6.25	71.8	2.33	15.8	598	3.9		12.9	99	16.3	26.3	30	3.4		47.1	5850		4.7	15.0		114	1.13				3730	2.6	22.0	141	141
123-10	90.20%	100	8.5	5.06	2.13	9.4	1.67	48.3	0.69	45.9	11.8	9.6	19.3	1.42	0.71	4.60	46.1	3.21		600	4.8		13.8	96		31.1	23	3.8		68.3	6760		6.9	16.4		154	1.24				4190	2.8	8.1	139	141
123-11	90.52%	97.8	8.2	4.92	2.02	9.0	1.64	47.0	0.67	44.2	11.4	9.2	18.4	1.38	0.69	4.49	44.1																												
123-12	90.65%	98.7	8.1	4.89	1.99	9.0	1.61	47.1	0.67	44.2	11.5	9.2	19.0	1.37	0.69	4.43	43.8																												
123-13	90.58%	102	8.2	4.82	2.05	9.1	1.62	48.3	0.66	45.7	11.8	9.5	19.4	1.39	0.68	4.48	44.4																												
123-14	91.02%	107	8.1	4.68	2.11	9.2	1.57	50.5	0.64	47.9	12.4	9.7	19.5	1.41	0.67	4.30	43.7																												
123-15	91.35%	106	8.1	4.67	2.12	9.3	1.57	50.3	0.63	47.4	12.5	9.7	19.3	1.39	0.65	4.29	42.4	2.40		438	4.4		14.5	92		31.2	5	3.6		73.6	7180		7.5	15.4		89	1.16				4110	2.7	8.6	134	127
123-16	90.78%	100	7.9	4.73	2.00	8.9	1.58	48.4	0.64	45.1	11.7	9.3	18.8	1.37	0.67	4.39	43.2																												
123-17	91.11%	109	8.2	4.71	2.15	9.7	1.60	51.2	0.63	49.1	12.7	10.1	19.3	1.43	0.64	4.34	42.6																												
123-18	91.30%	103	8.0	4.70	2.02	9.2	1.59	48.8	0.64	45.7	12.0	9.5	19.4	1.38	0.65	4.32	42.8																												
123-19	91.66%	98.8	7.9	4.60	1.96	8.8	1.53	47.4	0.62	44.6	11.6	9.2	18.8	1.32	0.63	4.30	41.4	2.14		424	5.2		14.8	94		30.3	3	3.9		66.9	7470		4.5	15.0		131	1.14				3650	2.4	7.8	139	124
123-2	86.13%	275	23.4	12.1	6.85	29.2	4.33	118	1.36	137	33.3	30.6	21.3	4.27	1.56	10.0	112	0.88	56.7	1070	1.1	0.10	0.55	10	21.9	6.0	44	1.2	<0.02	7.0	3430	205	10.5	4.8	8	376	0.38	<0.10	3.2	0.6	1140	3.1	24.0	17	42.8
123-3	88.36%	182	16.8	9.43	4.37	19.4	3.22	82.2	1.12	89.1	22.2	19.4	19.4	2.86	1.24	8.21	89.1		53.7						18.5		41						10.0										16.4		
123-4	88.85%	151	13.5	7.79	3.44	15.8	2.63	70.0	0.95	71.6	17.9	15.5	18.3	2.31	1.02	6.75	73.4		60.0						17.6		54						9.6										12.5		
123-5	90.86%	127	10.9	6.34	2.73	12.6	2.15	59.2	0.78	58.7	14.8	12.3	18.0	1.83	0.84	5.62	60.7	3.31	36.1	521	4.1		14.6	96	15.9	29.8	39	3.4		56.3	5820		7.0	16.1		115	1.20				4220	2.8	10.6	130	140
123-6	89.75%	111	9.4	5.48	2.36	10.6	1.86	53.0	0.74	50.5	12.9	10.5	17.5	1.61	0.77	4.97	51.7		42.2						15.4		37						6.8										8.6		
123-7	90.14%	108	9.4	5.51	2.37	10.6	1.85	52.0	0.72	50.6	12.8	10.6	18.2	1.60	0.76	4.91	50.5		62.5						15.7		44						8.1										8.2		
123-8	90.94%	111	9.2	5.40	2.33	10.4	1.82	53.2	0.71	50.5	13.1	10.5	18.6	1.60	0.76	4.91	50.0		40.6						16.2		23						6.8										8.4		
123-9	90.22%	101	8.5	5.06	2.15	9.4	1.69	48.1	0.68	46.3	11.8	9.6	18.7	1.43	0.72	4.57	45.5																												
123F	73.52%	197	17.9	8.94	5.39	22.3	3.24	86.2	1.02	105	25.3	24.2	18.2	3.27	1.18	7.24	82.9								20.1		193						22.0												
123Fr	94.52%	88.4		2.90		7.0		41.7		41.0			10.9				25.5						6.24			17.7	3			30.7				13.9			1.05				3030				
124F	90.23%	82.3	6.8	3.77	1.94	8.3	1.29	36.2	0.53	42.7	10.5	8.9	15.5	1.20	0.53	3.44	33.7								7.5		6						6.3												
124Fb	92.85%	79.6	6.2	3.54	1.73	7.5	1.21	34.4	0.47	39.5	9.8	8.2	12.7	1.09	0.49	3.17	31.1								5.7		4						3.2												
125C	18.64%	9.2	2.9	1.84	0.44	2.2	0.60	4.1	0.26	5.3	1.2	1.6	7.2	0.42	0.26	1.72	17.6								3.8		7						4.0												
125D	13.60%	20.7	2.2	1.24	0.49	2.3	0.42	8.6	0.17	9.8	2.5	2.2	5.5	0.36	0.17	1.14	9.1								4.4		1						18.0												
125E	34.32%	20.8	3.4	2.50	0.53	2.8	0.78	11.0	0.38	9.9	2.5	2.3	9.4	0.49	0.36	2.44	24.2								11.5		12						13.6												
125S	27.88%	27.3	3.1	1.97	0.43	2.9	0.64	12.6	0.29	12.0	3.2	2.8	3.6	0.49	0.28	1.86	19.8								3.1		2						6.1												
125T	77.66%	82.9	2.3	1.01	0.40	3.4	0.36	36.1	0.12	29.5	8.9	4.9	2.0	0.45	0.13	0.85	9.4								1.0		1						2.9												
125U	17.05%	18.9	1.5	0.88	0.17	1.4	0.29	7.6	0.13	6.3	1.7	1.4	1.7	0.23	0.13	0.86	8.1								1.1		2						5.4												
126C	15.94%	7.2	2.5	1.60	0.35	1.8	0.53	2.8	0.23	4.4	1.0	1.3	6.0	0.35	0.23	1.49	14.7								2.1		18						4.9												
126D	15.43%	18.1	2.2	1.28	0.46	2.2	0.43	7.6	0.18	9.0	2.3	2.1	6.1	0.36	0.18	1.20	10.1								5.6		2						15.4												
126ss	93.12%	36.3	2.3	1.44	0.69	2.8	0.45	17.8	0.20	15.8	4.2	3.1	6.6	0.39	0.19	1.41	12.6																												
127A	46.92%	26.1	6.0	3.81	0.96	4.8	1.26	13.3	0.54	13.7	3.3	3.6	14.5	0.87	0.53	3.49	35.5								7.9		6						9.7												
128C	30.24%	11.4	3.3	2.12	0.50	2.6	0.69	5.1	0.31	6.6	1.5	1.9	8.0	0.47	0.30	1.99	19.8								2.5		5						5.7												
129C	16.43%	12.8	3.8	2.52	0.53	2.9	0.81	5.7	0.36	7.2	1.7	2.0	8.0	0.54	0.35	2.31	24.7								4.0		10						4.0												
130C	35.49%	11.1	1.8	1.06	0.39	1.7	0.35	4.6	0.17	6.4	1.5	1.7	5.8	0.28	0.15	1.07	8.4								2.2		6						7.1												
130D	13.79%	56.3	11.5	7.28	1.81	9.8	2.42	29.3	1.03	26.7	6.6	6.3	23.1	1.70	1.00	6.47	73.0	3.58		989	7.6		0.12	10	58.6	14.2	4	0.9		5.1	5040		7.4	6.7		338	0.12				368	1.3	9.0	24	38.1

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

* Denotes duplicate sample analysis

Results initially reported in Kruger and others (2017)

Results initially reported in Murphy and others (2018)

Results initially reported in Kruger and others (2022)

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium
131C	14.41%	8.9	1.8	1.06	0.36	1.6	0.35	3.1	0.17	5.3	1.2	1.4	4.6	0.27	0.15	1.05	8.7
131D	22.40%	21.3	4.4	2.92	0.81	3.9	0.93	9.0	0.45	12.4	2.9	3.1	9.1	0.65	0.41	2.73	29.8
132H2	30.21%	9.7	2.6	1.86	0.44	1.9	0.60	5.1	0.30	5.1	1.2	1.3	12.3	0.36	0.27	1.83	19.4
132Hb	18.76%	9.7	2.3	1.50	0.37	1.8	0.51	4.8	0.19	4.9	1.2	1.3	4.3	0.33	0.20	1.21	16.2
132Hm	25.93%	10.5	2.6	1.92	0.44	1.9	0.60	5.4	0.29	5.3	1.3	1.4	12.7	0.36	0.27	1.81	20.2
132Ht	33.39%	15.8	4.4	3.31	0.67	2.9	1.01	8.7	0.55	7.9	2.0	2.1	25.0	0.58	0.49	3.38	32.1
133C	19.88%	6.3	1.4	0.91	0.27	1.2	0.29	2.6	0.14	3.7	0.9	1.0	3.9	0.21	0.13	0.90	7.6
133D	30.52%	93.6	12.1	7.22	2.71	12.5	2.41	41.3	1.03	48.6	11.6	10.8	24.5	1.94	0.99	6.49	66.6
134H2	32.35%	14.4	3.9	2.85	0.67	2.8	0.90	7.9	0.46	7.8	1.9	2.1	18.3	0.55	0.42	2.84	29.6
134H3	43.69%	39.5	4.8	2.92	1.07	4.3	0.99	22.1	0.42	17.9	4.8	3.8	15.0	0.74	0.41	2.70	30.3
134H4	40.97%	29.0	5.2	3.50	1.03	4.2	1.13	15.9	0.51	14.3	3.6	3.2	13.9	0.76	0.49	3.19	37.8
134Hb	31.94%	13.2	1.0	0.50	0.17	0.9	0.18	7.2	0.06	4.5	1.4	0.8	2.6	0.16	0.06	0.40	5.9
134Ht	31.21%	15.2	2.8	1.95	0.46	2.2	0.62	8.5	0.30	7.3	1.8	1.8	6.6	0.40	0.28	1.83	20.2
135C	94.99%	64.9		2.32		4.7		36.5		27.9			9.5				19.5
135D	94.71%	80.3		2.19		5.3		41.2		34.2			10.8				18.9
135E	61.90%	110	8.8	4.89	2.46	10.6	1.69	50.8	0.64	50.5	12.7	10.9	18.3	1.56	0.67	4.23	42.7
135F	94.20%	96.0		2.53		6.5		47.6		40.8			13.4				23.0
136B	95.04%	88.2		3.80		7.3		46.9		39.7			15.6				33.6
137A	73.84%	40.5		3.86		3.4		24.2		15.6			21.6				34.2
137B	20.34%	15.6		0.87		1.2		8.9		5.9			3.2				10.2
137C	39.20%	94.3		3.64		8.3		46.1		42.0			11.1				33.9
138E	49.60%	38.7		2.10		2.9		21.1		15.5			9.3				18.7
139E	43.20%	34.6		3.52		4.4		21.2		14.8			12.5				34.1
140C	32.34%	21.1	5.7	3.55	0.89	4.4	1.19	9.6	0.51	11.9	2.7	3.3	14.6	0.84	0.51	3.37	32.3
142C	19.62%	27.8	4.1	2.52	0.79	3.7	0.85	12.1	0.35	13.6	3.4	3.1	6.2	0.64	0.36	2.36	23.6
143C	16.14%	15.6	2.3	1.47	0.44	2.3	0.49	7.2	0.19	7.7	1.9	1.8	2.8	0.37	0.20	1.24	15.9
143Cb	38.08%	40.3	3.3	1.72	0.87	3.8	0.62	16.7	0.21	18.9	4.9	4.0	9.9	0.60	0.23	1.47	13.1
146A	30.44%	141	12.2	7.12	2.62	12.8	2.49	66.5	0.88	58.8	15.7	11.2	14.3	2.03	0.94	5.95	60.7
146B	80.17%	77.8	4.1	2.48	1.16	5.2	0.80	38.0	0.35	32.9	8.8	5.9	11.6	0.71	0.34	2.36	21.4
147A	90.85%	69.0	3.1	1.90	1.04	4.2	0.61	33.4	0.31	30.1	8.1	5.6	13.7	0.57	0.29	2.01	15.5
147B	56.24%	216	13.0	5.20	5.30	20.0	2.10	96.5	0.61	109	27.4	24.4	30.6	2.70	0.67	4.24	42.0
147C	77.72%	167	9.5	4.28	3.45	13.8	1.65	81.5	0.59	76.3	19.6	15.6	19.8	1.96	0.62	3.66	35.9
147D	43.32%	178	11.2	5.64	3.51	15.0	2.03	81.4	0.70	83.3	21.6	16.3	18.8	2.11	0.75	4.79	43.9
147E	23.15%	87.1	8.3	5.05	1.92	8.7	1.69	37.7	0.68	41.6	10.7	8.4	13.2	1.37	0.70	4.56	38.0
147F	64.96%	61.9	3.9	2.44	1.04	4.5	0.79	30.4	0.35	26.6	7.0	4.9	9.7	0.66	0.36	2.32	21.1
147G	86.68%	60.6	2.9	1.89	0.84	3.6	0.60	30.3	0.30	25.1	6.9	4.5	11.4	0.50	0.28	1.96	16.8
147I	26.55%	10.3		1.81		1.9		5.1		5.6			8.4				14.0
147Ib	46.35%	18.5		1.91		2.4		10.2		8.0			10.3				18.8
148A	70.31%	107	6.4	2.91	2.40	9.2	1.10	51.4	0.38	50.7	12.9	11.0	19.0	1.26	0.40	2.62	25.1
148B	81.53%	135	8.1	3.78	2.88	11.5	1.43	66.7	0.47	62.4	16.1	13.0	19.3	1.58	0.51	3.31	33.5
148C	34.78%	235	16.3	8.61	4.57	20.5	3.18	115	1.02	104	27.6	20.3	17.6	2.91	1.15	7.00	80.6

SAMPLE ID	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
131C								3.3		7						4.8												
131D								5.5		16						8.3												
132H2								4.3		23						4.0												
132Hb								10.6		16						1.9												
132Hm	2.98		1060	7.1		0.17	12	7.9	36.3	109	1.6		7.4	12800		6.3	7.5		520	0.20				474	10.0	7.8	39	149
132Ht								12.2		12						2.3												
133C	4.54	27.6	1240	2.5	<0.10	0.14	5	3.9	5.0	5	2.1	<0.02	3.7	3680	70	5.3	9.1	2	393	0.08	<0.10	1.1	0.2	233	1.0	3.8	25	241
133D	10.9	44.8	570	5.1	0.22	2.35	93	38.8	15.0	13	4.2	0.03	10.1	5190	165	12.6	20.0	27	363	0.34	<0.10	15.1	0.8	1110	2.6	16.4	287	235
134H2								9.4		14						1.2												
134H3								18.6		23						12.9												
134H4								16.5		19						1.6												
134Hb	0.30	2.2	1530	0.7	0.15	0.03	6	1.2	3.8	1	0.9	<0.02	9.1	4420	45	1.2	3.9	1	481	0.45	<0.10	4.8	0.9	952	1.6	2.1	6	30.5
134Ht								7.1		10						1.7												
135C									17.5	7																3.2		
135D									20.4	7																3.8		
135E	10.1	64.4		6.0		4.91	68	30.7	31.5	55			49.9	5790		10.0	16.5			0.68				2240	3.7	16.6	170	342
135F									23.5	9																6.0		
136B									27.6	8																5.3		
137A	2.14		1380	14.3		0.50	80	8.1	23.2	3	5.5		29.5	10600		10.4	50.9			4.31				10000	9.8	8.6	170	323
137B	0.44		1200	1.9		0.15	11	6.9	6.4	1	1.1		14.5	10600		1.8	7.6			0.62				1310	2.9	3.2	18	43.9
137C	18.9		1530	4.1		1.31	16	3.1	10.6	21	6.1		24.1	5390		45.8	11.0			0.31				758	2.5	21.7	81	328
138E	2.29		833	1.2		1.91	40	12.7	15.2	3	2.8		41.1	5600		2.5	14.4			1.05				3470	2.8	5.5	44	100
139E	4.01		1630	7.7		1.54	23	4.5	9.5	7	3.1		41.1	6250		8.5	5.2			0.47				1270	0.9	10.5	74	149
140C																												
142C																												
143C	0.42		372	2.1		0.30	5		5.8	3	0.8		6.3	6530		2.3	4.1		327	0.17				455	1.9	2.6	8	25.8
143Cb	5.20		1750	0.9		2.69	58		10.1	2	2.1		20.3	4660		12.8	7.9		785	0.30				870	1.3	7.5	96	71.2
146A																												
146B																												
147A		16.3						9.1		3						2.9												
147B	5.96	26.4	918	2.0		6.80	152	30.1	28.0	13	5.0		51.9	3730		17.3	14.5		299	0.77				2200	2.8	18.0	234	214
147C																												
147D																												
147E																												
147F																												
147G																												
147I				2.5		0.56				13	2.0		12.3	8130				7				3.0		448		7.8		87.3
147Ib				0.9		0.14				2	2.8		19.4	6790				2				21.0		4430		4.8		99.0
148A		33.6						12.5		8						13.1												
148B		8.9						12.2		4						8.1												
148C	4.32	32.0	204	4.2		2.58	52	26.4	14.1	9	2.3		32.9	1770		31.8	5.7		203	0.39				1150	2.6	14.2	111	72.2

* Denotes duplicate sample analysis

Results initially reported in Kruger and others (2017)

Results initially reported in Murphy and others (2018)

Results initially reported in Kruger and others (2022)

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
148D	21.81%	111	10.6	6.76	2.28	10.8	2.25	55.8	0.86	49.4	12.9	9.8	11.2	1.69	0.92	5.74	66.2	3.29		152	4.3		0.73	27		9.5	8	1.3		14.0	978		20.8	3.2		161	0.18				435	4.8	9.0	48	35.6
148E	70.91%	76.3	4.7	2.91	1.26	5.6	0.96	36.4	0.43	33.9	8.8	6.4	10.9	0.81	0.43	2.91	25.6																												
148F	88.01%	63.0	3.3	2.28	0.90	4.0	0.69	31.6	0.35	26.8	7.2	4.8	11.6	0.58	0.33	2.25	19.4																												
149A	82.67%	90.7	5.1	2.67	1.78	6.8	0.96	46.5	0.38	39.0	10.5	7.8	16.4	0.96	0.39	2.52	23.5		15.0						18.2		4						8.9												
149B	78.89%	125	6.5	3.14	2.19	9.0	1.17	63.1	0.41	52.6	14.4	10.4	16.8	1.24	0.43	2.76	29.2	2.16	10.4	753	2.8		13.1	96	12.5	28.9	5	3.3		64.0	4380		8.7	13.7		126	1.07				3710	2.6	6.3	135	116
149C	34.43%	116	7.7	4.22	2.01	9.1	1.50	57.4	0.52	49.1	13.2	9.1	13.3	1.34	0.57	3.58	38.5	7.27		696	2.7		1.14	33		12.3	11	2.1		21.1	1280		19.2	5.4		519	0.28				753	3.6	13.3	87	59.4
149D	68.80%	68.2	3.5	1.97	1.09	4.6	0.67	33.0	0.27	29.6	7.7	5.4	9.7	0.63	0.27	1.90	17.7																												
149E	84.44%	57.1	2.4	1.48	0.75	3.3	0.45	28.6	0.21	24.4	6.6	4.3	9.1	0.41	0.20	1.55	13.0																												
149F	84.88%	57.5	2.7	1.70	0.79	3.5	0.53	28.7	0.24	24.5	6.6	4.4	10.7	0.45	0.22	1.75	14.6																												
149H	34.38%	20.9	5.3	3.37	0.83	4.2	1.10	9.8	0.45	11.2	2.6	3.0	9.3	0.77	0.46	3.03	33.6	1.08	28.5	788	3.1	0.24	0.08	10	18.5	5.5	2	2.3	0.03	12.7	7020	82	3.6	10.6	1	391	0.99	0.12	10.1	1.4	2740	3.2	3.6	12	81.1
149Hb	20.36%	26.8	8.3	5.01	1.50	7.9	1.73	12.2	0.63	17.2	3.6	5.2	12.2	1.31	0.68	4.19	55.4																												
149I	32.82%	42.9	4.7	3.11	0.80	4.2	1.03	21.5	0.45	17.9	4.8	3.6	12.8	0.73	0.45	2.80	31.4	3.91	18.7	867	5.7	0.25	0.48	22	6.6	8.3	5	3.6	0.03	30.3	3350	74	12.4	6.2	6	394	0.58	<0.10	7.6	0.8	1390	1.2	14.0	72	179
149Ib	27.37%	18.2	2.6	1.55	0.45	2.2	0.53	10.1	0.23	7.9	2.0	1.8	9.7	0.41	0.23	1.45	16.2																												
151C	42.16%	41.7	5.9	3.39	1.06	5.7	1.20	21.8	0.45	19.2	4.8	4.5	9.3	0.96	0.47	2.99	33.9		11.2						31.4		2						3.0												
152C	22.35%	36.2	6.2	3.64	1.10	5.9	1.28	16.9	0.48	18.4	4.5	4.5	8.5	0.99	0.50	3.17	35.3		6.8						27.3		2						3.8												
153C	18.22%	58.2	5.2	3.05	0.93	5.2	1.08	42.4	0.37	20.0	5.8	3.9	7.1	0.83	0.41	2.53	32.3	1.53	10.2	1400	3.1		0.11	6	34.7	8.2	3	1.4		8.3	4570		5.7	4.3		895	0.32				857	3.0	4.5	10	49.4
153Z	93.82%	61.5	2.9	1.82	0.76	3.5	0.52	30.4	0.26	25.7	7.0	4.5	13.3	0.43	0.23	2.02	15.1	2.06		640	2.2		10.5	65		22.1	3	3.3		42.5	10500		1.7	15.2		79	1.23				3780	2.4	3.5	90	112
155A	72.55%	81.9	5.6	2.74	1.49	6.3	1.00	39.2	0.36	33.6	9.3	6.9	16.9	1.00	0.38	2.45	26.0																												
155B	83.82%	100	6.3	3.29	1.72	7.2	1.17	49.1	0.42	39.4	11.0	7.8	18.4	1.14	0.45	2.83	31.9																												
155C	65.33%	196	11.5	5.04	3.77	15.0	1.97	94.3	0.51	82.3	22.4	16.6	22.7	2.20	0.63	3.69	50.7																												
155D	39.97%	196	12.5	6.22	3.70	15.4	2.29	89.5	0.67	85.1	22.7	16.7	20.4	2.26	0.79	4.67	59.7	5.49		797	4.7		2.30	74		14.9	14	2.7		28.9	2770		20.2	8.8		307	0.44				1180	4.9	15.9	124	77.6
155E	74.32%	81.5	4.7	2.60	1.43	6.0	0.93	38.2	0.34	36.9	9.5	6.9	11.4	0.83	0.36	2.29	23.3																												
155F	86.43%	53.2	2.9	1.84	0.86	3.5	0.59	26.0	0.28	23.1	6.1	4.2	9.9	0.50	0.28	1.85	16.3																												
156C	34.60%	64.1	7.6	4.31	1.39	7.7	1.51	36.7	0.54	26.1	7.0	5.7	11.8	1.26	0.58	3.65	42.1																												
157C	11.74%	17.0	3.7	2.45	0.54	3.0	0.81	11.1	0.32	8.0	1.9	2.1	4.4	0.53	0.33	2.12	26.8	0.89	7.5	426	2.4	0.11	0.05	3	9.9	4.5	2	0.8	<0.02	7.1	7830	137	3.9	2.3	1	404	0.15	<0.10	1.7	0.4	331	2.2	3.5	6	30.9
157E	41.52%	87.2	8.5	4.67	2.36	9.8	1.60	32.4	0.62	48.9	12.1	10.6	25.5	1.45	0.63	4.25	39.9	4.92		1950	3.7		3.32	118		18.8	5	7.5		21.6	3770		14.2	12.5		268	0.77				2270	1.5	11.8	213	322
157Eb	47.32%	34.0	4.0	2.46	0.79	3.7	0.80	15.5	0.33	15.9	4.1	3.6	9.3	0.61	0.32	2.33	22.0	1.08		661	1.9		0.25	29		7.0	7	3.0		12.2	2240		2.6	14.0		244	1.07				2820	1.8	3.9	49	132
158C	35.07%	70.4	10.7	5.82	2.05	11.3	2.12	31.2	0.69	38.1	9.1	8.7	12.4	1.82	0.76	4.73	61.7		22.9						15.9		5						3.4										4.8		
159C	45.47%	51.0	5.4	2.91	1.17	5.7	1.03	23.9	0.37	23.2	6.0	5.1	10.4	0.91	0.40	2.55	25.9																												
160C	27.62%	22.8	4.5	2.68	0.75	4.0	0.92	11.9	0.36	11.7	2.8	3.0	10.1	0.71	0.38	2.37	24.8																												
161C	46.86%	32.8	4.3	2.64	0.72	4.0	0.91	20.3	0.35	13.2	3.5	2.8	10.0	0.67	0.37	2.35	26.8																												
161Cb	13.23%	10.8		1.45		2.0		4.8		5.4			8.2				11.6				1.3		1.34				2	1.5		10.5	3150				11				5.3		790		5.4		51.0
161D	22.17%	44.6	3.7	1.86	1.16	4.7	0.66	17.7	0.25	23.6	5.8	5.3	10.4	0.69	0.26	1.77	12.1				0.3		0.38				2	0.7		6.2	1010				6				5.7		434		12.1		22.5
161Db	5.25%	12.2	3.5	2.45	0.48	2.5	0.79	6.3	0.34	6.2	1.5	1.6	13.1	0.49	0.36	2.31	22.5				3.1		0.17				3	0.6		1.1	1070				3				1.0		121		1.9		42.4
162X	52.36%	34.6	3.9	2.41	0.82	3.9	0.80	16.5	0.34	16.6	4.2	3.6	7.9	0.63	0.33	2.26	23.1																												
162Y	47.49%	92.9	11.1	6.35	2.50	11.5	2.19	41.3	0.83	47.0	11.4	10.8	19.1	1.85	0.86	5.67	53.7	12.2		805	7.6		2.93	45		17.1	19	3.3		25.6	6130		27	13.2		398	0.44				1390	4.8	28.4	92	203
162Z	39.60%	55.0	6.4	3.91	1.33	6.3	1.28	24.2	0.51	25.7	6.5	5.7	11.7	1.01	0.50	3.45	35.9																												
163A	80.79%	80.4	8.8	5.28	2.05	9.6	1.75	35.4	0.67	45.1	11.0	9.4	18.9	1.45	0.68	4.61	51.5																												
163B1	39.76%	52.2		4.04		7.8		21.5		29.0			12.6				38.5				4.1		2.17				4	3.1		21	3130				28				12.8		1220		8.1		142
163C1	24.96%	50.5		3.66		6.2		21.7		24.8			11.8				33.2				3.7		0.26				2	1.1		13.6	3210				4				11.7		583		6.7		43
163C2	18.47%	9.3		0.49		0.9		4.4		4.5			1.7				4.7				0.5		0.13				<1	0.5		4.1	3170				2				1.2		229		1.0		16.7

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

* Denotes duplicate sample analysis

Results initially reported in Kruger and others (2017)

Results initially reported in Murphy and others (2018)

Results initially reported in Kruger and others (2022)

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
163E	29.69%	105.0	8.9	5.21	1.97	9.2	1.78	44.1	0.72	43.5	11.6	9.1	16.6	1.49	0.75	4.88	46.1				8.1		0.81				5	4.3		22.8	1820				11				6.4		1210		10.1		189
163U	71.29%	52.0		2.58		4.2		25.4		23.2			11.9				20.7				3.3		8.97				7	2.9		38.8	7470				106				10		2280		9		108
163V	23.82%	17.5	2.6	1.58	0.58	2.8	0.53	6.6	0.20	10.7	2.5	2.4	3.1	0.43	0.21	1.34	16.6																												
163X	29.15%	16.0		1.52		2.3		8.0		8.2			4.2				15.1				2.8		1.01				10	1.3		10.2	6360				12				4.5		880		5.7		42.6
165F	91.53%	120	9.5	5.26	2.60	11.6	1.82	58.5	0.66	56.1	14.1	11.7	18.1	1.69	0.72	4.67	48.5	2.41		440	5.0		12.3	93		30.9	4	3.6		73.0	7250		5.0	15.1		124	1.15				4170	2.7	14.5	135	135
166F	74.35%	98.6	11.0	5.76	3.55	14.0	2.03	39.3	0.73	57.2	13.1	14.4	23.2	2.03	0.75	5.06	47.4	6.67		10300	5.7		7.98	111		26.4	38	5.2		54.0	5360		12.3	16.2		134	0.95				2840	3.4	19.5	171	354
166F2	59.93%	44.8	2.6	1.80	0.73	3.1	0.54	22.1	0.28	19.5	5.2	3.7	11.4	0.42	0.24	1.94	15.4																												
166Fb	94.50%	123	8.6	5.12	2.47	10.4	1.74	60.3	0.72	53.9	14.1	11.1	17.1	1.52	0.72	4.64	46.5						4.85			33.9	43			46.2				15.8			0.59				1830				
167G	93.05%	132	10.1	5.9	2.75	12.3	2.03	63.5	0.76	59.5	14.8	12.3	12.4	1.78	0.83	5.28	58.1				3.8		9.87			22.7	10			46.9	7930				124				13.5		3130		6.3		
167Gb	92.64%	66.7		3.15		5.8		35.0		30.1			8.9				31.3				2.7		5.86			17.8	4			33.4	5250				94				10.8		2570		4		
167X	80.64%	63.8		1.97		4.3		32.1		28.7			18.9				15.5				1.5		12.0			27.5	13			34	5920				126				22.3		3330		16.8		
168C	38.72%	46.7	6.2	3.74	1.06	5.7	1.29	28.4	0.50	19.3	5.0	4.3	10.1	0.97	0.52	3.38	39.5																												
168Cb	33.43%	75.3		3.87		7.6		36.1		33.8			14.4				31.8								19.7	17.6		2.7						10.2			0.45				1130			53	
168D	24.35%	120	9.3	4.51	2.91	11.6	1.64	43.7	0.56	62.3	15.3	14.1	22.4	1.77	0.62	4.03	32.5								22.1	11.7		1.9						7.3			0.22				749			42	
168Db	6.46%	8.3		1.85		1.9		3.9		4.8			9.3				17.7								5.0	7.8		0.4						2.2			0.05				123			8	
169C	43.31%	69.5	10.5	5.74	2.05	10.7	2.06	28.3	0.71	36.8	9.0	8.8	13.6	1.76	0.77	4.87	54.6																												
170C	28.86%	19.0	1.8	1.14	0.45	2.0	0.37	8.9	0.15	8.8	2.2	1.8	3.5	0.30	0.16	1.05	11.9																												
172A	87.81%	80.0	6.0	3.16	1.68	6.9	1.10	38.7	0.43	36.1	9.4	7.6	19.6	1.05	0.45	2.92	26.2																												
172B	78.61%	166	12.7	5.60	4.16	16.4	2.12	75.0	0.63	81.2	20.4	18.3	25.5	2.43	0.71	4.50	46.4	2.45		427	3.8		12.6	138		29.7	5	3.8		59.1	5870		10.4	13.5		97	1.08				3590	2.3	10.3	197	140
172C	75.86%	164	11.6	5.54	3.94	15.2	2.05	72.6	0.64	80.0	20.3	17.5	19.8	2.22	0.72	4.54	46.6																												
172D	83.29%	131	8.7	4.28	2.86	11.7	1.55	59.0	0.47	62.8	16.0	13.1	16.2	1.65	0.54	3.56	36.5																												
172E	90.23%	82.6	5.2	2.94	1.54	6.6	0.94	39.2	0.36	37.9	9.9	7.4	13.5	0.90	0.37	2.63	24.8																												
172S	22.76%	42.7	4.1	2.52	0.53	3.9	0.83	21.8	0.35	16.9	4.7	3.7	4.1	0.65	0.35	2.38	26																												
172T	77.62%	64.3	1.8	0.74	0.31	2.8	0.22	29.1	0.03	23.1	6.9	4.0	1.8	0.30	0.03	0.60	7.4																												
172U	28.63%	99.4	4.4	2.31	0.54	5.1	0.78	41.8	0.30	33.3	9.9	6.3	3.6	0.76	0.31	2.07	22.9																												
173F	87.73%	76	8.1	5.39	1.76	8.3	1.74	40.6	0.76	36.3	9.1	7.6	19.1	1.31	0.75	5.05	51.5	2.97		392	4.4		12.8	92		31.8	4	3.5		67.0	7110		8.1	15.8		149	1.22				4170	2.9	8.5	138	133
173Fb	92.21%	86.6	6.6	3.96	1.69	7.5	1.33	44.6	0.55	39.9	10.1	7.7	18.3	1.12	0.55	3.68	38.4	1.91		679	4.4		14.4	88		28.9	3	3.3		64.5	8060		3.9	14.5		119	1.15				3600	2.4	6.9	130	116
174F	92.29%	116	12.4	7.84	2.65	12.4	2.61	59.6	1	54.9	13.7	11.7	19.1	1.97	1.06	6.91	75.8	1.78		331	6.9		12.2	103		36.6	4	3.9		75.3	8460		5.3	15.6		105	1.28				4380	3.0	9.4	156	145
174Fb	93.83%	78.2	5.7	3.64	1.39	6.3	1.17	40.5	0.51	34.1	9	6.6	16.3	0.92	0.51	3.48	34.2																												
175F	91.41%	130	12.8	7.64	3.01	13.9	2.61	64	0.95	61.2	15.3	13.3	20.5	2.15	1.05	6.71	72.2	3.15		552	6.1		13.5	102		34.7	5	3.9		71.0	7380		7.9	16.1		176	1.31				4270	2.9	15.1	157	152
175Fb	93.41%	86.1	5.9	3.62	1.57	7	1.21	43.9	0.51	37.4	9.7	7.4	16.6	1.03	0.52	3.48	33	2.53		600	4.0		14.2	85		29.2	4	3.7		59.6	7030		5.4	16.0		112	1.32				3930	2.6	6.7	129	126
176F	91.78%	98.7	9.9	5.98	2.26	10.7	2	50.9	0.77	46.4	11.6	10	19	1.63	0.83	5.44	56.1	3.39		6700	6.0		12.9	96		33.6	4	3.7		66.9	7640		7.4	16.1		195	1.29				4240	2.9	11.6	148	141
176Fb	93.52%	82.2	6.1	3.61	1.55	6.9	1.23	41.2	0.51	36.2	9.5	7.3	16.4	1.04	0.52	3.55	32.4																												
177F	91.94%	241	16.1	7.42	5.23	21.6	2.8	105	0.78	109	27.6	24	15.5	3.04	0.94	5.95	67.2	1.64		495	5		11.0	79		23.4	7	3.1		48.7	5350		3.3	14.1		119	1.17				3440	2.3	8.7	113	123
177H	83.02%	69.6		2.39		5.4		33.1		32.7			15.0				18.7	5.35		1010	1.9		10.3	74	9.7	21.7	13	4.3		31.6	5230		7.9	14.5			1.09				3280	2.1	8.1	135	189
177M	95.25%	78.4		2.70		5.7		40.5		34.6			15.8				24.5						12.4			22.2	3			47.3				15.3			1.12				3660				
177N	83.02%	78.0		2.69		6.0		39.7		35.3			15.1				24.4						12.0			23.7	3			47.5				16.4			1.25				4070				
178F	95.12%	116	7.3	3.55	2.51	9.8	1.29	51.6	0.43	55.3	14.1	12	12.8	1.4	0.47	3.11	30.3	1.22		823	3.1		9.78	58		20.1	4	2.6		44.1	4830		1.7	13		91	1.06				3270	2.4	5	80	98.0
178Fb	95.74%	98.2	6.3	3.33	1.98	7.9	1.18	44.4	0.43	45	11.7	9.8	12.2	1.17	0.46	3.06	28.4																												
179E	86.83%	58.9		1.51		3.5		30.3		24.2			11.0				12.8	1.68		515	2.5		9.03	55	3.7	30.0	5	3.0		82.8	8060		2.9	16.7			1.90				3140	2.5	9.3	86	99.2
179Eb	41.58%	34.1		1.76		2.6		18.3		14.2			9.2				16.3	2.74		387	0.9		2.1	29	3.2	14.9	5	2.3		20.2	3030		2.6	12.2			0.92				2960	3.2	8.3	40	83.3

* Denotes duplicate sample analysis
Results initially reported in Kruger and others (2017)
Results initially reported in Murphy and others (2018)
Results initially reported in Kruger and others (2022)

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium
179F	87.14%	60.8	3.5	2.13	1.07	4.2	0.68	29.6	0.33	27.0	7.1	5.4	15.6	0.62	0.31	2.21	17.4
180E	43.64%	25.6	2.3	1.53	0.48	2.2	0.50	13.6	0.22	10.7	2.8	2.1	6.5	0.36	0.22	1.45	14.4
180J1	73.03%	169	13.2	7.56	3.33	16.4	2.66	92.9	0.89	76.2	19.6	14.8	18.1	2.30	1.01	6.16	86.1
180J2	38.68%	114	18.7	12.2	3.48	18.7	4.10	51.4	1.63	62.8	14.5	14.0	13.8	2.98	1.69	10.5	124
180K	68.24%	78.0	8.6	5.01	2.46	10.4	1.74	38.6	0.67	45.0	10.2	10.5	16.7	1.50	0.72	4.61	46.6
181A	30.91%	16.8	1.2	0.72	0.44	1.6	0.24	7.7	0.1	9.1	2.2	1.9	3	0.22	0.1	0.69	6.5
181B	75.99%	84.3	4	2.31	1.4	5.4	0.78	39.1	0.33	33.8	9	6.4	12.2	0.72	0.33	2.26	19.6
181H	29.57%	50.6		2.00		4.5		22.6		24.7			9.2				18.1
181J	27.74%	46.9		3.61		4.9		27.8		19.4			11.3				34.7
181Jb	32.85%	29.6		1.52		2.6		15.8		12.5			5.8				15.6
181Jm	17.65%	13.0		0.81		1.4		6.5		6.6			3.4				6.9
181K	21.26%	19.7		1.89		2.6		10.7		9.9			7.8				18.2
181L	49.25%	51.7		2.56		4.0		33.1		21.7			8.7				24.6
181N	88.66%	64.1		2.05		4.4		34.4		28.4			12.8				16.8
181Nb	43.03%	53.6		2.49		4.5		28.5		25.2			13.2				19.7
181O	33.21%	31.8		1.90		4.2		11.5		20.2			5.4				16.8
181P	42.33%	38.7		2.87		3.7		21.5		17.8			13.4				22.7
181R	40.54%	107	9.0	5.28	2.54	10.4	1.84	44.8	0.71	49.4	12.2	10.0	13.2	1.60	0.71	4.52	45.9
181S	26.66%	16.6		2.63		2.9		8.6		9.0			11.5				25.9
182J	28.44%	61.5	5.2	3.3	1.15	5.4	1.11	34.9	0.45	24.2	6.4	4.8	10.2	0.85	0.47	2.99	36.3
182K	15.03%	25.6	1.7	0.96	0.7	2.2	0.33	10.4	0.13	14	3.3	2.9	7.7	0.31	0.14	0.92	8
182L	25.48%	10.3	1.7	1.24	0.38	1.4	0.39	5.6	0.19	5.1	1.2	1.2	7.2	0.25	0.19	1.27	12
182N	36.25%	96.4	7.2	3.9	2.63	9.1	1.35	38	0.55	51.9	12.5	11	11.7	1.27	0.56	3.74	28.4
182P	41.72%	32.1	3.6	2.72	0.94	3.1	0.82	18.5	0.45	14	3.7	2.9	16.6	0.51	0.42	2.89	22
183C	25.73%	13.8		1.91		1.9		7.2		7.2			7.8				15.0
183Cb	9.80%	4.0		1.15		1.4		1.8		2.9			4.2				11.0
183D	23.08%	9.3		1.39		1.6		4.3		5.2			8.3				12.6
183Db	47.68%	71.7		2.94		5.6		33.8		30.8			13				22.8
183H	34.87%	50.9		2.30		5.3		20.1		28.6			12.0				18.0
183Hb	45.07%	71.8		3.23		7.4		32.1		38.2			11.0				23.3
183J	86.05%	93.9		3.56		7.3		48.5		40.8			16.9				29.6
183J2	32.37%	32.6	2.7	1.57	0.83	3.1	0.54	12.4	0.2	17.1	4.3	3.4	6.1	0.46	0.22	1.42	15.1
183J2b	18.91%	22.4	2.4	1.61	0.58	2.3	0.52	10.9	0.23	10.4	2.7	2.1	7.5	0.38	0.23	1.51	15.3
183Jb	53.32%	56.2		2.49		5.1		27.9		28.3			11.9				19.2
183Jm	67.79%	99.9	7.2	4.04	2.01	8.1	1.39	51.5	0.53	43.4	11.3	8.6	17.3	1.27	0.56	3.65	36.6
183Jr	92.48%	61.8		2.17		4.2		35.5		26.4			15.2				17.2
183L	35.84%	29.3		1.88		3.6		14.6		15.6			6.7				15.1
183N	59.86%	39.6		2.56		3.5		21.0		15.8			9.2				25.9
183O	27.02%	38.1		2.07		4.7		14.6		22.0			5.3				17.9
183oy	79.83%	44.5		2.36		4.1		24.2		20.9			11.7				20.0
183P	29.18%	85.4		4.25		9.1		29.0		41.2			10.5				33.0

SAMPLE ID	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
179F	4.94		1610	2.1		10.1	98	32.8	20.8	4	4.2		38.3	6180		6.2	15.7			1.21				3740	2.4	10.6	176	202
180E	11.6		1150	2.5		0.97	24	2.3	14.8	3	4.4		57.6	3750		19.8	6.4			0.70				1710	1.0	11.4	68	184
180J1	4.24		464	8.6		10.9	76	10.1	26.5	14	3.8		68.5	6540		17.3	12.5			1.01				3210	2.6	8.9	141	157
180J2	3.57		688	11.7		3.78	39	26.1	15.2	14	2.0		28.8	4090		19.4	7.4			0.35				1050	3.6	8.0	83	97.7
180K	1.30		230	7.4		9.02	133	26.0	23.2	6	3.7		74.9	8160		8.1	12.3			0.86				2790	2.2	6.7	179	159
181A																												
181B																												
181H			635				37			4									453							5.8		
181J	1.00	5.6	172			0.60		31.5		4			26.6		326	1.5		6	211						1.0	4.1	49	
181Jb	0.98	24.1	1070			0.26		9.4		1			3.7		116	5.4		5	1190						1.7	2.4	26	
181Jm	1.46	6.4	1080			0.39		4.4		1			8.6		120	7.3		6	457						1.7	4.2	31	
181K			1190				11			5									502							2.9		
181L			2200				38			3									677							12.5		
181N	0.77	14.4	457	2.3				9.9		3			36.5	8430	97	3.0			165			11.8			1.7		121	
181Nb	2.08	9.8	141	3.2				6.8		9			33.1	3930	45	8.8			267			12.5			2.0		109	
181O			1010				33			6									432							2.5		
181P	2.52	26.7	337	6.7		2.35	55	35.0	25	18	3.2		19.7	15500	356	4.2	9.7	18	407	0.44		7.7			2.2	19.7	145	222
181R			1200				30			17									748							5.0		
181S			600				19			7									282							5.5		
182J	0.46		521	1.3		0.42	16		8.7	3	1.3		18.6	2650		1.4	5.6		245	0.54				979	1.1	3.0	24	56.0
182K																												
182L																												
182N	3.76	29.8	1920	2.3	0.36	2.36	29	12.5	11.0	5	1.9	0.03	14.7	3820	95	14.2	6.8	23	365	0.37	0.10	6.2	0.7	1040	5.8	8.2	95	68.8
182P	2.39		11500	7.4		2.35	197		40.1	41	7.0		17.9	20900		4.2	17.6		469	0.44				2100	2.9	17.2	423	845
183C			2020				18			4									273							10.3		
183Cb			262				3			1									256							1.3		
183D	1.59	8.9	1150	5.8		0.56	15	4.2	7.3	7	1.7		4.4	11500	318	4.0	6.6	7	452	0.14		1.5			1.4	3.6	61	91.7
183Db			273				46			4									244							6.6		
183H			844				102			11									276							3.5		
183Hb			5020				46			9									1260							3.1		
183J	1.37	9.5	326			8.66		8.0		3			89.9		134	4.5		63	296						2.7	7.2	155	
183J2																												
183J2b																												
183Jb	3.02	30.8	209			7.14		4.9		4			52.1		54	13.0		71	106						2.5	14.0	74	
183Jm	0.82	7.4	351			4.86		8.9		3			108		94	3.5		29	269						2.7	7.2	110	
183Jr		0.87	439	1.8		10.9	84	7.5	24.7	2	4.2		60.7	9890	127	2.6	15.5	103	715	1.19		11.2			2.3	5	142	125
183L			503				9			3									587							2.7		
183N	1.17	6.7	1050	5.0				4.7		5			48.4	23900	559	2.1			612			18.8			2.0		43	
183O			1920				20			9									595							1.8		
183oy	0.46	19.1	511	1.1		4.37	56	14.8	11.6	1	2.1		21.7	10200	474	1.4	8.4	59	477	0.71		5.7			1.0	2.5	80	66.1
183P	1.25	15.1	1100	3.0		1.55	20	9.6	10.4	10	2.6		13.0	6360	54	7.4	10.2	14	410	0.25		3.3			3.2	4.3	69	142

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

* Denotes duplicate sample analysis

Results initially reported in Kruger and others (2017)

Results initially reported in Murphy and others (2018)

Results initially reported in Kruger and others (2022)

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium
183R	45.47%	37.9		3.11		3.9		19.7		17.9			11.7				22.7
183S	5.93%	37.5	4.5	3.04	0.93	4.3	0.98	17.4	0.43	16.1	4.0	3.3	7.3	0.71	0.43	2.76	26.3
186F	93.07%	139	9.8	4.88	3.05	12.5	1.78	64.3	0.58	67.6	16.9	14.6	16.6	1.82	0.66	4.24	43.4
187F	94.67%	100	6.1	3.15	1.99	7.9	1.12	47.6	0.42	46.7	12.0	9.9	14.2	1.15	0.44	2.93	27.9
188F	96.31%	50.9	2.6	1.76	0.72	3.1	0.55	26.3	0.29	21.5	5.8	3.9	12.0	0.45	0.27	1.94	14.6
190F	94.91%	93.3	5.1	2.65	1.78	7.0	0.95	43.5	0.36	43.3	11.2	9.0	13.3	0.98	0.38	2.50	22.4
192F	92.22%	236	16.1	7.22	5.40	22.1	2.77	102	0.76	117	29.3	25.9	14.8	3.18	0.93	5.76	63.3
192Fb	95.40%	77.1	5.1	2.89	1.36	5.9	0.99	38.8	0.41	33.6	8.8	6.6	13.3	0.87	0.42	2.86	25.7
192G	94.17%	79.7		3.34		7.2		40.0		36.7			17.2				29.8
193G	93.57%	100	6.4	3.47	1.96	8	1.20	47.5	0.47	46.2	12.0	9.6	15.8	1.16	0.49	3.27	29.6
193H	94.84%	64		2.18		4.4		32.6		27.4			14.9				19.0
194F	95.48%	52.4	2.6	1.76	0.75	3.3	0.55	27.2	0.30	22.1	5.9	4.0	11.9	0.46	0.28	1.89	15.1
195A	86.58%	92.3		4.04		8.4		45.8		45.9			28.6				31.3
195B	94.94%	47.6		1.71		2.8		24.3		20.0			16.4				13.7
195C	95.77%	64.7		2.12		4.2		32.2		27.7			15.2				18.2
195D	95.94%	68.3		2.11		4.3		36.0		28.6			13.1				20.0
195E	96.35%	37.9		1.47		2.4		19.8		16.0			11.1				12.2
195F	95.74%	58.7	2.8	1.84	0.80	3.4	0.57	29.6	0.30	24.5	6.6	4.5	12.2	0.48	0.28	1.99	15.3
195G	95.01%	53.2		2.12		3.3		29.2		21.8			15.4				17.9
195H	95.99%	54.1		1.93		3.2		28.8		22.4			13.3				16.0
197A	51.06%	18.7		1.79		3.0		7.9		11.6			6.9				13.5
197B	68.84%	65.6		3.76		6.4		30.8		30.9			15.6				28.4
197C	70.86%	44.0		1.89		3.4		21.8		19.8			8.1				15.6
197D	33.65%	25.5		1.74		2.9		12.1		14.1			7.8				12.5
197E	43.96%	41.6		5.30		6.7		19.1		22.1			15.8				40.0
198A	89.62%	50.6		3.58		4.5		27.4		23.8			17.1				27.9
198I	41.08%	73.8		3.61		7.7		28.1		38.8			8.9				27.6
198Ib	29.13%	85.1	8.9	5.08	1.57	8.3	1.78	42.5	0.63	32.4	8.8	6.6	11.3	1.47	0.68	4.27	43.2
199J1	91.44%	57.7	6.1	3.70	1.52	6.5	1.24	30.3	0.56	30.3	7.4	6.8	18.0	1.02	0.55	3.80	28.4
199J2	67.68%	190	35.6	18.2	10.1	40.8	6.50	60.2	2.38	153	31.5	42.1	22.9	6.29	2.53	17.2	127
199Z	29.54%	39.5		5.92		6.8		19.0		22.1			14.4				49.3
200J1	91.59%	111	9.4	5.07	2.64	11.1	1.76	56.0	0.66	55.1	13.7	11.9	19.7	1.66	0.70	4.71	40.6
200J2	86.30%	264	35.0	20.2	7.71	35.0	7.01	123	2.51	145	34.7	32.9	31.1	5.70	2.82	18.3	151
201A	27.80%	97.7	37.0	18.6	10.1	43.3	6.86	20.3	2.34	147	24.1	42.6	39.9	6.65	2.50	16.0	137
201A2	49.70%	172	32.8	17.4	8.5	37.4	6.15	46.2	2.20	147	30.8	36.5	34.9	5.83	2.34	15.1	125
201A2b	59.93%	90.6	14	7.2	4.15	17.6	2.58	27.3	0.96	77.4	16.1	19.2	27.6	2.57	0.99	6.53	55.0
201I	64.28%	92.9	10.8	6.02	2.89	12.2	2.09	36.8	0.78	56.4	12.9	13.1	19.9	1.86	0.82	5.37	49.2
201Ir	85.88%	94.9	6.3	3.05	2.11	8.8	1.11	49.1	0.37	46.2	11.6	9.9	19.7	1.21	0.41	2.64	28.4
201T	82.60%	20		0.41		1.0		9.8		7.6			1.8				4.1
202A	33.12%	173	48.8	27.3	11.6	51.1	9.58	45.6	3.82	171	32.2	46.0	31.7	8.29	3.79	24.9	168
202I	58.08%	86.0		4.01		8.1		39.3		41.8			14.0				32.3

SAMPLE ID	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
183R			1000				42			25									481							9.1		
183S			43				17			68									34							2.2		
186F						11.0			29.0	4			67.7				17.5			1.26				4010				
187F						10.1			23.4	4			53.3				18.4			1.36				3980				
188F						10.0			20.6	3			39.3				17.0			1.26				3870				
190F						10.1			22.2	4			37.6				16.3			1.22				3460				
192F						10.4			22.4	7			47.0				15.9			1.21				3490				
192Fb						9.87			22.6	3			50.3				16.7			1.23				3650				
192G						12.8			27.1	3			57.1				15.4			1.13				3830				
193G				3.6		11.7			29.6	4			56.2	7040				115				15		4000		4.4		
193H				2.6		14.1			27.4	3			47.5	6700				162				14.3		4050		2.7		
194F						10.2			20.6	3			39.6				17.7			1.29				3940				
195A						10.5			40.9	30			32.5				16.6			0.96				3100				
195B						11.7			24.0	3			36.7				17.4			1.28				3850				
195C						9.81			23.9	3			36.7				19.6			1.44				4000				
195D						11.6			22.7	3			38.6				17.9			1.36				3940				
195E						7.58			19.3	2			30.7				13.6			1.04				3090				
195F						11.1			21.2	3			42.0				17.6			1.31				4060				
195G						14.5			27.1	3			47.9				16.2			1.20				3950				
195H						11.1			22.7	3			42.4				17.5			1.31				4120				
197A				1.8		1.88				5	2.8		10.8	4150				27				6.6		828		11.6		123
197B				2.6		7.47				9	4.8		93.9	13700				86				12.5		2640		9.1		235
197C				2.2		6.47				8	2.5		27.0	6520				91				7.9		2100		5.6		108
197D				2.6		3.57				12	7.1		11.9	9210				47				5.5		1170		18.6		465
197E				3.9		2.74				18	3.4		26.1	8740				36				7.9		1150		58.5		221
198A				4.0		9.86				12	5.1		42.8	18100				125				11.4		2860		8.6		300
198I				3.4		1.15				6	3.0		23.0	5440				11				8.9		1540		13.3		120
198Ib				2.7		1.05				6	2.0		22.1	6380				12				5.2		977		10.9		78.5
199J1				3.6		13.1				2	3.9		39.5	8310				111				18.0		4190		7.4		129
199J2				14.8		7.41				25	4.1		37.4	6230				85				11.5		2070		28.4		213
199Z				11.5		2.10				12	3.6		14.1	7670				19				10.7		1620		12.3		170
200J1				3.7		13.4				4	4.4		46.0	7360				107				28.8		4340		12.8		154
200J2				12.8		10.6				33	6.1		30.2	6120				78				24.0		3510		51.1		239
201A				6.1		1.88				8	3.7		14.4	8990				17				11.7		633		23.2		225
201A2				5.6		6.10			27.8	14			24.9	4700				63				12.9		1690		18.1		
201A2b				3.2		7.35			19.8	12			20.5	4790				96				20		2100		17.6		
201I				4.2		6.32				4	5.4		71.9	4610				43				27.3		3150		23.7		190
201Ir				2.4		9.06			35.3	4			153	5230				63				23.9		4510		10.7		
201T				1.1		1.12			59.0	2			193	3350				17				16		1230		1.8		
202A				7.1		2.06				6	2.6		14.1	10400				23				13.6		784		25.2		175
202I				3.5		2.43				3	4.2		69.6	8620				19				18.6		2660		14.4		153

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

* Denotes duplicate sample analysis
Results initially reported in Kruger and others (2017)
Results initially reported in Murphy and others (2018)
Results initially reported in Kruger and others (2022)

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium
203A	83.77%	97.8	6.4	3.54	1.97	8	1.21	47.7	0.49	48.5	12.5	10.0	17.5	1.16	0.51	3.42	27.7
203Ab	82.25%	113	6.9	3.15	2.43	9.7	1.16	58.7	0.39	54.9	14.1	11.5	18.3	1.33	0.42	2.75	27.1
203I	38.16%	134	10.3	5.55	2.69	11.9	1.96	58.3	0.71	59.9	15.3	12.5	12.8	1.81	0.77	4.92	47.4
204A	40.72%	212	18.5	9.72	5.42	22.7	3.44	86.3	1.22	112	27.2	24.6	26.6	3.33	1.31	8.52	79.9
204A2	25.73%	427	42.8	22	11.8	51.2	7.95	148	2.73	230	55.1	52.3	44.3	7.76	2.95	19.0	152
204A2b	27.89%	359	37	19.4	10.4	44.4	6.88	118	2.54	201	47.3	46.4	45.5	6.75	2.64	17.4	120
206A	95.76%	52.0		1.62		3.6		25.7		23.2			12.6				13.1
207A	64.30%	42.3		2.01		3.2		25.4		15.4			7.3				22.2
210J1	85.49%	98.5	8.5	4.85	2.23	10	1.67	49.8	0.61	47.9	11.8	10.0	17.9	1.48	0.66	4.31	45.7
210J2	87.48%	96.3	7.5	4.33	2.02	9.1	1.49	50.1	0.56	46.6	11.6	9.4	14.8	1.32	0.59	3.85	41.4
210J3	59.60%	271	25.8	13.7	7.28	33	4.96	116	1.61	153	35.4	33.1	23.9	4.68	1.79	11.3	125
210J4	44.74%	343	36.3	19.3	9.84	45.2	6.87	134	2.41	200	45.0	45.0	22.2	6.54	2.54	16.1	156
210J5	51.55%	281	29.7	16.1	7.91	37.1	5.67	109	1.99	161	36.6	36.1	24.1	5.33	2.12	13.4	129
211ash	97.04%	37.3		2.78		3.6		26.8		18.0			6.4				25.6
211J1	85.74%	126	7.2	4.26	2.15	9.5	1.40	64.9	0.60	55.0	14.4	10.7	18.0	1.32	0.60	4.08	38.7
211J2	69.01%	59	11.3	7.72	1.76	10.1	2.48	38.2	1.10	34.1	8.4	8.4	17.7	1.73	1.10	7.27	90.7
211Jf	85.41%	66.7		3.87		6.3		32.9		28.5			9.7				36.6
212J1	61.21%	66.6		4.12		8.9		33.3		39.6			11.0				37.6
212J2	30.24%	58.1		6.21		9.6		28.2		34.6			13.7				52.8
212J3	16.94%	17.9		4.99		4.3		8.2		10.4			7.8				40.8
212J4	49.19%	37.9		3.82		4.7		18.4		19.3			11.1				30.2
213J1	87.86%	132	13.2	6.78	3.7	16.1	2.48	63.4	0.80	71.6	17.0	16.2	18.6	2.43	0.91	5.66	64.5
213J2	71.42%	331	36.2	18.6	9.36	44.1	6.91	149	2.06	180	42.9	40.4	24.3	6.65	2.44	14.5	184
213J3	56.25%	377	39.7	23.8	7.53	43.4	8.45	193	2.70	160	40.4	31.0	18.7	6.76	3.09	18.1	278
213J4	29.39%	351	54.1	34.8	9.19	53.3	11.9	181	4.24	162	39.5	35.5	18.5	8.70	4.62	27.8	346
213J5	60.96%	193	34.8	21.8	6.55	34.4	7.45	82.8	2.82	104	24.2	25.4	22.1	5.63	3.01	18.7	195
216H	16.47%	52.9	4.7	2.48	1.79	5.9	0.87	15.4	0.33	32.7	7.5	7.0	11.7	0.88	0.34	2.23	19.1
216J	24.04%	23.1		2.15		2.6		13.4		9.8			7.7				19.7
216Jb	27.15%	48.9		3.41		6.8		18.3		31.3			15.4				24.0
216Jm	44.44%	47.5		1.70		3.3		26.9		19.3			7.2				14.8
216K	26.03%	21.3		1.66		2.5		9.8		10.9			7.3				15.0
216L	26.48%	22.4		3.00		3.7		11.3		13.3			11.0				23.3
216N	62.72%	64.8		2.90		6.3		29.9		33.7			10.1				22.4
216nod	74.90%	14.8		0.75		1.4		10.0		6.3			2.9				9.5
216O	32.90%	137	12.3	6.37	3.90	15.6	2.28	44.8	0.78	80.2	18.8	17.3	8.7	2.29	0.84	5.27	51.2
216R	33.93%	49.3		2.10		5.0		16.6		26.6			11.1				15.2
216S	36.60%	19.1		2.31		2.7		10.5		9.5			13.9				22.1
217N	46.11%	20.7		1.66		2.2		11.5		10.2			11.5				13.8
218A	74.31%	90.1	8.0	5.27	1.93	8.1	1.74	49.4	0.79	40.1	10.3	7.7	20.5	1.31	0.75	4.88	47.3
219A	49.48%	36.9		2.17		3.4		18.6		16.7			8.1				18.4
219B	29.60%	19.6		2.23		3.3		8.1		12.0			8.0				17.3

SAMPLE ID	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
203A				2.7		13.0			26.1	4			84.1	8970				108				21.6		3810		16.5		
203Ab				2.7		6.09			33.7	4			125	5680				49				22.9		4280		16.9		
203I				5.3		0.40				6	4.0		30.5	6550				5				11.4		1490		15.0		161
204A				5.9		3.76				8	3.1		12.6	4160				41				16.6		1340		20.5		105
204A2	3.49		1350	6.8	0.27	1.78	171	47.4	29.6	13	5.5	0.10	18.5	3140	33	16.0	13.2	17	112	0.38	<0.10	22.7	0.6	818	3.9	39.1	173	221
204A2b				5.6		2.25			27.4	12			9.8	2530				24				11.3		654		27.3		
206A				1.4		7.68			18.6	4			24.9	3440				139				18.8		3710		3.5		
207A				2.1		0.85			19.1	12			136	19400				13				9.9		2060		5.4		
210J1	2.17		570	4.5	0.89	11.9	91	12.2	29.1	4	3.8	0.11	65.3	8810	92	8.3	16.1	100	196	1.29	0.18	22.1	3.1	3630	3.0	13.7	149	145
210J2				3.8		11.8			28.0	4			69.6	7930				97				13.7		3790		8.7		
210J3				8.3		5.21			24.9	35			51.5	6550				45				21.6		2040		31.9		
210J4	8.69		1040	9.5	0.34	3.23	80	51.9	25.1	43	3.0	0.06	37.8	6200	64	59.6	8.3	31	187	0.45	0.11	10.7	1.1	1140	9.8	45.2	142	125
210J5				7.6		3.90			21.4	42			48.8	6460				49				17.8		1280		37.7		
211ash				1.2		0.46			23.6	4			64.4	3540				6				27.7		13100		5.1		
211J1				5.2		9.93			40.7	6			129	8600				72				17.7		4550		12.3		
211J2				14.7		1.42			35.8	11			265	12200				14				19.1		3460		39.6		
211Jf				8.1		2.91			43.0	11			302	15000				28				41.0		2680		9.2		
212J1				5.7		7.86			22.0	12			63.6	6460				63				11.9		2880		6.4		
212J2				10.5		1.77			12.5	15			26.9	6020				17				5.5		806		12.2		
212J3				11.5		0.64			7.9	7			13.5	8030				7				3.1		464		9.3		
212J4				4.8		5.10			15.1	8			30.9	5520				69				7.5		1550		6.7		
213J1				5.4		15.3			31.3	7			66.8	7740				117				20.8		4130		12.2		
213J2				14		10.9			29.8	25			57.8	7200				85				16.9		2880		26.2		
213J3				22.6		5.74			20.6	27			56.3	6720				39				14.8		1740		23.7		
213J4	6.73		703	30.7	0.22	0.86	45	89.2	16.9	28	2.1	0.03	23.4	8660	52	63.5	4.4	9	83	0.20	0.12	6.4	0.4	418	11.2	29.6	141	70.2
213J5				15.5		4.61			22.0	37			70.7	7970				60				15.6		1480		25.2		
216H			802				91			3									108							3.2		
216J	0.82	6.7	382			0.56		9.1		3			22.5		729	1.9		6	511						1.2	5.3	32	
216Jb	3.60	26.4	1370			1.31		6.9		3			7.0		44	11.3		19	245						2.1	12.4	128	
216Jm	0.80	4.1	647			2.92		2.5		2			42.9		281	2.5		26	470						1.8	3.3	67	
216K			900				38			6									456							2.7		
216L			1540				29			2									228							15.3		
216N	4.00	90.7	644	2.2				7.8		18			15.7	6310	80	21.0			295			8.5			3.0		154	
216nod				1.7		1.28	18		3.5	1				6590	9460	0.2	2.2							601		0.5	27	23.8
216O			1280				24			8									320							3.4		
216R			1980				30			9									373							5.3		
216S			880				29			5									547							5.2		
217N	2.47	60.4	1040	2.8				2.3		15			7.9	5390	87	8.5			325			4.9			3.4		170	
218A	2.29	8.7	270	7.2				7.5		7			89.7	9740	40	16.8			174			20.1			4.1		115	
219A				4.5		4.32	32		15.8	6				7610		3.9	13.4							1740		4.2	59	220
219B				2.9		1.48	18		12.7	7				2820		16.0	12.8							840		12.0	67	206

* Denotes duplicate sample analysis
Results initially reported in Kruger and others (2017)
Results initially reported in Murphy and others (2018)
Results initially reported in Kruger and others (2022)

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
219C	40.97%	64.0		4.17		8.5		29.8		32.3			10.8				37.4				2.5		0.79	28		12.5	2				4190		8.7	15.7							3080		9.2	80	145
219Cb	34.91%	83.2		5.07		11.2		30.0		49.4			19.3				33.4				3.0		2.42	73		24.7	4				4240		2.9	39.3							1590		6.6	202	399
219Cf	95.25%	51.9		1.46		3.3		26.1		22.5			9.0				12.7	1.47	5.2	580	1.3		7.72	45	4.1	17.8	3	2.6		31.5	7820	115	0.9	15.9	109	65	1.21		8.6		3070	2.3	2.5	69	83.4
219conc	67.67%	14.5		0.70		1.3		7.6		6.8			3.8				6.1				0.8		2.81	18		5.3	1				10600		0.2	4.0							949		1.0	29	30.0
219D	21.14%	16.1		1.73		2.6		7.0		9.3			5.6				13.9				2.8		0.78	10		8.0	3				6240		11.1	6.3							345		7.8	28	31.4
219Db	7.51%	5.0		1.20		1.4		2.3		3.2			1.9				10.5				2.4		0.05	2		2.0	<1				4810		3.2	0.7							79		1.5	3	7.5
219Df	91.40%	70.3		2.07		4.6		35.5		30.2			13.1				17.8	0.96	6.2	558	2.2		14.5	66	7.1	22.2	3	3.0		49.6	14300	182	0.7	14.5	162	109	1.11		12.4		3730	1.9	2.8	92	95.2
219E	27.66%	38.8		3.65		5.0		20.4		16.3			8.8				33.0				7.2		0.47	19		7.2	1				7160		1.4	6.3							1010		3.0	30	59.6
219Ef	88.20%	70.0		2.46		4.3		36.2		29.5			14.3				19.1	2.19	3.8	907	1.4		11.2	59	2.0	25.5	4	3.8		27.0	6580	51	2.7	20.3	100	91	1.55		11.7		5310	3.3	10.5	94	140
219Fb	93.22%	45.7		1.90		2.9		25.9		19.0			15.7				14.5				2.6		13.1	86		28.1	2				6730		2.5	17.1							4260		2.9	142	127
219Fm	92.65%	57.3		2.05		3.6		32.4		23.9			15.9				14.9				2.3		13.2	83		28.1	2				7070		2.5	16.1							3990		3.8	147	122
219Ft	92.89%	61.0		2.30		4.3		32.3		25.8			14.9				16.7				2.8		12.4	83		29.6	2				6530		2.3	17.3							4120		2.7	129	123
219G	95.34%	60.1		2.22		4.2		30.1		26.6			13.3				17.2				2.4		11.6	65		22.1	2				5960		2.1	16.5							3800		3.0	106	119
219Gr	95.22%	69.1		2.24		4.2		35.4		28.4			17.0				18.2	1.72	3.0	1010	2.3		16.4	79	4.5	27.3	3	3.9		46.1	7710	47	2.4	15.7	148	95	1.14		14		3720	2.2	4.6	135	125
219H	66.85%	82.5		3.84		7.3		42.4		36.7			17.2				29.7				2.9		9.87	76		26.1	10				6530		14.1	19.7							3050		9.8	160	304
219I	48.55%	41.4		2.53		5.5		16.7		27.1			17.3				17.7				1.7		4.00	78		20.7	7				3260		14.5	13.0							2000		11.7	172	229
219nod	78.71%	24.1		0.93		1.8		13.1		11.0			4.2				7.3				0.6		3.22	41		6.6	1				5410	151	12.2	6.6							1430		1.2	32	40.9
219T	62.38%	65.0		1.77		4.0		28.9		26.3			2.8				13.8	0.68								41.7		2.6		79.6				3.5			2.03		43.9	8.1	1170				54.0
219Y	89.05%	69.6		3.32		5.9		38.7		32.2			14.0				27.9				3.0		11.0	83		23.8	2				8130		3.0	15.2							3710		3.7	124	126
219Z	81.65%	48.7		2.20		4.0		25.1		22.2			10.8				18.4				2.6		9.26	57		19.1	5				22800		1.7	13.9							2840		2.9	75	105
221F	93.89%	95.7	8.4	4.97	2.18	9.9	1.74	50.3	0.67	47.2	11.2	9.8	13.4	1.45	0.69	4.45	43.9						9.05	67		20.5	4			46.0	10100		1.6	16.2									4.0	89	
221H	95.16%	65.7		2.19		4.7		33.2		28.8			13.1				17.1						9.38	65		22.3	3			34.5	5030		3.1	16.6									4.0	99	
238B	18.80%	142	9.5	5.02	2.98	12.6	1.77	73.1	0.67	66.2	16.6	13.5	19	1.79	0.66	4.39	41.1				3.6					33.0	8			144	8170		28.3	16.1			0.97				2720		26.5	174	234
238Cb	19.70%	10.8		0.37		0.7		5.9		4.7			2.4				3.4				0.5					4.4	1			6.0	5440		1.7	3.1			0.25				807		1.5	15	24.0
238Ct	39.24%	21		3.72		5.3		9.3		13.8			9.5				34.0				6.3					5.7	3			3.1	2980		2.7	5.3			0.25				817		5.5	20	52.1
238Eb	18.89%	12.3		0.82		1.5		6.4		5.5			3.4				8.0				0.7					7.9	3			21.6	10400		5.4	1.9			0.15				337		2.3	14	32.3
238Et	70.38%	131	10.0	5.32	3.12	11.9	1.86	56	0.70	65.8	16.4	14.1	22	1.85	0.73	4.61	40.0				3.4					16.1	5			18.0	6280		18.3	9.7			0.50				1580		24.6	231	251
238F	93.00%	58.4		1.89		3.7		28		25.1			9.7				13.2				1.3		3.31	60		16.7	3			25.3	3130		3.9	12.1									4.4	77	129
238G	93.46%	46.1		1.65		2.8		23.3		19.2			7.6				12.5				1.0		4.07	38		16.8	2			31.7	2930		1.1	12.3									3.1	55	121
239E	54.14%	35.5		1.93		3.7		13.9		19.9			11.3				12.5				1.6					16.3	11			44.4	4900		29.9	13.4			1.22				2570		11.5	70	528
239Eb	39.53%	74.1		4.85		7.5		39.7		30.8			13.5				44.4				4.3					18.9	13			27.2	8040		2.9	9.5			0.61				1800		6.4	42	134
239F	93.04%	68.6		2.20		4.6		37.4		30.3			15.4				16.5				2.2		9.04	83		22.8	5			38.7	7870		3.1	14.3									5.8	157	157
240E	35.28%	18.5		2.30		2.8		10		9.6			7.8				18.0				5.4					13.2	7			9.8	13100		25.3	11.4			0.27				554		13.5	47	112
240Eb	64.21%	44.8		1.62		3.2		21.7		20.6			9.6				11.4				0.9					16.3	7			16.3	4260		23.7	13.3			0.93				2870		10.6	80	129
240F	85.14%	76.9		3.14		6.3		34.3		38.5			20.3				20.9				1.8		12.0	129		25.7	26			35.5	5440		12.3	16.5									21.3	264	328
240F2	91.10%	70.2		2.33		4.8		33.4		32.3			18.8				16.3				1.8		13.5	99		25.7	21			35.1	5390		9.6	17.3									17.0	158	228
240T	85.74%	28.8		0.29		1.2		15.3		10.5			1.4				2.3	0.96	1.9	250	0.8	0.55	0.4	4	0.4	59.9	2	2.9	0.02	147	2890	14	1.3	6.4	14	49	2.83	<0.10	11	6.1	1250	1.1	1.7	8	31.6
241E	51.18%	127	12.3	7.38	2.64	13	2.52	56.8	1.04	59.6	14.9	12.3	13.6	2.08	1.03	6.67	60.2				5.5					24.0	6			41.2	5090		18.1	13.0			1.33				3150		17.5	76	283
241Eb	72.54%	67.1		2.93		5.2		32.4		29.4			19.4				22.9				1.7					27.7	7			28.4	6040		5.2	16.7			1.21				3990		10.1	114	153
241F	76.70%	55.2		2.22		4.5		25.9		27.4			23.8				15.1				1.6		10.2	136		23.3	18			29.6	5780		21.2	16.4									27.6	249	343
241F2	85.21%	82.7		3.06		6.3		39.5		37.7			22				21.7				2.3		13.5	159		33.8	30			29.4	6080		28.3	19.0									23.6	290	376

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

* Denotes duplicate sample analysis
Results initially reported in Kruger and others (2017)
Results initially reported in Murphy and others (2018)
Results initially reported in Kruger and others (2022)

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium
241F2b	94.80%	76.1		2.31		5.1		36.0		33.2			14.4				17.3
241G	79.72%	63.7		2.88		5.5		29		31.5			34.4				19.0
242A	88.74%	78.1		3.47		6.5		36.3		36.1			20.8				26.4
242B	88.46%	76.1		2.79		5.8		37.7		34.1			16.1				22.8
242C	89.33%	75.4		2.39		5.5		37.3		33			13.6				20.9
242D	83.45%	63.5		2.29		4.5		31.3		26.6			12.7				20.9
242E	86.88%	65.2		3.77		6.4		31.8		30.9			10.9				34.2
242F	89.85%	55.3		2.44		6.3		20.3		34.4			7.6				19.7
243ash	86.63%	75.2		2.64		4.8		48.4		27.1			13.1				24.3
243B	25.76%	35.3		6.22		9.2		18.4		22.2			12.9				59.2
243E	49.83%	30.6		5.18		5.6		15.9		15.7			8.3				56.5
243Eb	44.85%	27.6		1.73		2.9		16.6		11.9			5.1				19.2
243F	93.92%	58.0		2.87		7.9		27.7		32.7			10.6				20.9
244F	90.56%	95.2		2.74		6.9		45.7		45.0			15.5				19.4
244G	92.60%	84.1		3.17		7.3		45.1		38.1			11.5				29.8
245C	29.97%	52.1		5.59		8.3		22.8		27.3			11				43.5
245Eb	35.52%	54.5		3.82		5.7		30.7		23.9			14.2				34.9
245Et	55.77%	93.7		3.95		7.3		42.4		40.8			14.6				31.4
245F	73.42%	109	7.2	3.36	2.45	9.5	1.23	46.5	0.45	54.3	13.6	12.2	30.2	1.42	0.45	2.96	23.3
246A	32.46%	69.4	11.8	8.21	2.26	10.6	2.65	35.6	1.22	35.9	8.5	8.3	15.6	1.82	1.15	7.33	84.8
246Cb	11.86%	9.7		0.51		1		5.1		4.6			1.3				4.5
246Ct	33.21%	58.5		5.48		10		22.6		36			13.1				43.0
246Eb	46.81%	25.3		2.18		2.7		14.6		10.7			5.1				18.6
246Et	77.68%	47.9		2.55		4.8		24.2		24.5			16.2				19.2
246F	94.94%	109		1.92		6.6		51.1		47.4			10.8				15.1
246T	79.38%	27.6		0.55		1.4		13.9		10.2			1.4				5.2
246Z	36.35%	16.5		3.54		4.4		8.1		10.1			9.4				33.3
280V	57.41%	70.2		4.84		8.7		30.0		37.1			17.9				41.6
280Vb	67.46%	116	9.4	5.09	2.85	11.6	1.77	49.9	0.67	57.2	14.3	12.8	19.7	1.70	0.69	4.47	42.3
280W	90.34%	80.2		2.89		6.5		39.0		38.3			15.3				23.2
280X	92.38%	112	6.3	3.43	2.17	8.3	1.19	52.7	0.46	48.2	12.6	9.9	20.5	1.17	0.48	3.09	29.1
280Xb	92.70%	103	7.1	3.63	2.17	9.1	1.31	50.3	0.46	45.4	11.6	9.4	13.9	1.31	0.50	3.16	32.2
280Y	89.54%	95.1		3.36		7.2		51.9		36.3			16.4				32.7
280Z	84.27%	159	11.8	5.12	3.85	14.8	1.99	70.8	0.52	71.8	18.8	16.4	18.9	2.22	0.65	3.81	45.4
284B	26.35%	31.9		2.32		3.5		15.6		14.0			6.8				23.4
284C	65.84%	39.2		4.50		5.4		19.7		19.9			21.4				36.8
284D	59.83%	49.3		3.37		5.2		25.9		23.9			15.6				29.2
284E	48.30%	61.4		4.35		6.8		28.8		30.4			25.7				35.3
284F	29.93%	53.5		4.19		6.3		31.1		23.7			15.4				40.0
284G	42.06%	45.6		2.10		3.7		23.7		19.1			6.7				21.6
284Gb	33.97%	33.8		3.48		4.4		18.0		14.8			8.5				33.0

SAMPLE ID	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
241F2b				1.5			52		17.2	8	3.3			3640		6.7	17.1							4020		8.4	88	120
241G				1.8		11.1	181		22.7	4			34.2	6270		5.6	12.0									22.1	196	227
242A				5.4		11.3	82		31.5	14			55.3	11000		2.7	14.1									10.1	130	193
242B				4.3		11.4	75		27.4	6			55.8	10400		1.8	14.1									5.5	108	126
242C				3.2		11.3	68		27.4	3			59.3	9400		1.5	14.9									3.6	98	107
242D				4.9		9.22	61		25.9	4			68.2	9830		2.0	11.8									4.1	105	91.9
242E				4.3		6.73	58		21.2	5			40.5	10900		4.7	10.9									12.4	107	184
242F				1.4		2.29	118		13.2	21			12.7	2280		5.1	9.6									2.4	93	280
243ash	2.70	40.9	5940	2.2	<0.10	0.66	33	4.9	22.1	3	5.0	0.10	143	32800	1790	2.4	19.4	13	2850	1.57	0.52	22.3	3.5	4380	5.9	7.5	131	166
243B				7.3					10.7	7			5.5	6600		26.0	9.1			0.26				828		13.6	84	234
243E				8.3					14.2	2			52.9	4790		16.7	11.1			0.93				2290		16.5	47	94.5
243Eb				3.2					14.4	4			56.8	20600		16.3	4.4			0.34				1020		4.6	20	38.0
243F				1.7		3.02	78		16.1	4			22.0	4400		7.9	9.3									3.6	132	166
244F				1.7		8.98	110		23.5	11			24.2	3710		6.4	18.7									9.9	146	202
244G				4.0		9.01	61		26.0	3			97.5	7050		5.0	14.2									6.6	100	112
245C				4.9					10.1	10			12.1	5010		7.6	4.6			0.26				901		12.2	21	57.4
245Eb				3.9					16.0	5			23.3	7470		3.0	9.6			0.72				2120		3.7	52	98.9
245Et				4.0					19.1	8			44.5	5590		8.4	8.2			0.88				2330		14.5	71	161
245F				1.6		10.5	255		29.1	25			37.2	5970		39.9	16.5									38.6	414	613
246A				7.3					16.7	18			13.3	11100		10.2	15.5			0.35				1060		9.4	91	321
246Cb				0.5					1.7	<1			3.0	5300		1.5	1.0			0.07				228		1.2	6	13.7
246Ct				3.7					9.7	3			7.8	6560		7.7	9.0			0.33				1080		11.0	48	141
246Eb				1.0					11.0	6			26.0	11200		9.8	11.1			0.75				2340		6.1	34	119
246Et				1.9					27.1	9			36.4	6370		13.7	13.8			1.21				3720		12.6	146	247
246F				1.3		3.24	52		21.7	3			23.1	4240		17.5	12.6									3.6	106	92.0
246T	1.05	4.1	685	1.0	0.74	0.34	5	4.4	60.6	2	2.1	0.05	129	3080	25	3.8	4.1	14	97	2.40	0.17	21.8	10.0	1480	1.3	3.2	9	38.0
246Z				7.3					11.2	4			7.5	18100		7.6	5.8			0.17				677		11.4	19	88.7
280V									16.6	18																17.0		
280Vb	4.36	24.1		3.7		5.64	93	13.9	26.3	15			47.1	3780		7.1	12.9			0.88				3460	1.7	16.3	150	215
280W									25.1	8																4.8		
280X	2.07	21.5		2.6		9.74	127	14.9	32.2	10			49.4	8370		3.6	15.8			1.1				5060	2.1	4.4	198	128
280Xb	1.97	30.6		2.3		5.9	74	12.3	22.4	10			39.2	4680		2.7	13.4			0.96				3970	1.8	5.4	126	133
280Y									30.3	9																4.9		
280Z	1.43	9.5		3.3		3.72	87	17.2	21.0	13			27.1	2920		3.4	14.3			1.05				3820	2.2	4.6	133	130
284B									10.1	8																5.2		
284C									33.6	13																24.1		
284D									22.7	9																17.8		
284E									26.9	15																19.1		
284F									23.1	6																12.1		
284G									11.9	7																4.7		
284Gb									25.6	14																6.3		

* Denotes duplicate sample analysis
Results initially reported in Kruger and others (2017)
Results initially reported in Murphy and others (2018)
Results initially reported in Kruger and others (2022)

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium
284H	89.08%	81.7		2.69		6.0		38.9		38.9			20.6				19.8
284I2b	52.26%	100	9.5	5.76	2.35	10.9	1.95	51.3	0.79	51.8	12.3	10.6	20.1	1.62	0.80	5.14	53.3
284I2m	35.62%	207	16.2	9.32	4.17	20.1	3.26	116	1.17	97.8	23.8	19.5	21.4	2.90	1.25	7.68	99.8
284I2t	55.10%	1090	54.1	23.2	19.50	81.4	9.07	526	2.20	483	124.0	98.2	26.2	11.10	2.83	16.40	225
284I3b	60.98%	200	17.1	9.15	5.04	21.6	3.21	86.3	1.11	109	25.8	23.6	23.8	3.08	1.21	7.57	83.1
284I3r	91.74%	121	6.4	3.39	2.12	8.8	1.19	60.2	0.45	54.7	14.1	10.9	14.9	1.24	0.47	3.06	30.0
284I3t	88.37%	336	21.0	10.2	6.89	28.0	3.72	135	1.09	157	39.4	34.2	11.0	4.03	1.31	8.10	91.4
284Ib	66.78%	226	14.3	7.79	4.45	19.9	2.73	109	1.01	108	27.0	21.7	22.0	2.66	1.05	6.78	78.4
284Im1	45.97%	651	44.2	24.3	12.20	55.3	8.62	299	2.69	298	75.0	60.6	29.4	8.06	3.15	18.80	248
284Im2	36.53%	224	23.1	13.9	5.41	25.2	4.74	103	1.76	109	26.1	24.2	28.9	3.87	1.90	11.90	141
284Im3	44.00%	222	18.9	11.2	4.91	22.6	3.83	102	1.41	109	26.1	23.0	25.5	3.32	1.51	9.43	112
284It	55.74%	686	39.5	19.5	12.50	53.7	7.22	316	2.08	307	78.0	62.1	24.9	7.57	2.54	15.00	195
285A	35.57%	12.2		0.75		1.4		5.5		6.7			5.5				6.8
285Ab	45.67%	16.2		2.10		2.4		8.9		7.6			6.2				21.5
285B	94.66%	35.9		2.16		3.2		20.6		15.7			7.0				19.4
285Bb	93.53%	26.3		2.39		2.4		16.1		10.7			9.5				20.9
285C	78.53%	66.2		3.63		5.9		34.6		29.5			16.1				32.1
285Cb	82.47%	51.4		2.14		3.8		29.0		22.5			15.1				18.8
286A	86.41%	32.3		1.78		2.0		19.5		12.7			13.0				14.8
286B	61.00%	154	9.1	4.46	3.08	12.0	1.64	67.1	0.52	67.0	17.1	13.5	11.6	1.70	0.59	3.68	40.6
287A	87.64%	171	11.9	6.26	3.33	14.5	2.26	85.2	0.77	75.5	19.6	15.2	19.2	2.16	0.84	5.24	63.0
288A	92.87%	68.2		2.31		4.7		35.8		30.5			17.6				18.6
288Ab	92.22%	62.5		2.08		4.3		34.0		27.5			16.5				16.7
289A	30.56%	30.0		2.94		4.7		11.9		17.5			9.4				25.2
289Am	14.35%	12.6		0.91		1.7		5.9		6.3			2.4				13.5
289Lb	48.15%	31.8		3.15		4.4		16.6		16.1			11.6				32.2
290A	69.53%	154	10.8	5.33	4.48	15.3	1.90	67.2	0.71	85.7	20.1	19.6	27.0	2.09	0.74	4.88	40.7
294T	80.59%	15.5		0.22		0.6		8.2		5.1			1.4				2.0
294V	31.96%	37.1		2.36		4.2		18.1		17.1			6.2				22.6
294Vb	79.09%	59.0		2.31		3.5		31.6		24.3			12.2				20.4
294W	80.09%	104	8.1	4.41	2.13	9.3	1.55	53.1	0.59	47.3	12.4	9.8	21.6	1.40	0.60	3.91	40.4
294X	93.21%	78.4		2.44		5.5		39.4		34.2			14.6				20.7
294Y	92.47%	156	8.7	4.15	2.81	11.9	1.55	77.8	0.52	69.3	18.5	13.6	17.3	1.67	0.56	3.50	38.5
294Z	94.53%	55.3		1.88		3.6		29.0		23.5			13.3				16.2
295T	80.86%	12.2		0.20		0.5		6.5		4.1			1.3				1.7
295V	32.44%	22.6		3.08		3.4		12.9		10.8			14.7				28.0
295Vb	66.28%	31.8		1.93		2.7		17.9		12.7			7.2				16.8
295W	71.72%	140	13.0	6.74	3.30	16.1	2.44	67.7	0.76	72.2	17.6	14.4	16.1	2.27	0.83	4.97	72.2
295W2	84.21%	86.0		3.70		7.9		39.2		42.7			22.1				27.0
295Y	91.28%	103	6.8	3.61	1.89	8.2	1.24	55.7	0.52	46.4	12.4	9.2	20.7	1.19	0.51	3.33	32.5
295Z	94.67%	76.9		2.34		5.5		38.3		34.0			13.5				20.1

SAMPLE ID	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
284H									30.1	10																11.2		
284I2b	6.77	45.2		6.3		4.85	81	20.7	29.9	18			52.5	3370		27.8	15			0.89				1890	3.1	13.7	156	270
284I2m	7.55	17.1	1000	12.4	0.35	1.08	33	33.2	24.3	33	3.1	0.04	34.3	2420	37	14.1	13.7	11	358	0.94	0.1	11.5	1.5	1920	3.4	8.0	65	145
284I2t	2.19	29.2	1390	14.9	0.32	3.46	90	32.4	18.3	21	2.8	0.05	58.8	2950	41	5.7	9.4	41	343	0.78	0.05	11.1	1.8	2060	1.5	20.8	158	123
284I3b	1.98	27.7	1010	6.5	0.20	1.16	90	10	10.2	11	3.7	0.07	33.2	1050	20	5	12.7	17	225	1.04	0.06	19	1.7	2860	6.6	22.2	153	205
284I3r	1.41	9.1		3.1		9.54	70	10.9	23.2	4			54.8	5900		1.6	15.3			1.09				3640	2.1	5.3	113	113
284I3t	1.02	9.3	363	2.3	0.13	0.9	33	6.3	6.7	8	2.6	0.02	17.1	604	15	3.2	11.3	11	92	0.94	0.03	7.8	1.1	2670	3.4	8.1	56	105
284Ib	2.97	7.4	1040	7.2	0.71	8.25	55	7	37.6	24	5.00	0.07	49.3	5020	58	14.5	21.8	65	255	2.16	0.1	18.9	4.4	4450	3.9	11.5	102	204
284Im1	5.88	30.9	1250	9.1	0.33	2.71	60	23.2	18.7	24	4.7	0.04	47.6	4060	49	27.7	10	30	382	0.9	0.1	11.8	2.0	2020	1.8	20.9	232	256
284Im2	5.53	22.0	1580	9.3	0.39	1.23	34	17	25.3	29	4.4	0.03	36.4	3300	35	29.9	11.5	11	386	0.87	0.16	9.4	1.4	2160	2.1	9.7	85	232
284Im3	4.62	16.9	1520	8.0	0.44	1.61	35	12.5	17.7	19	4.1	0.04	40.8	3450	36	27.1	12	15	316	0.98	0.11	10.5	1.6	2350	2	10.5	71	202
284It	3.80	36.0	1670	10.0	0.24	2.87	68	43.4	37.0	45	3.3	0.03	41.4	4110	97	11.9	9.1	32	411	0.8	0.05	8.2	1.3	2020	1.4	26.1	175	156
285A									3.0	12																5.8		
285Ab									21.4	25																11.2		
285B									24.7	4																5		
285Bb									37.2	4																5.2		
285C									30.2	8																5.0		
285Cb									27.5	9																7.1		
286A									26.3	6																3.0		
286B	2.71	19.4		2.6		3.85	53	18.1	20.8	21			21.5	4760		23.4	11.1			0.65				2210	2.6	3.8	109	206
287A	3.70	20.4		4.9		11.6	97	7.4	34.6	17			219	7900		8.9	21.6			1.47				4030	2.9	13.8	209	194
288A									30.1	6																6.8		
288Ab									29.1	6																6.4		
289A									8.4	4																11.0		
289Am									4.1	1																2.1		
289Lb									12.8	7																10.4		
290A	5.15	57.7		2.8		9.85	163	10.4	32.2	24			31.3	7370		13.6	17.9			0.99				3390	3.6	20.1	271	373
294T									65.5	3																0.9		
294V									8.5	8																9.6		
294Vb									32.2	8																6.4		
294W	6.22	22.9		4.8		13.1	116	51.9	31.0	25			54.9	8240		9.2	14.9			0.98				3410	2.3	8.9	232	282
294X									25.0	8																7.1		
294Y	3.02	10.1		3.9		11.9	88	8.2	33.0	13			85.4	6720		2.8	19.3			1.45				4690	3.4	10.1	144	142
294Z									25.1	6																3.7		
295T									57.3	3																1.5		
295V									24.7	6																10.6		
295Vb									8.9	5																5.9		
295W	15.4	87.1		4.4		12.0	143	38.2	32.3	57			38.7	9180		30.7	18.7			0.85				2920	2.3	29.3	289	585
295W2									28.0	27																10.0		
295Y	3.87	10		4.7		16.4	101	8.9	36.5	10			90.9	9810		4.8	17.6			1.34				4320	3.3	8.7	172	168
295Z									24.1	7																6.8		

* Denotes duplicate sample analysis

Results initially reported in Kruger and others (2017)

Results initially reported in Murphy and others (2018)

Results initially reported in Kruger and others (2022)

Appendix B - Analytical Results

Concentrations are reported on a whole coal/rock basis (dry) as ug/g or parts per million

SAMPLE ID	Ash (wt%)	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium	Neodymium	Praseodymium	Samarium	Scandium	Terbium	Thulium	Ytterbium	Yttrium
295Z2	88.00%	54.6		2.02		3.5		29.4		22.9			14.6				16.1
300A	78.21%	439	24.6	11	9.82	35.9	4.08	159	1.26	218	53.8	48.8	30.5	4.95	1.44	8.94	92.2
300B	88.72%	134	10.4	5.78	3.13	12.5	1.99	58	0.77	67.7	16.7	15.0	21	1.85	0.81	5.27	49.4
300C	91.20%	67.2		2.2		4.8		34.5		29.4			14.6				19.9
300Cb	65.60%	96		3.44		7.3		47.6		42.8			16.3				31.6
301A	34.20%	101	12.2	6.55	3.08	14.2	2.32	31.4	0.86	58.9	13.5	13.4	33	2.16	0.89	5.76	57.8
302A	41.80%	99.9		3.78		9.3		42.5		50			8.1				30.9
302Ab	35.58%	46.2		2.2		3.6		25.7		17.1			19.2				22
302B	75.56%	128	11.6	5.23	3.72	14.1	1.95	48.1	0.62	66.5	16.7	17.4	31.3	2.18	0.68	4.22	48.2
302Bb	90.07%	54		1.94		3.4		32.7		21.4			18.1				16.9
302C	88.46%	99.7	10.9	7.04	2.43	10.8	2.32	50.2	0.96	48.6	12.0	10.9	21.3	1.75	0.99	6.48	65.9
302Cb	91.31%	58.5		2.62		4.6		33.1		25.4			15.7				24.3
302T	78.07%	31.9		0.86		2		16.5		12.2			1.6				9
302X	59.49%	35.8		2.6		4.1		19		17.2			9.7				33.1
303A	43.09%	24.1		4.04		4.3		12		12.9			18.1				38.3
303A2	40.16%	27.2		2.78		3.3		14.7		12.1			21.1				27.5
303Ab	62.16%	21.9		3.38		3.4		10		10.1			12.4				31
303B	73.17%	369	24.4	10.8	8.50	34.2	4.14	158	1.22	180	44.4	39.5	28.8	4.82	1.40	8.62	91.7
303B2	53.30%	443	25.3	10.4	10.00	40.3	4.11	187	1.07	228	55.7	51.0	26.6	5.40	1.30	7.81	86.4
303C	73.13%	64.4		3.11		5		33.2		27.4			15.8				27.1
303D	33.36%	25.5		1.96		3.2		11.8		13.6			11.6				17
303Db	82.26%	54.2		1.85		3.3		29.5		22.3			16.4				15.7
304A	72.62%	420	17.6	7.76	6.82	27.9	2.99	184	0.82	185	47.8	34.4	16.4	3.64	0.98	5.83	75
304B	38.28%	128	11.3	6.29	3.10	13.1	2.17	45.9	0.83	63.2	15.6	14.2	19.6	1.99	0.87	5.56	54.7
304Bb	64.52%	46.4		2.54		3.8		23.8		18.9			11.2				23.5
304C	56.67%	76.2		3.98		8.6		30.5		40			16.1				32.9
304D	39.53%	117	10.9	5.93	3.28	13.5	2.06	38	0.81	63.9	14.9	14.6	25.8	2.00	0.81	5.32	46.5
305A	87.76%	99.3		1.93		5.9		44.6		42.4			14.7				16.5
305Ab	74.81%	408	17.1	7.11	7.08	26.9	2.76	172	0.74	176	46.3	35.0	35.8	3.65	0.88	5.35	60.1
305B	36.98%	113	14.4	9.06	3.17	15.1	3.08	49.5	1.19	56.7	13.6	12.5	14.3	2.40	1.22	7.43	110
305Bb	23.91%	91.8	14.2	9.93	2.83	13.6	3.24	43.6	1.51	47.3	11.3	11.0	16.9	2.24	1.39	8.80	114

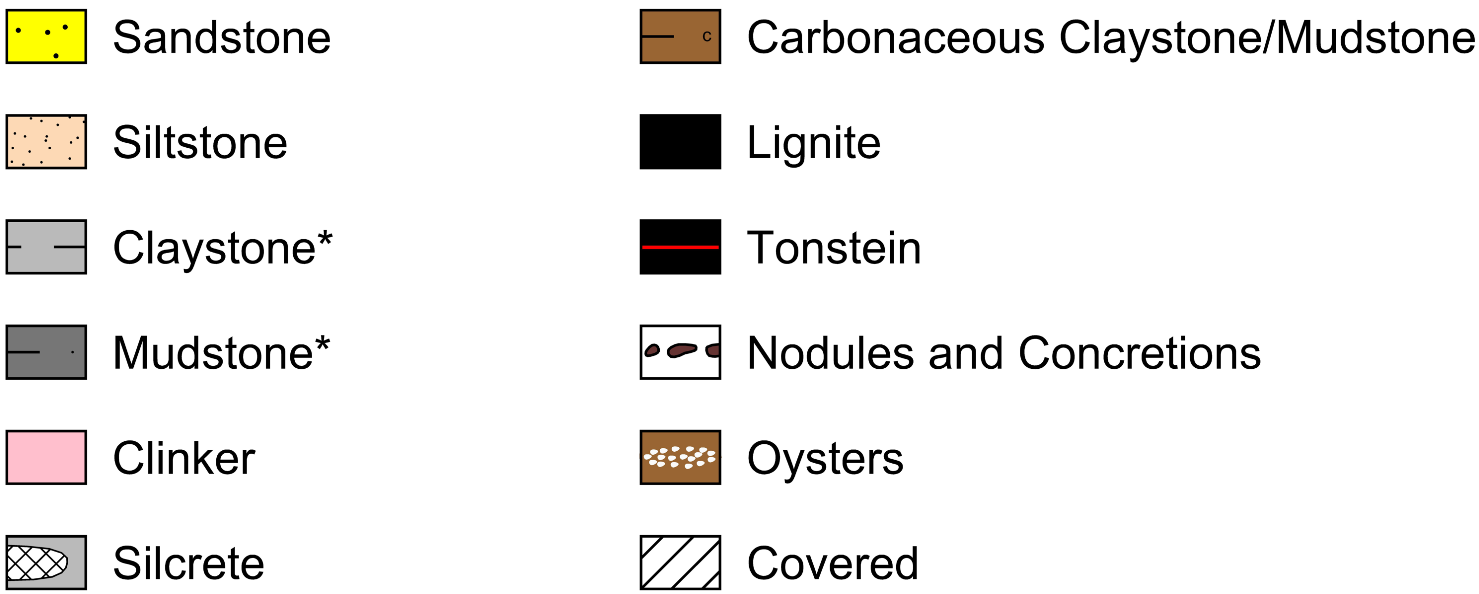
SAMPLE ID	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cesium	Chromium	Cobalt	Gallium	Germanium	Hafnium	Indium	Lithium	Magnesium	Manganese	Molybdenum	Niobium	Rubidium	Strontium	Tantalum	Tellurium	Thorium	Tin	Titanium	Tungsten	Uranium	Vanadium	Zirconium
295Z2									29.3	11																7.6		
300A	12.1	159	318	3.1	0.61	9.19	125	10.8	27.2	31	6.4	0.13	40.3	4730	40	73.7	14.3	125	581	0.93	0.19	17.4	2.4	2540	5.6	28.4	286	342
300B	5.33	82.1		2.7		11.1	92	8	24.9	24			45.5	6420		37.1	15.9			1.14				3770	3.8	10.9	161	244
300C									23.2	3																4.5		
300Cb									23.1	13																7.2		
301A	20.2	78.8		3.8		2.77	71	20.9	21.6	12			16.5	3270		39	18.6			0.38				1100	4.1	27.6	224	185
302A									6.7	11																8.1		
302Ab									20.6	12																8.7		
302B	3.43	7.7		6.0		6.82	131	8.7	23.6	4			69.6	6060		5.4	13.6			0.97				3260	2.3	13.2	212	179
302Bb									29.7	3																6.6		
302C	1.88	12		4.1		14.7	110	13.8	31.6	4			49.4	5460		5	20.9			1.53				5380	3.4	6.9	173	208
302Cb									26.6	4																3.3		
302T									59.5	2																2.1		
302X									13.3	3																8.6		
303A									80.9	40																56.2		
303A2									34.5	20																19.0		
303Ab									18.9	12																11.0		
303B	3.27	51.8	989	5.4	0.24	2.44	109	11.2	18.9	14	6.8	0.08	24.9	1960	16	4.3	25.4	31	184	1.96	0.09	18.5	2.7	5140	3.8	18.6	184	347
303B2	3.01	38.6	861	4.3	0.32	2.12	110	9.5	14.1	12	6.1	0.05	33.4	2470	38	7	14.5	20	285	1.29	0.13	20.7	2.0	3220	2.3	20.6	185	323
303C									22.3	10																8.7		
303D									15.7	28																9.9		
303Db									22.8	7																5.4		
304A	2.99	24.1	1060	7.3	0.17	1.9	73	25.6	14.9	16	4.0	0.04	37.8	2800	63	6.3	13.9	25	166	1.13	0.05	12.5	2.0	2870	6.7	9.5	177	210
304B	3.22	15.8		4.8		0.49	40	16.5	12.4	5			33.8	4540		16.4	25.9			0.87				1640	2.7	13.5	86	226
304Bb									24.0	15																6.5		
304C									12.9	12																15.9		
304D	4.60	89.6		2.8		0.87	60	14.1	12.9	4			9.7	5190		33.6	12.9			0.2				589	5.3	25.4	65	147
305A									21.2	6																5.3		
305Ab	6.32	107	135	2.7	0.39	5.43	238	12.5	27.8	35	8.1	0.11	41.8	3840	34	14.6	12.5	51	142	0.79	0.07	43.1	1.9	2260	2.1	27.3	252	439
305B	4.10	71.6		16.1		1.65	60	31.3	11.3	15			11.1	4280		14.7	8.7			0.35				1120	2.8	9.7	88	192
305Bb	4.51	43.2		18.7		0.85	62	44	13.8	7			9.6	4590		17.2	6.1			0.19				560	4.3	16.0	89	99.5

Appendix C

Elemental Concentrations by Stratigraphic Position

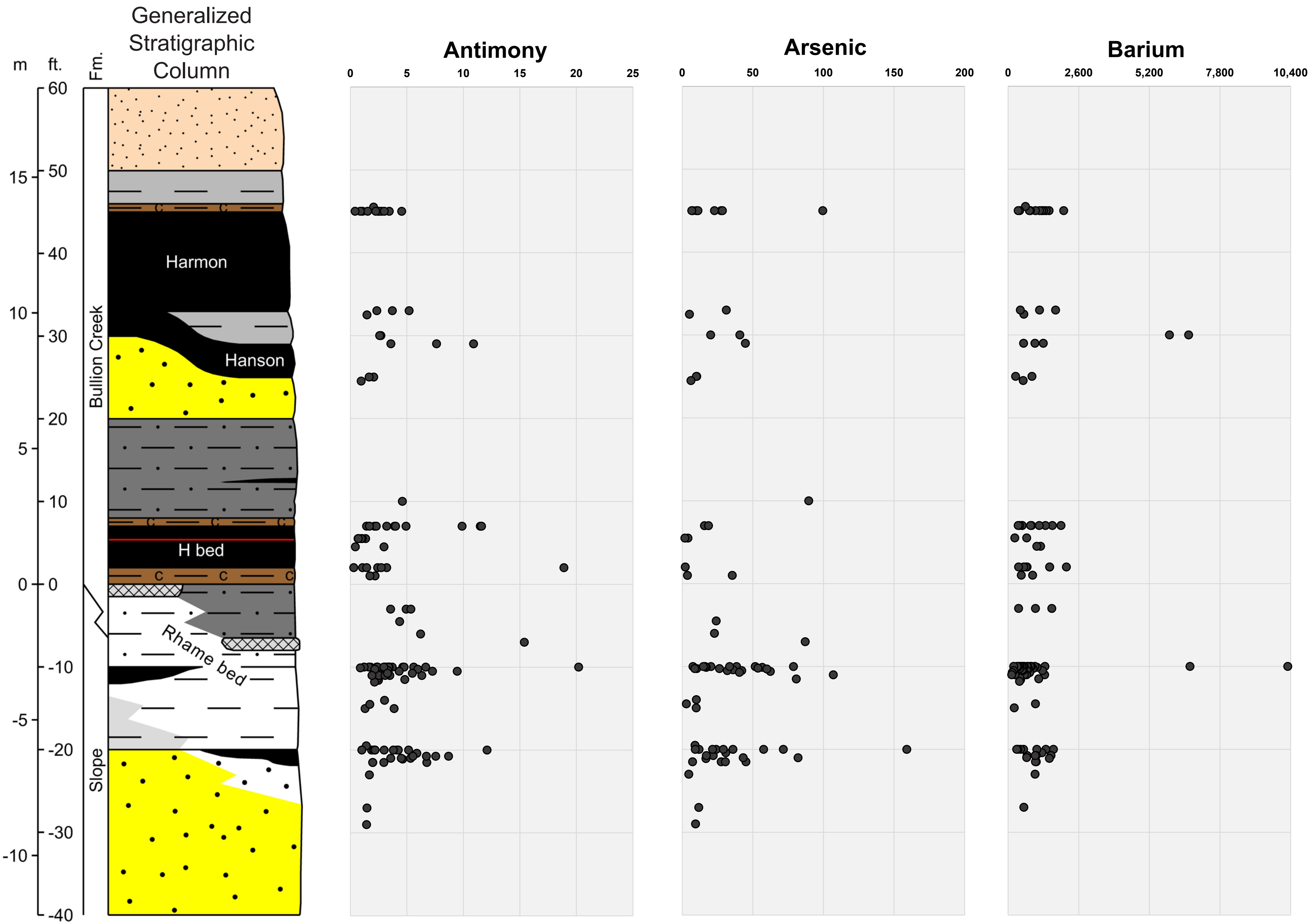
Reported in ug/g or ppm

Lithology Key for Generalized Stratigraphic Column

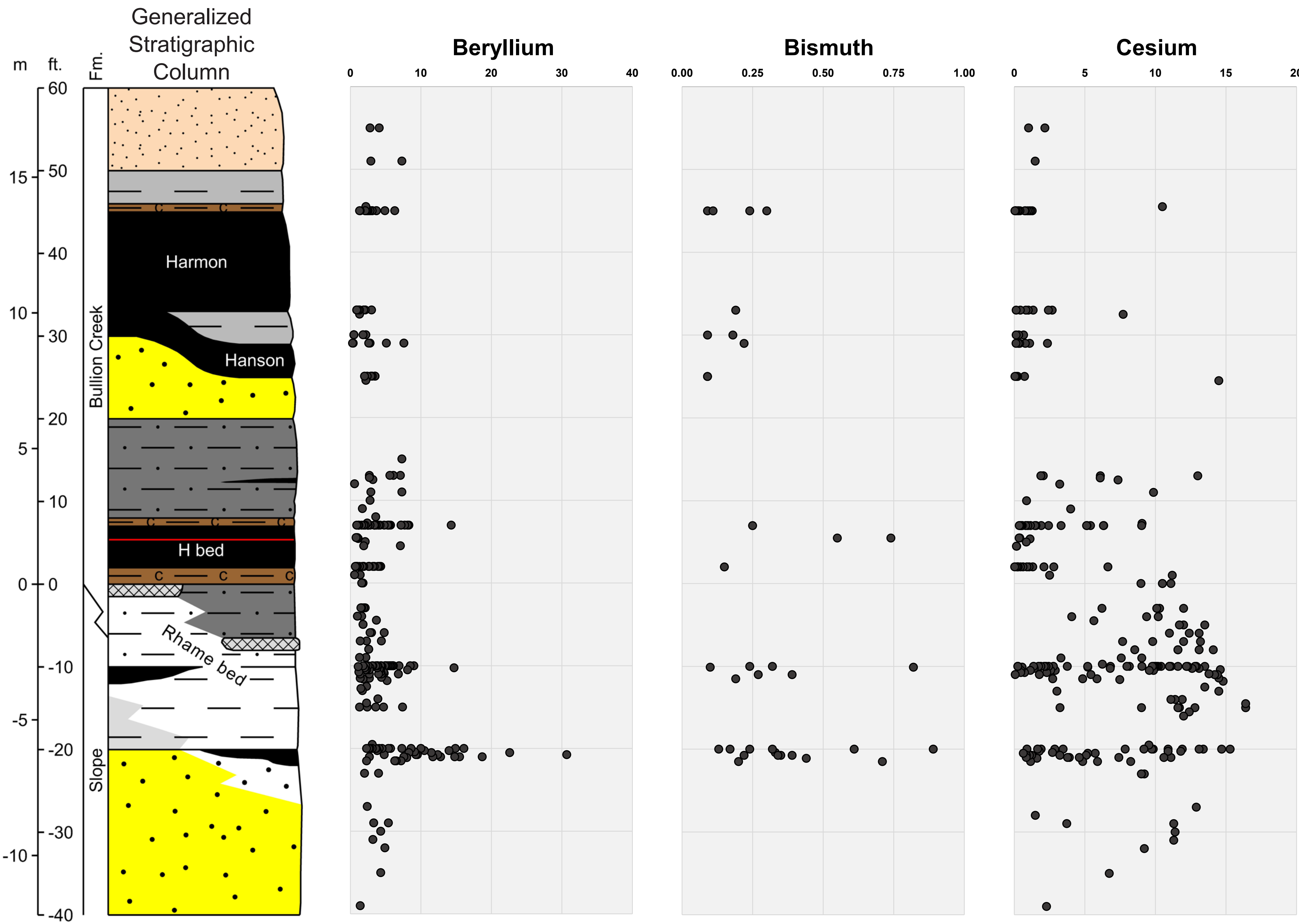


*Colors of claystone and mudstone vary according to those observed in the field

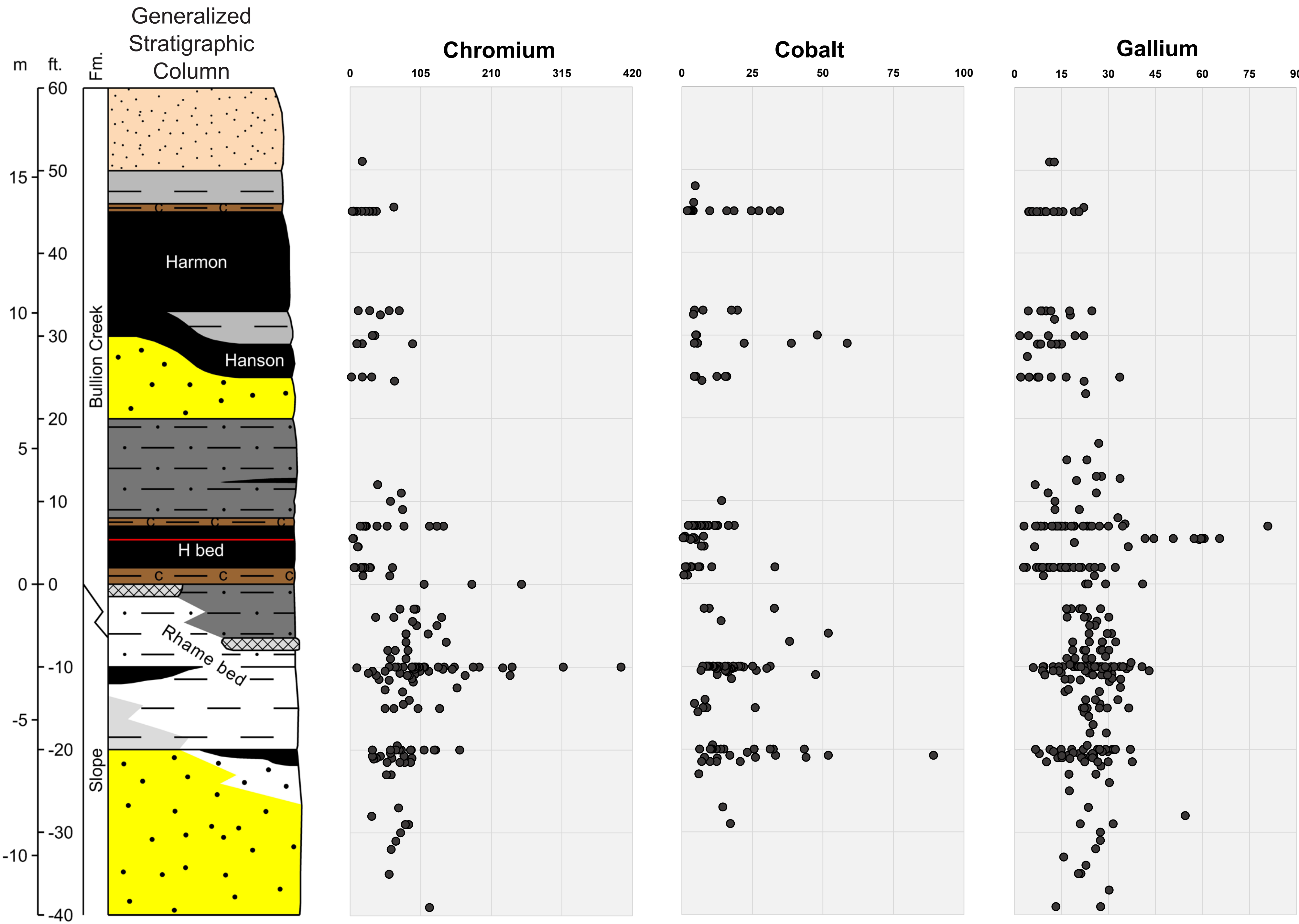
See figure 30 within report for ΣREE concentrations by stratigraphic position.



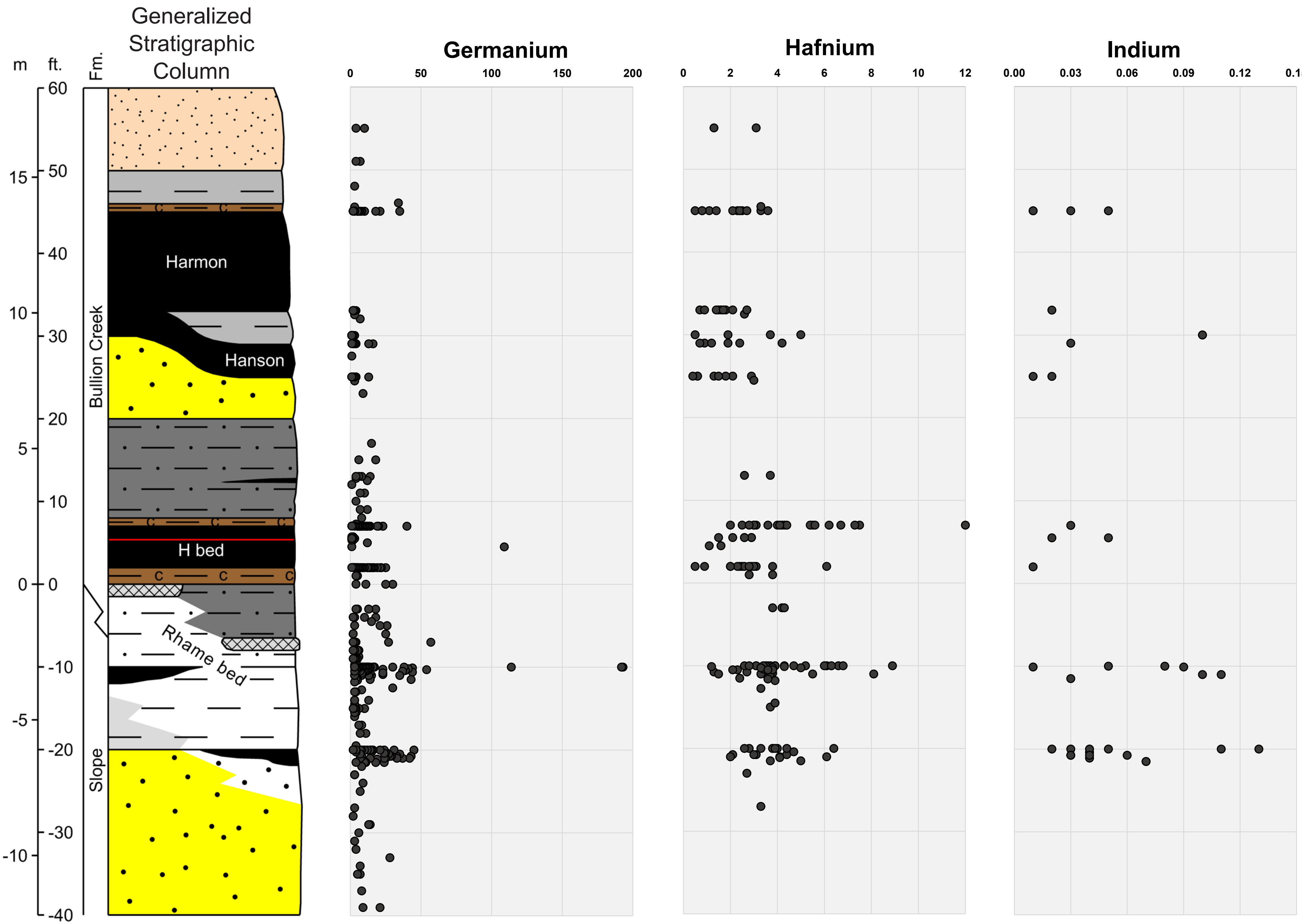
Generalized Stratigraphic Column
m
ft.
Fm.
Bullion Creek
Slope
Harmon
Hanson
H bed
Rhame bed
Antimony
Arsenic
Barium
0
5
10
15
20
25
50
100
150
200
2,600
5,200
7,800
10,400
60
50
40
30
20
10
0
-10
-20
-30
-40
-5
-10



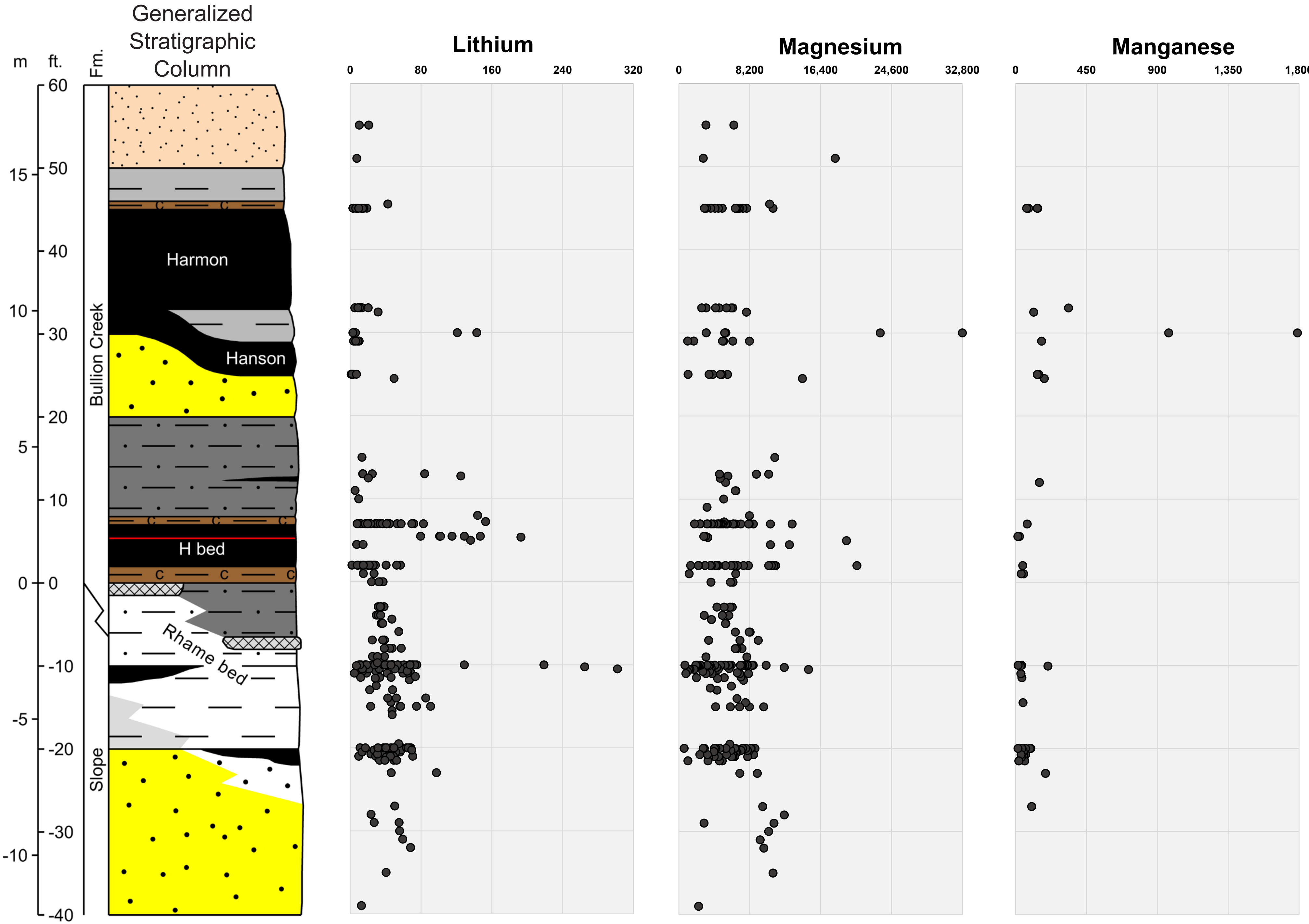
Generalized Stratigraphic Column
m
ft.
Fm.
Bullion Creek
Slope
Harmon
Hanson
H bed
Rhame bed
Beryllium
Bismuth
Cesium
60
50
40
30
20
10
0
-10
-20
-30
-40
15
10
5
0
-5
-10
0 10 20 30 40
0.00 0.25 0.50 0.75 1.00
0 5 10 15 20



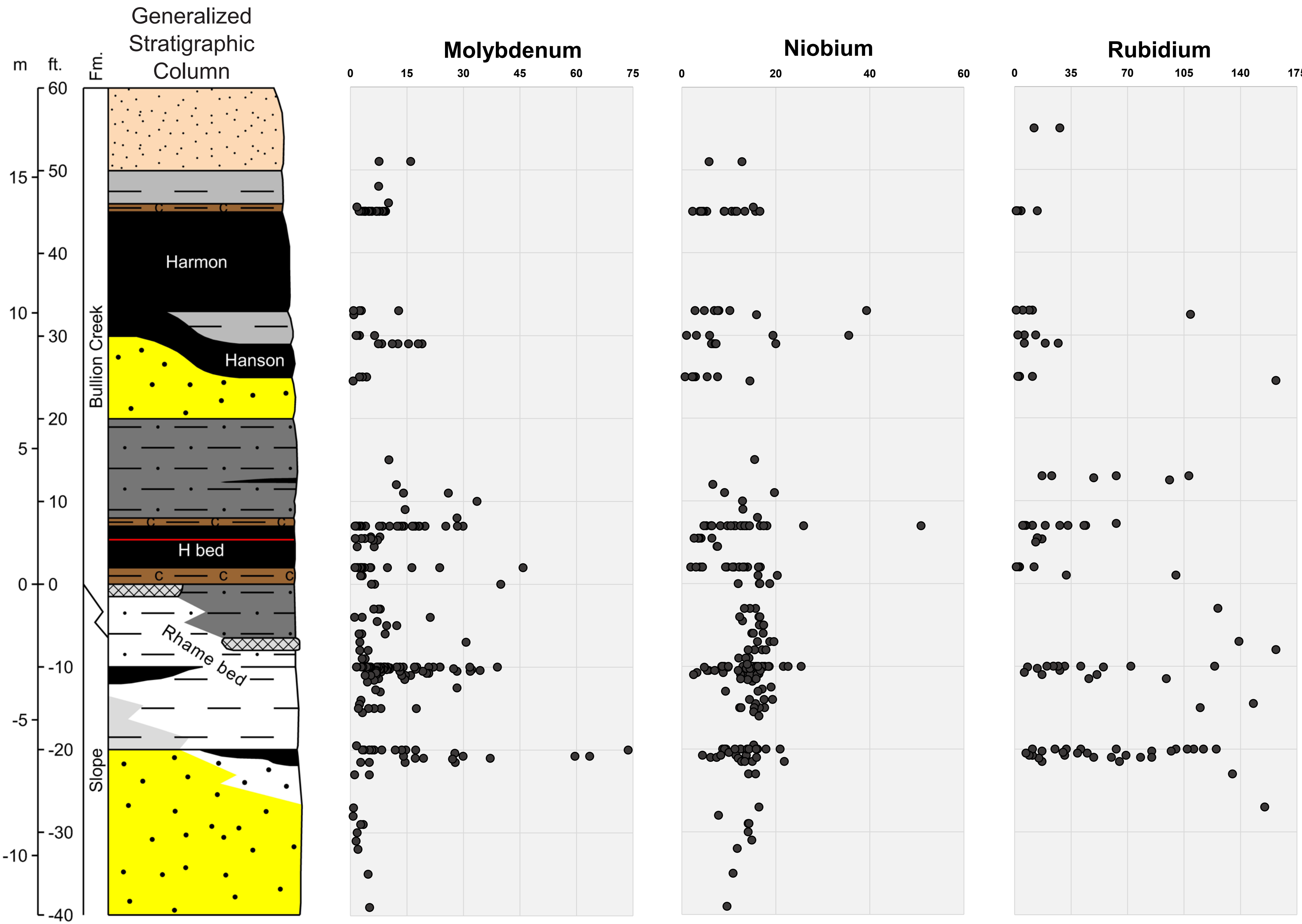
Generalized Stratigraphic Column
m
ft.
Fm.
Bullion Creek
Slope
Harmon
Hanson
H bed
Rhame bed
Chromium
Cobalt
Gallium



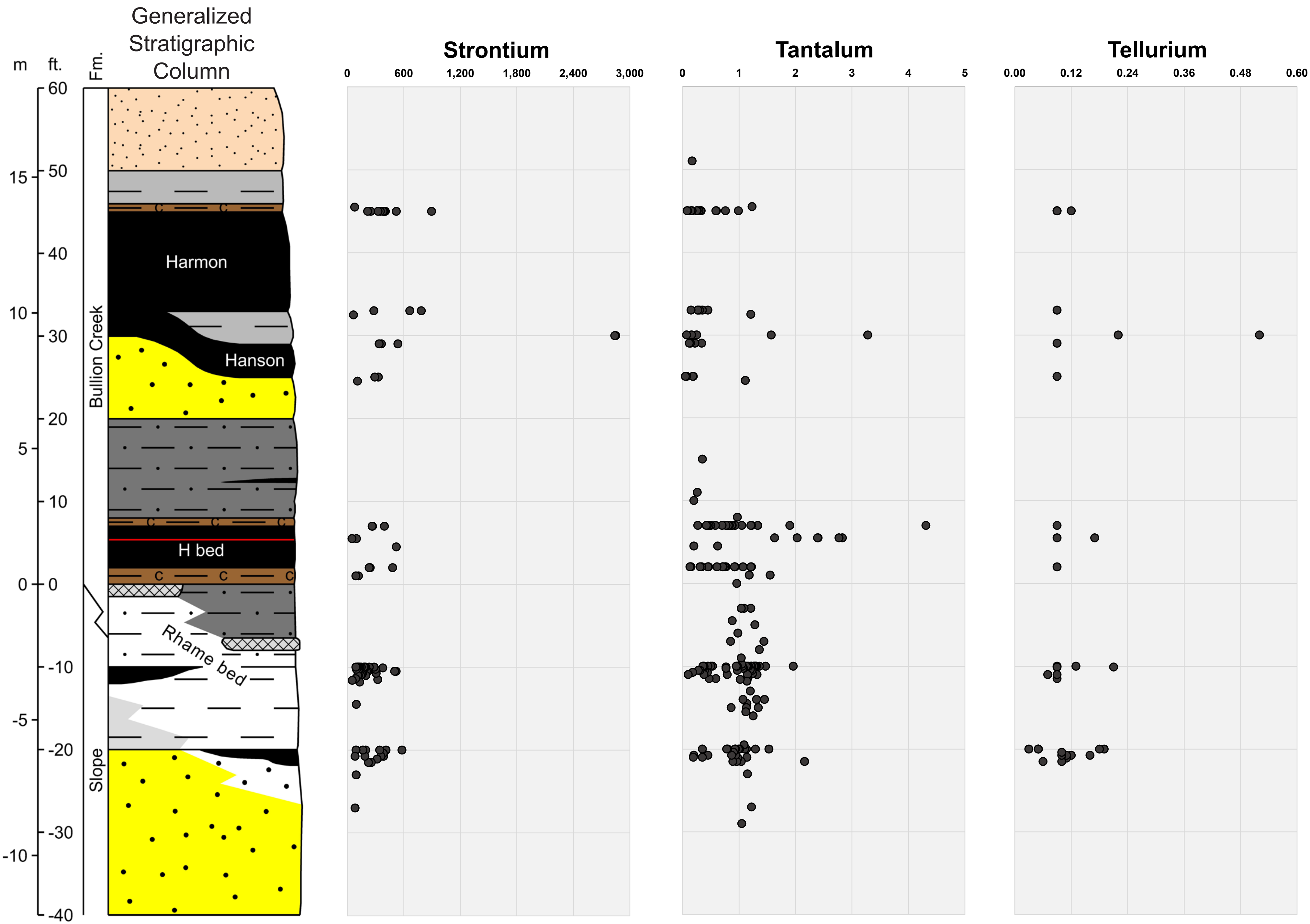
m
ft.
Fm.
Generalized Stratigraphic Column
Germanium
Hafnium
Indium
0
50
100
150
200
0
2
4
6
8
10
12
0.00
0.03
0.06
0.09
0.12
0.15
60
15
50
40
10
30
20
5
10
0
0
-10
-5
-20
-30
-10
-40
Bullion Creek
Slope
Harmon
Hanson
H bed
Rhame bed
C



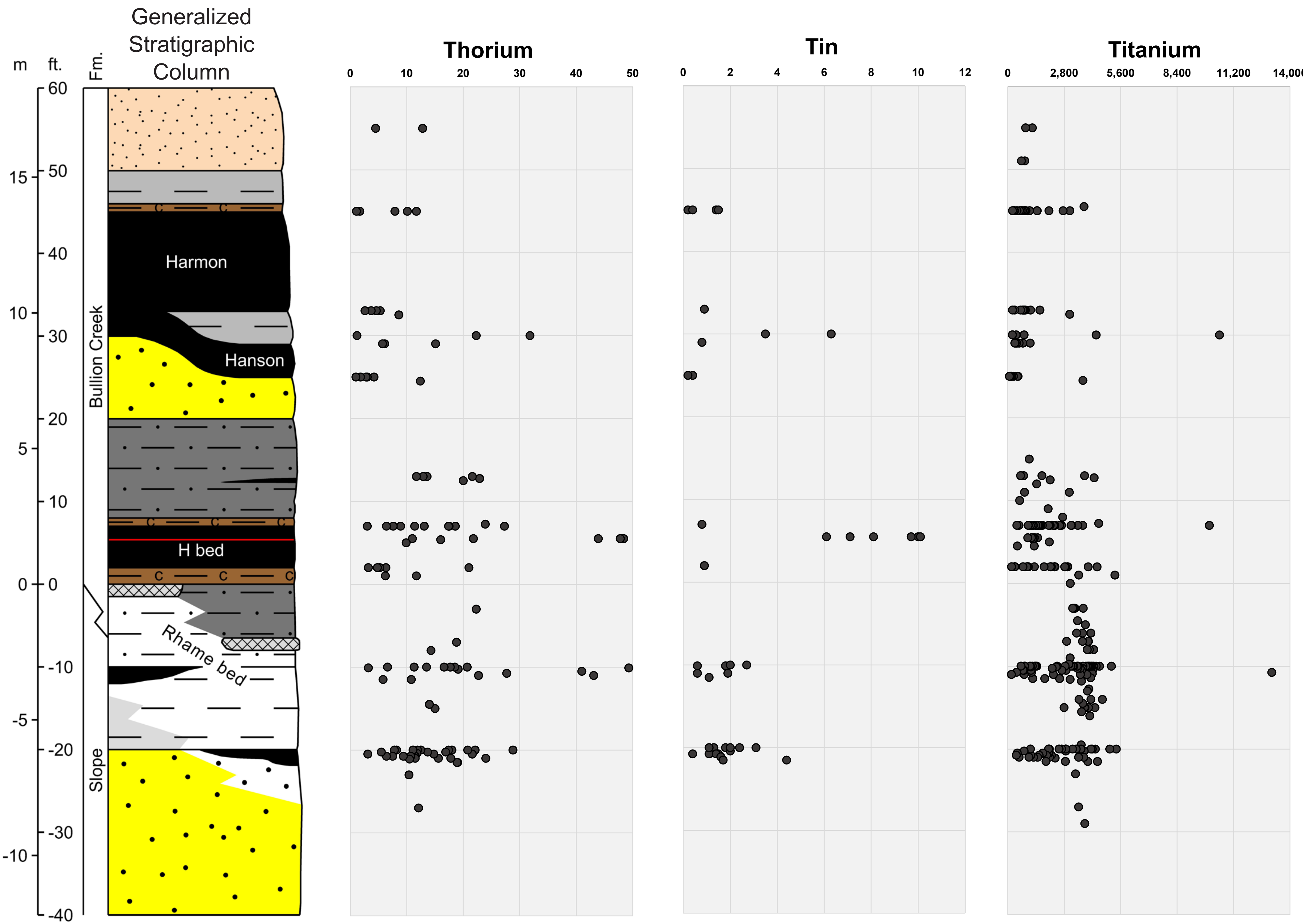
Generalized Stratigraphic Column
m
ft.
Fm.
Bullion Creek
Slope
Harmon
Hanson
H bed
Rhame bed
60
50
40
30
20
10
0
-10
-20
-30
-40
15
10
5
0
-5
-10
Lithium
0
80
160
240
320
Magnesium
0
8,200
16,400
24,600
32,800
Manganese
0
450
900
1,350
1,800

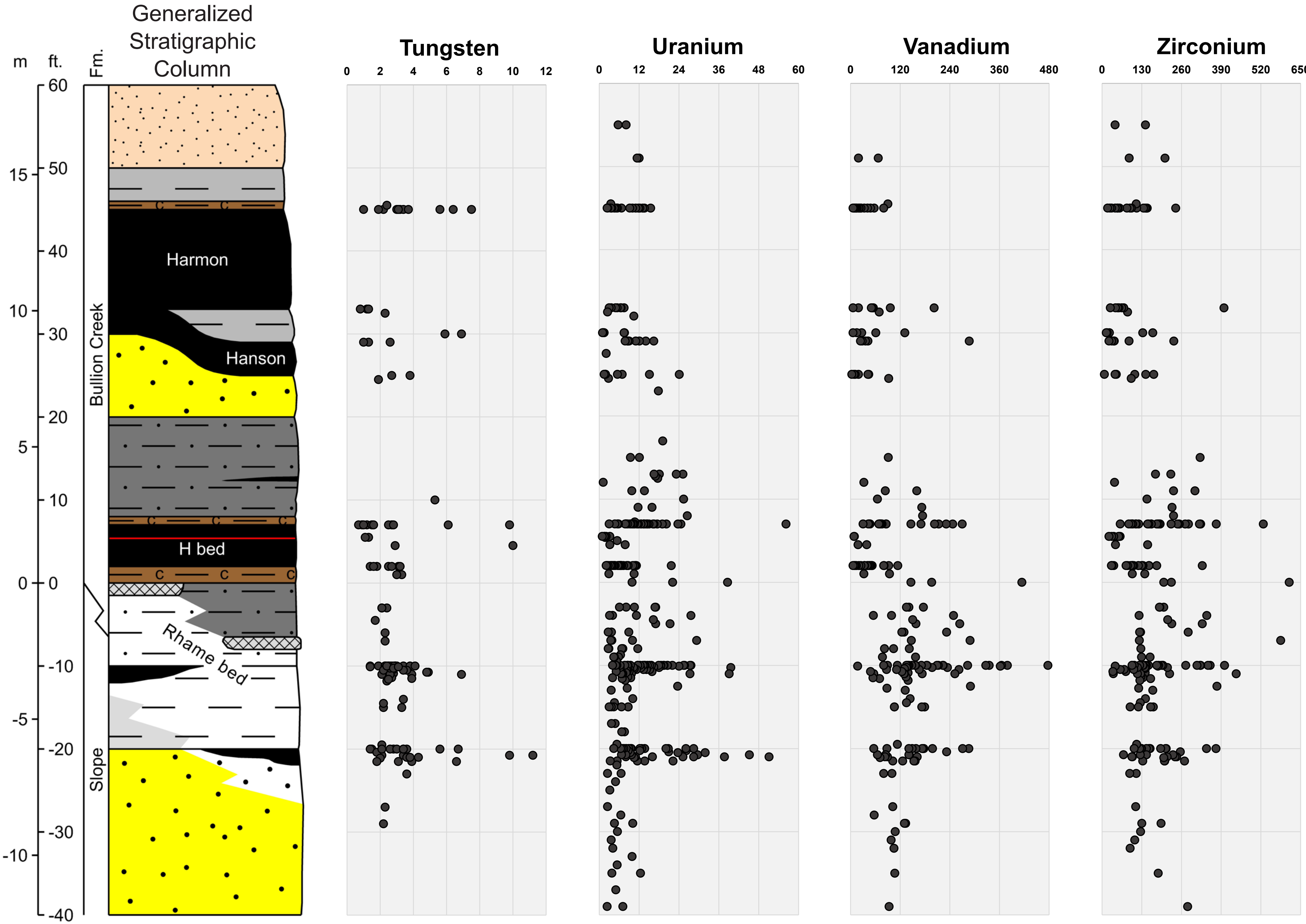


Generalized Stratigraphic Column
m
ft.
Fm.
Bullion Creek
Slope
Harmon
Hanson
H bed
Rhame bed
C
Molybdenum
0 15 30 45 60 75
Niobium
0 20 40 60
Rubidium
0 35 70 105 140 175
15 10 5 0 -5 -10
60 50 40 30 20 10 0 -10 -20 -30 -40



m
ft.
Fm.
Generalized Stratigraphic Column
Bullion Creek
Slope
Harmon
Hanson
H bed
Rhame bed
Strontium
Tantalum
Tellurium
0
600
1,200
1,800
2,400
3,000
1
2
3
4
5
0.00
0.12
0.24
0.36
0.48
0.60


Generalized Stratigraphic Column
m
ft.
Fm.
Bullion Creek
Slope
Harmon
Hanson
H bed
Rhame bed
Thorium
0 10 20 30 40 50
Tin
0 2 4 6 8 10 12
Titanium
0 2,800 5,600 8,400 11,200 14,000
60 50 40 30 20 10 0 -10 -20 -30 -40
15 10 5 0 -5 -10



m
ft.
Fm.
Generalized Stratigraphic Column
Tungsten
Uranium
Vanadium
Zirconium
Harmon
Hanson
H bed
Rhame bed
Bullion Creek
Slope
0 2 4 6 8 10 12
0 12 24 36 48 60
0 120 240 360 480
0 130 260 390 520 650
15 10 5 0 -5 -10
60 50 40 30 20 10 0 -10 -20 -30 -40