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Provenance Analysis of the Grover Gravel Using Detrital Zircon Geochronology, Petrology and Heavy Mineral Analysis

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PROVENANCE ANALYSIS OF THE GROVER GRAVEL USING DETRITAL ZIRCON GEOCHRONOLOGY, PETROLOGY AND HEAVY-MINERAL ANALYSIS

A Masters Thesis

Presented to

The Graduate College of

Missouri State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Geospatial Science in Geography, Geology and Planning

By

Grant Spoering

December 2017

PROVENANCE ANALYSIS OF THE GROVER GRAVEL USING DETRITAL ZIRCON GEOCHRONOLOGY, PETROLOGY AND HEAVY-MINERAL ANALYSIS

Geography, Geology, and Planning

Missouri State University, December, 2017

Master of Science

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ABSTRACT

The Grover Gravel in the St. Louis, Missouri area contains a mix of chert, quartzite, jasper, and ironstone in clast sizes ranging up to 60 cm. The gravel varies in thickness from a veneer to over 30 feet and rests on upland surfaces at elevations sometimes exceeding 300 feet above the floors of major valleys. A pre-Pleistocene age generally has been proposed or assumed for the gravel, which classically has been interpreted to be a meandering-stream deposit atop an extensive flat upland surface, which was subsequently eroded and dissected by rejuvenated streams. However, large quartzite boulders in the gravel also indicate a history of glacial transport. In this study, the Grover Gravel is compared to the Mill Creek till and Atlanta till as possible sources, along with another gravel known as the Mounds Gravel located in southeastern Missouri and southern Illinois. Detrital zircon uranium-lead geochronology analysis reveals that the gravels and the Mill Creek till are all dominated by the Western Cordillera and Grenville Provinces. A pebble count and heavy mineral analysis of the Mill Creek and Atlanta tills shows that the two deposits are not from the same glaciation. The Mill Creek till contains more unstable weathered mafic grains, less tourmaline and garnet, and a much higher percentage of polished chert, oolitic chert, vein quartz, agate, and quartzite pebbles than the Atlanta till. However, the Mill Creek and Grover Gravel share similar amounts of those types of pebbles and both units have a very similar distribution of zircon ages. This implies that the Mill Creek till represents a major glaciation that reached south of the Missouri River in St. Louis County. In addition, the small percentage of grains from the Superior Province within the Grover and Mounds Gravels indicate that these two units do not require fluvial transport from the north via a giant ancestral Mississippi River as has been hypothesized by recent studies.

KEYWORDS: detrital zircon, geochemistry, uranium-lead dating, provenance analysis, glacial, Missouri, Grover Gravel

This abstract is approved as to form and content

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Dr. Charles Rovey, II

Chairperson, Advisory Committee
Missouri State University

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Approved:

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Dr. Charles Rovey, II

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Dr. Gary Michelfelder

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Dr. Matthew P. McKay

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Dr. Julie Masterson: Dean, Graduate College

In the interest of academic freedom and the principle of free speech, approval of this thesis indicates the format is acceptable and meets the academic criteria for the discipline as determined by the faculty that constitute the thesis committee. The content and views expressed in this thesis are those of the student-scholar and are not endorsed by Missouri State University, its Graduate College, or its employees.

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CHAPTER ONE: INTRODUCTION

The Grover Gravel

The Grover Gravel in St. Louis County, Missouri is composed mostly of chert with a coating of red fines. The composition and color are comparable to the "Lafayette-type gravels" that occupy similar upland positions along the Mississippi Embayment and Crowley's Ridge to the south (Figure 1). The southern gravels occur as the highest terrace around the Mississippi Embayment (Figure 2), and they have been assigned ages ranging from Miocene to Pleistocene, although most authors have considered these to be Pliocene deposits, e.g. Autin et al. (1991); Saucier (1994). The gravels around the Mississippi Embayment commonly preserve large-scale cross bedding confirming fluvial deposition (Potter, 1955; Thompson, 1995), a feature that is conspicuously absent within the Grover (Rovey et al., 2016). A recent study by Cox et al. (2014) interpreted the entire group of gravels to be a single deposit of a giant ancestral Mississippi River that extended all the way into Canada.

Other researchers however have interpreted the Grover Gravel to have a different provenance and age than the rest of the "Lafayette- type gravels" based on the presence of purple quartzite boulders, and certain heavy mineral ratios have suggested that the clasts were derived from an early continental glaciation (Goodfield, 1965; Willman and Frye, 1970; Rovey et al., 2016). The heavy mineral ratios imply an eastern (Labradoran) source in Canada, which could not be part of any proposed drainage system feeding into the ancestral Mississippi River. Eastern Canadian sources are distinctly different in age than sources to the west and should be easily identified with detrital zircon ages.

Moreover, if it can be shown that the Grover is reworked from local glacial sediment, then the glacial boundary in eastern Missouri would have to be placed farther south, since the Grover Gravel can be found in many places south of the Missouri River (the current glacial boundary) in St. Louis County (Spoering and Rovey, 2017). Additionally, this glaciation could be correlated to one of the glaciations known to have reached Missouri (Balco and Rovey, 2010) by a comparison of heavy mineral ratios, detrital zircon ages, or a combination of the two. Rovey et al. (2016), for example, suggested that Grover sediment was derived from the earliest glaciation (ca. 2.4 Ma) known to have reached Missouri (Figure 3; Balco and Rovey, 2010).

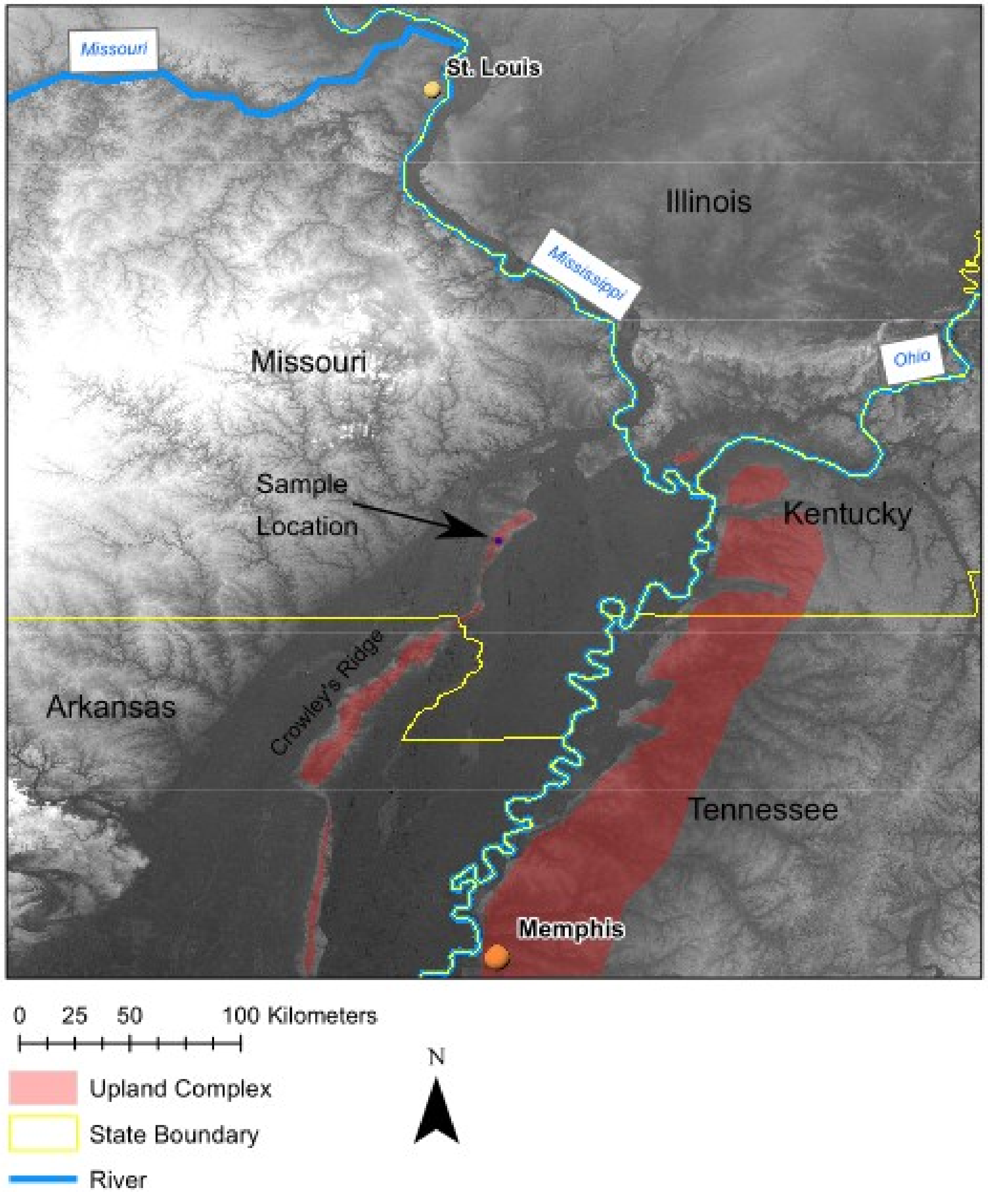

Figure 1. Digital elevation model containing the location of the Upland Complex along Crowley's Ridge and farther to the East within the Mississippi Embayment. The red shading shows the general area of the Mounds Gravel/Upland Complex although the distribution is discontinuous. The primary study area for this project is near St. Louis. Modified from Van Arsdale et al. (2007).

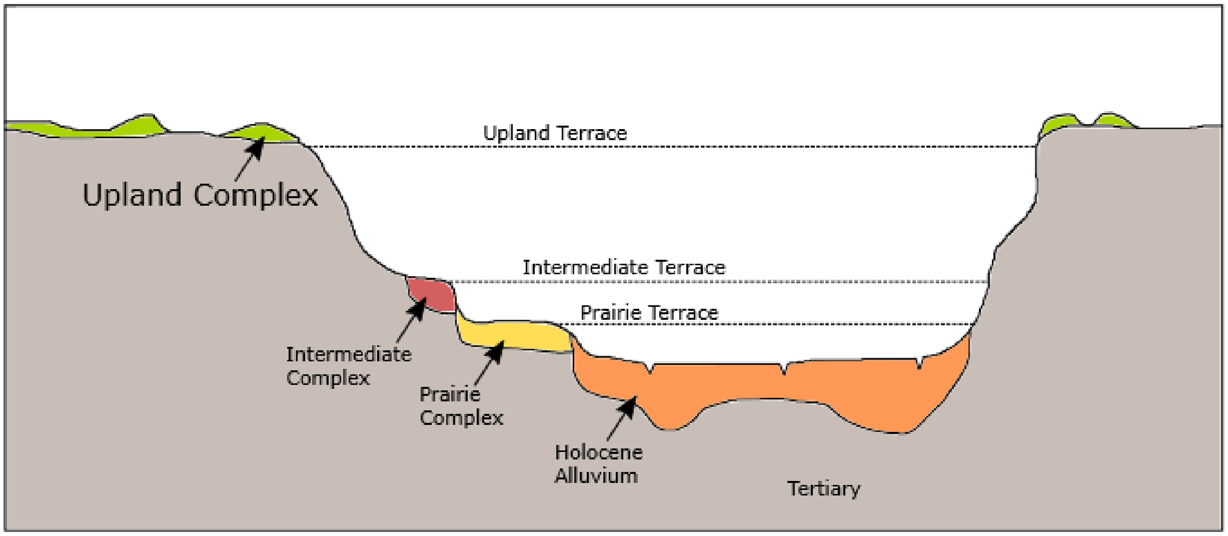

Figure 2. Generalized cross section of the Lower Mississippi Valley. The Upland Complex is located above the floors of major valleys. Modified from Autin et al. (1991).

Generalized Till Stratigraphy	
Till Name	Age
Macon	0.21 ± 0.18 Ma
Columbia	0.22 ± 0.16 Ma
Fulton	0.79 ± 0.056 Ma
Moberly	1.3 ± 0.089 Ma
Atlanta	2.4 ± 0.14 Ma

Figure 3. Generalized till stratigraphy of Missouri. Modified from Balco and Rovey (2010) and Rovey and McLouth (2015).

The main objectives of this thesis are addressing the origin and correlation of the Grover Gravel, specifically by testing the following hypotheses: (1) the Grover and

Mounds Gravels in Missouri are correlative deposits, both lithostratigraphically and chronostratigraphically; (2) both formations (Grover and Mounds) were deposited by an ancestral Mississippi River that extended northward into Canada; and (3) the Grover is derived from an Early Pleistocene glaciation dated at 2.4 Ma.

To test whether or not the Grover and Mounds Gravels are equivalent, a detrital zircon analysis from four sites was used to assess similarities and differences in their provenances and to compare the Grover to the nearby Mill Creek till, which is present at scattered sites within St. Louis County (Goodfield, 1965; Rovey et al., 2016). This analysis also allows for testing whether or not sediment was derived from a larger ancestral Mississippi drainage basin extending into Canada, which was proposed by Cox et al., (2014). Pebble counts were completed to compare the lithologic characteristics of the Grover Gravel, Mill Creek till, and Atlanta till dated at 2.4 Ma, which is present north of the Missouri River (Balco and Rovey, 2010). Finally, a heavy mineral analysis was also used to compare various heavy-mineral ratios within each of the two tills, along with the state of weathering of mafic grains. If these two tills are really equivalent, that correlation would give the date at which the Grover materials arrived in St. Louis County.

CHAPTER TWO: BACKGROUND

Lafayette Type Gravels

"Lafayette Formation" was originally applied to a thin deposit underlying the Columbia Group throughout the Atlantic and eastern Gulf Coastal Plains (Potter, 1955a and references therein). The formation was considered Pliocene by some writers and early Pleistocene by others. Eventually it was noted that the Lafayette name had been mistakenly applied to different deposits located in different areas. For example, it was discovered that the deposits in the type area of Lafayette County, Mississippi actually belong to a nearby formation that had already been defined. Thereafter, "Lafayette" was abandoned as a formal name around the Mississippi Embayment, although it remains in common use as an informal term for multiple formal lithostratigraphic units. "Grover Gravel" is applied to deposits in St. Louis County and adjacent parts of Illinois (Rubey, 1952; Willman and Frye, 1970; Thompson, 1995). Farther south around the Mississippi Embayment "Mounds Gravel" is the formal name in Missouri and Illinois (Willman and Frye, 1970; Thompson, 1995), while farther south "Upland Complex" is used routinely (Cupples and Arsdale, 2014). The origin and deposition of these gravels is related to various aspects of the geologic history of the midcontinental United States. Some of the most important geologic aspects and events are described in the following subsections.

Atlanta Formation and the Mill Creek Till

The Grover Gravel in St. Louis County seems to be derived from an old till that is preserved locally throughout the county (Goodfield, 1965; Rovey et al., 2016). This till is

very cobbly and most clasts are chert with lesser amounts of quartzite and very low concentrations of igneous materials. This till visually resembles the oldest till known in Missouri, which is within the Atlanta Formation. The Atlanta-Formation till was dated using cosmogenic-nuclides, resulting in an age of ~2.4 Ma (Figure 3) (Balco and Rovey, 2010). This ^{26}Al-^{10}Be burial dating technique relies on the 6.75:1 production ratio of ^{26}Al:^{10}Be in quartz grains that is produced near the ground surface under exposure to cosmic rays. These isotopes have a half life of 0.705 Ma for ^{26}Al and 1.39 Ma for ^{10}Be. When buried deeply enough by younger sediment, the ^{26}Al and ^{10}Be begin to decay, with the ^{26}Al:^{10}Be ratio decreasing from the production ratio in proportion to burial time. The ratio of these isotopes can then be used to date overlying deposits such as glacial till~~s~~. (Balco and Rovey, 2008; Balco and Rovey, 2010).

The till in St. Louis County is informally named the "Mill Creek" till (Goodfield, 1965) where it is closely associated with the Grover Gravel, and in some cases is the apparent source. (Rovey et al., 2016). While the Mill Creek till has not been dated, it is similar to the Atlanta till with respect to its matrix texture and sand-fraction lithology, and both have a much higher concentration of chert clasts than the other younger tills in Missouri, which have a much higher percentage of igneous material (Figure 3).

Heavy Mineral Analysis of Tills

Several heavy-mineral studies of tills located close to the Canadian Shield have been completed to differentiate different source areas based on percentages of these minerals (Dreimanis et al., 1957; Dworkin et al., 1985). The majority of till samples from eastern (Grenville Province) till samples have an abundance of garnet at 7-48% within

the sand-sized fraction while containing lower amounts of epidote, with garnet:epidote ratios of > 2. However, the tills from farther west (Superior Province) typically contain a higher amount of epidote at 2-10%, with lower percentages of garnet, with garnet: epidote ratios < 1. Thus, garnet:epidote ratios are especially useful in discerning a till's general provenance and to test purported correlations such as that between the Atlanta and Mill Creek tills.

Continental Scale Drainage Basin History

During the Early Cretaceous, the dominant drainage pattern of North America was defined by shedding of material westward from the Appalachians to the northwestern Boreal Sea. This drainage pattern changed during the Paleocene as uplift of the Rocky Mountains reversed the drainage direction, and rivers began transporting material eastward from the Western Cordillera region to the Mississippi Embayment and the Gulf of Mexico in the south and towards Hudson Bay and the Atlantic coast in northern areas (Finzel, 2014; Craddock and Kylander-Clark, 2013; Blum and Pecha, 2014). Therefore, sediment derived from Early Pleistocene tills could be enriched in zircon and other minerals derived from a Cordilleran source (Cenozoic age) that were transported to the northeast by this northeast-flowing river system.

Giant Ancestral Mississippi

Possible relict meanders of the proposed giant ancestral Mississippi River were studied by Cox et al. (2014) to discern their authenticity and implications. These meanders are incised within the Upland Complex (the formal name of the "Lafayette-type gravel") in the lower Mississippi Valley. While this gravel is generally considered to be a

deposit from a braided alluvial channel of the ancestral Mississippi (Potter, 1955), three curved valleys or tributaries have been found in the region, which suggests that a meander belt developed during the final deposition of the Upland Complex (Cox et al., 2014). The size of the meanders indicated that the proposed giant ancestral Mississippi River had a depth three times the modern Mississippi at the same latitude. To account for the larger size of the Pre-Pleistocene meanders, a higher discharge of Mississippi River during that time was proposed that could have been a result of a wetter climate, or most likely, a larger drainage basin. The proposed northern limits of the former drainage basin extent northward well into Canada. If this hypothesis is correct, the Upland Complex should be enriched in zircon from the Penokean Province (2000-1800 Ma) as well as the Superior Province with Archean ages greater than 2.5 Ga. (Figure 4). Therefore, a detrital zircon provenance study of the Upland Complex and possible equivalents would help in evaluating this hypothesis and determining the extent of the Mississippi drainage basin at that time. If a large Archean population is present that matches the ages of the Penokean and Superior Provinces (Figure 4), then a larger drainage basin is plausible. However, if the ages do not match, a wetter climate might be responsible for the postulated higher discharge (Cox et al., 2014). Alternatively, glacial meltwater might be the cause for the higher discharge.

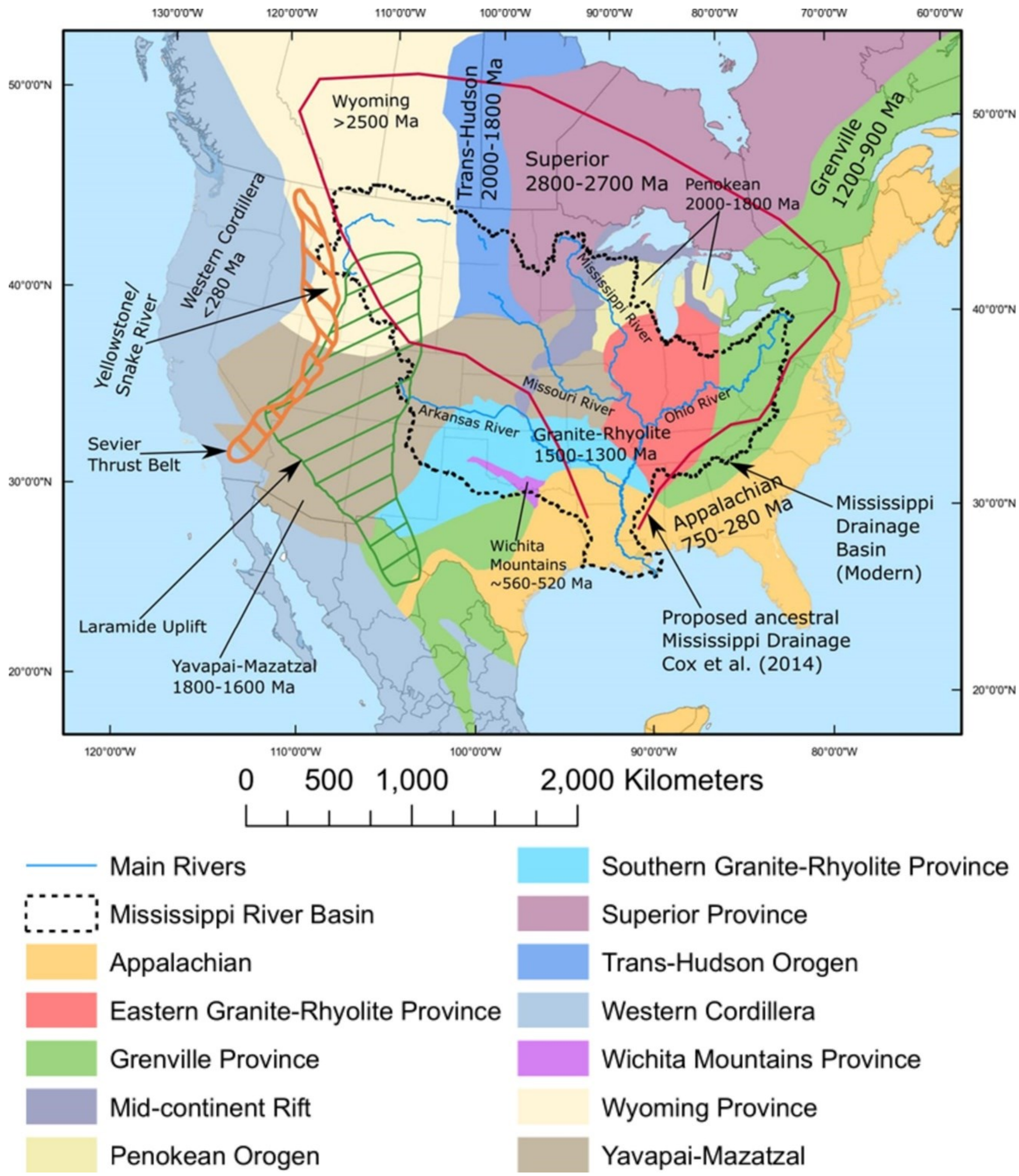

Figure 4. Locations and ages of the major crustal provinces of North America. The extent of the current Mississippi drainage basin is shown for comparison, as well as the locations of the Sevier and Laramide orogenies. Modified from Fildani et al. (2016).

Zircon Mineralogy

Zircon ($Zr[SiO_4]$) is composed of chains of SiO_4 tetrahedra with ZrO_8 dodecahedra that extend parallel to the z axis (Deer et al., 1982). This mineral has a specific gravity of 4.6-4.7 and a hardness of 7.5. Zircon has an imperfect {110} cleavage and a prismatic habit. Zircon can be reddish brown, yellow, grey, green, or colorless in hand samples. In thin sections, the mineral is colorless to pale brown.

Zircon is a common accessory mineral of igneous rocks, especially plutonic rocks rich in sodium. While small zircon crystals generally form early and are then enclosed in later minerals, it is possible for larger more developed zircon crystals to form in granite pegmatites and more predominantly in nepheline-syenites (Deer et al., 1982).

In sedimentary rocks, zircon is also a common accessory mineral, since it is very resistant to weathering and can survive multiple episodes of weathering and sedimentation. Because zircon crystals preferentially incorporate uranium into their structure when forming, but exclude lead, and they are able to travel great distances while still being distinguishable from other deposited grains, they are ideal for U-Pb geochronology studies of detrital sediment (Deer et al., 1982; Schoene, 2014).

CHAPTER THREE: STUDY AREA

The main study area is in St. Louis County, Missouri, but also includes one location from Crowley's Ridge at Dexter, Missouri (Figure 5). One of the exposures in St. Louis County is in Rockwoods Reservation park, which includes the type section for the Grover Gravel (Figure 5; Rubey, 1952; Willman and Frye, 1970). The exposure of the gravel is located along highwalls that were part of a clay mining operation during the early to mid1900s. A cosmogenic nuclide burial date from weathered bedrock beneath the gravel at another pit adjacent to the type section gives a maximum depositional age of 0.87 +/- 0.41Ma (Rovey et al., 2016). A second sampling site is located along Dunn Road near the modern Mississippi River channel (Figure 6). This deposit has been correlated to the Grover Gravel based on similarities in composition, even though the gravel here contains abundant igneous erratics, which are nearly absent within the type deposit (Rovey et al., 2016). Two burial ages at this site give maximum depositional ages of 2.99 +/-0.53 and 3.29 +/- 0.68 Ma, respectively (Rovey et al., 2016). These burial ages are within the late Pliocene and so are preglacial, but the true age is likely younger. Additional samples of Mill Creek till were collected from exposures near the Ridge Meadows Elementary School (Figure 7). A sample that was previously collected from the Mounds Gravel atop Crowley's Ridge as part of another project at MSU was also used for this project (Figure 8). Finally, samples of the Atlanta till were collected from the Polston Pit (Figure 9).

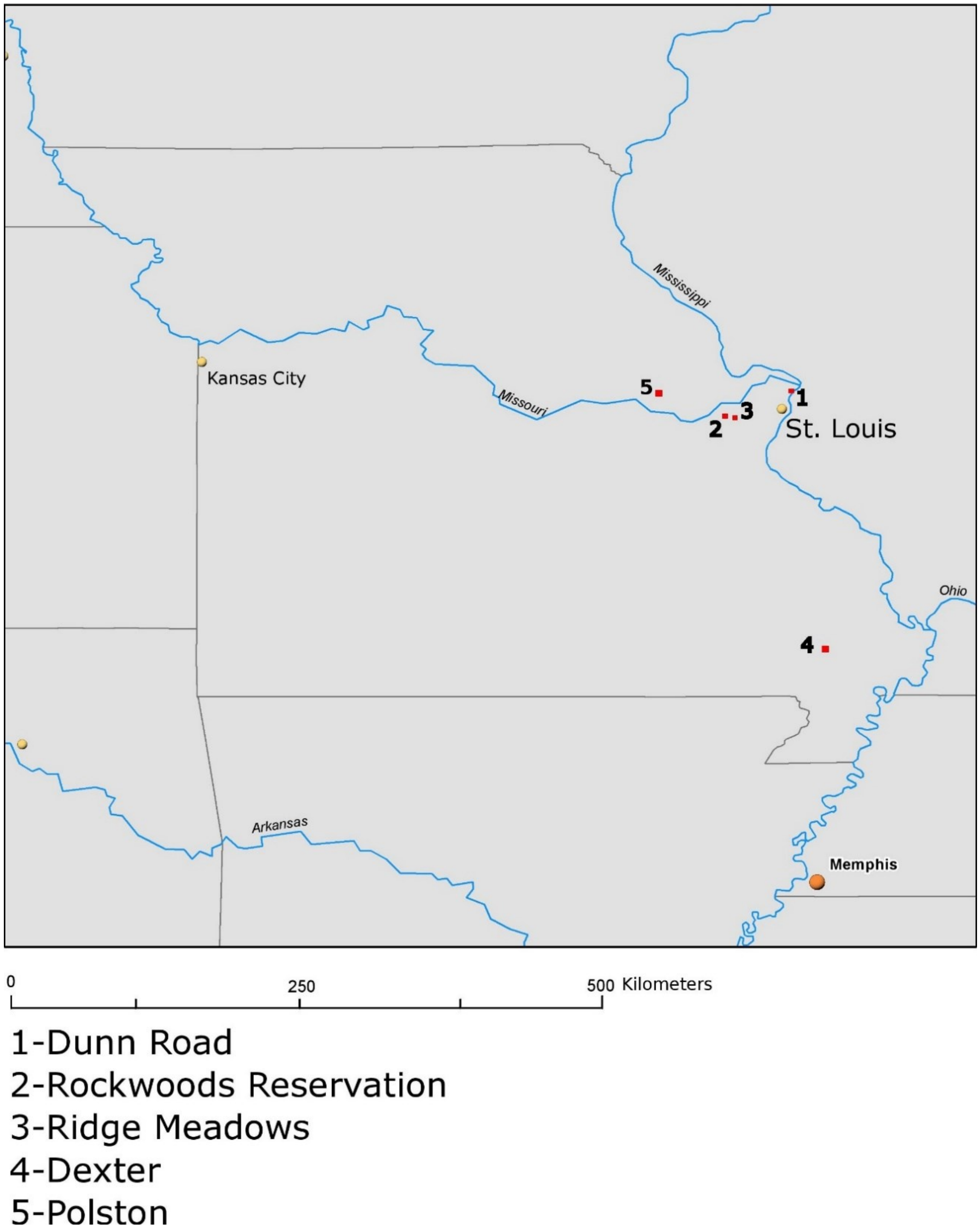

Figure 5. Location map with sample locations.

Figure 6. A Google Earth image and photograph of the type section of the Grover Gravel at the Rockwoods Reservation Park in Wildwood, MO. Located at 38.5794°N, 90.6761°W.

Figure 7. A Google Earth image and photograph showing the Dunn Road exposure. Geologist (Mike Siemens of the Missouri Geological Survey) is standing at the bedrock-gravel contact with the Mississippi River in the background. Located at 38.7719°N, 90.1835°W.

Figure 8. A Google Earth image and photograph of the exposure near Ridge Meadows Elementary School. Note the old highwall in the background marking the edge of a former clay pit. Located at 38.5711°N, 90.6000°W.

Figure 9. A Google Earth image and photograph of the Mounds Gravel exposure near Dexter, MO. The approximate sampling location is highlighted by the red square. The Wilcox Group is located beneath the red line with the base of the Mounds starting at the line. Located at 36.8464°N, 89.9275°W.

Figure 10. A Google Earth image and photograph of the Polston pit near Warrenton, MO. Located at 38.75667°N, 91.18528°W. The red arrow points to the Atlanta till located above the line.

CHAPTER FOUR: METHODS

Sieving and Separations

Samples were collected at varying elevations (Table 1) along the type section of the Grover Gravel and at the Dunn Road section, with a base about 50 feet above the modern floodplain of the Mississippi River. The samples were collected near the base and top of the exposures as well as at several points in between. Each sample was bagged and labeled for processing. After collection, sample preparation began with the disaggregation of the sediment using Calgon followed by wet sieving. The samples were sieved down to a fine sand size of 2-3 phi for one sample (Rockwood) and 3-4 phi for the rest and then placed in an ultrasonic bath to disperse the remaining sediment. The Polston and Ridge Meadows samples were wet sieved and the heavy fractions were separated using standard heavy liquids procedures (density = 2.86) followed by mounting the heavy minerals onto microscope slides. Photographs in Mange and Maurer (1992) were used to identify heavy mineral grains. For the Dunn Road Igneous sample, granitic pebbles were hand-picked at the Dunn Road exposure, and then were crushed and then milled down to a 2-3 phi size. The pebbles used in the pebble count analysis were separated by one-phi increments during sieving.

[redacted]

mple. This table shows the amount of [redacted] how many were
nally used in the probability plots. The [redacted]ove base) of each

[redacted]

Additional density separations (density = 3.3) were used to segregate the heaviest minerals such as zircon from the lighter minerals. A Franz magnetic separator was then used to isolate the zircon from most of the remaining heavy minerals, which are mainly iron oxides and hydroxides. The zircon grains were then hand-picked using a petrographic microscope followed by a random selection of fewer grains from the larger sample size during mounting (Table 1). In some cases the final number of grains mounted and analyzed was limited by funding.

Detrital Zircon Geochronology and Rare Earth Process

Five sets of samples were analyzed in this project and include grains from exposures at Ridge Meadows, Rockwood, Dexter, and Dunn Road (along with grains derived from crushed igneous clasts found at this site). The grains were mounted into epoxy followed by polishing and cathodoluminescence imaging at the University of Iowa. The spots for analysis were then marked on the rim of each grain. The analysis of the zircon crystals from every sample were analyzed with a Thermo Element2 magnetic sector field ICP mass spectrometer (single collector) at the isotope geochemistry lab at the University of Kansas. The analysis was completed during two different runs, the first one on the Dunn Road, Dexter, and Rockwoods samples, and the next run on the Ridge Meadows sample, Dunn Road igneous sample, and additional Rockwoods grains. During the first run, each crystal was analyzed with one 25 micron spot zone and an approximate pit depth of 20 microns with the ablation duration lasting 25 seconds. The second run used 20 micron spot zones at an approximate 18 micron depth with the ablation duration lasting 25 seconds. The ages were calibrated to the primary GJ1 reference zircon standard

(609 Ma) and checked against two secondary standards (Plesovice zircon at 337 Ma, and Fish Canyon Tuff zircon at 28 Ma) (Jackson et al., 2004; Sláma et al., 2008; Wotzlaw et al., 2013). A common lead correction was not completed due to a high background of Mercury. The accuracy of data for the secondary standards indicates that this correction would be insignificant. The concordance between the ^{238}U and ^{235}U ages also indicates that most samples had negligible loss or gain of lead. Additional details are given in Appendix I.

For detrital zircon studies, at least 100 randomly selected zircon grains typically are analyzed from each sample to identify main age groups, although here the Dexter and Ridge Meadows samples were slightly undersampled. The samples from these two sites were originally intended to be analyzed as part of a different project, and only small portions of the original samples remained. Additionally, fewer of the picked grains from these sites were successfully mounted. $^{206}Pb/^{238}U$ dates were used for analyses <900 Ma, and $^{207}Pb/^{206}Pb$ dates were used for analyses >900 Ma. Samples with greater than 30% discordance between the $^{206}Pb/^{238}U$ - $^{207}Pb/^{235}U$ ages were not used in the final age distributions and probability plots, except for a few grains with $^{206}Pb/^{238}U$ ages less than 10 Ma. Some of these grains had > 30% discordance but the ages were still within error limits of one another. There were no ages older than 900 Ma that were over 30% discordant. To avoid compromising ages determined from single grain analyses (which can experience inheritance as well as Pb loss), age significance is attached only to clusters of at least three overlapping analyses. This ensured finding the youngest age represented within the zircon population (maximum depositional age) (Gehrels et al., 2006). Age results are plotted and analyzed with the program *Density Plotter*

(Vermeesch, 2012), and the complete set of uranium-series measurements is tabulated in Appendix I and II.

On the second run, a select sample of previously dated grains from the first run and randomly selected grains from the second run were chosen for a rare earth element analysis. The rare earth elements that were analyzed are: lanthanum, cerium, praseodymium, neodymium, samarium, europium, gadolinium, dysprosium, erbium, and ytterbium. The operating procedures for this analysis can be found in Appendix I and the data table with the rare earth element concentrations can be found in Appendix III with the plotted concentrations located in Appendix IV.

CHAPTER FIVE: RESULTS AND DISCUSSION

Pebble Counts

All of the samples are very cobbly and are dominated by chert. However, there are several compositional differences between the Atlanta and Mill Creek tills (Table 2). The Mill Creek and Grover Gravel samples contain abundant oolitic chert and quartzite pebbles as well as low amounts of agate, but there are no oolitic pebbles and fewer quartzite pebbles within the Atlanta. It is important to establish that the agate is not the Lake Superior variety, as it is commonly attached to or present within chert. The Mill Creek and Grover Gravel samples also contain a large percent of rounded and polished pebbles, along with vein quartz, and some agate. These types of pebbles are absent or nearly so within the Atlanta.

ins the percentage of different pebble constituents in each Mill Creek till, Grover Gravel, and
Grover Gravel samples share many of the same types of pebbles, while the Atlanta sample is

PEBBLE COUNTS	Chert (undiff.)	Oolitic	Jasper	Polished	Pink Quartzite	White Quartzite	Agate	Vein Quartz	Ironstone	Sandstone/ Detrital	Igneous	Schist	Limestone	Total Grains:	
RM Highwall >32 mm	80.0%	0.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	N/A	5	Mill Creek till
RM Highwall 16-32 mm	79.8%	13.5%	3.8%	1.9%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	N/A	104	
RM Highwall 8-16 mm	84.8%	1.7%	1.4%	3.5%	1.0%	1.4%	1.0%	5.2%	0.0%	0.0%	0.0%	0.0%	N/A	289	
RM Highwall 4-8 mm	69.8%	3.2%	3.2%	4.8%	0.5%	2.6%	0.5%	12.7%	0.0%	2.6%	0.0%	0.0%	N/A	189	
RM Gulley >32 mm	75.0%	8.3%	8.3%	0.0%	0.0%	8.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	N/A	12	
RM Gulley 16-32 mm	78.3%	3.8%	2.8%	1.9%	0.9%	7.5%	0.0%	3.8%	0.0%	0.9%	0.0%	0.0%	N/A	106	
RM Gulley 8-16 mm	64.3%	2.6%	6.1%	0.9%	5.2%	4.3%	4.3%	12.2%	0.0%	0.0%	0.0%	0.0%	N/A	115	
RM 16 #1 +5 ft 8-16 mm	86.7%	0.0%	0.0%	0.0%	6.7%	0.0%	0.0%	6.7%	0.0%	0.0%	0.0%	0.0%	N/A	15	
RM 16 #1 +5 ft 4-8 mm	62.3%	0.0%	1.5%	0.8%	1.5%	3.1%	0.8%	29.2%	0.0%	0.8%	0.0%	0.0%	N/A	130	
RM 16 #1 +5 ft 2-4 mm	55.0%	0.2%	2.2%	0.0%	0.5%	0.5%	0.0%	41.6%	0.0%	0.0%	0.0%	0.0%	N/A	404	
RM 16 #2 +5 ft 8-16 mm	84.4%	0.0%	0.0%	4.7%	3.1%	4.7%	0.0%	3.1%	0.0%	0.0%	0.0%	0.0%	N/A	64	
RM 16 #2 +5 ft 4-8 mm	60.8%	2.4%	3.0%	0.0%	2.4%	4.2%	0.0%	25.9%	0.0%	0.0%	0.6%	0.6%	N/A	162	
RM 16 #2 +5 ft 2-4 mm	62.7%	1.0%	1.3%	0.0%	1.7%	1.3%	0.0%	32.0%	0.0%	0.0%	0.0%	0.0%	N/A	297	
Polston Pit East Side 16-32 mm	42.9%	0.0%	14.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.3%	0.0%	0.0%	28.6%	7	Atlanta till
Polston Pit East Side 8-16 mm	70.6%	0.0%	2.9%	0.0%	0.0%	2.9%	0.0%	2.9%	0.0%	2.9%	0.0%	0.0%	17.6%	34	
Polston Pit East Side 4-8 mm	79.1%	0.0%	4.3%	0.0%	0.0%	0.4%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	15.7%	254	
Polston Pit East Side 2-4 mm	79.0%	0.0%	5.5%	0.0%	0.6%	0.6%	0.0%	0.0%	0.0%	0.3%	0.6%	0.3%	13.1%	329	
Polston Pit East Side 1-2 mm	64.9%	0.0%	4.8%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%	29.0%	231	
RW Gulley 2 +0.5 ft >16 mm	52.5%	3.3%	4.9%	24.6%	3.3%	11.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	61	Grover Gravel
RW Gulley 2 +0.5 ft 8-16 mm	64.5%	1.1%	2.2%	20.4%	0.7%	4.7%	0.0%	6.5%	0.0%	0.0%	0.0%	0.0%	0.0%	279	
RW Gulley 2 +0.5 ft 4-8 mm	54.0%	0.3%	3.2%	1.6%	3.2%	0.5%	0.0%	37.3%	0.0%	0.0%	0.0%	0.0%	0.0%	378	
RW Gulley 2 +0.5 ft 2-4 mm	29.6%	0.0%	1.1%	0.0%	3.3%	1.1%	0.4%	64.6%	0.0%	0.0%	0.0%	0.0%	0.0%	274	
RW Gulley 2 +8 ft >16 mm	73.0%	6.3%	0.0%	9.5%	0.0%	11.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	63	
RW Gulley 2 +8 ft 8-16 mm	79.5%	1.8%	2.7%	8.2%	1.4%	5.0%	0.0%	1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	219	
RW Gulley 2 +8 ft 4-8 mm	79.7%	0.0%	2.5%	3.3%	0.0%	2.2%	0.0%	12.3%	0.0%	0.0%	0.0%	0.0%	0.0%	276	
RW Gulley 2 +0-5 ft 2-4 mm	71.7%	0.4%	1.6%	0.0%	0.4%	0.0%	0.0%	25.9%	0.0%	0.0%	0.0%	0.0%	0.0%	251	

Heavy Mineral Counts

The heavy mineral percentages also show differences between the Atlanta and Mill Creek tills with the primary distinction being the amount of mafic minerals (Table 3). Mainly, the Mill Creek till contains the higher amount of pyroxene/amphibole grains than the Atlanta Formation. However, the Atlanta samples contain approximately twice the amount of tourmaline grains as the Mill Creek samples. Also, the Mill Creek samples contain a large percentage of mafic minerals in a low state of weathering, but the Atlanta samples contain a higher proportion of mafic minerals that are in a high state of weathering (Figure 10; Figure 11). Thus, given the differences in both clast and heavy-mineral composition, the Atlanta Formation is not the same stratigraphic unit as the Mill Creek till in St. Louis County, and the two deposits appear to represent different glaciations.

[redacted]

ble compares the heavy minera [redacted] s.
als (pyroxenes and amphiboles [redacted] f

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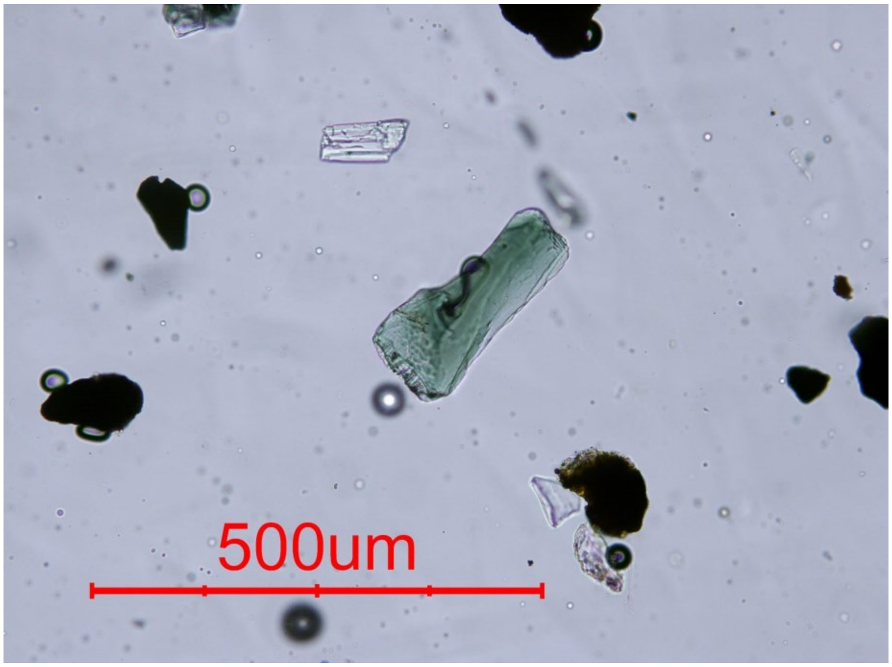

Figure 11. A relatively unweathered mafic grain from the Mill Creek till at the Ridge Meadows site. This is apparent from the lack of surficial pitting, etched cleavages, and hacksaw terminations.

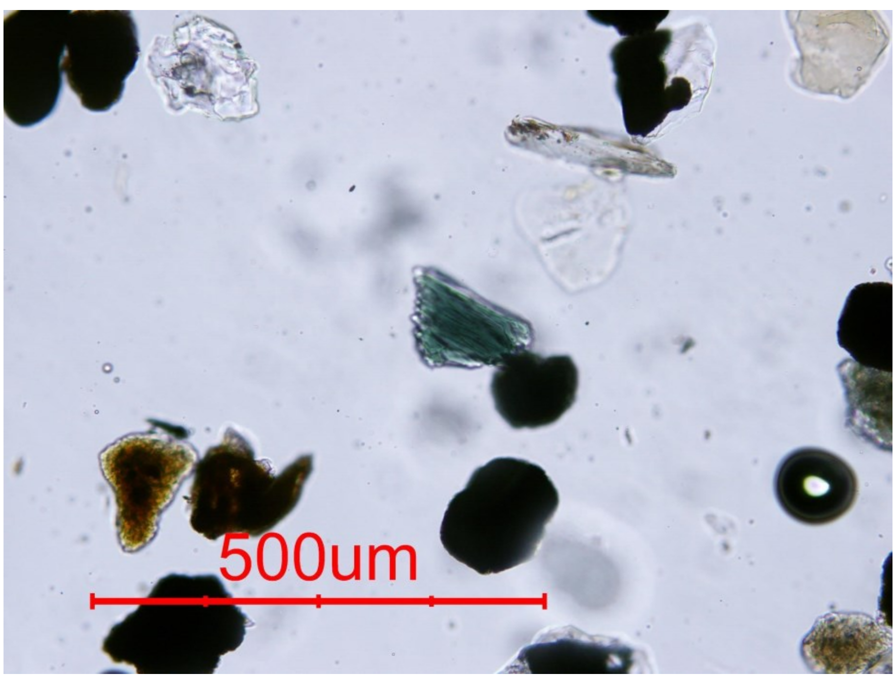

Figure 12. A weathered mafic grain from the Atlanta till at the Polston Pit. This is apparent from the surficial pitting and hacksaw terminations.

Detrital Zircon Geochronology

Analysis of zircon crystals from five samples was completed and then plotted in single and stacked probability plots for interpretation. Provenance interpretation of age populations is based on the age ranges shown in Figure 4.

Ridge Meadows (n=67). The Ridge Meadows sample (Mill Creek till) is dominated by grains 1200-900 Ma in age (Grenville, 26.9%) and <280 Ma (western Cordillera Province, 25.4%; Figure 13). The Western Cordilleran population displays four prominent peaks corresponding to 14 grains that fall within the Late Cretaceous to Miocene, with the youngest age at 7.05 Ma, which falls within the proto-Yellowstone eruption record (Perkins and Nash, 2002). Appalachian and Gondwana Province ages (750-280 Ma) constitute 9% and 1.5%; together with the Grenville, the northeastern provinces comprise 37.4% of the total zircon population. The (combined) midcontinental Granite-Rhyolite Province (1500-1300 Ma) has a modest contribution of 4.5%, while Yavapai-Mazatzal Province ages (1800-1600 Ma) amount to 9%. Thus, the western sources (Cordilleran and Yavapai-Mazatzal) comprise 34.4% of the total. The relative scarcity of Wyoming/Superior (>2500 Ma, 14.9%) and Trans-Hudson/Penokean (2000-1800 Ma, 4.5 %) ages indicates that this glaciation entrained very little material originally sourced from these (north to northwestern) provinces, which have a very wide areal distribution (and outcrop) across the Canadian Shield south and west of Hudson Bay (Figure 4). The remaining grains (4.5%) are within time gaps between major provinces.

Rockwood (n=217). The Rockwoods sample, which is the type Grover Gravel, has a very similar age distribution as the till at Ridge Meadows (Figure 14). The main differences are that the Rockwoods sample contains even less zircon from the

Wyoming/Superior Province (5.1%), but slightly more with Gondwana (3.7%) and midcontinent ages (10.6%). Again, the zircon population is dominated by Grenville (28.6%) and western Cordillera (31.3%) ages. The Cordilleran ages display six peaks defined by 53 grains that fall within the Cenozoic, with a youngest age of ~8 Ma defined by six grains. These youngest grains are probably derived from an early (proto) Yellowstone eruption (Perkins and Nash, 2002). A modest portion (7.4%) of the sample again represents the Appalachian Province, followed by the Yavapai-Mazatzal with 2.3%. Northeastern sources (Grenville, Appalachian and Gondwana) total 39.7%, while western sources (Cordilleran plus Yavapai-Mazatzal) amount to 33.6%. 2.3% of the grains have Trans-Hudson/Penokean ages, for a total of 7.4 % (along with Wyoming/Superior) from north to northwestern source areas. 5.5% of the zircon ages fall within time gaps between the major provinces.

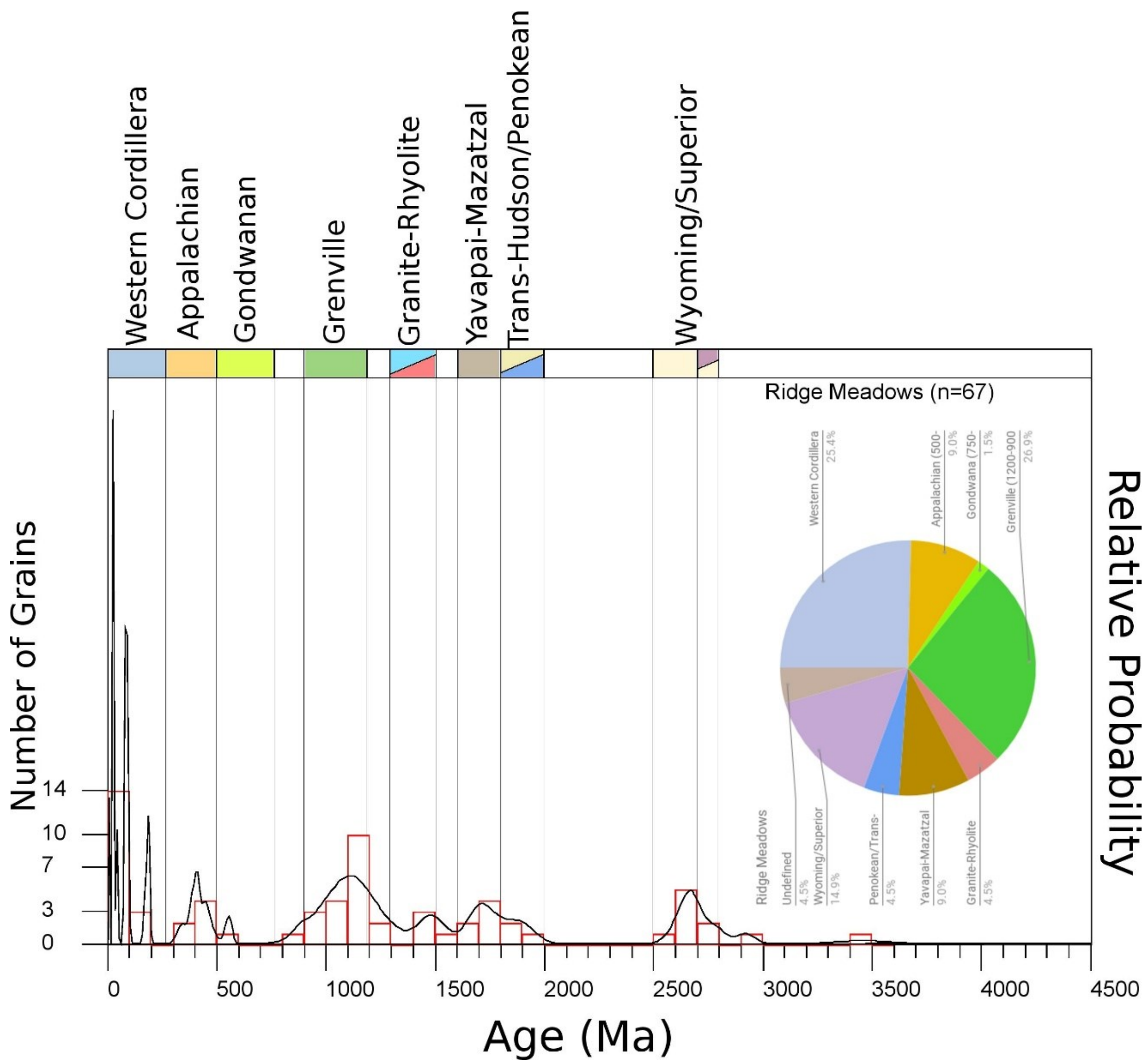

Figure 13. Density probability plot of the Ridge Meadows (Mill Creek till) zircon ages.

Dunn Road (n=98). This sample is again dominated by Grenville (21%) and Western Cordilleran (44%) ages, but with a significantly higher proportion of Cordilleran ages (Figure 15). The Cordilleran distribution includes eight peaks defined by 38 grains. The youngest group of ages is defined by three grains at ~1.9 Ma that are within error limits of the first major Yellowstone eruption, which deposited the Huckleberry Ridge

Tuff and correlative ash beds at about 2.08 Ma (Wotzlaw et al., 2015). These zircon ages are all slightly younger than the eruption age, but they are not corrected for initial U-Th disequilibrium, which typically results in an underestimation of the true age by about 0.1 Ma (Ickert et al., 2015). Regardless, this group provides a maximum possible age of this deposit that is within the Early Pleistocene; the gravel here is not preglacial as has generally been assumed (Lumsden, et al., 2016) or suspected (Rovey et al., 2016). The higher totals for the Western Cordillera are paralleled by an increase in those from the Yavapai-Mazatzal (12%) for a total of 56% from westerly sources. The Appalachian and Gondwana ages amount to 3% and 2%, respectively for a total of 26% (including Grenville) with a northeastern provenance. The Wyoming/Superior Province accounts for 6% of the grains followed by 4% from the Trans-Hudson/Penokean, for a total of 10% with a north to northwestern provenance. Finally, the midcontinent Granite-Rhyolite Province accounts for 4% of the grains with another 4% within time gaps between major provinces.

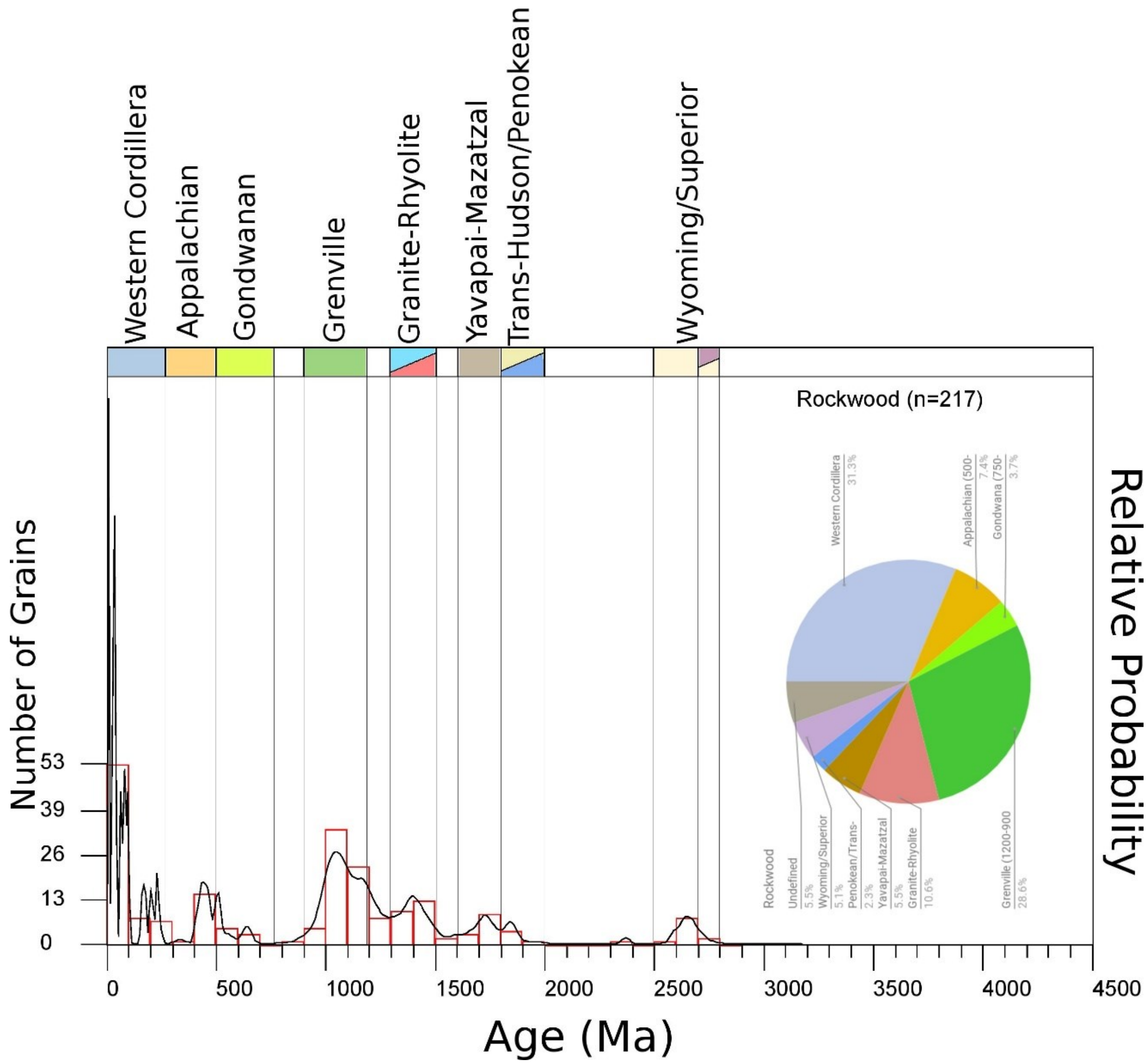

Figure 14. Density probability plot of zircon ages of the Grover Gravel at the Rockwoods site.

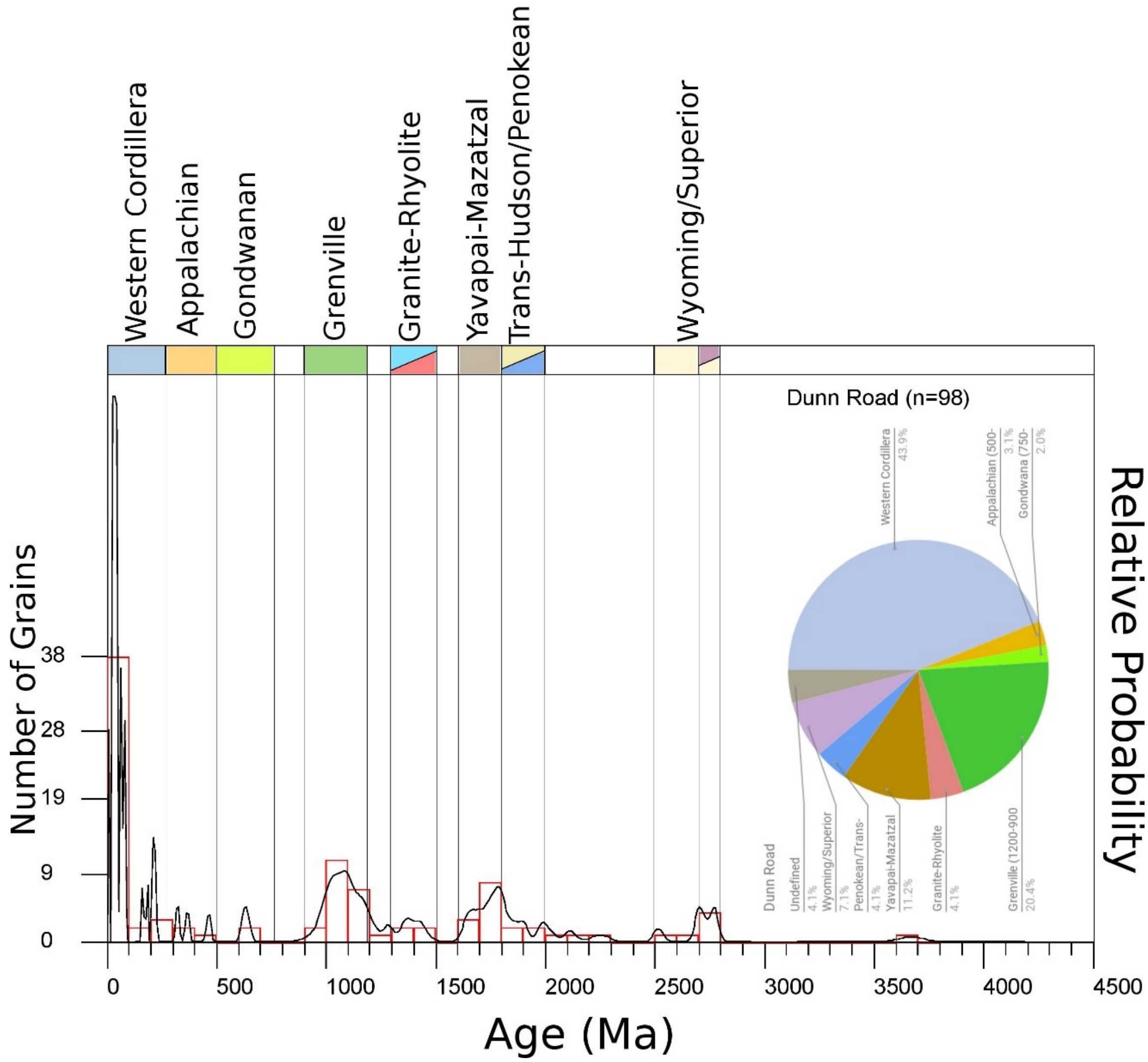

Figure 15. Probability plot of the Dunn Road zircon ages.

Dunn Road Igneous. The grains from the Dunn Road Igneous sample were obtained by crushing granite clasts up to cobble size. All of these grains, with the exception of one outlier, provided Grenville dates with an error-weighted mean of 1091 ± 21 Ma (Table 4). An online database of radiometric ages (Canadian Geochronology Knowledgebase, 2013) shows that these clasts probably originated from east of Hudson

Bay. Since the Cenozoic paleodrainage pattern from this area was characterized by the transport of sediment eastward to the Atlantic Ocean or into Hudson Bay, and to the Boreal Sea before that, the granite clasts would have had no other transport mechanism than glacial to move them southwest to the study area (Finzel, 2014; Craddock and Kylander-Clark, 2013; Blum and Pecha, 2014).

Table 4. Ages for the zircon from the crushed granite clasts from the Dunn Road exposure.

Age (Ma)	±2σ abs
1156	140
1120	64
1100	91
1039	65
1136	62
1082	58
1436	47
1060	61
1130	82
1146	110
1096	59
1104	64
1104	110

Dexter (n=66). The sample of Mounds Gravel at Dexter, MO is most similar to the Grover Gravel and Mill Creek till samples, even though it has a higher percentage of Western Cordilleran grains and lacks any zircon of proto-Yellowstone age (≦ 16 Ma; Figure 16). The Cordilleran population (36%) displays four prominent peaks defined by

21 grains, with the youngest age occurring at 20.9 Ma. Appalachian and Gondwana ages total 3%, and 0% of the grains, respectively for a total of 27% (including Grenville) from northeastern source areas. The Yavapai-Mazatzal Province accounts with 9% for a combined total of 45% (along with the Cordilleran) from western sources. The Trans-Hudson/Penokean and Wyoming/Superior provinces amount to 5% and 3%, respectively for a total of 8% from north to northwestern areas. Finally, the midcontinent Granite-Rhyolite province has 11% of the grains, with the remaining (9%) filling in time gaps between major provinces.

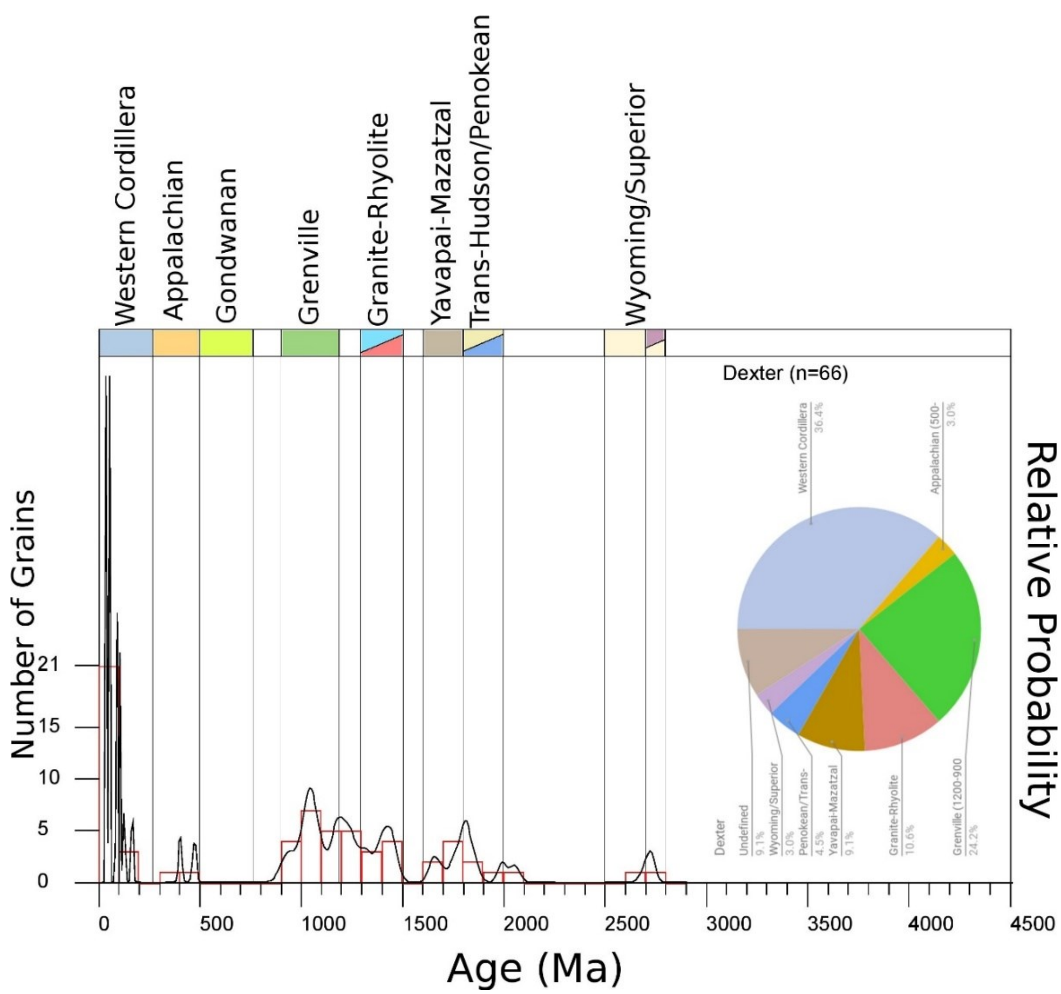

Figure 16. Probability plot of the zircon grains from the Mounds Gravel at Dexter, MO.

Rare Earth Analysis

For the rare earth element (REE) analysis, most age groups do not have any distinct differences in REE concentrations with the exception of a few samples with lower Europium concentrations in the Western Cordillera plot. This implies that there are not any easily discernible sub-populations within the major provinces (Figure 17; Figure 18). Additional REE plots of each individual sample within the province age ranges and a table with the concentrations of each element for each sample are given in Appendix III and IV.

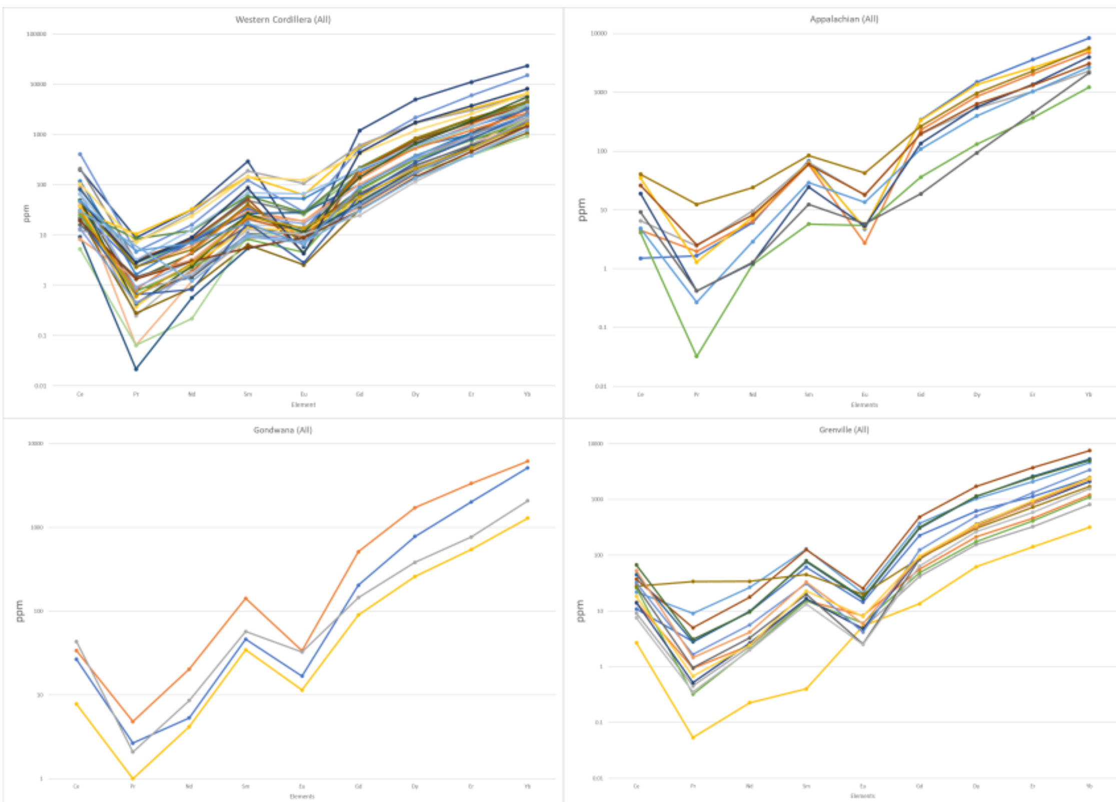

Figure 17. Rare earth element plots. REE plots are shown for every sample within the Western Cordillera, Gondwana, Appalachian, and Grenville Provinces in parts per million.

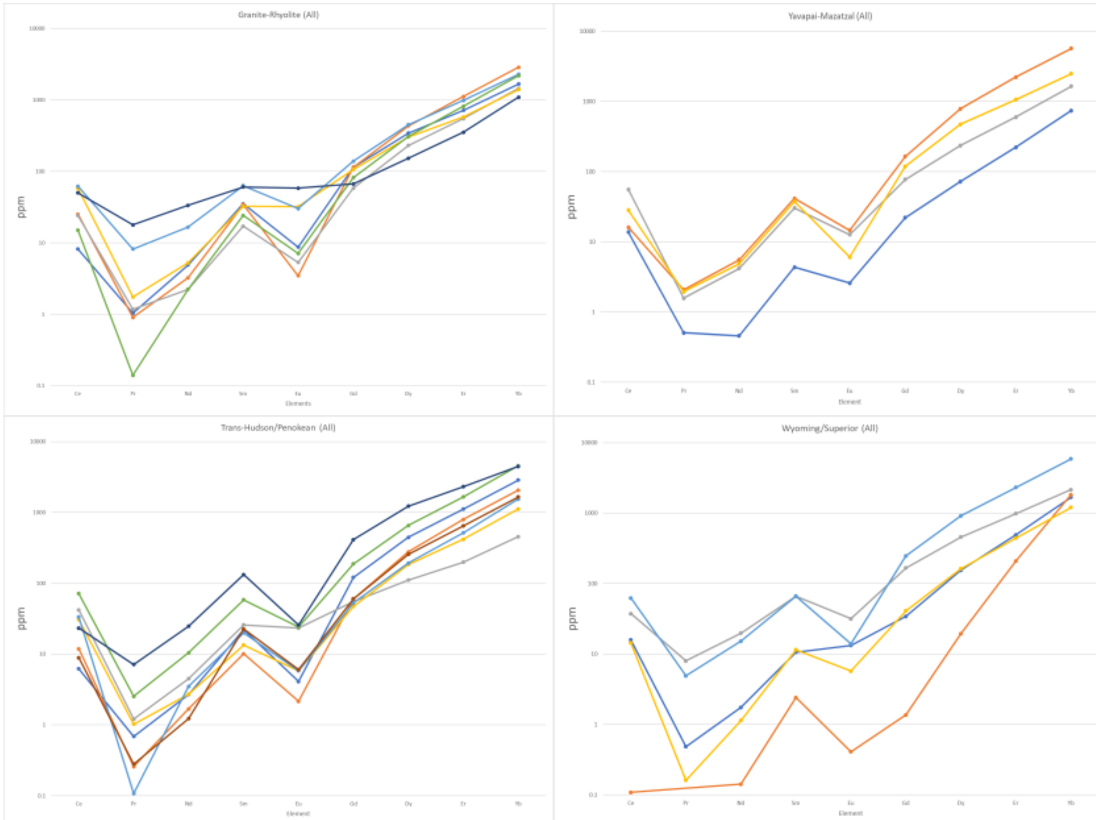

Figure 18. Additional rare earth element plots. REE plots for every sample within the Granite-Rhyolite, Trans-Hudson/Penokean, Yavapai-Mazatzal, and Wyoming/Superior provinces in parts per million.

Discussion

Stacked probability and cumulative probability plots of the four zircon samples (Figures 19 - 21) illustrate that each deposit has a similar distribution of ages, which likely reflects a common source or sources. Thus, the zircon ages support the same conclusion for the Grover Gravel and Mill Creek till, based on the close correspondence in grain counts. Each sample is dominated by grains from the Western Cordillera and Grenville Provinces with totals averaging around 50-60% of the total population. None of these samples, however, has a large population of zircons derived from areas to the north or northwest (Wyoming/Superior and Trans-Hudson/Penokean), which would have

to be the case if they had been eroded and deposited by an ancestral Mississippi River system with headwaters far north of the United States - Canadian border. Totals from these provinces average less than 10% for the three gravel samples: Rockwoods, Dexter and Dunn Road (Table 5), amounts that could easily be recycled from Paleozoic formations within the current Mississippi drainage basin, e.g. (Finzel, 2014). The Mill Creek till sample does have a slightly higher count of Superior-aged zircon (approximately 15%), but the Superior Province extends far enough eastward that a glacial advance from east of Hudson Bay would almost certainly entrain some Superior-age zircon.

The Dexter (Mounds Gravel) and Rockwoods (Grover Gravel) samples have the closest similarities in their cumulative probability plots, again indicating a close genetic relationship (Figure 21), but based on general (lumped) provenance areas, these two samples fall into different groups (Table 5). The Dexter and Dunn Road samples are the most-enriched in Western Cordillera grains, while the Rockwoods and Ridge Meadows samples have more grains sourced from the northeast. The high percentage of northeast grains (nearly 40%) within these samples is evidence that the glaciation which deposited the Mill Creek till was centered east of Hudson Bay, which is consistent with the high ratio of garnet:epidote. Nevertheless, this glaciation entrained sediment as young as 7 Ma (late Miocene) that was derived from western source areas (Figure 20). Thus, this glaciation entrained (and perhaps removed) young deposits that are no longer preserved east of the Mississippi River.

The samples with the highest percentage of total western-source ages (Dexter and Dunn Road) have a common denominator; these sites are directly adjacent to the modern

Mississippi floodplain and were obviously deposited by an ancestral Mississippi River system. The Dunn Road sample has the highest percentage (55%) of zircon derived from the west, which is consistent with its location just several kilometers south of the confluence between the modern Mississippi and the Missouri River. The modern Missouri River drains an area extending westward to the Rocky Mountains via the Platte River. An ancestral Platte River that connected with the southern (pre-glacial) segment of the Missouri River east of Kansas City, Missouri likely accounts for this enrichment in Western Cordillera grains. The lower concentration (46%) of western grains at the Dexter site, which is several hundred kilometers downstream, reflects dilution of the Missouri-River sediment with other sources. For example, the Dexter sample has a higher percentage of Granite-Rhyolite age zircon grains (Figures 15 and 16), which are likely sourced from the nearby St. Francois Mountains, which are part of the Granite-Rhyolite Province.

The close similarities in zircon ages and clast composition indicate that the type Grover Gravel at Rockwoods is derived from the Mill Creek till (Tables 2, 3, and 5). Both deposits share the same approximate proportions of diagnostic and nearly unique clast types, including high proportions of oolitic chert, various types of quartzite and highly polished grains. This conclusion is consistent with previous observations that, in places, the Grover Gravel in its type area (western St. Louis County) directly overlies highly weathered remnants of the Mill Creek till. Additionally, the type Grover Gravel is a Pleistocene deposit younger than about 0.85 Ma, based on burial dating (Rovey et al., 2016). Despite similar visual appearances, however, the Mill Creek till is much different from the 2.4 Ma Atlanta till (Tables 2 and 3) with respect to both pebble and heavy

mineral contents. Thus, the Grover Gravel was not derived from the Atlanta till and the age of the glaciation in St. Louis County remains unknown.

The Gravel at Dunn Road is also derived, at least in part, from glacial sediment. First, the gravel here contains zircon as young as ca. 2 Ma, so it is no older than the Early Pleistocene (Figure 20). Secondly, this deposit has common igneous clasts (up to cobble size), which were derived from the Grenville Province east of Hudson Bay, based on zircon ages (Table 4). It would be nearly impossible for large clasts from this provenance to have reached northeast Missouri without glacial transport. Given that this gravel also contains the same diagnostic types of pebbles as the type-Grover Gravel and the Mill Creek till (Rovey et al., 2016), it too was derived in part from either the Mill Creek or another source common to both.

The Mounds Gravel at Dexter, Missouri has only poor age constraints provided by the youngest zircon age of approximately 20 Ma (Figure 20). Nevertheless, it too shares the same rock types as the Mill Creek till and Grover Gravel, even though samples here were not available for pebble counts. The Mounds Gravel also shares a very similar distribution of zircon ages as the Grover Gravel and Mill Creek tills in St. Louis County (Figures 19 - 21). These similarities are consistent with the possibility that the Grover and Mounds Gravels are both Pleistocene-age deposits that are broadly correlative in both a lithostratigraphic and chronostratigraphic sense.

To summarize the discussion with respect to hypotheses from the Introduction, a general correlation between the Grover and Mounds Gravels cannot be disproven based on zircon percentages and pebble counts. Next, the two formations were not sourced from a giant ancestral Mississippi River that extended into Canada, based on the small

percentage of grains from that region (Table 5). Finally, the Grover Gravel is indeed derived from glacial sediment, but not that of the 2.4 Ma Atlanta Formation. Thus, the Mill Creek till (the source of the Grover Gravel) represents a major, but undated, glaciation that reached a position south of the Missouri River in St. Louis County.

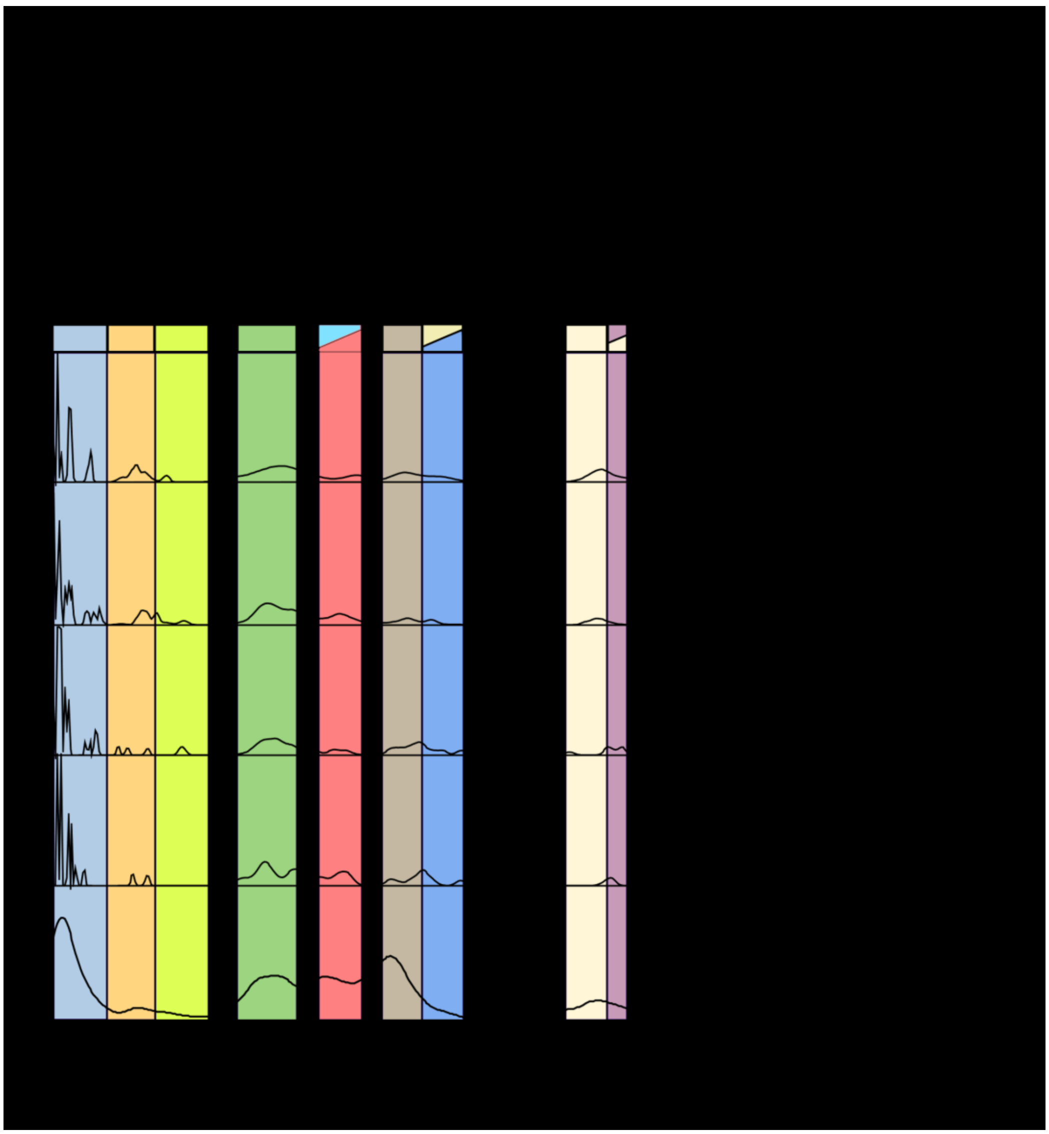

Figure 19. Stacked probability plots of zircon ages from each sample.

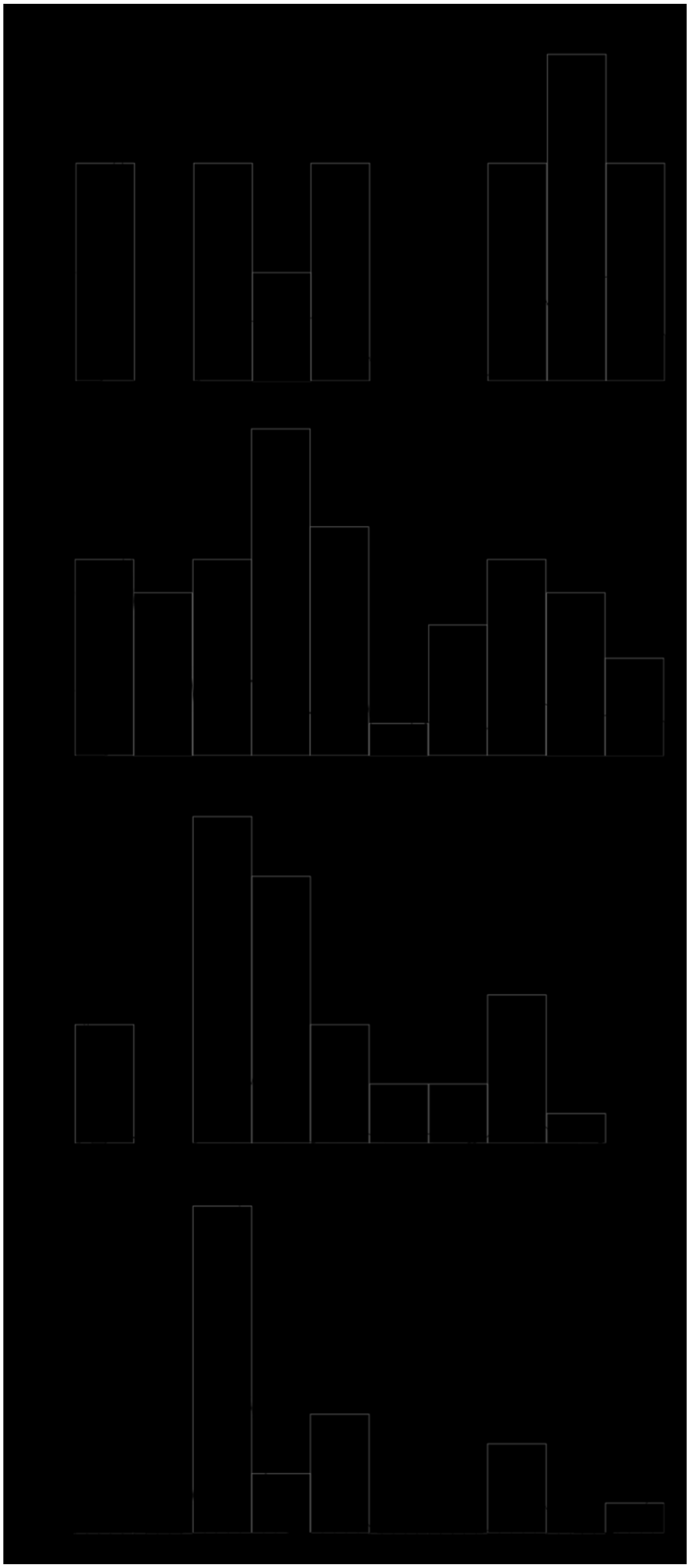

Figure 20. Stacked probability plot for each sample for zircon grains less than 100 Ma. The rectangles are histogram bins for the number of grains.

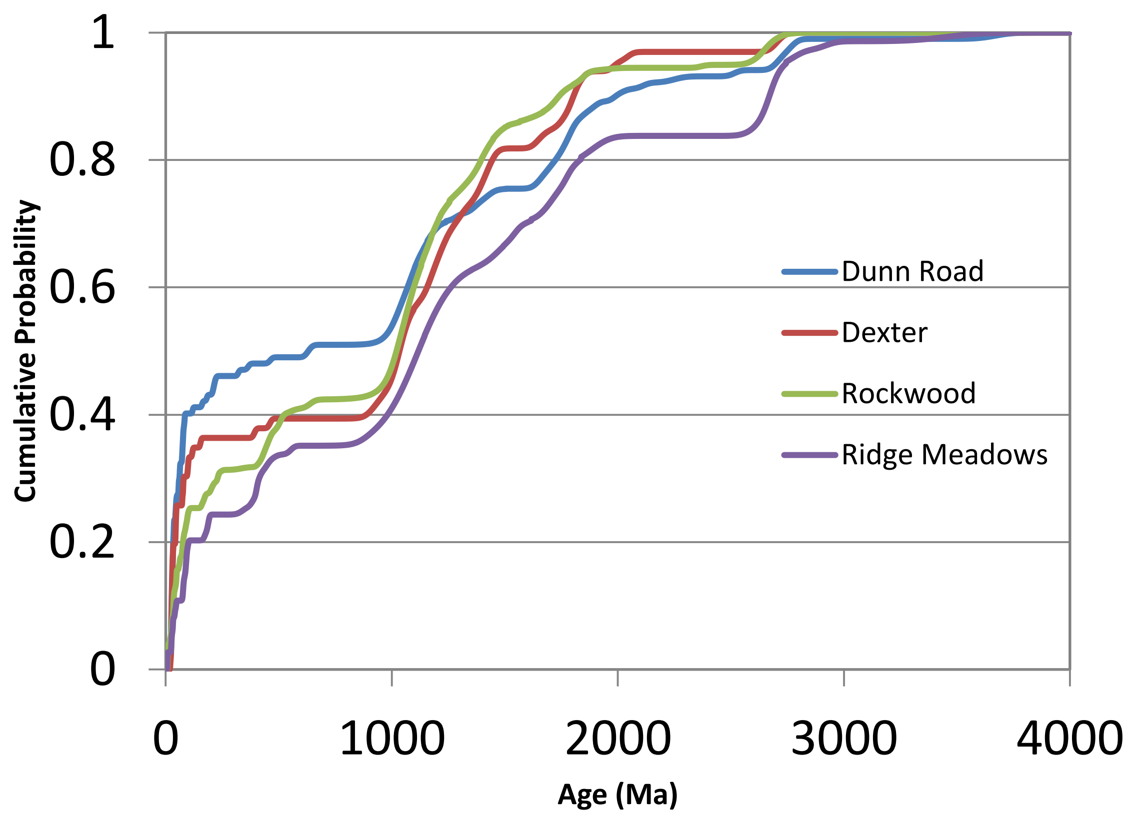

Figure 21. Cumulative probability plot for all samples. The Dexter (Mounds Gravel) and Dunn Road samples are similar to one another along with Ridge Meadows (Mill Creek till) and Rockwood (Grover Gravel) also sharing many of the same trends.

Table 5. Percent of zircon ages within general source areas. This table simplifies several of the provinces into general source areas. The north-northwestern source area is made up of the Trans-Hudson, Superior, and Wyoming provinces. The northeastern source area consists of the Grenville, Gondwana, and Appalachian provinces. The western source area contains the western cordillera and Yavapai-Mazatzal provinces.

General	Sample			
Source Area:	Rockwoods	Ridge Meadows	Dexter	Dunn Road
North-Northwest	7.4%	19.4%	7.5%	11.2%
Northeast	39.7%	37.4%	27.2%	25.5%
Western	36.8%	34.4%	45.5%	55.1%

CHAPTER SIX: SUMMARY AND CONCLUSIONS

To constrain the possible source regions for the Grover Gravel and compare and contrast this unit to the Mill Creek till, Atlanta till, and Mounds Gravel, a combination of detrital zircon geochronology analysis, heavy mineral counts, and pebble counts were used.

All the gravel samples share a similar cobbly texture dominated by chert, quartzite, and vein quartz. The Atlanta and Mill Creek tills are also very cobbly with chert as the predominant clast. Both of these tills have a high garnet:epidote ratio, which indicates that the main source area for both is east of Hudson Bay. However, they differ substantially in their amounts of mafic grains and proportions of pebble sized constituents. The Mill Creek till samples contain a high amount of unstable mafic grains in a low state of weathering as well as a high proportion of rounded and polished pebbles, along with quartzite, oolitic chert, and vein quartz. However, the Atlanta till samples contain very few mafic grains, and these are highly weathered. The Atlanta also contains practically no pebbles of vein quartz and few of the specific types of chert as those present in the Mill Creek. The Grover Gravel shares the same diagnostic types of pebbles, and in approximately the same proportions, as the Mill Creek till. Thus, the Mill Creek till is not equivalent to the Atlanta Till, but is virtually identical to the Grover Gravel with regard to pebble content.

The detrital zircon results show another strong correlation among both gravels and the Mill Creek till, with similar percentages of grains derived from various source areas. However, these gravels nearly lack grains from the (northern) Superior Province,

which suggests that the hypothesis proposed by Cox et al. (2014), that they were largely derived from Canada by a giant ancestral Mississippi River system, is not valid.

These results therefore provide high confidence in evaluating the project's initial hypotheses. First, the small amount of zircons sourced from the Superior Province is not compatible with the northern drainage basin hypothesis of Cox et al. (2014). These gravels were not derived from central Canada by a mega-scale ancestral Mississippi River system. Secondly, the Grover Gravel is sourced from a Pleistocene Glaciation, but not the one dated at 2.4 Ma by Balco and Rovey (2010), which deposited the Atlanta till north of the Missouri River. The pebble composition of the Grover is nearly identical to that of the Mill Creek till, but the Atlanta till has a much different pebble composition from both the Grover and the Mill Creek till, as well as a distinctly different suite of heavy minerals compared to the Mill Creek.

Finally, these results do not disprove and generally support the hypothesis that the Grover and Mounds Gravels are correlative deposits. These gravels share very similar age distributions of detrital zircon, indicating that they are derived from the same sources and in nearly the same same proportions. Also, at least two of the three gravels investigated here (the type Grover Gravel and the gravel at Dunn Road) are Pleistocene in age and contain reworked glacial sediment, and they both contain the same unusual types of clasts as the Mill Creek till and the Mounds Gravel. The Dunn Road deposit contains Pleistocene-age zircons, and large granitic clasts from east of Hudson Bay that must have been transported by glacial ice. The type Grover Gravel also has essentially the same types and percentages of clasts as the Mill Creek till, and previous studies have documented that the gravel is a Pleistocene deposit preserved directly atop weathered

Mill Creek in some locations. Thus, the lithologic and topographic similarities between the Grover and Mounds gravels imply a reasonable possibility that the Mounds Gravel is also a Pleistocene deposit that contains glacigenic sediment.

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APPENDICES

These appendices contain data tables for the settings used on the ICP-MS at the University of Kansas as well as the dates, isotopic ratios, and rare earth concentrations from the analyses.

Appendix I. University of Kansas ICP-MS Methods Tables
Run Number One (University of Kansas - 2/06/2017)

Laboratory & Sample Preparation	
Laboratory name	The University of Kansas, Dept. of Geology, Isotope Geochemistry Lab
Sample type/mineral	Zircon
Sample preparation	Polished epoxy grain mounts
Imaging	Cathodoluminescence at the University of Iowa
Laser ablation system	
Make, model & type	ATL Arf excimer laser (193 nm), Photon Machines Analyte G2
Ablation cell & volume	Hel Ex II (Teledyne Photon Machines)
Laser wavelength	193 nm
Pulse width (ns)	5 ns
Fluence	2.0 J/cm^2
Repetition rate	10 Hz

Spot size (um)	25 µm
Sampling mode / pattern	Single spots
Carrier gas	He: 1.1 l/min, Ar: 1.085 l/min
Ablation duration	25 s
Cell carrier gas flow	He1: 0.51 l/min; He2: 0.50 l/min
ICP-MS Instrument	
Make, Model & type	Thermo Element2 magnetic sector field ICP-MS (single collector)
Sample introduction	Aerosol with sample + He was mixed with Ar using a T-connector ca. 15 cm upstream from torch.
RF power	1165 W
Make-up gas flow	Ar, 16 l/min
Sampling depth	ca. 20 µm
Detection system	single detector (SEM), counting & analog modes
Elements/ isotopes analyzed	206Pb, 207Pb, 208Pb, 232Th, 238U
Integration time per peak (Sample Time in miliseconds)	206Pb=2, 207Pb=5, 208Pb=1, 232Th=1, 238U=2
Total integration time (Segment Duration in miliseconds)	206Pb=8, 207Pb=20, 208Pb=4, 232Th=5, 238U=10
Total method time	46 s (200 runs, 4 passes)

Sensitvity (cps/ppm)	232Th=1930 cps/ppm, 238U=2900 cps/ppm
ICP Dead time	2 ns
UO+/U+	0.06%
238U+/232Th+	1.7
Data Processing	
Gas blank	21 s
Calibration strategy	Standard-sampling bracketing
Reference material info	GJ1 (Jackson et al., 2004)
Internal std for trace elements	n/a
Data processing package used / Correction for laser induced elemental fractionation (LIEF)	IGOR PRO, Iolite 2.5 (Patton et al. 2011): U_Pb_Geochronology (Paton, et al. 2010) and VizualAge data reduction schemes (Petrus & Kamber, 2012), exponential LIEF correction for U-Pb ratios.
Common-Pb correction, composition and uncertainty	Not performed because of high Hg backgrounds
Uncertainty level & propagation	2SE propogated uncertainty from VizualAge data reduction scheme. Concordia diagrams were plotted using ET_Redux (McLean et al. 2016) with 2s uncertainty ellipses.
Reproducibility	206Pb/238U=1.5-2.0%; 207Pb/235U=2.0-2.5%
Quality control / Validation	Plesovice zircon (Sláma et al., 2008); FCT zircon (Wotzlaw et al., 2013)

Appendix I Continued. University of Kansas ICP-MS Methods Tables
Run Number Two (University of Kansas - 5/19/2017)

Laboratory & Sample Preparation	
Laboratory name	The University of Kansas, Dept. of Geology, Isotope Geochemistry Lab
Sample type/mineral	Zircon
Sample preparation	Polished epoxy grain mounts
Imaging	Cathodoluminescence at the University of Iowa
Laser ablation system	
Make, model & type	ATL Arf excimer laser (193 nm), Photon Machines Analyte G2
Ablation cell & volume	Hel Ex II (Teledyne Photon Machines)
Laser wavelength	193 nm
Pulse width (ns)	5 ns
Fluence	2.2 J/cm^2
Repetition rate	10 Hz
Spot size (um)	20 µm
Sampling mode / pattern	Single spots
Carrier gas	He: 1.1 l/min, Ar: 1.093 l/min

Ablation duration	25 s
Cell carrier gas flow	He1: 0.51 l/min; He2: 0.50 l/min
ICP-MS Instrument	
Make, Model & type	Thermo Element2 magnetic sector field ICP-MS (single collector)
Sample introduction	Aerosol with sample + He was mixed with Ar using a T-connector ca. 15 cm upstream from torch.
RF power	1195 W
Make-up gas flow	Ar, 16 l/min
Sampling depth	ca. 18 µm
Detection system	single detector (SEM), counting & analog modes
Elements/ isotopes analyzed	206Pb, 207Pb, 208Pb, 232Th, 238U
Integration time per peak ('Sample Time' in miliseconds)	206Pb=2, 207Pb=5, 208Pb=1, 232Th=1, 238U=2
Total integration time ('Segment Duration' in miliseconds)	206Pb=8, 207Pb=20, 208Pb=4, 232Th=5, 238U=10
Total method time	46 s (200 runs, 4 passes)
Sensitvity (cps/ppm)	232Th=1800 cps/ppm, 238U=2500 cps/ppm
ICP Dead time	2 ns
UO+/U+	0.24%

238U+/232Th+	1.5
Data Processing	
Gas blank	21 s
Calibration strategy	Standard-sampling bracketing
Reference material info	GJ1 (Jackson et al., 2004)
Internal std for trace elements	n/a
Data processing package used / Correction for laser induced elemental fractionation (LIEF)	ET_Redux v. 3.6.16 (McLean et al., 2016). LIEF corrected using the intecept fractionation technique.
Common-Pb correction, composition and uncertainty	Not performed because of high Hg backgrounds
Uncertainty level & propagation	2s propogated uncertainty for ratios and dates
Reproducibility	206Pb/238U=2.0-3.0%; 207Pb/235U=3.0-4.0%
Quality control / Validation	Plesovice zircon (Sláma et al., 2008); FCT zircon (Wotzlaw et al., 2013)

Appendix II. Isotopic Ratios and Age Dates
Run Number One (University of Kansas - 2/06/2017)

Spoering Zircon										
	Isotopic Ratios									
					Correlation coefficients			Correlation coefficients		
Sample and Analysis Number	207Pb/ 235U a	±2σ %	206Pb/ 238U a	±2σ %	206Pb/238U 207Pb/235U	207Pb/ 206Pb a	±2σ %	207Pb/206Pb 238U/206Pb	208Pb/ 232Th a	±2σ %
Dunn::Dunn										
.dunn-44.FIN2	-0.001	-220.0	0.00029	17.6	-0.017233	-0.02	-455.0	-0.062590653	0.000135	67.4074
.dunn-16.FIN2	0.0019	57.9	0.00029	9.9	-0.068606	0.075	66.7	0.23403237	0.000125	45.6
.dunn-51.FIN2	0.0022	54.5	0.00031	11.1	-0.17815	0.081	51.9	0.362325819	0.000141	36.1702
.dunn-46.FIN2	0.01	65.0	0.00125	14.4	-0.034863	0.091	62.6	0.248509103	0.00025	140
.dunn-1.FIN2	0.0232	6.5	0.00353	3.4	0.10549	0.0486	6.6	0.389070263	0.00118	8.47458
.dunn-62.FIN2	0.0249	19.3	0.00376	4.8	-0.17644	0.05	20.0	0.396227044	0.00121	18.1818
.dunn-77.FIN2	0.02432	4.1	0.00383	2.5	0.076214	0.046	3.9	0.480479509	0.001318	7.58725
.dunn-37.FIN2	0.0254	5.9	0.00389	2.8	-0.030863	0.0477	5.9	0.454371133	0.001196	9.19732
.dunn-75.FIN2	0.0275	10.9	0.00397	3.5	-0.01508	0.0511	11.2	0.320523683	0.0017	11.1765
.dunn-54.FIN2	0.0264	6.8	0.00404	3.2	0.23666	0.0471	6.8	0.235363452	0.001509	8.61498
.dunn-48.FIN2	0.0256	13.3	0.00407	4.4	0.15218	0.0468	13.0	0.17996011	0.00151	13.245
.dunn-24.FIN2	0.0269	5.6	0.00416	2.9	0.069521	0.049	5.9	0.409982941	0.001399	8.57756
.dunn-83.FIN2	0.0281	8.2	0.00428	3.7	0.062705	0.0481	8.7	0.367214807	0.00155	9.67742
.dunn-7.FIN2	0.0285	9.1	0.0044	3.2	0.19416	0.0482	9.1	0.155693609	0.00144	9.72222
.dunn-45.FIN2	0.0319	6.9	0.00448	2.9	0.11871	0.0502	7.0	0.291032119	0.00156	10.2564
.dunn-20.FIN2	0.0313	7.3	0.00476	2.7	0.12914	0.0468	7.3	0.237571867	0.00162	9.25926
.dunn-73.FIN2	0.0341	7.9	0.00494	2.8	-0.024022	0.0509	7.9	0.356896244	0.00201	9.45274
.dunn-3.FIN2	0.0319	10.0	0.00495	3.4	0.046183	0.0462	10.4	0.284262991	0.00153	9.15033
.dunn-67.FIN2	0.0326	5.5	0.00501	2.6	0.25314	0.0474	5.3	0.218683902	0.001662	7.22022
.dunn-34.FIN2	0.0343	14.3	0.00504	4.8	0.11805	0.0501	14.8	0.211877126	0.00214	12.1495
.dunn-5.FIN2	0.0323	10.8	0.0052	4.4	0.29239	0.0459	11.1	0.120210401	0.00185	13.5135
.dunn-28.FIN2	0.0334	6.3	0.00546	2.6	0.10961	0.0456	6.1	0.2873585	0.001844	8.13449
.dunn-23.FIN2	0.038	10.8	0.00559	4.7	-0.067381	0.0507	11.4	0.446927176	0.00187	16.5775
.dunn-6.FIN2	0.0374	5.6	0.00576	2.4	-0.058462	0.0467	6.0	0.441587593	0.00181	8.83978
.dunn-59.FIN2	0.045	4.0	0.00677	2.4	0.15466	0.0481	3.7	0.403815811	0.002195	7.28929
.dunn-60.FIN2	0.0443	3.4	0.00696	2.2	0.19692	0.047	2.8	0.409398243	0.002285	7.43982
.dunn-74.FIN2	0.047	4.5	0.00726	2.6	0.08098	0.046	4.6	0.451783001	0.00287	8.01394
.dunn-11.FIN2	0.0432	16.2	0.00753	5.3	0.14203	0.0419	16.2	0.184482612	0.00248	18.9516
.dunn-52.FIN2	0.058	7.2	0.0089	2.9	0.16105	0.0476	6.9	0.238493592	0.00286	10.8392
.dunn-14.FIN2	0.0569	3.5	0.00891	2.2	0.12331	0.0465	3.4	0.460836545	0.0028	8.21429
.dunn-59A.FIN2	0.823	3.9	0.00938	5.1	0.066405	0.669	6.1	0.781466847	0.00318	7.86164
.dunn-17.FIN2	0.0637	2.7	0.0098	2.1	0.20662	0.04747	2.1	0.520431087	0.00337	9.79228
.dunn-32.FIN2	0.0634	3.6	0.00982	2.2	-0.0087411	0.0471	3.4	0.530800552	0.00308	8.44156
.dunn-55.FIN2	0.0726	4.1	0.01136	2.6	0.10917	0.0469	4.1	0.470428473	0.004	7.5
.dunn-50.FIN2	0.0746	4.4	0.01161	2.5	-0.014905	0.0479	4.6	0.501481208	0.00404	11.3861
.dunn-25.FIN2	0.0759	7.2	0.01171	3.3	0.20778	0.0491	6.9	0.24931619	0.00372	12.0968
.dunn-79.FIN2	0.0783	4.3	0.01207	2.5	0.22622	0.0477	3.8	0.334870627	0.00389	8.22622
.dunn-15A.FIN2	0.3	21.3	0.0121	10.7	-0.34637	0.179	26.3	0.671447598	0.00621	16.1031
.dunn-69A.FIN2	0.0786	8.0	0.01214	3.8	0.093881	0.0486	8.2	0.355657392	0.00403	14.3921
.dunn-64B.FIN2	0.3106	3.5	0.0129	3.0	0.25041	0.1774	3.7	0.528838554	0.00997	7.52257
.dunn-57.FIN2	0.0888	4.8	0.01314	2.7	0.10433	0.0496	4.6	0.408986776	0.00509	8.84086
.dunn-64A.FIN2	0.365	3.6	0.01867	2.8	0.090817	0.1421	3.7	0.578463701	0.00827	7.73881
.dunn-12.FIN2	0.1651	6.1	0.02537	2.5	0.0046355	0.0467	6.4	0.380825811	0.0083	8.6747
.dunn-13.FIN2	0.1931	3.6	0.02867	2.2	0.11183	0.0493	3.0	0.451707805	0.00893	7.61478

.dunn-87.FIN2	0.2233	2.9	0.03279	2.2	0.17777	0.0499	2.6	0.519944151	0.01082	7.30129
.dunn-81.FIN2	0.2312	3.9	0.03387	2.3	0.28961	0.05	3.6	0.307735153	0.01144	7.95455
.dunn-31.FIN2	0.235	4.7	0.03476	2.4	0.21755	0.0488	4.3	0.292648727	0.011	8.81818
.dunn-49.FIN2	0.3653	3.0	0.05119	2.1	0.11317	0.0523	2.7	0.517217019	0.01709	7.60679
.dunn-69.FIN2	0.425	4.5	0.0583	2.6	0.2378	0.0528	4.4	0.328406497	0.01742	8.61079
.dunn-84.FIN2	0.578	3.1	0.0745	2.3	0.095306	0.0563	2.8	0.539260154	0.02298	7.8329
.dunn-86.FIN2	0.909	3.2	0.1015	2.2	0.25404	0.0647	2.5	0.402572128	0.03326	6.91521
.dunn-30.FIN2	0.873	3.2	0.1043	2.2	0.23996	0.0614	2.8	0.418695081	0.0321	7.47664
.dunn-91.FIN2	1.267	5.1	0.1221	3.3	0.33687	0.0746	4.6	0.305144771	0.0392	10.4592
.dunn-52A..FIN2	1.371	3.8	0.1396	2.7	0.1948	0.0723	3.6	0.457034216	0.055	7.63636
.dunn-26.FIN2	1.483	2.7	0.1496	2.3	0.35364	0.0721	2.1	0.463272187	0.0473	7.18816
.dunn-66.FIN2	1.659	2.5	0.1641	2.1	0.42811	0.0735	1.8	0.433641269	0.0505	7.32673
.dunn-15.FIN2	1.668	3.2	0.165	2.3	0.13454	0.0741	3.1	0.503096916	0.0513	8.38207
.dunn-64.FIN2	1.693	2.1	0.1694	2.1	0.45676	0.07298	1.5	0.5009361	0.05225	6.69856
.dunn-70.FIN2	1.751	2.3	0.1714	2.1	0.27616	0.0741	1.8	0.556212051	0.055	7.27273
.dunn-43.FIN2	1.833	4.3	0.1725	2.6	-0.0028136	0.0783	4.7	0.511109715	0.0558	9.67742
.dunn-89.FIN2	1.77	2.5	0.1736	2.2	0.33438	0.0739	1.9	0.487783514	0.0541	6.83919
.dunn-19.FIN2	1.772	2.4	0.1747	2.1	0.25857	0.0748	1.7	0.54929505	0.0542	6.82657
.dunn-40.FIN2	1.812	2.9	0.1753	2.2	0.10674	0.0744	2.6	0.557957454	0.0558	7.70609
.dunn-38.FIN2	1.835	2.3	0.1766	2.1	0.42187	0.0757	1.7	0.461932733	0.0561	6.95187
.dunn-47.FIN2	1.883	2.2	0.18	2.2	0.46176	0.07676	1.4	0.498178024	0.0598	7.19064
.dunn-65.FIN2	1.938	3.0	0.18	2.4	0.26712	0.0784	2.4	0.49545716	0.0553	7.59494
.dunn-9.FIN2	1.913	3.1	0.1825	2.4	0.20395	0.0758	2.8	0.487954491	0.0585	7.86325
.dunn-4.FIN2	1.94	2.1	0.1863	2.1	0.6506	0.07592	1.1	0.408560082	0.0612	14.0523
.dunn-2.FIN2	1.968	2.9	0.1879	2.3	0.33108	0.0773	2.5	0.440864875	0.0582	8.0756
.dunn-90.FIN2	2.115	2.5	0.1951	2.2	0.20009	0.0797	2.1	0.579309993	0.0598	7.52508
.dunn-88.FIN2	2.111	2.1	0.1954	2.1	0.69859	0.07891	1.2	0.397256672	0.0586	6.99659
.dunn-41.FIN2	2.167	2.8	0.1984	2.3	0.36848	0.08	2.4	0.450349194	0.0636	7.54717
.dunn-29A..FIN2	2.603	2.0	0.2262	2.0	0.70905	0.08368	1.0	0.355267664	0.06927	6.78504
.dunn-78.FIN2	2.752	2.1	0.231	2.0	0.49062	0.087	1.4	0.478450631	0.0702	6.98006
.dunn-33.FIN2	2.833	2.3	0.2375	2.1	0.53217	0.0877	1.4	0.410465755	0.0726	6.88705
.dunn-85.FIN2	3.027	2.6	0.2444	2.5	0.42488	0.0905	2.1	0.517267793	0.0727	7.01513
.dunn-80.FIN2	3.049	2.2	0.2489	2.0	0.61233	0.0901	1.3	0.361376523	0.075	6.93333
.dunn-8.FIN2	3.641	3.0	0.2625	2.9	0.8539	0.1011	1.6	0.196725447	0.0865	7.63006
.dunn-42.FIN2	3.899	2.3	0.2802	2.1	0.51958	0.1014	1.5	0.430986316	0.0869	6.90449
.dunn-36.FIN2	4.123	2.1	0.2893	2.1	0.6146	0.1046	1.2	0.459551496	0.0861	6.8525
.dunn-35.FIN2	4.192	2.3	0.29	2.2	0.59716	0.1049	1.4	0.401328902	0.0891	7.07071
.dunn-39.FIN2	4.117	2.3	0.2912	2.2	0.38628	0.1023	1.6	0.526661547	0.0879	6.82594
.dunn-18.FIN2	4.297	2.0	0.2923	2.1	0.62641	0.1067	1.2	0.449838157	0.0884	7.01357
.dunn-71.FIN2	4.364	2.1	0.2972	2.1	0.58765	0.1076	1.2	0.420940421	0.0865	7.05202
.dunn-56.FIN2	4.41	2.7	0.2981	2.5	0.62918	0.1083	1.7	0.368140125	0.0933	7.07395
.dunn-29.FIN2	5.88	3.2	0.2993	2.8	0.50368	0.142	2.5	0.389079961	0.0975	7.89744
.dunn-93.FIN2	4.641	2.0	0.3109	2.0	0.60686	0.10917	1.1	0.443786753	0.0928	6.89655
.dunn-76.FIN2	4.895	2.2	0.3164	2.1	0.20301	0.1134	1.5	0.587659453	0.0928	6.89655
.dunn-82.FIN2	4.765	2.1	0.3165	2.2	0.41476	0.11	1.5	0.565591594	0.0954	7.2327
.dunn-21.FIN2	4.891	2.0	0.3243	2.0	0.61411	0.11	1.2	0.453514738	0.0957	6.89655
.dunn-92.FIN2	5.034	2.6	0.3247	2.2	0.32662	0.1142	2.0	0.498814934	0.0944	7.09746
.dunn-68.FIN2	5.347	2.1	0.3339	2.1	0.51276	0.1166	1.1	0.507973683	0.0966	6.8323
.dunn-63.FIN2	5.911	2.4	0.3487	2.3	0.48634	0.1241	1.5	0.483261141	0.0989	7.07786
.dunn-10.FIN2	5.862	2.0	0.3497	2.1	0.67992	0.12156	1.1	0.420471092	0.1034	6.86654

.dunn-22.FIN2	6.661	2.1	0.3707	2.1	0.3679	0.1312	1.4	0.554990441	0.1058	7.18336
.dunn-27.FIN2	10.42	2.1	0.4573	2.1	0.55568	0.1658	1.3	0.475163525	0.1349	6.81987
.dunn-61.FIN2	13.19	2.1	0.5093	2.2	0.67399	0.189	1.3	0.421571974	0.1472	6.79348
.dunn-58.FIN2	13.51	2.4	0.5109	2.5	0.78912	0.1937	1.2	0.380328644	0.1412	7.01133
.dunn-53.FIN2	13.71	2.0	0.5136	2.1	0.68527	0.1936	1.0	0.48348789	0.1505	6.64452
.dunn-72.FIN2	13.09	2.1	0.5146	2.1	0.62624	0.1851	1.2	0.465533028	0.1437	6.81976
.dunn-52B.FIN2	13.32	2.0	0.5245	2.1	0.62058	0.1858	1.2	0.466937518	0.1549	7.10136
.dunn-32A.FIN2	26.4	5.7	0.559	3.6	0.50727	0.343	4.4	0.140648327	0.397	9.82368
DX::DX										
.dx-18.FIN2	0.0222	11.7	0.00325	4.0	0.15646	0.0501	11.6	0.184180532	0.00109	12.844
.dx-16.FIN2	0.0235	26.4	0.00371	5.7	0.21185	0.047	25.5	0.002759178	0.00132	16.6667
.dx-14.FIN2	0.027	18.5	0.0039	3.8	0.033353	0.0521	19.0	0.171841548	0.00153	14.3791
.dx-19.FIN2	0.0255	4.7	0.00399	2.8	0.022255	0.0462	5.0	0.490877036	0.001216	9.04605
.dx-1.FIN2	0.026	4.6	0.00418	2.4	0.10461	0.0447	4.3	0.37979282	0.001331	7.51315
.dx-64.FIN2	0.0262	5.3	0.00431	2.6	-0.016236	0.0453	5.7	0.442852916	0.00134	11.194
.dx-29.FIN2	0.0279	5.4	0.00434	2.5	0.24936	0.0471	5.3	0.223511068	0.001438	7.64951
.dx-34.FIN2	0.0287	6.3	0.00438	2.5	0.06318	0.0476	6.5	0.319985532	0.001398	9.299
.dx-43.FIN2	0.026	10.8	0.00439	3.6	0.15141	0.0442	10.6	0.185904589	0.0014	13.5714
.dx-32.FIN2	0.0269	8.2	0.00448	2.9	0.033483	0.044	8.2	0.306076444	0.00137	10.9489
.dx-40.FIN2	0.0291	7.2	0.00466	3.0	-0.17977	0.0455	7.9	0.518233005	0.001543	8.42515
.dx-28.FIN2	0.0316	5.7	0.00483	2.7	-0.041529	0.048	5.8	0.45755533	0.001654	8.46433
.dx-50.FIN2	0.0343	7.9	0.00515	2.9	-0.027147	0.0473	8.0	0.369229932	0.001616	8.04455
.dx-12.FIN2	0.0448	5.1	0.00676	2.5	0.07206	0.0475	5.3	0.38634386	0.002154	7.89229
.dx-20.FIN2	0.043	5.6	0.00686	2.8	0.081359	0.0454	5.5	0.384291646	0.00233	7.72532
.dx-17.FIN2	0.0462	2.8	0.00709	2.1	0.15961	0.0472	2.5	0.514737044	0.002386	7.54401
.dx-59.FIN2	0.0486	6.2	0.00738	2.8	-0.04726	0.0479	6.7	0.453480046	0.00256	9.76563
.dx-33.FIN2	0.0734	4.4	0.01153	2.3	0.066748	0.0462	4.3	0.411498631	0.00381	8.39895
.dx-43.FIN2	0.0797	2.8	0.01203	2.2	0.28994	0.04813	2.1	0.457959331	0.00423	7.0922
.dx-38.FIN2	0.0778	6.8	0.01226	2.9	-0.055916	0.0462	7.1	0.438360004	0.00399	10.5263
.dx-48.FIN2	0.1	3.3	0.01516	2.2	0.15156	0.0477	2.9	0.471204419	0.00494	7.69231
.dx-62.FIN2	0.103	3.1	0.01574	2.1	0.24109	0.048	2.7	0.408029717	0.0052	7.30769
.dx-58.FIN2	0.1251	5.0	0.01847	2.7	-0.048785	0.05	5.2	0.504801388	0.00632	9.81013
.dx-42.FIN2	0.162	5.9	0.02426	2.9	0.14288	0.0489	5.7	0.338619077	0.00809	11.8665
.dx-47.FIN2	0.472	3.2	0.06278	2.2	0.21504	0.0546	2.7	0.446015963	0.0204	7.84314
.dx-10.FIN2	0.579	2.4	0.07429	2.2	0.34783	0.0563	2.0	0.501099404	0.02316	6.90846
.dx-8.FIN2	1.442	2.1	0.1482	2.0	0.42855	0.06969	1.4	0.493798043	0.045	6.88889
.dx-2.FIN2	1.467	2.7	0.152	2.2	0.16819	0.0699	2.1	0.537329194	0.0482	7.46888
.dx-61.FIN2	1.55	2.6	0.1559	2.2	0.27978	0.0719	2.1	0.493468276	0.0507	7.29783
.dx-24.FIN2	1.689	2.4	0.1658	2.1	0.37339	0.0736	1.8	0.453005694	0.0522	6.89655
.dx-25.FIN2	1.704	2.0	0.169	2.0	0.32473	0.07316	1.2	0.568686224	0.05198	6.73336
.dx-11.FIN2	1.746	2.3	0.1711	2.1	0.52094	0.07397	1.5	0.402279376	0.052	7.11538
.dx-41.FIN2	1.827	3.0	0.1719	2.4	0.1901	0.077	2.7	0.522854011	0.0539	7.42115
.dx-63.FIN2	1.76	2.3	0.1726	2.3	0.70943	0.07378	1.3	0.374638609	0.0543	6.99816
.dx-27.FIN2	1.727	3.9	0.1735	2.8	0.36366	0.0724	3.6	0.364224788	0.0525	7.80952
.dx-3.FIN2	1.755	2.6	0.1736	2.1	0.3566	0.0734	2.0	0.439057397	0.0528	7.19697
.dx-21.FIN2	1.797	2.3	0.1738	2.1	0.20452	0.0741	1.6	0.585154014	0.0532	7.14286
.dx-35.FIN2	1.827	2.1	0.1775	2.0	0.4888	0.07522	1.3	0.467462274	0.0545	6.78899
.dx-30.FIN2	1.967	2.7	0.1847	2.3	0.17514	0.077	2.3	0.564259342	0.0554	7.94224
.dx-49.FIN2	2.1	2.1	0.1924	2.0	0.49786	0.07875	1.3	0.476142255	0.0592	6.92568

.dx-26.FIN2	2.084	2.2	0.1934	2.1	0.56138	0.07868	1.4	0.432042498	0.06007	6.82537
.dx-39.FIN2	2.157	2.3	0.196	2.2	0.32947	0.08	1.6	0.558852278	0.0592	6.92568
.dx-54.FIN2	2.18	2.5	0.1969	2.2	0.20992	0.081	2.2	0.577828627	0.0602	6.97674
.dx-44.FIN2	2.181	2.5	0.1981	2.2	0.43446	0.0805	1.6	0.440731172	0.0619	7.10824
.dx-60.FIN2	2.266	3.2	0.2021	2.4	0.44086	0.0825	2.5	0.328092657	0.0623	7.70465
.dx-15.FIN2	2.303	2.0	0.2046	2.0	0.28509	0.08126	1.2	0.588025138	0.0613	7.01468
.dx-55.FIN2	2.386	2.3	0.2056	2.2	0.53276	0.0835	1.4	0.427149175	0.0656	7.0122
.dx-51.FIN2	2.713	2.6	0.226	2.3	0.31247	0.0871	2.2	0.51234752	0.0695	7.6259
.dx-57.FIN2	2.727	2.0	0.2266	2.1	0.57041	0.08802	1.2	0.504451392	0.068	6.91176
.dx-36.FIN2	2.7	2.1	0.2295	2.1	0.4694	0.08518	1.3	0.521028382	0.0683	6.73499
.dx-5.FIN2	2.914	2.2	0.2363	2.0	0.50193	0.0889	1.3	0.451483787	0.0687	7.13246
.dx-53.FIN2	3.059	2.2	0.2461	2.0	0.34045	0.0905	1.4	0.520728443	0.0735	7.21088
.dx-4.FIN2	3.07	2.3	0.2468	2.0	0.41328	0.0897	1.6	0.45301529	0.0718	6.96379
.dx-52.FIN2	3.107	2.2	0.2471	2.1	0.46319	0.0908	1.3	0.486816174	0.0757	6.86922
.dx-65.FIN2	3.854	2.1	0.2774	2.1	0.49681	0.101	1.4	0.484658516	0.0843	6.76157
.dx-31.FIN2	3.997	2.5	0.2826	2.1	0.42937	0.1025	1.7	0.43521435	0.0837	7.04898
.dx-56.FIN2	4.461	2.2	0.3019	2.2	0.57018	0.1075	1.5	0.455069791	0.0927	6.90399
.dx-6.FIN2	4.642	2.0	0.3059	2.0	0.68017	0.10989	1.0	0.423285116	0.0908	6.82819
.dx-46.FIN2	4.701	2.1	0.3116	2.2	0.53722	0.1098	1.4	0.505553975	0.0909	7.26073
.dx-9.FIN2	4.761	2.3	0.3198	2.9	0.68774	0.1075	1.8	0.608997975	0.0986	7.30223
.dx-45.FIN2	4.979	2.0	0.3195	2.0	0.4565	0.1129	1.3	0.519447629	0.0948	6.85654
.dx-37.FIN2	4.929	2.0	0.3208	2.1	0.54762	0.1114	1.3	0.486920823	0.0963	6.95742
.dx-7.FIN2	5.934	2.0	0.3509	2.1	0.60962	0.1217	1.2	0.467416361	0.1035	6.8599
.dx-13.FIN2	6.393	2.2	0.3649	2.1	0.57826	0.1259	1.4	0.427068892	0.1064	6.8609
.dx-22.FIN2	12.7	2.2	0.5029	2.0	0.45104	0.1844	1.4	0.450905978	0.1405	6.90391
.dx-23.FIN2	13.12	2.1	0.5086	2.2	0.66752	0.1874	1.1	0.457827207	0.1399	7.14796
RW:RW										
.rw-245.FIN2	0.0092	19.6	0.00135	5.0	-0.058244	0.0496	19.4	0.299041257	0.000515	17.6699
.rw-38.FIN2	0.0095	17.9	0.00137	5.5	-0.13392	0.054	18.5	0.404993054	0.00047	21.2766
.rw-238.FIN2	0.0328	5.2	0.00524	2.9	0.14235	0.0464	5.2	0.382657266	0.00178	8.98876
.rw-16.FIN2	0.0482	10.8	0.00696	3.3	0.036756	0.0489	10.4	0.260429224	0.00232	10.7759
.rw-165.FIN2	0.0467	5.1	0.00725	2.5	0.22913	0.0464	4.7	0.252462943	0.002455	7.73931
.rw-135.FIN2	0.0478	11.3	0.00736	3.3	0.11047	0.0474	9.7	0.176461346	0.00244	9.83607
.rw-261.FIN2	0.0498	4.2	0.00748	2.5	0.012524	0.0485	4.1	0.50807889	0.00246	8.53659
.rw-30.FIN2	0.0471	8.9	0.00751	3.2	0.10701	0.0452	8.8	0.245108854	0.00251	9.16335
.rw-169.FIN2	0.0584	7.5	0.009	2.7	-0.027816	0.0467	7.7	0.356770856	0.0029	9.31034
.rw-252.FIN2	0.0615	4.6	0.00974	2.4	0.18044	0.0458	4.4	0.325179633	0.00317	7.88644
.rw-264.FIN2	0.0767	6.3	0.01161	2.8	0.074533	0.0486	6.2	0.355800885	0.00387	8.78553
.rw-265.FIN2	0.101	7.8	0.01497	3.3	-0.079847	0.0494	8.1	0.453253983	0.00456	11.4035
.rw-243.FIN2	0.1821	4.0	0.02715	2.4	0.1451	0.0486	3.7	0.415615249	0.00935	7.37968
.rw-145.FIN2	0.2186	3.4	0.03173	2.8	0.40043	0.0501	2.8	0.421809436	0.01095	7.48858
.rw-256.FIN2	0.2521	3.1	0.03619	2.1	0.25158	0.051	2.4	0.410806504	0.01163	7.2227
.rw-35.FIN2	0.257	3.0	0.03643	2.3	0.30413	0.0506	2.6	0.445944406	0.01213	7.83182
.rw-148.FIN2	0.2552	2.7	0.03683	2.1	0.2084	0.0503	2.2	0.492729674	0.01205	7.21992
.rw-259.FIN2	0.49	3.9	0.06532	2.3	0.039126	0.0544	3.9	0.484284098	0.0208	9.13462
.rw-251.FIN2	0.5422	2.4	0.06879	2.0	0.30455	0.05695	1.9	0.496133983	0.02186	6.86185
.rw-5.FIN2	0.573	2.8	0.07	2.4	0.20637	0.0589	2.7	0.561152462	0.02495	7.21443
.rw-154.FIN2	0.58	2.9	0.07382	2.2	0.26213	0.0576	2.6	0.443368848	0.02371	7.59173
.rw-22.FIN2	0.581	2.6	0.0748	2.3	0.42476	0.0569	2.1	0.449493464	0.02503	7.19137

.rw-44.FIN2	0.654	3.1	0.0803	2.2	0.23194	0.0587	2.7	0.457926157	0.025	8.4
.rw-263.FIN2	0.661	3.5	0.0806	2.2	0.03576	0.0592	3.5	0.518541882	0.0257	7.7821
.rw-21.FIN2	0.659	2.4	0.08196	2.1	0.37676	0.05798	1.7	0.458224599	0.02705	7.02403
.rw-139.FIN2	0.668	2.4	0.08285	2.1	0.36636	0.05836	1.7	0.466182643	0.02695	7.05009
.rw-151.FIN2	0.654	2.4	0.08326	2.2	0.43012	0.0573	1.7	0.448932471	0.02652	6.78733
.rw-134.FIN2	0.888	3.0	0.1046	2.2	0.092892	0.0615	2.9	0.534865114	0.0346	7.51445
.rw-170.FIN2	1.526	2.5	0.1493	2.3	0.16578	0.0726	2.1	0.618210117	0.0464	7.11207
.rw-146.FIN2	1.463	2.8	0.1535	2.3	0.25639	0.0699	2.3	0.499445848	0.0456	7.67544
.rw-26.FIN2	1.58	2.5	0.1591	2.2	0.3207	0.0712	2.1	0.500955858	0.0506	7.11462
.rw-6.FIN2	1.611	2.6	0.1612	2.3	0.30376	0.0728	2.3	0.517791026	0.0539	7.79221
.rw-31.FIN2	1.644	3.0	0.1621	2.4	0.2256	0.0724	2.8	0.501996821	0.0523	7.26577
.rw-249.FIN2	1.622	2.1	0.1622	2.1	0.21732	0.0724	1.5	0.625571738	0.0515	7.37864
.rw-158.FIN2	1.628	2.6	0.1622	2.2	0.30444	0.0728	2.2	0.490308001	0.0516	7.36434
.rw-11.FIN2	1.699	2.5	0.1655	2.7	0.55613	0.0738	2.0	0.529095351	0.0561	7.48663
.rw-239.FIN2	1.691	2.2	0.1664	2.1	0.47887	0.07386	1.4	0.461851283	0.0528	6.81818
.rw-141.FIN2	1.654	2.8	0.1669	2.2	0.33096	0.0719	2.1	0.413150217	0.0541	7.39372
.rw-45.FIN2	1.699	2.2	0.1673	2.0	0.32838	0.07354	1.5	0.521548899	0.0528	7.38636
.rw-34.FIN2	1.697	2.7	0.1672	2.3	0.4062	0.0731	1.9	0.460019377	0.0523	7.45698
.rw-43.FIN2	1.721	2.7	0.1681	2.2	0.13647	0.0743	2.3	0.559939158	0.0518	7.33591
.rw-163.FIN2	1.691	2.2	0.1682	2.1	0.398	0.0725	1.5	0.498814987	0.0508	7.28346
.rw-149.FIN2	1.719	2.8	0.1688	2.2	0.30685	0.0736	2.2	0.448910783	0.0541	7.7634
.rw-240A.FIN2	1.748	2.1	0.1697	2.0	0.59791	0.07503	1.2	0.398841051	0.0526	7.03422
.rw-10.FIN2	1.721	3.1	0.1702	2.3	0.1486	0.0736	2.7	0.515848804	0.0547	7.49543
.rw-137.FIN2	1.727	2.3	0.171	2.0	0.33868	0.0734	1.6	0.498999448	0.052	6.92308
.rw-247A.FIN2	1.766	2.4	0.1713	2.1	0.28733	0.0738	1.9	0.515208428	0.0533	6.94184
.rw-244.FIN2	1.751	2.3	0.1717	2.2	0.37518	0.074	1.6	0.522565384	0.055	7.09091
.rw-258.FIN2	1.766	2.5	0.1725	2.3	0.29158	0.0746	2.1	0.54293829	0.0522	7.47126
.rw-167.FIN2	1.762	2.2	0.1754	2.1	0.54475	0.07301	1.3	0.459103079	0.05441	6.80022
.rw-138.FIN2	1.828	2.2	0.1758	2.1	0.41086	0.07524	1.5	0.500813623	0.0547	6.76417
.rw-268.FIN2	1.793	2.1	0.1761	1.9	0.54463	0.0747	1.2	0.422534645	0.0538	6.69145
.rw-155.FIN2	1.797	2.5	0.1764	2.1	0.1518	0.0744	2.2	0.57006335	0.0544	6.98529
.rw-142.FIN2	1.773	2.0	0.1768	2.0	0.52408	0.0732	1.3	0.490015694	0.05602	6.78329
.rw-36.FIN2	1.851	2.6	0.1779	2.2	0.32212	0.0751	2.0	0.483748407	0.0566	7.24382
.rw-42.FIN2	1.89	2.2	0.1796	2.0	0.41761	0.07624	1.4	0.47043226	0.0566	6.89046
.rw-248.FIN2	1.904	2.0	0.1805	2.0	0.49015	0.07608	1.3	0.505456184	0.05783	6.91683
.rw-106.FIN2	1.907	2.2	0.1824	2.1	0.48982	0.07517	1.5	0.463562754	0.0595	7.73109
.rw-29.FIN2	1.957	2.3	0.1827	2.1	0.32631	0.0766	1.7	0.537188797	0.0563	7.1048
.rw-157.FIN2	1.924	2.4	0.1828	2.1	0.50487	0.076	1.6	0.389098657	0.05812	6.88231
.rw-166.FIN2	1.895	2.5	0.1854	2.1	0.38935	0.075	1.9	0.445846727	0.057	6.84211
.rw-132.FIN2	1.991	2.3	0.1858	2.2	0.37527	0.0777	1.7	0.514761927	0.0563	6.92718
.rw-140.FIN2	1.961	2.2	0.1861	2.2	0.56348	0.07672	1.4	0.4711211	0.0597	6.86767
.rw-144.FIN2	1.985	3.2	0.1863	2.3	0.27516	0.0783	2.8	0.41236098	0.0609	7.88177
.rw-250.FIN2	2.021	2.7	0.1869	2.2	0.39221	0.0784	2.0	0.422498788	0.0601	7.48752
.rw-275.FIN2	2.087	2.5	0.1887	2.2	0.48621	0.0813	1.7	0.42228513	0.0574	7.14286
.rw-136.FIN2	2.042	2.6	0.1904	2.2	0.28009	0.0772	2.1	0.51041596	0.0577	6.93241
.rw-17.FIN2	2.069	2.0	0.1905	2.2	0.51825	0.07903	1.4	0.535288083	0.0615	6.99187
.rw-242.FIN2	2.089	2.5	0.191	2.1	0.29658	0.0798	1.9	0.484457408	0.0607	7.41351
.rw-25.FIN2	2.085	2.4	0.1914	2.2	0.40051	0.0785	1.8	0.518379659	0.0594	7.23906
.rw-153.FIN2	2.09	2.3	0.1924	2.1	0.4935	0.0788	1.6	0.44679392	0.0603	7.29685

.rw-1.FIN2	2.118	2.4	0.1933	2.4	0.66906	0.0794	1.5	0.416726715	0.0647	7.10974
.rw-147.FIN2	2.129	2.3	0.1948	2.1	0.42205	0.0793	1.6	0.477309852	0.0605	7.27273
.rw-164.FIN2	2.093	2.2	0.197	2.0	0.35035	0.07755	1.4	0.53559644	0.0598	6.85619
.rw-4.FIN2	2.255	2.8	0.1983	2.3	0.51504	0.0821	2.1	0.332593885	0.0683	7.17423
.rw-159.FIN2	2.164	2.3	0.1988	2.2	0.54953	0.0791	1.5	0.41995656	0.0621	6.92432
.rw-14.FIN2	2.156	2.7	0.1993	2.6	0.2807	0.0786	2.2	0.572699107	0.0683	7.61347
.rw-33.FIN2	2.3	2.7	0.2023	2.3	0.37159	0.0817	2.2	0.442841146	0.0589	7.13073
.rw-270.FIN2	2.245	2.2	0.2021	2.0	0.49652	0.0809	1.5	0.430798094	0.0614	6.84039
.rw-12.FIN2	2.226	4.0	0.2025	2.7	0.22397	0.0791	3.7	0.429158076	0.0658	9.72644
.rw-150.FIN2	2.201	2.2	0.2021	2.1	0.59016	0.07935	1.4	0.412494757	0.0636	6.91824
.rw-18.FIN2	2.309	2.3	0.204	2.2	0.49602	0.082	1.7	0.454977853	0.0673	7.13224
.rw-2.FIN2	2.608	4.2	0.2125	3.2	0.094787	0.0869	4.6	0.548334283	0.075	11.0667
.rw-9.FIN2	2.586	2.5	0.2152	2.3	0.33977	0.0869	2.0	0.525072588	0.0717	7.11297
.rw-143.FIN2	2.923	2.5	0.2169	2.3	0.66897	0.0981	1.4	0.316688256	0.0944	7.09746
.rw-156.FIN2	2.523	2.3	0.2194	2.1	0.44837	0.0839	1.7	0.463609675	0.069	7.24638
.rw-247.FIN2	2.5	5.2	0.2196	3.5	-0.025956	0.0825	6.1	0.568891437	0.0679	7.95287
.rw-15.FIN2	2.576	3.0	0.2194	2.3	0.26445	0.0841	2.6	0.458792313	0.0718	7.79944
.rw-57.FIN2	2.698	2.0	0.2206	2.1	0.75644	0.08822	1.0	0.426083546	0.0693	6.92641
.rw-160.FIN2	2.544	2.8	0.2211	2.3	0.48492	0.0835	2.2	0.348688548	0.0654	7.33945
.rw-257.FIN2	2.667	2.2	0.225	2.0	0.32178	0.0859	1.5	0.523857754	0.0693	7.21501
.rw-273.FIN2	2.719	2.4	0.2264	2.2	0.42126	0.0878	1.8	0.484691135	0.0673	6.98366
.rw-8.FIN2	2.7	2.6	0.2281	2.6	0.44634	0.0852	2.1	0.524551088	0.077	7.27273
.rw-19.FIN2	2.771	2.9	0.2294	2.3	0.34795	0.0878	2.4	0.430491348	0.0725	7.86207
.rw-253.FIN2	2.883	2.2	0.234	2.1	0.50847	0.08977	1.3	0.475358459	0.0706	6.94051
.rw-246.FIN2	2.89	2.1	0.2347	2.2	0.44569	0.0884	1.5	0.535220595	0.0748	7.21925
.rw-162.FIN2	2.87	2.1	0.2365	2.2	0.4921	0.0877	1.4	0.526704827	0.0715	6.99301
.rw-255.FIN2	2.915	2.2	0.2373	2.1	0.43856	0.0892	1.6	0.504602666	0.0723	6.77732
.rw-254.FIN2	2.978	2.2	0.2406	2.1	0.49052	0.0905	1.3	0.456538052	0.0703	6.82788
.rw-23.FIN2	3.1	3.5	0.2442	3.3	0.74646	0.0908	2.2	0.256752956	0.0828	7.36715
.rw-262.FIN2	3.131	2.2	0.2459	2.1	0.34655	0.0923	1.5	0.55579292	0.074	7.16216
.rw-32.FIN2	3.114	3.5	0.2458	2.6	0.14399	0.0914	3.2	0.514086819	0.0755	7.28477
.rw-274.FIN2	3.146	2.5	0.2491	2.4	0.47685	0.092	2.0	0.478089214	0.0739	8.11908
.rw-276.FIN2	3.972	2.5	0.2865	2.3	0.35672	0.1021	2.0	0.51298758	0.0796	7.78894
.rw-241.FIN2	4.27	2.2	0.293	2.3	0.54199	0.1059	1.5	0.496938385	0.093	7.09677
.rw-240.FIN2	4.299	2.1	0.2941	2.0	0.55182	0.1059	1.2	0.438097515	0.0888	6.86937
.rw-237.FIN2	4.2	4.0	0.2958	3.2	0.61427	0.1027	2.5	0.231228055	0.0917	7.52454
.rw-271.FIN2	4.473	2.2	0.3082	2.4	0.75592	0.1056	1.4	0.420655217	0.0924	6.81818
.rw-28.FIN2	4.756	2.3	0.3141	2.1	0.43097	0.1095	1.6	0.478173778	0.0968	7.43802
.rw-20.FIN2	4.985	2.0	0.3154	2.2	0.41765	0.1132	1.4	0.595155922	0.0991	7.06357
.rw-260.FIN2	4.922	2.2	0.322	2.1	0.51171	0.1119	1.4	0.461644386	0.0952	6.93277
.rw-171.FIN2	5.257	2.1	0.3377	2.1	0.35562	0.1136	1.6	0.578764023	4900	59.1837
.rw-168.FIN2	5.307	2.1	0.3408	2.1	0.67948	0.1131	1.1	0.420242731	0.1035	6.76329
.rw-13.FIN2	5.69	2.8	0.3497	2.9	0.38943	0.1194	2.4	0.563042979	0.1188	7.32323
.rw-152.FIN2	8.476	2.0	0.4049	2.1	0.78494	0.1519	1.1	0.373449271	0.1178	6.79117
.rw-3.FIN2	11.26	2.7	0.4512	2.7	0.52772	0.1809	2.1	0.484546988	0.1419	7.04722
.rw-27.FIN2	11.1	2.0	0.4616	2.0	0.7495	0.1728	1.0	0.374072346	0.1384	6.79191
.rw-7.FIN2	13.07	2.2	0.5039	2.2	0.58062	0.1866	1.3	0.44380796	0.1563	7.03775
.rw-267.FIN2	12.54	2.6	0.5081	2.6	0.63091	0.1805	1.7	0.432080486	0.1259	7.46624
.rw-161.FIN2	12.56	2.3	0.512	2.3	0.36565	0.1793	1.7	0.57222548	700	557.143
.rw-133.FIN2	12.51	2.2	0.5133	2.1	0.55774	0.177	1.4	0.46435149	0.1466	6.82128
.rw-269.FIN2	12.65	2.3	0.5134	2.3	0.87182	0.179	1.1	0.288789459	0.1445	6.92042
.rw-266.FIN2	13	2.0	0.5197	2.1	0.62726	0.1828	1.1	0.484243603	0.1444	6.71745

Appendix II Continued. Isotopic Ratios and Age Dates for Run Number One (University of Kansas - 2/06/2017)

	Dates (Ma)										Composition		
Sample and Analysis Number	206Pb/ 238U b	±2σ abs	207Pb/ 235U b	±2σ abs	% disc c	207Pb/ 206Pb b	±2σ abs	% disc d	208Pb/ 232Th e	±2σ abs	conc U(ppm)	Th (ppm) f	Th/ U f
Dunn::Dunn													
.dunn-44.FIN2	1.87	0.33	-1.1	2.2	270	-2600	2000	100.1	2.7	1.8	116.9	83.7	0.715996578
.dunn-16.FIN2	1.89	0.19	1.9	1.1	0.5	-1240	980	100.2	2.5	1.1	243.7	111.8	0.458760771
.dunn-51.FIN2	1.97	0.22	2.2	1.2	10.5	110	720	98.2	2.9	1	213.2	135.9	0.637429644
.dunn-46.FIN2	8.1	1.1	9.8	6.5	17.3	100	1100	91.9	5.1	7	57.6	23.22	0.403125
.dunn-1.FIN2	22.73	0.75	23.5	1.5	3.3	140	130	83.8	23.8	2	297	218.1	0.734343434
.dunn-62.FIN2	24.2	1.2	24.8	4.7	2.4	40	330	39.5	24.4	4.5	112.9	84.3	0.746678477
.dunn-77.FIN2	24.63	0.62	24.39	0.98	-1.0	32	76	23.0	26.6	2.1	645	364.2	0.564651163
.dunn-37.FIN2	25.02	0.7	25.4	1.5	1.5	110	110	77.3	24.2	2.2	388	194.9	0.502319588
.dunn-75.FIN2	25.57	0.9	27.8	2.9	8.0	240	200	89.3	34.4	3.8	175.5	113.2	0.645014245
.dunn-54.FIN2	25.99	0.81	26.4	1.8	1.6	70	120	62.9	30.5	2.7	278.4	190.1	0.68283046
.dunn-48.FIN2	26.2	1.1	26	3.4	-0.8	100	220	73.8	30.4	4	96.4	64	0.663900415
.dunn-24.FIN2	26.73	0.8	27	1.5	1.0	130	110	79.4	28.3	2.4	310	208	0.670967742
.dunn-83.FIN2	27.51	1.1	28.1	2.3	2.1	140	160	80.4	31.3	3	158.5	136.9	0.863722397
.dunn-7.FIN2	28.29	0.88	28.4	2.6	0.4	90	170	68.6	29.1	2.8	191	123.6	0.647120419
.dunn-45.FIN2	28.82	0.86	31.9	2.1	9.7	210	130	86.3	31.5	3.1	272	195	0.716911765
.dunn-20.FIN2	30.61	0.84	31.3	2.3	2.2	100	130	69.4	32.8	3	311.2	208.4	0.66966581
.dunn-73.FIN2	31.76	0.88	34	2.6	6.6	200	150	84.1	40.7	3.8	299	254	0.849498328
.dunn-3.FIN2	31.84	1.1	31.8	3.2	-0.1	10	170	-218.4	30.9	2.8	143.9	167.2	1.161917999
.dunn-67.FIN2	32.21	0.85	32.5	1.8	0.9	77	100	58.2	33.6	2.5	410	521.5	1.27195122
.dunn-34.FIN2	32.4	1.5	34	4.8	4.7	120	250	73.0	43.2	5.3	64.7	51.72	0.799381762
.dunn-5.FIN2	33.4	1.5	32.2	3.4	-3.7	-	-	-	37.4	5	162.8	71.7	0.44041769
.dunn-28.FIN2	35.07	0.91	33.3	2.1	-5.3	40	120	12.3	37.2	3	271.1	313	1.154555515
.dunn-23.FIN2	36	1.7	37.7	4	4.5	150	200	76.0	38.4	6	95.8	39.5	0.412317328
.dunn-6.FIN2	36.99	0.92	37.3	2.1	0.8	90	110	58.9	36.6	3.2	303	159	0.524752475
.dunn-59.FIN2	43.5	1	44.6	1.8	2.5	109	74	60.1	44.3	3.3	539.3	359.8	0.667161135
.dunn-60.FIN2	44.68	0.97	44	1.4	-1.5	61	57	26.8	46.1	3.4	963	501	0.520249221
.dunn-74.FIN2	46.63	1.2	46.6	2.1	-0.1	37	86	-26.0	57.8	4.6	243	144.3	0.59382716
.dunn-11.FIN2	48.3	2.5	42.6	6.8	-13.4	-120	250	140.3	50.1	9.4	53.4	24.45	0.457865169
.dunn-52.FIN2	57.1	1.7	57.1	4	0.0	90	130	36.6	57.8	6.3	165.4	52.3	0.316203144
.dunn-14.FIN2	57.21	1.3	56.2	1.9	-1.8	32	68	-78.8	56.5	4.6	515	126.3	0.245242718
.dunn-59A.FIN2	60.1	3.1	607	18	90.1	4640	100	98.7	64.1	5.1	37.4	203.2	5.43315508
.dunn-17.FIN2	62.87	1.3	62.6	1.6	-0.4	76	46	17.3	68	6.6	1004	73.5	0.073207171
.dunn-32.FIN2	63.02	1.4	62.4	2.2	-1.0	67	66	5.9	62.1	5.3	393	82.8	0.210687023
.dunn-55.FIN2	72.8	1.9	71.1	2.8	-2.4	60	79	-21.3	80.6	6.1	393	198	0.503816794
.dunn-50.FIN2	74.4	1.9	73	3.1	-1.9	97	89	23.3	81.4	9.2	231.5	40	0.172786177
.dunn-25.FIN2	75	2.5	75.2	5.4	0.3	150	130	50.0	75	9.1	105.9	38	0.358829084
.dunn-79.FIN2	77.3	1.9	76.4	3.2	-1.2	112	78	31.0	78.5	6.4	273	126.7	0.464102564
.dunn-15A.FIN2	77.6	8.6	258	50	69.9	2530	470	96.9	125	20	10.5	19.5	1.857142857
.dunn-69A.FIN2	77.8	2.9	77.5	5.7	-0.4	150	160	48.1	81	12	110.9	27.71	0.249864743
.dunn-64B.FIN2	82.6	2.5	274.8	8.5	69.9	2621	62	96.8	200.4	15	94.6	56.9	0.601479915
.dunn-57.FIN2	84.1	2.2	86.2	4	2.4	172	92	51.1	102.6	9	192.8	59	0.306016598
.dunn-64A.FIN2	119.3	3.4	315	9.3	62.1	2235	64	94.7	166.4	13	71.8	91.3	1.271587744
.dunn-12.FIN2	161.5	4	154.4	9	-4.6	70	120	-130.7	167	14	69.8	65.2	0.934097421
.dunn-13.FIN2	182.2	4	179	5.8	-1.8	157	63	-16.1	179.6	14	249	85.4	0.342971888

.dunn -87.FIN2	208	4.6	204.9	5.2	-1.5	192	56	-8.3	217.5	16	242.6	112.3	0.462901896
.dunn -81.FIN2	214.7	4.9	211.5	7.3	-1.5	184	73	-16.7	230	18	97.1	50.3	0.518022657
.dunn -31.FIN2	220.7	5.1	215.5	9.3	-2.4	141	87	-56.5	221	19	84.8	26.3	0.310141509
.dunn -49.FIN2	321.8	6.9	315.6	8.2	-2.0	282	59	-14.1	342	25	156.6	53.4	0.340996169
.dunn -69.FIN2	365.1	8.9	358	14	-2.0	335	86	-9.0	349	29	42.5	25.69	0.604470588
.dunn -84.FIN2	462.9	10	463.3	11	0.1	469	62	1.3	459	36	98.1	41.9	0.427115189
.dunn -86.FIN2	623.4	13	655	15	4.8	747	51	16.5	661	46	202.4	161.8	0.799407115
.dunn -30.FIN2	639.7	14	637	15	-0.4	637	61	-0.4	639	46	48.3	31.47	0.651552795
.dunn -91.FIN2	742	23	835	28	11.1	1066	83	30.4	776	81	68	14.14	0.207941176
.dunn -52A..FIN2	842	21	876	22	3.9	989	73	14.9	1083	81	331	66.9	0.202114804
.dunn -26.FIN2	899	19	922	16	2.5	989	43	9.1	933	66	61.1	22.62	0.370212766
.dunn -66.FIN2	979	19	992	16	1.3	1027	37	4.7	995	70	110.9	26.93	0.24283138
.dunn -15.FIN2	984	21	993	20	0.9	1028	61	4.3	1011	82	27.4	9.23	0.336861314
.dunn -64.FIN2	1009.6	19	1005.4	14	-0.4	1011	30	0.1	1029	68	202	181.1	0.896534653
.dunn -70.FIN2	1020	20	1028.5	14	0.8	1042	33	2.1	1082	77	100.6	26.23	0.260735586
.dunn -43.FIN2	1026	24	1053	28	2.6	1120	92	8.4	1093	100	11.29	5.39	0.47741364
.dunn -89.FIN2	1032	21	1033	17	0.1	1028	40	-0.4	1066	72	81.6	86.7	1.0625
.dunn -19.FIN2	1039	21	1034	15	-0.5	1059	37	1.9	1066	72	71	69.9	0.984507042
.dunn -40.FIN2	1041	22	1047	19	0.6	1056	52	1.4	1101	83	31.47	11.73	0.372735939
.dunn -38.FIN2	1048	20	1058	16	0.9	1092	35	4.0	1102	75	71.4	50.8	0.711484594
.dunn -47.FIN2	1067	21	1075.3	15	0.8	1116	29	4.4	1174	83	193.9	34.7	0.178958226
.dunn -65.FIN2	1067	24	1094	20	2.5	1151	48	7.3	1087	81	49.2	21.82	0.443495935
.dunn -9.FIN2	1080	23	1084	21	0.4	1093	58	1.2	1149	88	22	8.76	0.398181818
.dunn -4.FIN2	1101	21	1095.2	14	-0.5	1091	22	-0.9	1190	160	466	1.95	0.004184549
.dunn -2.FIN2	1110	24	1110	21	0.0	1111	50	0.1	1147	89	29.1	7.69	0.264261168
.dunn -90.FIN2	1149	23	1152	17	0.3	1187	42	3.2	1173	86	52.4	10.97	0.209351145
.dunn -88.FIN2	1150	22	1152.5	15	0.2	1167	24	1.5	1150	78	250	41.6	0.1664
.dunn -41.FIN2	1166	25	1171	20	0.4	1189	45	1.9	1246	91	43.4	15.44	0.355760369
.dunn -29A..FIN2	1316	24	1300.8	15	-1.2	1285	20	-2.4	1354	88	464	169.1	0.364439655
.dunn -78.FIN2	1341	25	1341.8	16	0.1	1359	28	1.3	1371	92	108.6	42.8	0.394106814
.dunn -33.FIN2	1373	25	1363	17	-0.7	1372	27	-0.1	1416	95	96.8	45.3	0.467975207
.dunn -85.FIN2	1409	32	1413	20	0.3	1429	41	1.4	1417	96	57.9	38.7	0.668393782
.dunn -80.FIN2	1432	26	1420	17	-0.8	1429	25	-0.2	1462	97	220	66.1	0.300454545
.dunn -8.FIN2	1502	39	1561	25	3.8	1651	29	9.0	1675	120	730	101	0.138356164
.dunn -42.FIN2	1592	30	1614	19	1.4	1650	27	3.5	1684	110	81.9	69.2	0.844932845
.dunn -36.FIN2	1637	30	1658	17	1.3	1706	23	4.0	1668	110	151.7	62.9	0.414634146
.dunn -35.FIN2	1641	31	1674	19	2.0	1716	28	4.4	1724	120	53.7	29.69	0.552886406
.dunn -39.FIN2	1647	31	1658	18	0.7	1669	29	1.3	1703	110	49.8	48.98	0.983534137
.dunn -18.FIN2	1653	30	1692	17	2.3	1748	22	5.4	1712	120	126.2	31.33	0.248256735
.dunn -71.FIN2	1679	30	1707.7	17	1.7	1757	22	4.4	1675	110	154.8	31.61	0.204198966
.dunn -56.FIN2	1681	38	1713	22	1.9	1777	31	5.4	1802	120	53.4	17.39	0.325655431
.dunn -29.FIN2	1688	42	1957	28	13.7	2249	43	24.9	1880	140	223.1	38.18	0.171134021
.dunn -93.FIN2	1747	30	1755.8	17	0.5	1787	20	2.2	1792	120	225.9	68.8	0.30455954
.dunn -76.FIN2	1772	32	1801	18	1.6	1850	27	4.2	1793	120	73.7	53.5	0.725915875
.dunn -82.FIN2	1772	34	1780.1	18	0.5	1798	27	1.4	1840	130	64.8	17.34	0.267592593
.dunn -21.FIN2	1810	32	1800	17	-0.6	1798	21	-0.7	1847	120	198	54.4	0.274747475
.dunn -92.FIN2	1812	36	1828	20	0.9	1859	36	2.5	1822	120	28.91	20.16	0.697336562
.dunn -68.FIN2	1857	34	1876.6	17	1.0	1903	21	2.4	1863	120	246.3	81.3	0.330085262
.dunn -63.FIN2	1928	38	1963	20	1.8	2020	26	4.6	1905	130	66.3	30.05	0.453242836
.dunn -10.FIN2	1933	35	1954.7	18	1.1	1981	19	2.4	1989	130	101.4	50.8	0.500986193

.dunn -22.FIN2	2032	36	2066	19	1.6	2112	26	3.8	2031	140	43.2	17.13	0.396527778
.dunn -27.FIN2	2427	43	2471	20	1.8	2516	22	3.5	2557	160	74.4	67.4	0.905913978
.dunn -61.FIN2	2657	48	2694	19	1.4	2734	22	2.8	2783	180	95.5	41.2	0.431413613
.dunn -58.FIN2	2659	54	2714	23	2.0	2772	20	4.1	2668	170	202	38.4	0.19009901
.dunn -53.FIN2	2677	47	2730	18	1.9	2772	17	3.4	2838	190	261.1	47.1	0.180390655
.dunn -72.FIN2	2680	46	2686	20	0.2	2698	19	0.7	2713	170	113.3	73.1	0.645189762
.dunn -52B.FIN2	2717	45	2701.6	19	-0.6	2703	19	-0.5	2909	180	113.8	114.6	1.007029877
.dunn -32A..FIN2	2859	84	3355	51	14.8	3668	63	22.1	6780	570	3.007	2.71	0.901230462
DX::DX													
.dx-18.FIN2	20.9	0.82	22.2	2.6	5.9	210	220	90.0	22.1	2.9	238.9	153.9	0.644202595
.dx-16.FIN2	23.9	1.4	23.9	6	0.0	-	-	-	26.6	4.3	51.8	49.02	0.946332046
.dx-14.FIN2	25.12	0.95	26.9	5	6.6	230	340	89.1	31	4.4	203.9	115	0.564001962
.dx-19.FIN2	25.68	0.69	25.6	1.2	-0.3	44	95	41.6	24.6	2.3	640	236.2	0.3690625
.dx-1.FIN2	26.9	0.64	26	1.1	-3.5	-27	77	199.6	26.89	2	679	319	0.469808542
.dx-64.FIN2	27.72	0.7	26.3	1.4	-5.4	-10	100	377.2	27	3	504	124.8	0.247619048
.dx-29.FIN2	27.91	0.74	28	1.5	0.3	50	100	44.2	29	2.2	453.8	517	1.1392684
.dx-34.FIN2	28.19	0.71	28.7	1.8	1.8	100	120	71.8	28.2	2.6	403	180.4	0.44764268
.dx-43.FIN2	28.23	1	26.1	2.8	-8.2	-50	190	156.5	28.2	3.9	1200	428	0.356666667
.dx-32.FIN2	28.79	0.84	26.9	2.2	-7.0	-30	140	196.0	27.7	2.9	190.3	125.8	0.661061482
.dx-40.FIN2	29.99	0.89	29	2.1	-3.4	20	140	-50.0	31.2	2.6	226.6	194.1	0.856575463
.dx-28.FIN2	31.05	0.81	31.5	1.8	1.4	90	110	65.5	33.4	2.9	326.4	179.6	0.550245098
.dx-50.FIN2	33.09	0.98	34.1	2.7	3.0	100	150	66.9	32.6	2.6	212.3	304.5	1.434291098
.dx-12.FIN2	43.44	1.1	44.4	2.2	2.2	82	100	47.0	43.5	3.4	270.5	211.3	0.781146026
.dx-20.FIN2	44.08	1.2	42.7	2.4	-3.2	-10	100	540.8	47	3.7	241	161.3	0.669294606
.dx-17.FIN2	45.57	0.93	45.9	1.3	0.7	67	50	32.0	48.2	3.6	1282	430.4	0.335725429
.dx-59.FIN2	47.4	1.4	48.1	2.9	1.5	120	120	60.5	51.7	5	162	81.5	0.50308642
.dx-33.FIN2	73.9	1.7	72.2	2.9	-2.4	41	82	-80.2	76.8	6.5	331	97.9	0.295770393
.dx-43.FIN2	77.07	1.6	77.8	2	0.9	101	46	23.7	85.3	6	1534	776	0.505867014
.dx-38.FIN2	78.5	2.3	75.8	5	-3.6	40	130	-96.3	80.4	8.5	125.7	43.8	0.348448687
.dx-48.FIN2	97	2.1	96.7	3	-0.3	88	59	-10.2	99.5	7.7	471	156.2	0.33163482
.dx-62.FIN2	100.7	2.1	99.5	3	-1.2	103	55	2.2	104.7	7.7	578	193.1	0.334083045
.dx-58.FIN2	118	3.1	120.1	5.7	1.7	200	110	41.0	127.4	12	113.1	36.27	0.320689655
.dx-42.FIN2	154.5	4.5	151.7	8.3	-1.8	130	110	-18.8	163	19	71.1	16.51	0.232208158
.dx-47.FIN2	392.5	8.3	392.5	10	0.0	371	61	-5.8	408	31	125.5	38.1	0.303585657
.dx-10.FIN2	461.9	9.7	463.9	9.4	0.4	477	43	3.2	463	33	186	82.7	0.444623656
.dx-8.FIN2	890.8	17	905.8	13	1.7	915	29	2.6	889	61	177.3	56.55	0.318950931
.dx-2.FIN2	911.9	18	915	16	0.3	933	44	2.3	952	70	57.1	19.1	0.334500876
.dx-61.FIN2	934	19	952	16	1.9	982	42	4.9	999	71	67.1	21.21	0.31609538
.dx-24.FIN2	991.2	20	1004	15	1.3	1035	36	4.2	1031	68	82.3	50.7	0.616038882
.dx-25.FIN2	1007.4	19	1010.4	13	0.3	1018	26	1.0	1024	68	358	78.2	0.218435754
.dx-11.FIN2	1018	20	1025	15	0.7	1037	29	1.8	1023	72	144.8	41.2	0.284530387
.dx-41.FIN2	1022	23	1058	19	3.4	1110	54	7.9	1061	77	29.4	23.36	0.794557823
.dx-63.FIN2	1026	22	1030.2	15	0.4	1035	27	0.9	1068	73	410	124.8	0.304390244
.dx-27.FIN2	1031	27	1015	25	-1.6	996	72	-3.5	1033	78	20.4	17.34	0.85
.dx-3.FIN2	1033	21	1030	17	-0.3	1018	40	-1.5	1043	73	51.8	36.77	0.70984556
.dx-21.FIN2	1033	20	1043	15	1.0	1042	33	0.9	1047	73	100.7	37	0.367428004
.dx-35.FIN2	1053.2	20	1055.2	14	0.2	1073	28	1.8	1072	72	210	65.9	0.313809524
.dx-30.FIN2	1092	23	1104	18	1.1	1122	47	2.7	1089	84	46	9.9	0.215217391
.dx-49.FIN2	1134.2	21	1148	15	1.2	1163	26	2.5	1163	79	225.6	37.4	0.165780142

.dx-26.FIN2	1139	22	1142.9	15	0.3	1165	26	2.2	1179	77	234	213	0.91025641
.dx-39.FIN2	1153	23	1169	16	1.4	1195	32	3.5	1162	78	77.2	71.3	0.92357513
.dx-54.FIN2	1160	23	1180	17	1.7	1218	42	4.8	1181	80	73.5	43.5	0.591836735
.dx-44.FIN2	1168	22	1175	17	0.6	1206	33	3.2	1213	83	71.5	22.58	0.315804196
.dx-60.FIN2	1186	26	1198	22	1.0	1253	49	5.3	1225	91	29.9	11.62	0.388628763
.dx-15.FIN2	1201	22	1213.4	15	1.0	1230	26	2.4	1202	81	202	46.78	0.231584158
.dx-55.FIN2	1205	24	1238	17	2.7	1279	29	5.8	1283	87	114.9	53.3	0.463881636
.dx-51.FIN2	1313	27	1330	20	1.3	1364	41	3.7	1363	100	42.6	15.45	0.362676056
.dx-57.FIN2	1316	25	1335.1	15	1.4	1380	25	4.6	1329	89	217	44.9	0.206912442
.dx-36.FIN2	1332	25	1327.9	15	-0.3	1317	25	-1.1	1334	88	227	66.2	0.291629956
.dx-5.FIN2	1369	26	1385.6	16	1.2	1403	27	2.4	1342	93	133.9	35.3	0.263629574
.dx-53.FIN2	1418	26	1425	17	0.5	1442	28	1.7	1432	99	78.6	26.82	0.341221374
.dx-4.FIN2	1421	26	1424	18	0.2	1418	29	-0.2	1400	95	60.3	25.13	0.416749585
.dx-52.FIN2	1423	26	1433.5	16	0.7	1443	26	1.4	1475	98	151.8	44.3	0.291831357
.dx-65.FIN2	1578	29	1604.3	17	1.6	1639	25	3.7	1636	110	162.2	197.7	1.218865598
.dx-31.FIN2	1604	30	1638	20	2.1	1671	30	4.0	1628	110	39.5	45.2	1.144303797
.dx-56.FIN2	1700	33	1722	19	1.3	1753	27	3.0	1792	120	65.2	27.52	0.42208589
.dx-6.FIN2	1720	30	1757.1	16	2.1	1799	18	4.4	1756	110	177	63.1	0.356497175
.dx-46.FIN2	1750	32	1766.4	18	0.9	1793	25	2.4	1756	120	96.5	18.8	0.194818653
.dx-9.FIN2	1788	45	1777	20	-0.6	1762	33	-1.5	1900	130	284	99.2	0.349295775
.dx-45.FIN2	1788	31	1814.8	17	1.5	1846	24	3.1	1830	120	96.4	59.4	0.616182573
.dx-37.FIN2	1795	32	1807.2	18	0.7	1821	23	1.4	1858	120	119.3	44.83	0.375775356
.dx-7.FIN2	1941	36	1966.3	18	1.3	1981	21	2.0	1989	130	72.4	42.7	0.589779006
.dx-13.FIN2	2005	36	2030	19	1.2	2043	24	1.9	2043	130	57	54.3	0.952631579
.dx-22.FIN2	2625	45	2657	20	1.2	2689	24	2.4	2657	170	29.5	28.5	0.966101695
.dx-23.FIN2	2650	45	2688.5	20	1.4	2720	18	2.6	2644	180	80.5	12.74	0.15826087
RW::RW													
.rw-245.FIN2	8.66	0.43	9.2	1.8	5.9	170	340	94.9	10.4	1.8	169.1	131.4	0.777054997
.rw-38.FIN2	8.85	0.48	9.6	1.7	7.8	240	310	96.3	9.5	2.1	179.3	71.8	0.40044618
.rw-238.FIN2	33.67	0.93	32.8	1.7	-2.7	53	98	36.5	35.9	3.2	488	195.9	0.401434426
.rw-16.FIN2	44.9	1.5	47.6	5	5.7	140	190	67.9	46.8	5	135.2	97.6	0.721893491
.rw-165.FIN2	46.59	1.1	46.3	2.3	-0.6	47	91	0.9	49.6	3.8	351.4	213.1	0.606431417
.rw-135.FIN2	47.3	1.6	48.1	5	1.7	150	190	68.5	49.3	4.8	137.4	184.5	1.34279476
.rw-261.FIN2	48.04	1.2	49.3	2	2.6	134	80	64.1	49.6	4.3	342	140.5	0.410818713
.rw-30.FIN2	48.2	1.5	46.6	4.1	-3.4	-	-	-	50.6	4.7	114.2	90.4	0.791593695
.rw-169.FIN2	57.7	1.5	57.4	4.2	-0.5	70	140	17.6	58.6	5.4	112.7	84.6	0.750665484
.rw-252.FIN2	62.5	1.5	60.5	2.7	-3.3	18	83	-247.2	64	5.1	333	159.6	0.479279279
.rw-264.FIN2	74.4	2.1	74.8	4.5	0.5	130	120	42.8	78.1	6.9	128.9	78.5	0.608999224
.rw-265.FIN2	95.8	3.2	98.6	7.5	2.8	180	160	46.8	91.9	10	59.8	28.52	0.476923077
.rw-243.FIN2	172.7	4.1	169.6	6.3	-1.8	149	77	-15.9	188	14	209	125.7	0.601435407
.rw-145.FIN2	201.4	5.6	200.6	6.2	-0.4	194	64	-3.8	220.1	16	914	201	0.219912473
.rw-256.FIN2	229.2	4.8	228	6.3	-0.5	230	52	0.3	233.6	17	236	108.2	0.458474576
.rw-35.FIN2	230.6	5.3	232	6.2	0.6	220	56	-4.8	244	19	201	56.8	0.282587065
.rw-148.FIN2	233.1	4.8	230.5	5.7	-1.1	201	50	-16.0	242	17	300	111.2	0.370666667
.rw-259.FIN2	407.8	9.3	403	13	-1.2	384	80	-6.2	415	37	69	18.06	0.26173913
.rw-251.FIN2	428.8	8.5	439.5	8.7	2.4	498	40	13.9	437.1	30	205.8	183	0.889212828
.rw-5.FIN2	436.2	10	462.1	11	5.6	568	58	23.2	498	35	121.8	105.4	0.865353038
.rw-154.FIN2	459.1	9.7	463.4	11	0.9	504	57	8.9	473	35	121.9	43.17	0.35414274
.rw-22.FIN2	465.2	10	465.4	9.6	0.0	480	44	3.1	500	36	163.4	62.8	0.384332925

.rw-44.FIN2	497.9	11	510	13	2.4	551	60	9.6	500	42	56.2	15.49	0.275622776
.rw-263.FIN2	499.9	11	513	14	2.6	553	79	9.6	513	40	54.4	19.56	0.359558824
.rw-21.FIN2	507.8	10	515	9.8	1.4	520	39	2.3	539	37	298	100.5	0.337248322
.rw-139.FIN2	513.1	10	519.3	9.5	1.2	535	38	4.1	537	38	235	85.5	0.363829787
.rw-151.FIN2	515.5	10	510.3	9.7	-1.0	506	38	-1.9	529	36	280	170.5	0.608928571
.rw-134.FIN2	641.4	14	647	15	0.9	654	65	1.9	687	51	64.2	22.04	0.343302181
.rw-170.FIN2	897	19	941	15	4.7	1010	43	11.2	916	63	67.9	39	0.57437408
.rw-146.FIN2	921	20	913	17	-0.9	919	49	-0.2	901	67	35.5	15.49	0.436338028
.rw-26.FIN2	952	20	962	16	1.0	965	45	1.3	997	69	83.2	50.1	0.602163462
.rw-6.FIN2	965	21	976	17	1.1	999	48	3.4	1059	81	44.34	14.92	0.336490753
.rw-31.FIN2	968	22	987	19	1.9	1017	56	4.8	1030	74	39.6	16.76	0.423232323
.rw-249.FIN2	968.9	19	979.2	13	1.1	996	33	2.7	1015	72	153	28.19	0.184248366
.rw-158.FIN2	969	20	979	17	1.0	1008	45	3.9	1017	72	49.5	20.11	0.406262626
.rw-11.FIN2	987	25	1008	16	2.1	1042	42	5.3	1103	80	235.1	47.59	0.2024245
.rw-239.FIN2	992.3	19	1005.3	14	1.3	1034	28	4.0	1039	70	154.9	79.5	0.513234345
.rw-141.FIN2	995	20	993	18	-0.2	969	44	-2.7	1065	77	50.8	16.25	0.31988189
.rw-45.FIN2	998.3	19	1007.6	14	0.9	1027	31	2.8	1043	77	116.7	21.78	0.186632391
.rw-34.FIN2	999	21	1007	17	0.8	1014	38	1.5	1029	75	192	63.9	0.3328125
.rw-43.FIN2	1001	20	1016	18	1.5	1047	46	4.4	1020	72	30.4	21.92	0.721052632
.rw-163.FIN2	1002	19	1004.2	14	0.2	1008	31	0.6	1001	71	89.9	30.8	0.342602892
.rw-149.FIN2	1005	21	1017	18	1.2	1042	41	3.6	1065	80	44.1	12.01	0.272335601
.rw-240A.FIN2	1010.4	19	1027.5	14	1.7	1068	24	5.4	1036	72	356	31.49	0.088455056
.rw-10.FIN2	1014	22	1019	20	0.5	1020	56	0.6	1075	79	29.04	16.81	0.578856749
.rw-137.FIN2	1017.4	19	1017.7	14	0.0	1031	32	1.3	1025	70	102.1	46.2	0.452497551
.rw-247A.FIN2	1020	20	1034	16	1.4	1031	39	1.1	1049	71	66.1	65	0.983358548
.rw-244.FIN2	1023	21	1026.6	15	0.4	1045	35	2.1	1082	74	95.3	38.51	0.40409234
.rw-258.FIN2	1026	22	1032	17	0.6	1052	42	2.5	1028	75	107.6	39.9	0.370817844
.rw-167.FIN2	1042	20	1030.8	14	-1.1	1011	26	-3.1	1071	71	242	92.6	0.382644628
.rw-138.FIN2	1044	20	1054.7	15	1.0	1077	28	3.1	1076	71	136.2	82.9	0.60866373
.rw-268.FIN2	1045.7	19	1042.5	13	-0.3	1058	24	1.2	1059	70	384	198.2	0.516145833
.rw-155.FIN2	1047	20	1046	17	-0.1	1049	46	0.2	1070	73	56	35.6	0.635714286
.rw-142.FIN2	1049.5	20	1036	13	-1.3	1018	25	-3.1	1102	73	324	312	0.962962963
.rw-36.FIN2	1055	21	1062	17	0.7	1074	41	1.8	1113	78	60.4	19.17	0.317384106
.rw-42.FIN2	1064.7	19	1077.7	15	1.2	1097	29	2.9	1113	75	141.8	62.6	0.441466855
.rw-248.FIN2	1069	20	1082	14	1.2	1096	26	2.5	1136	76	234.1	86.5	0.369500214
.rw-106.FIN2	1080	21	1083.8	14	0.4	1071	28	-0.8	1168	87	167.4	11.42	0.068219833
.rw-29.FIN2	1082	21	1099.7	15	1.6	1116	33	3.0	1107	77	98	36.52	0.372653061
.rw-157.FIN2	1082	21	1088	16	0.6	1096	32	1.3	1142	76	85.7	77.2	0.900816803
.rw-166.FIN2	1096	21	1079	17	-1.6	1071	37	-2.3	1121	75	117.7	51.2	0.435004248
.rw-132.FIN2	1098	22	1112.6	15	1.3	1143	32	3.9	1106	75	91.5	47.6	0.520218579
.rw-140.FIN2	1100	22	1101.4	15	0.1	1120	29	1.8	1172	78	186	63.3	0.340322581
.rw-144.FIN2	1101	23	1113	21	1.1	1147	55	4.0	1194	91	31	9.46	0.30516129
.rw-250.FIN2	1104	22	1120	18	1.4	1161	43	4.9	1179	86	39.1	16.8	0.429667519
.rw-275.FIN2	1114	23	1143	17	2.5	1229	33	9.4	1128	77	60	37.3	0.621666667
.rw-136.FIN2	1123	23	1129	18	0.5	1136	42	1.1	1134	77	50.4	31.2	0.619047619
.rw-17.FIN2	1124	22	1138.2	14	1.2	1177	26	4.5	1206	82	287	32.3	0.112543554
.rw-242.FIN2	1126	22	1145	18	1.7	1189	36	5.3	1191	86	60.5	12.27	0.202809917
.rw-25.FIN2	1129	23	1144	17	1.3	1161	36	2.8	1165	82	141	36.92	0.261843972
.rw-153.FIN2	1134	22	1147	16	1.1	1163	31	2.5	1183	84	103.2	16.76	0.162403101

.rw-1.FIN2	1139	25	1153	17	1.2	1176	29	3.1	1267	87	150.4	47.9	0.318484043
.rw-147.FIN2	1147	22	1158	16	0.9	1181	33	2.9	1187	84	69.2	28.16	0.406936416
.rw-164.FIN2	1159.2	21	1145.9	15	-1.2	1134	27	-2.2	1173	79	156.3	53.7	0.343570058
.rw-4.FIN2	1168	25	1197	20	2.4	1250	41	6.6	1335	92	49.4	23.18	0.469230769
.rw-159.FIN2	1169	23	1168	16	-0.1	1177	32	0.7	1217	81	93.7	60.8	0.648879402
.rw-14.FIN2	1171	27	1166	19	-0.4	1158	43	-1.1	1334	98	232.7	39.41	0.169359691
.rw-33.FIN2	1187	25	1210	20	1.9	1246	42	4.7	1157	81	40.5	23.23	0.573580247
.rw-270.FIN2	1187	22	1195.5	16	0.7	1222	28	2.9	1204	80	165.5	91.6	0.55347432
.rw-12.FIN2	1188	29	1185	28	-0.3	1153	74	-3.0	1295	120	11.27	3.27	0.290150843
.rw-150.FIN2	1188	23	1182.9	16	-0.4	1180	26	-0.7	1247	83	117.3	103.5	0.882352941
.rw-18.FIN2	1196	23	1214	16	1.5	1242	33	3.7	1317	91	82.7	36.7	0.443772672
.rw-2.FIN2	1244	35	1298	30	4.2	1363	91	8.7	1470	160	6.06	2.117	0.349339934
.rw-9.FIN2	1256	26	1296	18	3.1	1354	38	7.2	1398	97	57.5	26.86	0.467130435
.rw-143.FIN2	1265	26	1386	19	8.7	1588	27	20.3	1826	120	167	39.3	0.235329341
.rw-156.FIN2	1279	25	1279	17	0.0	1302	30	1.8	1352	94	62	14.61	0.235645161
.rw-247.FIN2	1279	40	1282	43	0.2	1270	130	-0.7	1348	120	43.2	22.24	0.514814815
.rw-15.FIN2	1280	27	1295	22	1.2	1288	51	0.6	1399	110	27.8	10.24	0.368345324
.rw-57.FIN2	1285	25	1331	15	3.5	1388	20	7.4	1357	89	815	80	0.098159509
.rw-160.FIN2	1287	27	1282	20	-0.4	1275	41	-0.9	1280	91	37.3	14.7	0.394101877
.rw-257.FIN2	1308	24	1318.4	16	0.8	1334	30	1.9	1354	93	111.8	35.13	0.314221825
.rw-273.FIN2	1315	26	1335	18	1.5	1377	36	4.5	1319	88	71.7	25.12	0.350348675
.rw-8.FIN2	1324	31	1327	19	0.2	1316	40	-0.6	1498	100	141.1	57.7	0.408929837
.rw-19.FIN2	1331	27	1347	21	1.2	1374	46	3.1	1412	110	27.16	8.35	0.307437408
.rw-253.FIN2	1355	26	1376.6	16	1.6	1420	26	4.6	1379	92	98.8	37.1	0.375506073
.rw-246.FIN2	1362	26	1378.3	16	1.2	1396	27	2.4	1457	100	90.8	20.61	0.226982379
.rw-162.FIN2	1370	26	1373.2	16	0.2	1375	27	0.4	1395	93	139.9	33.4	0.238741959
.rw-255.FIN2	1376	26	1387	17	0.8	1403	30	1.9	1411	93	85.4	67.4	0.789227166
.rw-254.FIN2	1389	26	1402	17	0.9	1436	26	3.3	1373	91	114.5	129	1.126637555
.rw-23.FIN2	1408	41	1430	28	1.5	1438	42	2.1	1608	110	134.1	91.8	0.684563758
.rw-262.FIN2	1417	27	1439.3	17	1.5	1479	29	4.2	1443	99	68.5	24.16	0.35270073
.rw-32.FIN2	1418	33	1435	26	1.2	1436	61	1.3	1476	110	15.04	17.11	1.137632979
.rw-274.FIN2	1434	31	1444	19	0.7	1465	36	2.1	1440	110	449	34.9	0.077728285
.rw-276.FIN2	1626	34	1629	21	0.2	1658	37	1.9	1546	120	42.8	15.58	0.364018692
.rw-241.FIN2	1656	33	1689	18	2.0	1725	28	4.0	1802	120	76.6	23.9	0.312010444
.rw-240.FIN2	1662	29	1694.3	18	1.9	1734	23	4.2	1723	110	141.1	101.9	0.722182849
.rw-237.FIN2	1670	48	1671	33	0.1	1671	47	0.1	1774	130	102.2	101.8	0.996086106
.rw-271.FIN2	1731	36	1727	20	-0.2	1724	26	-0.4	1785	120	335	305.3	0.911343284
.rw-28.FIN2	1760	33	1777	20	1.0	1791	31	1.7	1866	130	27.54	11.74	0.426289034
.rw-20.FIN2	1767	34	1816.8	18	2.7	1850	26	4.5	1909	130	98.2	22.9	0.233197556
.rw-260.FIN2	1799	33	1806	19	0.4	1835	25	2.0	1838	120	57.9	31.5	0.544041451
.rw-171.FIN2	1875	35	1861	18	-0.8	1853	28	-1.2	57000	####	55.3	0.0291	0.000526221
.rw-168.FIN2	1890	34	1869.1	17	-1.1	1851	21	-2.1	1991	130	129.5	116.6	0.9003861
.rw-13.FIN2	1932	50	1932	22	0.0	1949	45	0.9	2269	160	39.3	37.15	0.945292621
.rw-152.FIN2	2191	39	2282.5	18	4.0	2369	19	7.5	2251	150	170.9	53.8	0.314803979
.rw-3.FIN2	2398	53	2544	24	5.7	2657	34	9.7	2687	180	15.69	8.72	0.555768005
.rw-27.FIN2	2451	43	2531.7	18	3.2	2586	16	5.2	2619	170	791	81.3	0.10278129
.rw-7.FIN2	2636	46	2686	21	1.9	2710	22	2.7	2931	200	30.7	15.94	0.519218241
.rw-267.FIN2	2648	57	2645	24	-0.1	2657	27	0.3	2397	170	421	269	0.638954869
.rw-161.FIN2	2667	53	2649	22	-0.7	2640	29	-1.0	57000	####	10.19	0.0352	0.003454367
.rw-133.FIN2	2670	47	2645	20	-0.9	2625	23	-1.7	2764	180	78.7	60.8	0.772554003
.rw-269.FIN2	2670	52	2653	22	-0.6	2643	18	-1.0	2747	180	275	44.5	0.161818182
.rw-266.FIN2	2697	45	2678.5	19	-0.7	2678	17	-0.7	2726	170	105.6	54.8	0.518939394

Appendix II Continued. Isotopic Ratios and Age Dates for Run Number Two (University of Kansas - 5/19/2017)

	Isotopic Ratios								
Sample and Analysis Number	207Pb/ 235U a	±2σ %	206Pb/ 238U a	±2σ %	207Pb/ 206Pb a	±2σ %	Corr. Coeff. 206Pb/238U-207Pb/235U	208Pb/ 232Th a	±2σ %
RM16::RM16									
RM16-01	0.732	4.5	0.0896	3	0.0592	3.3	0.65	0.0287	5.7
RM16-02	0.268	19	0.01212	4.3	0.161	19	0.15	0.0163	44
RM16-03	0.429	8.9	0.0545	6.5	0.0571	6	0.73	0.0151	9.9
RM16-04	0.0539	12	0.00731	4.8	0.0535	11	0.3	0.00298	14
RM16-05	0.0393	9.7	0.00623	5	0.0458	8.3	0.45	0.00204	4.6
RM16-06	0.0769	8.7	0.01191	4	0.0469	7.7	0.38	0.0039	12
RM16-07	0.099	15	0.01272	5.6	0.0567	14	0.26	0.00493	16
RM16-08	3.21	4.3	0.2524	2.8	0.0922	3.2	0.64	0.0749	5.2
RM16-09	1.9	7.3	0.1804	4.3	0.0766	5.8	0.51	0.0528	11
RM16-10	2.39	6.8	0.2175	3.6	0.0796	5.7	0.45	0.0607	12
RM16-11	13.72	4.8	0.527	3.5	0.1891	3.2	0.72	0.1446	4.9
RM16-12	14.62	3.7	0.541	2.8	0.1961	2.4	0.75	0.1468	4.5
RM16-13	2.21	5.5	0.204	3.7	0.0785	4.1	0.66	0.0574	6.6
RM16-14	5.3	6.7	0.372	6.1	0.1033	2.8	0.91	0.0937	6.8
RM16-15	16.77	3.5	0.574	2.2	0.2118	2.7	0.61	0.1491	4.9
RM16-16	0.093	5	0.01395	3	0.0483	4	0.56	0.00488	11
RM16-17	0.159	23	0.00116	9.6	1	21	0.25	0.59	24
RM16-18	12.97	3.5	0.521	2.5	0.1805	2.4	0.69	0.1353	4.7
RM16-19	2.67	4.5	0.232	2.6	0.0836	3.7	0.53	0.0672	6.6
RM16-20	0.1061	5.6	0.01556	3	0.0495	4.7	0.49	0.0048	8.2
RM16-21	2.013	4.8	0.1896	2.7	0.077	3.9	0.5	0.0569	6.6
RM16-22	1.642	3.4	0.1654	2.2	0.072	2.7	0.61	0.0462	6.6
RM16-23	12.62	4.4	0.507	2.7	0.1806	3.4	0.58	0.1338	5.4
RM16-24	4.46	3.3	0.3108	2.1	0.1041	2.6	0.6	0.0854	5.3
RM16-25	19.9	11	0.487	7.3	0.297	8.6	0.51	0.59	69
RM16-26	13.98	6.1	0.561	5.7	0.181	2.3	0.93	0.177	7
RM16-27	0.211	6.3	0.03004	2.8	0.0511	5.6	0.4	0.00899	7.5
RM16-28	0.487	6.2	0.066	2.9	0.0535	5.4	0.39	0.019	9.7
RM16-29	4.49	4.8	0.3028	2.9	0.1077	3.8	0.56	0.0837	6.3
RM16-30	0.613	7.1	0.0758	5.1	0.0588	5	0.71	0.0227	9.1
RM16-32	0.552	5.1	0.0714	3.4	0.0561	3.9	0.63	0.0212	6.5
RM16-33	0.0784	8.9	0.01208	3.3	0.0471	8.2	0.31	0.00369	11
RM16-34	1.796	4.7	0.1733	2.7	0.0752	3.8	0.53	0.0492	4.4
RM16-35	11.89	2.8	0.4681	1.6	0.1843	2.3	0.41	0.1378	3.8
RM16-36	2.06	5	0.1915	2.8	0.078	4.2	0.51	0.0543	6.9
RM16-37	4.27	6.3	0.294	3.8	0.1056	5.1	0.57	0.085	43
RM16-38	0.0911	9	0.01401	5	0.0472	7.5	0.49	0.00475	11
RM16-39	0.457	8.1	0.0612	3.3	0.0542	7.4	0.3	0.0182	9.7
RM16-41	3.7	6.1	0.283	4.3	0.0947	4.3	0.68	0.0736	12
RM16-42	0.0348	17	0.00477	6.8	0.0529	16	0.23	0.00186	15
RM16-43	1.76	8.9	0.1604	4.2	0.0797	7.9	0.31	0.0486	8.9
RM16-44	11.84	3.7	0.493	2.4	0.1743	2.8	0.61	0.1361	5.4
RM16-45	0.53	7.6	0.0653	3.2	0.0589	6.9	0.31	0.0204	12
RM16-46	1.74	6	0.1474	5.1	0.0857	3.1	0.85	0.025	11
RM16-47	1.854	5.2	0.1818	3.2	0.074	4.2	0.57	0.0526	6.3
RM16-48	4.53	3.8	0.3124	2.6	0.1052	2.8	0.66	0.0863	5.9
RM16-49	1.66	7.8	0.168	3.3	0.0718	7.1	0.3	0.0431	11
RM16-50	4.82	4.9	0.321	2.9	0.109	4	0.51	0.096	11
RM16-51	0.1001	4.9	0.01456	3	0.0499	3.8	0.59	0.00515	6.4
RM16-52	1.487	5.3	0.1523	3	0.0709	4.3	0.53	0.0451	7.2
RM16-53	2.004	4.7	0.1934	3.1	0.0752	3.5	0.65	0.0598	5.7
RM16-54	0.206	6.9	0.0293	3.5	0.0509	5.9	0.47	0.00939	9
RM16-55	0.15	21	0.00109	11	1	18	0.31	0.6	18
RM16-56	1.97	8.7	0.1776	3.5	0.0806	8	0.37	0.0559	7.7

RM16-57	3.4	4.2	0.268	2.9	0.0922	3.1	0.68	0.0808	5.8
RM16-58	3.06	5.5	0.1875	4.5	0.1184	3.1	0.81	0.0832	4.9
RM16-59	1.76	5.6	0.163	3.5	0.0783	4.4	0.58	0.0552	9.3
RM16-60	0.173	9.4	0.0272	4.4	0.0463	8.3	0.38	0.00809	9
RM16-61	0.0247	17	0.00387	5.3	0.0462	16	0.21	0.00122	14
RM16-62	2.02	5.3	0.1889	3.1	0.0777	4.4	0.53	0.0587	6.1
RM16-63	2.21	5.6	0.2012	3.5	0.0796	4.4	0.59	0.0628	7.6
RM16-64	12	10	0.48	9.5	0.1807	3.7	0.93	0.0649	10
RM16-65	5.05	4.6	0.3283	3	0.1117	3.5	0.63	0.0972	6.1
RM16-66	1.98	5.3	0.1865	3.2	0.0769	4.3	0.56	0.0584	7.6
RM16-67	5.57	4.4	0.349	3.5	0.1158	2.8	0.77	0.1047	6.2
RM16-68	0.0306	12	0.00414	4.7	0.0537	11	0.28	0.00161	19
RM16-69	3.24	4.5	0.2526	3.3	0.0932	3.1	0.71	0.0802	6
RM16-70	1.924	5.1	0.1866	3	0.0748	4.2	0.55	0.056	6.8
DRI::DRI									
DRI-01	1.75	9.1	0.162	5.3	0.0784	7.4	0.55	0.0556	11
DRI-02	1.879	4.7	0.1771	3.4	0.077	3.3	0.71	0.0547	6.5
DRI-03	1.88	6.4	0.1789	4.4	0.0762	4.7	0.67	0.0573	8
DRI-04	1.862	4.4	0.1827	2.9	0.0739	3.3	0.63	0.0555	7.2
DRI-06	1.918	5	0.1793	3.9	0.0776	3.2	0.77	0.0559	5.9
DRI-07	1.939	3.8	0.1862	2.5	0.0755	2.9	0.64	0.0564	5.1
DRI-08	3.17	3.8	0.2542	2.9	0.0906	2.5	0.75	0.0747	7.5
DRI-09	1.957	4.2	0.19	2.8	0.0747	3.1	0.65	0.0577	5.4
DRI-10	1.897	5.2	0.1779	3	0.0774	4.2	0.54	0.0535	7.3
DRI-11	1.96	6.8	0.1822	3.5	0.078	5.8	0.46	0.056	8.1
DRI-12	2.105	4.1	0.2008	2.8	0.0761	3	0.66	0.0599	6.5
DRI-14	1.913	4.2	0.1818	2.7	0.0764	3.3	0.61	0.051	6
DRI-15	1.93	6.4	0.1838	3.4	0.0764	5.4	0.47	0.0525	10
RWN::RWN									
RWN-01	0.548	6.4	0.0717	2.9	0.0554	5.7	0.38	0.0249	7.7
RWN-02	1.794	4.6	0.1757	3	0.0741	3.4	0.62	0.045	8.6
RWN-03	0.186	10	0.0277	3.9	0.0488	9.7	0.24	0.0093	12
RWN-04	4.45	4.7	0.308	3.2	0.1046	3.4	0.66	0.097	7.6
RWN-05	0.087	24	0.00958	7.6	0.066	23	0.18	0.00358	23
RWN-06	0.222	7.4	0.033	4.3	0.0487	6.1	0.53	0.0107	8.4
RWN-07	0.083	23	0.01307	6.9	0.046	22	0.13	0.0047	39
RWN-08	1.875	5.2	0.1844	3.3	0.0738	4.1	0.6	0.0594	8
RWN-09	1.68	7.5	0.179	4.2	0.0681	6.2	0.5	0.0561	13
RWN-10	0.081	13	0.00981	4.3	0.0598	13	0.2	0.0044	15
RWN-11	0.117	14	0.01568	4.6	0.054	13	0.21	0.00592	15
RWN-12	1.95	8.3	0.184	4.2	0.0771	7.1	0.43	0.0591	13
RWN-13	0.0962	9.2	0.01401	3.6	0.0498	8.4	0.31	0.00465	10
RWN-14	0.0822	10	0.01177	4.7	0.0507	8.9	0.33	0.00387	15
RWN-15	13.22	5	0.541	3.4	0.1772	3.6	0.64	0.147	7.6
RWN-16	3.2	3.6	0.2604	2.6	0.089	2.4	0.73	0.0729	5.9
RWN-17	0.0459	11	0.00639	4.1	0.0521	10	0.26	0.00225	17
RWN-18	0.092	25	0.01069	7.7	0.062	23	0.09	0.61	22
RWN-19	0.269	7	0.0389	3.6	0.0502	6	0.45	0.0125	9.8
RWN-20	0.0706	9.6	0.01146	4.9	0.0447	8.2	0.44	0.00359	12
RWN-21	2.12	9.7	0.1969	4.3	0.078	8.7	0.33	0.0594	12
RWN-22	2.87	9.5	0.229	7.6	0.0909	5.8	0.78	0.0802	12
RWN-23	0.552	15	0.0725	4.4	0.0553	14	0.14	0.0287	22
RWN-24	3.24	5.3	0.2565	3.1	0.0917	4.3	0.53	0.0783	9.7
RWN-25	1.85	6.2	0.1807	3.3	0.0744	5.2	0.46	0.0584	11
RWN-26	3.47	6.6	0.261	4.1	0.0966	5.1	0.56	0.087	13
RWN-27	14.8	4.4	0.564	3.3	0.1904	2.9	0.72	0.161	9.1
RWN-28	0.0503	13	0.00586	3.7	0.0623	12	0.2	0.0023	17
RWN-29	1.83	9.8	0.1699	4.4	0.0781	8.8	0.33	0.0545	17
RWN-30	2.003	4.6	0.1968	3.1	0.0739	3.4	0.65	0.0614	7.2
RWN-31	1.99	8	0.191	4	0.0757	6.9	0.42	0.0588	13
RWN-32	1.98	6.1	0.1886	2.9	0.0763	5.4	0.39	0.0593	7.3

	Dates (Ma)										Composition		
Sample and Analysis Number	206Pb/ 238U b	±2σ abs	207Pb/ 235U b	±2σ abs	207Pb/ 206Pb	±2σ abs	6/38 vs. 7/6 % disc c	6/38 vs. 7/ % disc d	208Pb/ 232Th	±2σ abs	U (ppm)	Th (ppm)	Th/ U
RM16::RM16													
RM16-01	*553*	*16*	*558*	*19*	*574*	*70*	*3.61*	*0.90*	*576*	*32*	*330.54*	*253*	*0.77*
RM16-02	*77.7*	*3.3*	*241*	*41*	*2461*	*290*	*96.84*	*67.76*	*328*	*140*	*250.8*	*52.1*	*0.21*
RM16-03	*342*	*22*	*362*	*27*	*495*	*130*	*30.97*	*5.52*	*305*	*30*	*626.56*	*512*	*0.82*
RM16-04	*46.9*	*2.2*	*53.3*	*6.3*	*350*	*240*	*86.61*	*12.01*	*60.5*	*8.3*	*394.32*	*80.7*	*0.2*
RM16-05	*40*	*2*	*39.2*	*3.7*	*-12*	*190*	*424.1*	*-2.04*	*41.4*	*1.9*	*957.69*	*1302*	*1.36*
RM16-06	*76.3*	*3*	*75.2*	*6.3*	*41*	*180*	*-85.7*	*-1.46*	*79*	*9.2*	*420.56*	*145*	*0.35*
RM16-07	*81.5*	*4.6*	*96*	*14*	*478*	*280*	*82.96*	*15.10*	*100*	*16*	*112.59*	*57.3*	*0.51*
RM16-08	*1451*	*37*	*1459*	*32*	*1471*	*59*	*1.38*	*0.55*	*1468*	*74*	*129.28*	*53.9*	*0.42*
RM16-09	*1069*	*42*	*1083*	*47*	*1110*	*110*	*3.67*	*1.29*	*1046*	*110*	*26.295*	*12.4*	*0.47*
RM16-10	*1268*	*41*	*1239*	*47*	*1187*	*110*	*-6.85*	*-2.34*	*1197*	*140*	*27.104*	*7.81*	*0.29*
RM16-11	*2727*	*78*	*2731*	*44*	*2734*	*52*	*0.22*	*0.15*	*2745*	*130*	*49.53*	*28.7*	*0.58*
RM16-12	*2787*	*63*	*2791*	*34*	*2794*	*39*	*0.25*	*0.14*	*2784*	*120*	*198.04*	*129*	*0.65*
RM16-13	*1197*	*41*	*1183*	*38*	*1159*	*79*	*-3.26*	*-1.18*	*1134*	*73*	*238.98*	*81.7*	*0.34*
RM16-14	*2039*	*110*	*1869*	*56*	*1684*	*50*	*-21.12*	*-9.10*	*1820*	*120*	*995.82*	*79.5*	*0.08*
RM16-15	*2926*	*53*	*2922*	*33*	*2919*	*43*	*-0.24*	*-0.14*	*2826*	*130*	*66.011*	*29.2*	*0.44*
RM16-16	*89.3*	*2.6*	*90.3*	*4.3*	*115*	*92*	*22.57*	*1.11*	*99*	*11*	*1576.5*	*117*	*0.07*
RM16-17	7.45	0.72	150	32	8312	11000	99.91	95.03	9413	1700	436.11	165	0.38
RM16-18	*2705*	*54*	*2677*	*32*	*2657*	*40*	*-1.79*	*-1.05*	*2580*	*110*	*75.34*	*41.9*	*0.56*
RM16-19	*1345*	*31*	*1321*	*33*	*1283*	*70*	*-4.81*	*-1.82*	*1322*	*84*	*88.708*	*25.6*	*0.29*
RM16-20	*99.5*	*3*	*102*	*5.4*	*170*	*110*	*41.44*	*2.83*	*97.4*	*7.9*	*929.06*	*350*	*0.38*
RM16-21	*1119*	*28*	*1120*	*32*	*1121*	*77*	*0.13*	*0.09*	*1124*	*72*	*88.887*	*47.4*	*0.53*
RM16-22	*987*	*20*	*986*	*22*	*986*	*53*	*-0.06*	*-0.10*	*919*	*59*	*242.84*	*24.1*	*0.1*
RM16-23	*2644*	*59*	*2652*	*41*	*2658*	*56*	*0.52*	*0.30*	*2552*	*130*	*40.851*	*35.4*	*0.87*
RM16-24	*1745*	*32*	*1723*	*27*	*1697*	*47*	*-2.82*	*-1.28*	*1666*	*85*	*245.48*	*60.8*	*0.25*
RM16-25	*2558*	*150*	*3088*	*100*	*3454*	*130*	*25.93*	*17.16*	*9390*	*4600*	*2.4212*	*0.06*	*0.03*
RM16-26	*2869*	*130*	*2749*	*57*	*2661*	*38*	*-7.8*	*-4.37*	*3318*	*210*	*709.89*	*204*	*0.29*
RM16-27	*191*	*5.3*	*195*	*11*	*243*	*120*	*21.34*	*2.15*	*182*	*14*	*582.06*	*200*	*0.34*
RM16-28	*412*	*12*	*403*	*20*	*350*	*120*	*-17.6*	*-2.23*	*383*	*37*	*144.25*	*59.4*	*0.41*
RM16-29	*1705*	*44*	*1730*	*39*	*1760*	*68*	*3.11*	*1.45*	*1634*	*98*	*56.228*	*38.5*	*0.69*
RM16-30	*471*	*23*	*486*	*27*	*557*	*110*	*15.47*	*3.09*	*457*	*41*	*511.78*	*57*	*0.11*
RM16-32	*445*	*14*	*446*	*18*	*455*	*83*	*2.28*	*0.22*	*426*	*27*	*308.35*	*190*	*0.62*
RM16-33	*77.4*	*2.5*	*76.6*	*6.5*	*54*	*190*	*-43.7*	*-1.04*	*74.9*	*7.9*	*909.57*	*224*	*0.25*
RM16-34	*1030*	*26*	*1044*	*30*	*1073*	*75*	*4.03*	*1.34*	*976*	*42*	*99.751*	*97.4*	*0.98*
RM16-35	*2475*	*32*	*2596*	*26*	*2692*	*38*	*8.04*	*4.66*	*2624*	*93*	*39.14*	*53.1*	*1.36*
RM16-36	*1129*	*29*	*1135*	*34*	*1146*	*81*	*1.41*	*0.53*	*1074*	*72*	*98.575*	*28.1*	*0.29*
RM16-37	*1659*	*55*	*1688*	*51*	*1724*	*90*	*3.75*	*1.72*	*1653*	*670*	*221.52*	*2.61*	*0.01*
RM16-38	*89.7*	*4.4*	*88.6*	*7.6*	*58*	*170*	*-55.18*	*-1.24*	*96*	*11*	*931.54*	*237*	*0.25*
RM16-39	*383*	*12*	*382*	*25*	*377*	*160*	*-1.54*	*-0.26*	*366*	*35*	*78.494*	*29.6*	*0.38*
RM16-41	*1607*	*61*	*1570*	*48*	*1521*	*80*	*-5.62*	*-2.36*	*1443*	*170*	*144.74*	*57.2*	*0.4*
RM16-42	*30.7*	*2.1*	*34.7*	*5.9*	*323*	*330*	*90.52*	*11.53*	*37.8*	*5.7*	*184.06*	*96.2*	*0.52*
RM16-43	*959*	*37*	*1032*	*56*	*1189*	*150*	*19.33*	*7.07*	*964*	*84*	*14.78*	*22.3*	*1.51*
RM16-44	*2582*	*51*	*2592*	*34*	*2599*	*46*	*0.63*	*0.39*	*2593*	*130*	*57.855*	*34.3*	*0.59*
RM16-45	*408*	*13*	*432*	*27*	*564*	*140*	*27.77*	*5.56*	*411*	*49*	*90.56*	*22.3*	*0.25*
RM16-46	*886*	*42*	*1024*	*38*	*1331*	*59*	*33.41*	*13.48*	*503*	*55*	*242.47*	*124*	*0.51*
RM16-47	*1077*	*32*	*1065*	*34*	*1041*	*82*	*-3.46*	*-1.13*	*1042*	*64*	*104.63*	*44.7*	*0.43*
RM16-48	*1752*	*40*	*1736*	*32*	*1717*	*51*	*-2.05*	*-0.92*	*1683*	*94*	*170.5*	*50.1*	*0.29*
RM16-49	*1001*	*30*	*994*	*48*	*978*	*140*	*-2.32*	*-0.70*	*857*	*90*	*27.962*	*13*	*0.46*
RM16-50	*1795*	*45*	*1788*	*40*	*1781*	*70*	*-0.77*	*-0.39*	*1872*	*190*	*29.134*	*6.46*	*0.22*
RM16-51	*93.2*	*2.8*	*96.8*	*4.5*	*188*	*87*	*50.35*	*3.72*	*105*	*6.7*	*1620.1*	*423*	*0.26*
RM16-52	*914*	*26*	*925*	*31*	*953*	*86*	*4.1*	*1.19*	*896*	*63*	*96.333*	*29.7*	*0.31*
RM16-53	*1140*	*33*	*1117*	*31*	*1072*	*68*	*-6.32*	*-2.06*	*1180*	*66*	*159.02*	*114*	*0.72*
RM16-54	*186*	*6.5*	*190*	*12*	*237*	*130*	*21.47*	*2.05*	*190*	*17*	*321.6*	*133*	*0.41*
RM16-55	7.05	0.77	142	28	8324	9700	99.92	95.04	9501	1300	276.9	143	0.52
RM16-56	*1054*	*34*	*1106*	*57*	*1211*	*150*	*12.98*	*4.70*	*1106*	*83*	*85.842*	*33.5*	*0.39*

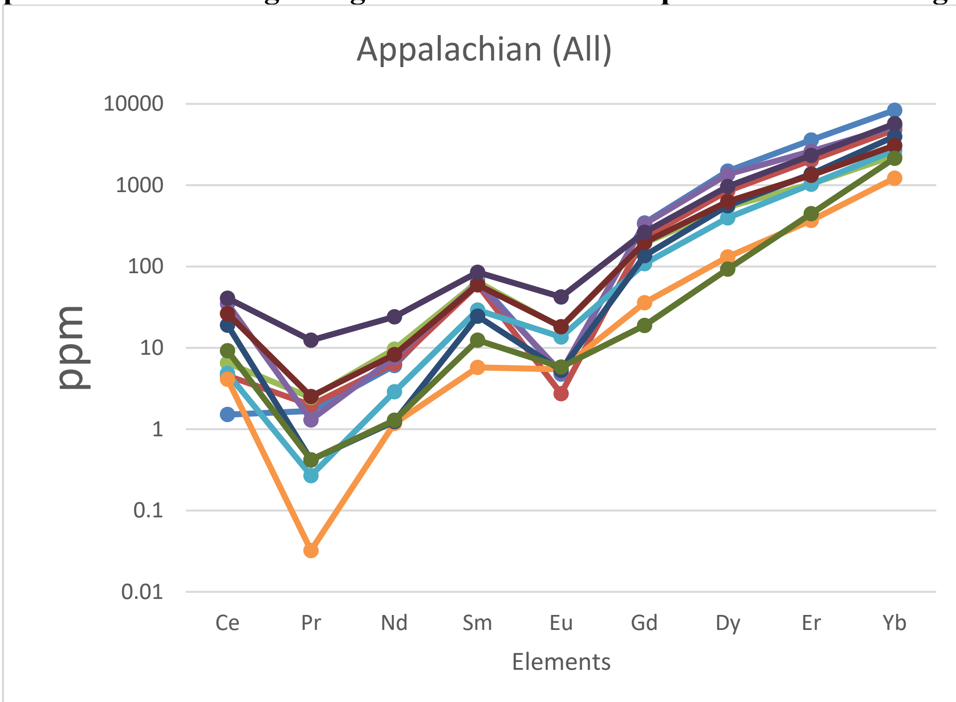
RM16-57	1530	40	1505	33	1470	58	-4.08	-1.66	1580	88	353.58	110	0.31
RM16-58	1108	46	1422	41	1931	55	42.63	22.08	1624	77	59.909	36.7	0.61
RM16-59	974	31	1031	36	1155	85	15.67	5.53	1092	98	84.971	15.6	0.18
RM16-60	173	7.5	162	14	10	190	-1658.07	-6.73	164	15	143.43	69.8	0.49
RM16-61	24.9	1.3	24.7	4.1	6	350	-308.93	-0.81	24.9	3.5	432.3	283	0.65
RM16-62	1116	31	1123	36	1138	85	1.97	0.62	1160	69	85.59	44.9	0.53
RM16-63	1182	38	1183	38	1186	84	0.4	0.08	1237	91	82.386	30.8	0.37
RM16-64	2527	200	2601	92	2659	60	4.96	2.85	1278	130	270.23	208	0.77
RM16-65	1830	47	1829	38	1827	62	-0.17	-0.05	1885	110	122.31	59.1	0.48
RM16-66	1102	33	1108	35	1118	83	1.43	0.54	1154	85	88.544	29.5	0.33
RM16-67	1931	57	1912	38	1891	50	-2.08	-0.99	2024	120	403.28	193	0.48
RM16-68	26.6	1.3	30.6	3.7	357	240	92.54	13.07	32.6	6.2	649.17	174	0.27
RM16-69	1452	42	1468	35	1491	58	2.62	1.09	1567	91	151.37	49.7	0.33
RM16-70	1103	31	1089	34	1063	82	-3.78	-1.29	1108	73	91.722	59.7	0.65
DRI::DRI													
DRI-01	968	47	1027	57	1156	140	16.31	5.74	1100	120	98.826	65.5	0.66
DRI-02	1051	33	1074	31	1120	64	6.16	2.14	1082	68	261.48	51.9	0.2
DRI-03	1061	43	1074	42	1100	91	3.57	1.21	1132	88	190.56	85.6	0.45
DRI-04	1082	29	1068	28	1039	65	-4.15	-1.31	1097	76	130.52	41.8	0.32
DRI-06	1063	38	1087	33	1136	62	6.39	2.21	1106	63	428.94	160	0.37
DRI-07	1101	25	1095	25	1082	58	-1.73	-0.55	1115	55	376.96	276	0.73
DRI-08	1460	37	1450	29	1436	47	-1.63	-0.69	1463	110	524.12	60.1	0.11
DRI-09	1121	29	1101	28	1060	61	-5.75	-1.82	1140	60	276.96	155	0.56
DRI-10	1055	29	1080	34	1130	82	6.57	2.31	1060	76	99.929	36.3	0.36
DRI-11	1079	35	1101	44	1146	110	5.88	2.00	1108	87	85.103	56.9	0.67
DRI-12	1180	30	1151	28	1096	59	-7.66	-2.52	1183	74	227.98	94.9	0.42
DRI-14	1077	27	1086	28	1104	64	2.43	0.83	1011	59	231.51	133	0.57
DRI-15	1088	34	1093	42	1104	110	1.47	0.46	1041	100	88.51	39.8	0.45
RWN::RWN													
RWN-01	447	12	444	23	428	120	-4.35	-0.68	500	38	147.69	68.9	0.47
RWN-02	1043	29	1043	29	1043	68	-0.01	0.00	894	75	115.16	28.7	0.25
RWN-03	176	6.8	173	17	137	210	-28.13	-1.79	189	23	102.46	58.8	0.57
RWN-04	1733	49	1721	38	1707	61	-1.52	-0.70	1881	140	81.855	50.6	0.62
RWN-05	61.5	4.6	85	20	812	420	92.43	27.65	73	16	82.691	52.3	0.63
RWN-06	210	8.8	203	14	132	140	-59.16	-3.25	216	18	239.95	146	0.61
RWN-07	83.7	5.7	81	18	1	470	-7551.3	-3.33	95	37	150.41	37.8	0.25
RWN-08	1091	33	1072	34	1034	80	-5.54	-1.77	1173	90	95.481	32	0.33
RWN-09	1062	41	1001	47	869	120	-22.12	-6.09	1110	140	33.351	7.72	0.23
RWN-10	62.9	2.7	79	10	594	250	89.41	20.38	89	14	224.94	60.6	0.27
RWN-11	100	4.6	112	15	368	270	72.78	10.45	120	18	128.28	51.4	0.4
RWN-12	1089	42	1100	54	1123	140	3.02	1.00	1168	150	31.72	9.34	0.29
RWN-13	89.7	3.2	93.3	8.2	186	190	51.78	3.86	94.2	9.4	373.96	203	0.54
RWN-14	75.5	3.5	80.2	7.7	225	190	66.41	5.86	78	12	225.81	106	0.47
RWN-15	2788	77	2695	46	2626	59	-6.17	-3.45	2787	200	22.891	17.7	0.77
RWN-16	1492	35	1456	27	1404	46	-6.29	-2.47	1431	81	708.65	293	0.41
RWN-17	41.1	1.7	45.5	5	288	220	85.72	9.67	45.6	7.9	479.49	92.3	0.19
RWN-18	68.6	5.2	89	21	677	430	89.87	22.92	9638	1700	44.56	27	0.61
RWN-19	246	8.6	242	15	204	130	-20.28	-1.53	253	25	218.95	60.1	0.27
RWN-20	73.4	3.6	69.3	6.4	-71	190	202.81	-5.92	72.8	8.4	319.16	176	0.55
RWN-21	1159	45	1154	65	1145	160	-1.17	-0.43	1172	130	15.755	9.98	0.63
RWN-22	1329	91	1374	69	1445	110	8.02	3.28	1568	180	139.98	56.7	0.41
RWN-23	451	19	447	52	422	290	-6.89	-0.89	575	130	21.754	7.45	0.34
RWN-24	1472	40	1467	40	1459	80	-0.84	-0.34	1531	140	60.914	14.9	0.25
RWN-25	1071	33	1064	40	1051	100	-1.91	-0.66	1154	120	43.562	14	0.32
RWN-26	1495	54	1521	51	1558	94	4	1.71	1702	210	26.74	6.31	0.24
RWN-27	2884	75	2803	41	2745	48	-5.09	-2.89	3033	260	46.452	10.8	0.23
RWN-28	37.6	1.4	49.8	6.1	685	240	94.5	24.50	46.6	7.9	643.85	153	0.24
RWN-29	1012	41	1056	63	1149	170	11.97	4.17	1079	180	15.585	6.17	0.4
RWN-30	1158	33	1117	31	1037	67	-11.67	-3.67	1212	85	131.03	50.6	0.39
RWN-31	1127	41	1113	52	1085	130	-3.82	-1.26	1161	140	41.714	18	0.43
RWN-32	1114	30	1110	41	1103	100	-0.95	-0.36	1171	83	51.083	55.6	1.09

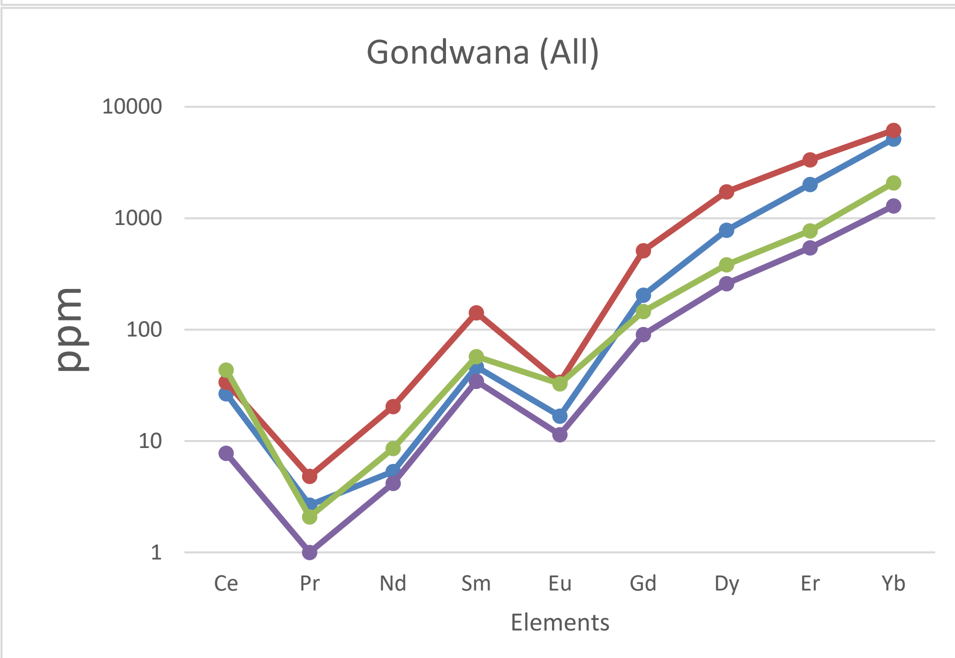
Appendix III. Rare Earth Element Concentrations Table For Run Number Two (University of Kansas - 5/19/2017)

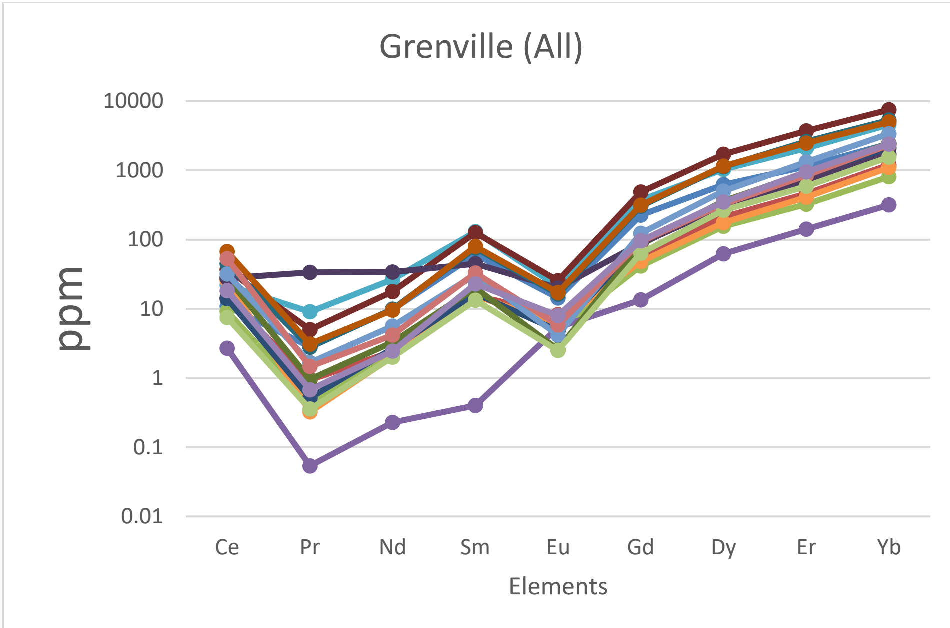
				REE Concentration (ppm)					
Sample:	Ce	Pr	Nd	Sm	Eu	Gd	Dy	Er	Yb
DRREE-02	31.33117	2.346609	7.50547	34.22819	12.85714	187.8173	624.4898	1437.5	3188.679
DRREE-15	29.22078	0.828848	4.595186	38.5906	8.5	165.4822	535.5102	1231.25	2735.849
DRREE-05	12.67857	7.255113	28.44639	191.2752	107.6786	618.7817	1714.286	3075	6132.075
RWREE-03	30.43831	10.55974	32.82276	146.3087	63.75	581.2183	1689.796	3287.5	6685.535
RM16REE-55	47.24026	4.843918	6.958425	17.38255	6.446429	90.86294	387.7551	993.75	2509.434
RWREE-09	24.91883	0.753498	2.297593	8.389262	4.589286	77.66497	321.2245	783.75	1962.264
CSREE-24	201.1364	8.934338	32.82276	294.6309	5.803571	1208.122	5020.408	11181.25	23647.8
RWSREE-23	38.14935	3.240043	8.315098	52.75168	4.482143	199.4924	775.5102	1756.25	3874.214
CSREE-30	16.16883	1.474704	3.21663	15.10067	9.107143	68.0203	247.3469	611.25	1490.566
DRREE-04	49.83766	2.335845	5.142232	41.34228	6.857143	208.6294	857.1429	2112.5	4528.302
RWSREE-28	81.33117	3.1324	7.286652	26.84564	28.39286	102.5381	375.102	1093.75	3421.384
RWSREE-24	19.80519	1.334769	4.376368	24.56376	11.78571	82.2335	331.4286	778.75	1691.824
CSREE-31	412.3377	4.682454	16.19256	125.5034	29.28571	525.3807	2200	6056.25	15188.68
CSREE-3	88.96104	2.314316	6.170678	30.26846	19.10714	132.4873	554.6939	1581.25	4503.145
RWSREE-20	46.59091	0.247578	2.166302	20.33557	11.96429	68.0203	228.1633	656.25	2150.943
DXREE-04	38.14935	0.376749	2.560175	13.75839	12.32143	48.22335	182.8571	547.5	2012.579
RM16REE-61	30.35714	-0.01076	1.225383	9.261745	6.982143	30.96447	137.1429	387.5	1251.572
RWSREE-29	38.7987	2.787944	7.199125	49.19463	25.71429	165.9898	577.9592	1406.25	3685.535
RM16REE-68	20.27597	0.65662	0.83151	17.58389	2.839286	60.91371	282.449	825	2572.327
CSREE-14	28.57143	0.452099	1.859956	21.61074	10.53571	77.66497	331.0204	1000	3232.704
CSREE-5	211.039	3.046286	7.768053	48.99329	27.14286	212.1827	697.9592	1756.25	4779.874
RM16REE-42	30.68182	0.602799	2.778993	23.48993	13.92857	57.86802	212.2449	543.75	1685.535
RWSREE-12	119.6429	1.657696	7.527352	57.58389	53.75	215.2284	576.3265	1026.25	2201.258
CSREE-33	29.87013	8.503767	12.47265	60.33557	28.39286	221.8274	824.4898	1981.25	4270.44
DRREE-07	65.74675	0.914962	3.107221	23.48993	16.96429	102.0305	346.5306	867.5	2194.969
RWNREE-28	45.94156	0.064586	1.225383	8.456376	10.89286	35.53299	166.1224	587.5	2528.302
RWSREE-32	21.75325	0.764263	2.582057	16.10738	14.46429	53.29949	173.8776	512.5	1427.673
DXREE-05	104.2208	7.265877	24.07002	144.9664	125	418.7817	1224.49	2618.75	6503.145
DXREE-14	65.42208	3.229279	13.08534	69.79866	66.78571	203.5533	607.3469	1418.75	3924.528
RWNREE-17	5.275974	0.064586	0.218818	10	11.96429	43.65482	182.0408	390.625	933.3333
RM16REE-14	49.35065	2.831001	9.146608	87.91946	4.285714	438.0711	1755.102	3756.25	8207.547
RM16REE-38	19.43182	1.345533	3.019694	5.637584	8.928571	30.96447	146.1224	462.5	1484.277
RWNREE-14	48.37662	0.818084	1.444201	10.60403	11.25	38.07107	173.0612	540	1974.843
RWNREE-7	21.59091	0.279871	0.897155	6.442953	2.571429	32.18274	135.9184	385.625	1081.761
DXREE-08	9.237013	0.021529	0.568928	5.436242	8.964286	45.17766	204.898	580	1748.428
RM16REE-51	49.02597	0.430571	2.407002	26.71141	11.51786	141.6244	669.3878	1881.25	5635.22
RM16REE-20	13.39286	0.452099	1.66302	10.26846	7.678571	40.10152	180.4082	550	1918.239
DXREE-13	8.295455	1.356297	3.21663	24.7651	19.28571	103.5533	390.6122	962.5	2566.038
RM16REE-54	20.77922	0.667384	1.750547	12.81879	10.35714	24.72081	117.1429	398.125	1452.83
DXREE-09	1.50974	1.668461	6.061269	68.45638	4.75	343.6548	1493.878	3600	8352.201
DRREE-03	4.545455	1.980624	6.43326	59.73154	2.732143	228.4264	853.0612	2037.5	4805.031
DRREE-13	6.542208	2.443488	9.649891	64.42953	17.85714	193.9086	540.8163	1038.125	2308.176

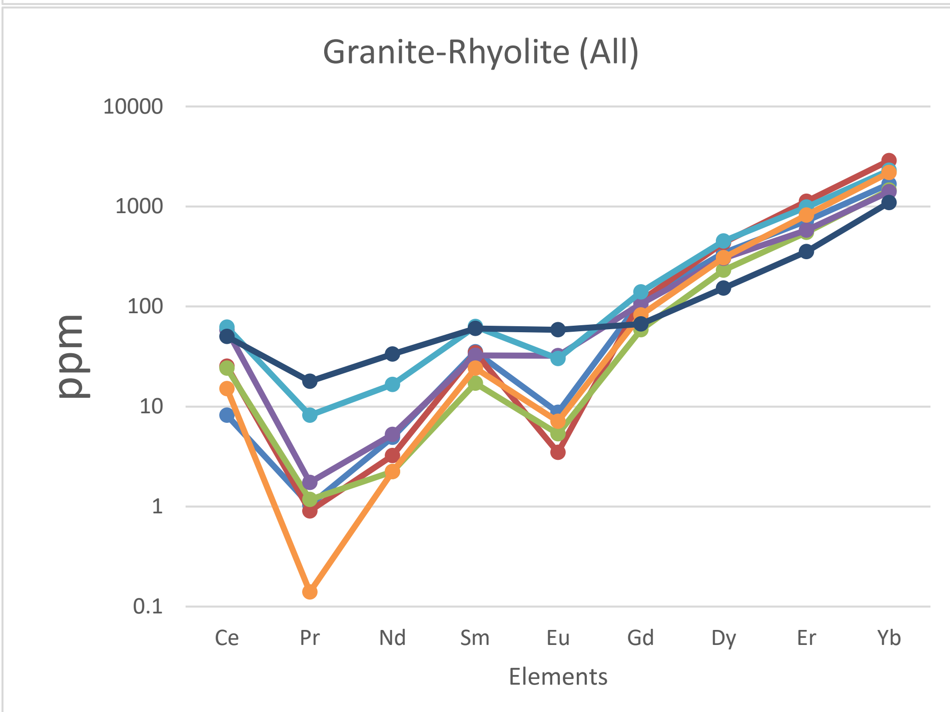
RM16REE-39	35.06494	1.302476	7.592998	62.41611	5	333.5025	1359.184	2625	5283.019
RWNREE-23	4.837662	0.269107	2.888403	29.12752	13.57143	108.6294	396.3265	1031.25	2691.824
RWREE-01	4.123377	0.032293	1.181619	5.771812	5.446429	36.04061	131.0204	369.375	1220.126
RWNREE-1	19.07468	0.419806	1.247265	24.56376	5.303571	136.0406	559.1837	1368.75	3968.553
RM16REE-32	26.2987	2.529602	8.271335	59.73154	18.21429	197.9695	632.6531	1325	3075.472
RWREE-05	9.204545	0.419806	1.291028	12.41611	5.803571	18.83249	93.06122	447.5	2144.654
RM16REE-30	40.58442	12.3789	24.07002	84.56376	42.32143	263.9594	967.3469	2318.75	5685.535
DXREE-02	26.62338	2.658773	5.317287	46.30872	16.78571	204.5685	779.5918	2012.5	5150.943
RWREE-07	33.7987	4.82239	20.37199	142.2819	33.75	511.6751	1722.449	3350	6157.233
DRREE-09	43.34416	2.088267	8.599562	57.18121	32.67857	145.1777	382.8571	770.625	2075.472
DRREE-06	7.792208	1.001076	4.179431	34.49664	11.42857	90.35533	259.5918	543.75	1289.308
DXREE-15	10.90909	2.831001	9.737418	61.07383	14.28571	225.8883	621.2245	1137.5	2427.673
RWREE-13	14.30195	0.936491	2.428884	15.43624	8.267857	55.83756	213.0612	461.25	1201.258
RWREE-04	9.155844	0.452099	2.297593	16.6443	4.892857	41.72589	156.3265	325	810.6918
DRREE-18	2.694805	0.053821	0.227571	0.402685	5.375	13.45178	62.04082	141.875	316.3522
DRIREE-11	21.91558	9.041981	26.47702	129.5302	20.89286	372.5888	1032.653	2087.5	4578.616
DRREE-14	25.84416	0.322928	2.035011	15.36913	6.035714	48.22335	175.5102	412.5	1100.629
DRIREE-15	14.04221	0.516685	2.669584	16.57718	4.821429	91.37056	333.8776	843.75	2100.629
DRIREE-14	37.01299	5.005382	17.81182	126.1745	25.35714	485.7868	1714.286	3712.5	7522.013
DRIREE-10	28.01948	0.958019	3.304158	19.86577	2.571429	84.77157	359.5918	916.875	2465.409
DRIREE-1	27.75974	33.69214	33.91685	44.96644	20	88.32487	302.0408	731.25	1704.403
DRIREE-3	44.96753	2.787944	9.890591	75.83893	16.25	305.0761	1130.612	2606.25	5314.465
DRIREE-4	66.88312	3.110872	9.606127	79.86577	17.14286	314.7208	1151.02	2487.5	4993.711
DRIREE-6	32.01299	1.668461	5.645514	31.07383	4.178571	123.8579	502.0408	1324.375	3377.358
RM16REE-31	52.92208	1.46394	4.179431	32.88591	5.892857	93.40102	324.4898	850.625	2320.755
DRREE-08	7.516234	0.355221	1.991247	13.28859	2.5	63.95939	264.0816	586.875	1559.748
DXREE-11	18.23052	0.678149	2.450766	22.81879	7.982143	96.4467	350.6122	956.25	2408.805
RWREE-11	8.181818	1.033369	4.901532	35.2349	8.732143	114.7208	343.6735	717.5	1679.245
DRREE-11	25.29221	0.904198	3.238512	34.36242	3.464286	114.7208	434.2857	1121.25	2874.214
RWREE-02	24.10714	1.173305	2.231947	17.11409	5.339286	58.37563	231.0204	548.125	1452.83
DRREE-10	58.11688	1.743811	5.251641	32.41611	32.14286	106.599	303.6735	579.375	1402.516
RM16REE-19	62.17532	8.18084	16.6302	63.08725	30.17857	139.5939	451.8367	987.5	2295.597
DXREE-12	15.03247	0.139935	2.231947	24.22819	7.125	82.2335	308.1633	818.75	2182.39
RM16REE-6	50.16234	17.86868	33.47921	60.40268	58.39286	67.00508	152.6531	354.375	1094.34
RWREE-15	13.78247	0.50592	0.459519	4.362416	2.589286	22.13198	72.2449	221.875	742.1384
RM16REE-24	16.1039	2.077503	5.557987	41.61074	14.64286	164.467	788.1633	2218.75	5698.113
DXREE-16	55.68182	1.571582	4.179431	30.40268	12.67857	77.15736	236.3265	598.125	1641.509
DRREE-17	28.24675	1.948332	4.87965	37.58389	6.071429	118.7817	473.4694	1062.5	2490.566
DXREE-01	6.217532	0.688913	2.691466	22.14765	4.107143	121.3198	446.9388	1118.75	2867.925
RWREE-10	11.86688	0.258342	1.684902	10.13423	2.160714	60.40609	277.9592	795	2062.893
RWREE-12	42.20779	1.205597	4.507659	25.90604	23.39286	55.32995	111.0204	198.75	454.717
DRREE-12	30.66558	1.022605	2.713348	13.42282	5.821429	47.20812	183.6735	418.75	1123.27
DXREE-10	33.47403	0.107643	3.501094	19.93289	5.803571	52.79188	193.0612	514.375	1547.17
DRREE-16	71.59091	2.529602	10.43764	58.38926	24.28571	187.8173	657.1429	1662.5	4566.038
DXREE-03	23.27922	7.136706	24.72648	132.8859	25.89286	414.2132	1228.571	2312.5	4477.987
RWREE-14	8.863636	0.279871	1.225383	22.61745	6.053571	60.40609	256.3265	645.625	1660.377
RWREE-08	15.86039	0.484392	1.750547	10.60403	13.21429	34.31472	155.102	492.5	1679.245
RWREE-06	0.108766	-0.16146	0.142232	2.416107	0.410714	1.370558	19.38776	209.375	1823.899
DXREE-06	37.33766	7.987083	19.73742	65.77181	31.60714	166.4975	458.3673	987.5	2150.943
DXREE-07	14.35065	0.161464	1.137856	11.47651	5.732143	41.11675	163.2653	443.125	1201.258
DRREE-01	62.33766	4.89774	15.22976	66.44295	13.92857	246.7005	918.3673	2318.75	5893.082

Appendix IV. Rare Earth Element Concentration Charts for Run Number Two (University of Kansas - 5/19/2017) Concentrations are in parts per million with the plots divided into age ranges as well as each sample within those ranges.






Grenville (All)
10000
1000
100
10
1
0.1
0.01
ppm
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb
Elements


Granite-Rhyolite (All)
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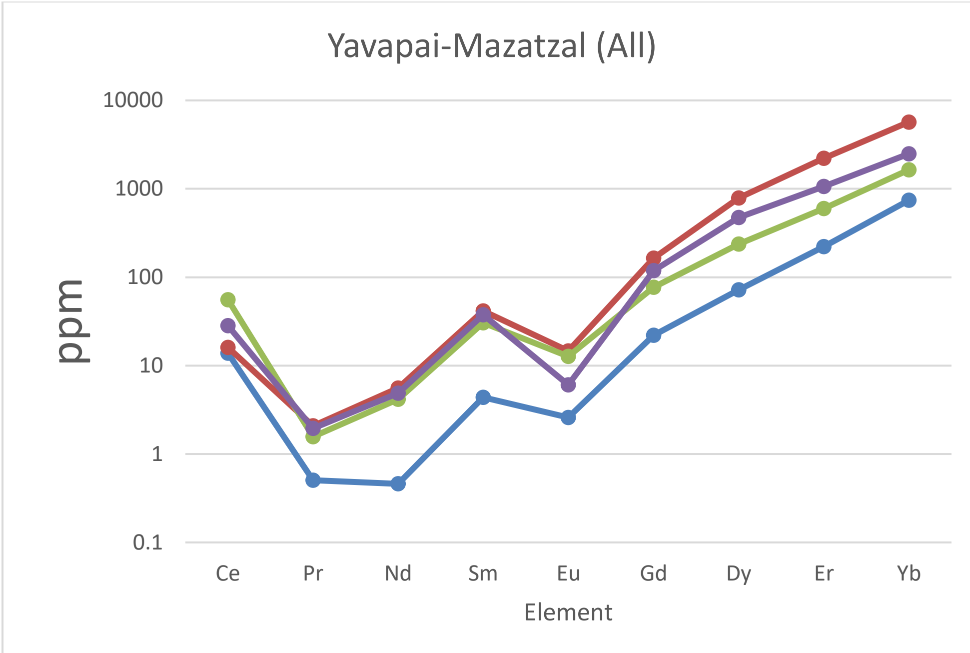
1000
100
10
1
0.1
ppm
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb
Elements


Yavapai-Mazatzal (All)
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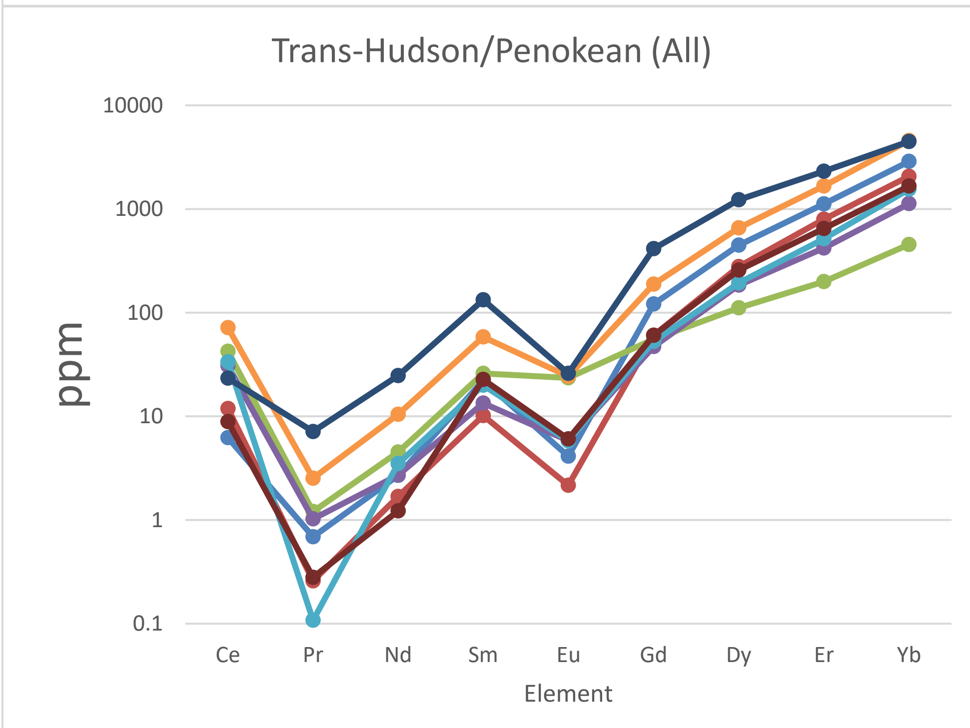
1000
100
10
1
0.1
ppm
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb
Element


Trans-Hudson/Penokean (All)
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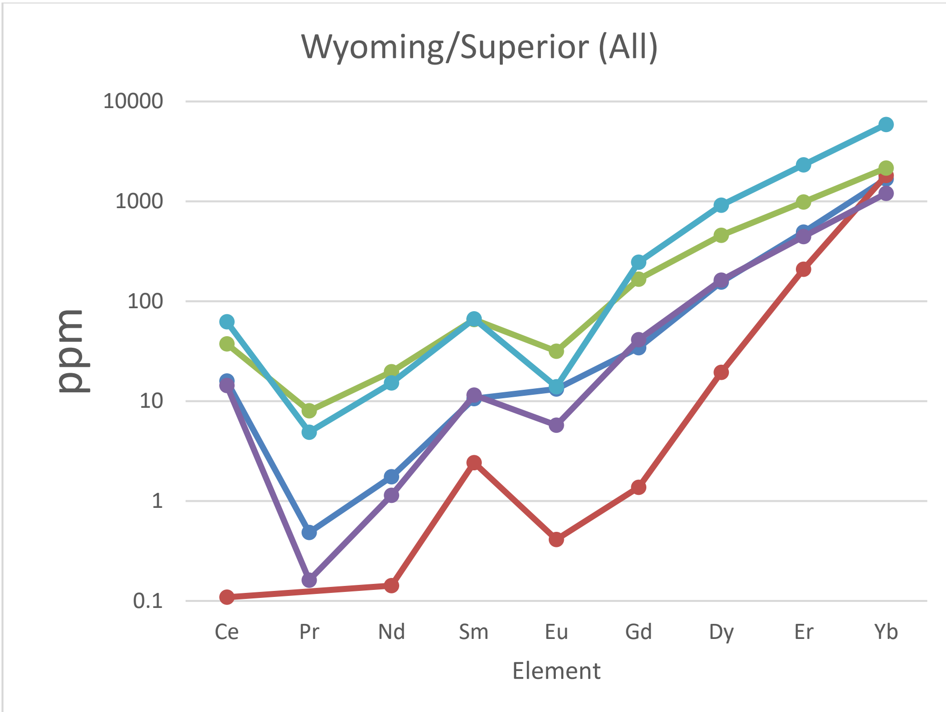
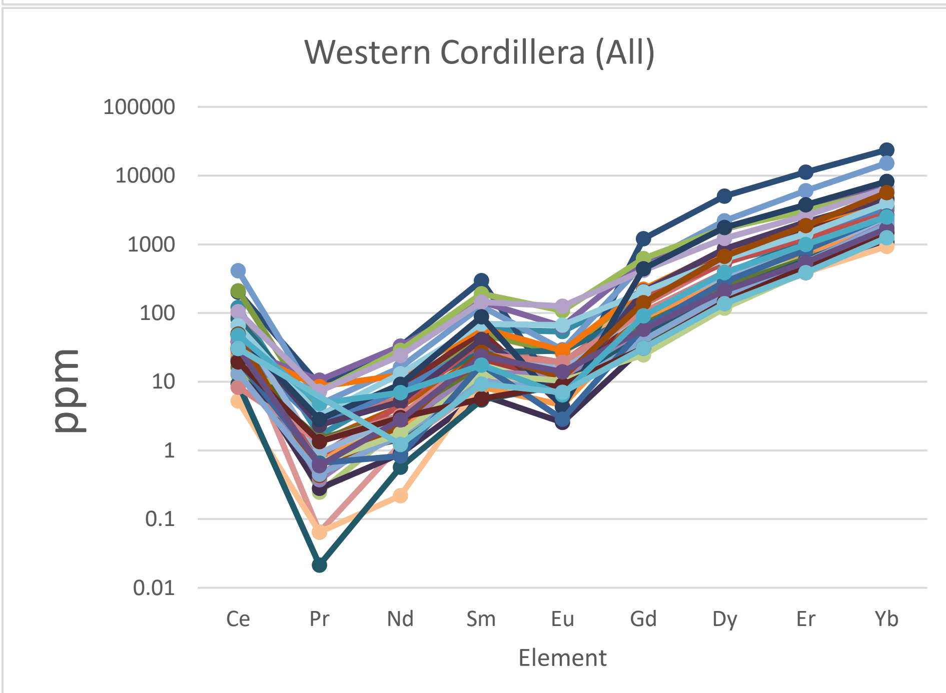
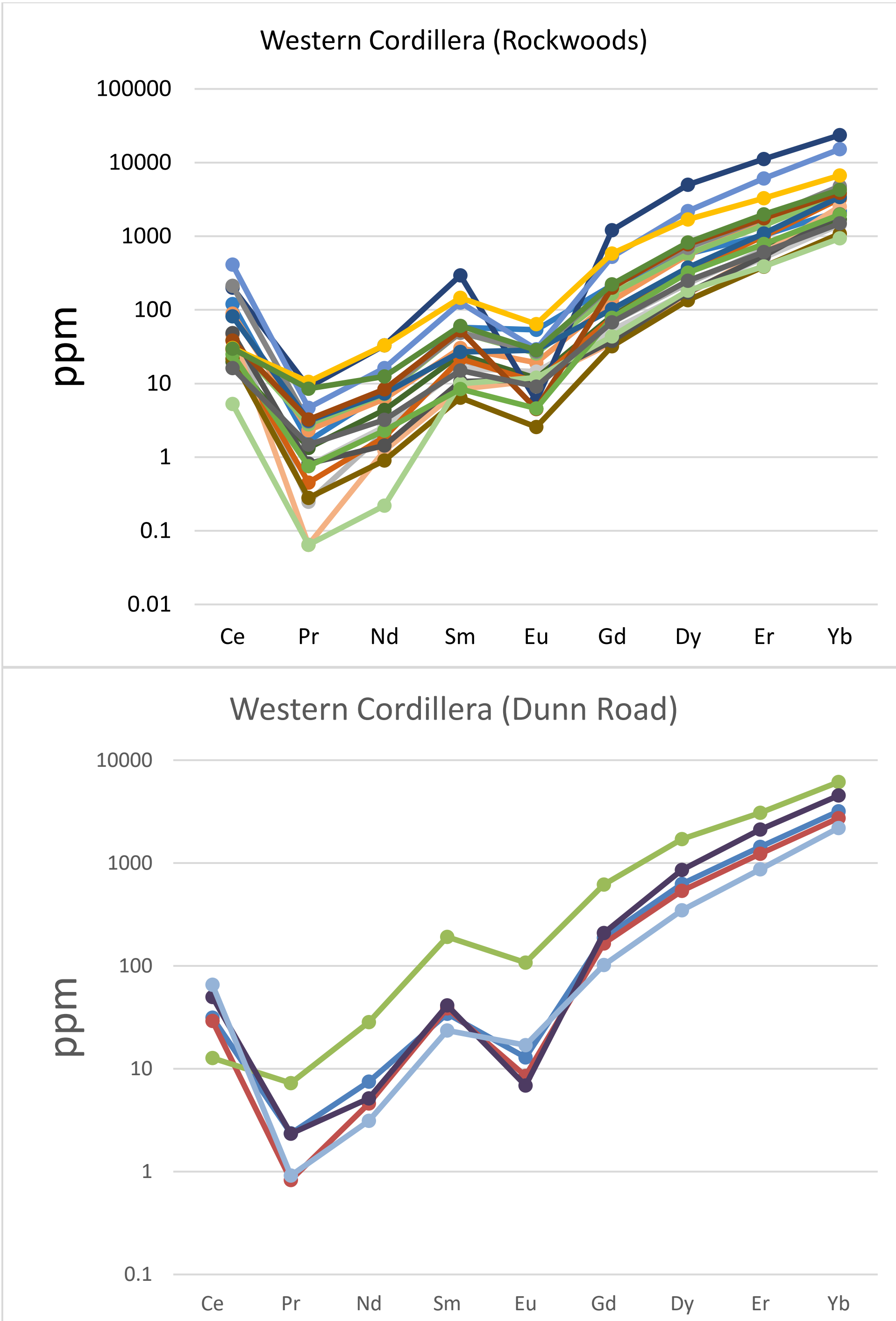
1000
100
10
1
0.1
ppm
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb
Element



Wyoming/Superior (All)
10000
1000
100
10
1
0.1
ppm
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb
Element



Western Cordillera (All)
100000
10000
1000
100
10
1
0.1
0.01
ppm
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb
Element


Western Cordillera (Rockwoods)
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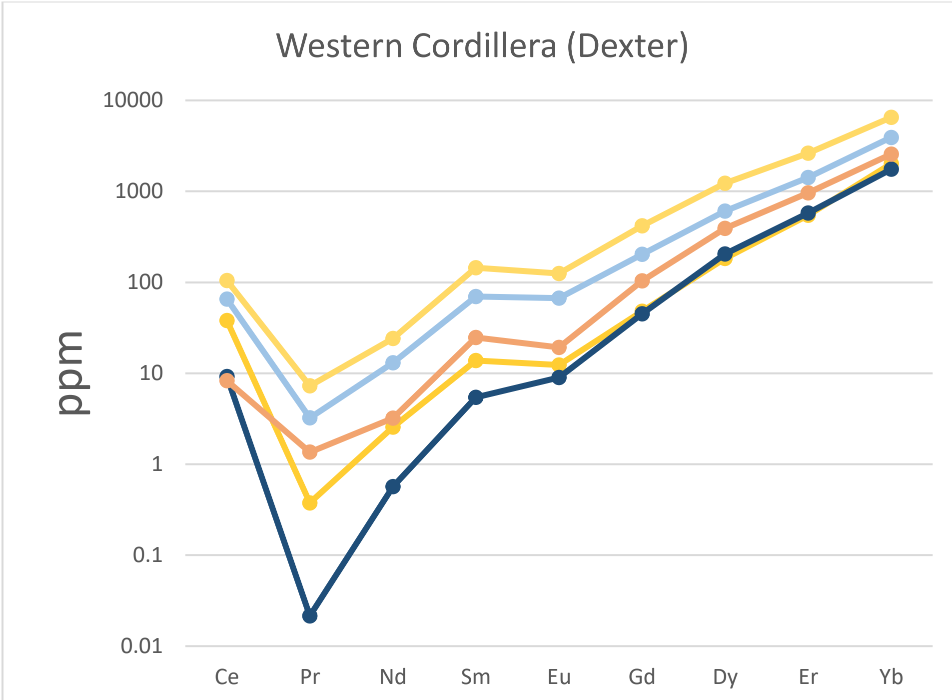
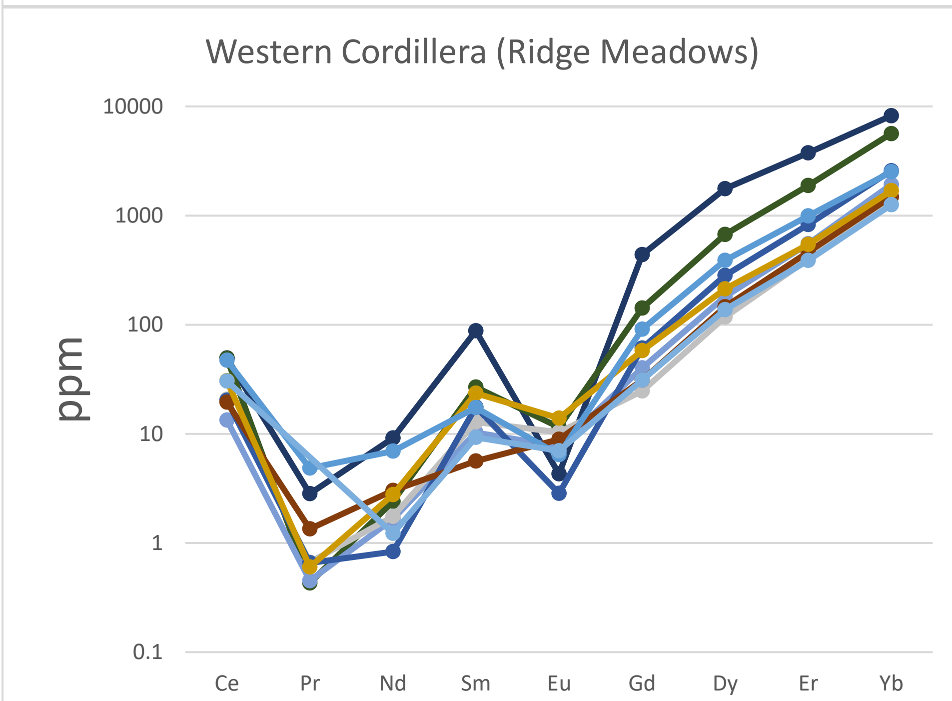
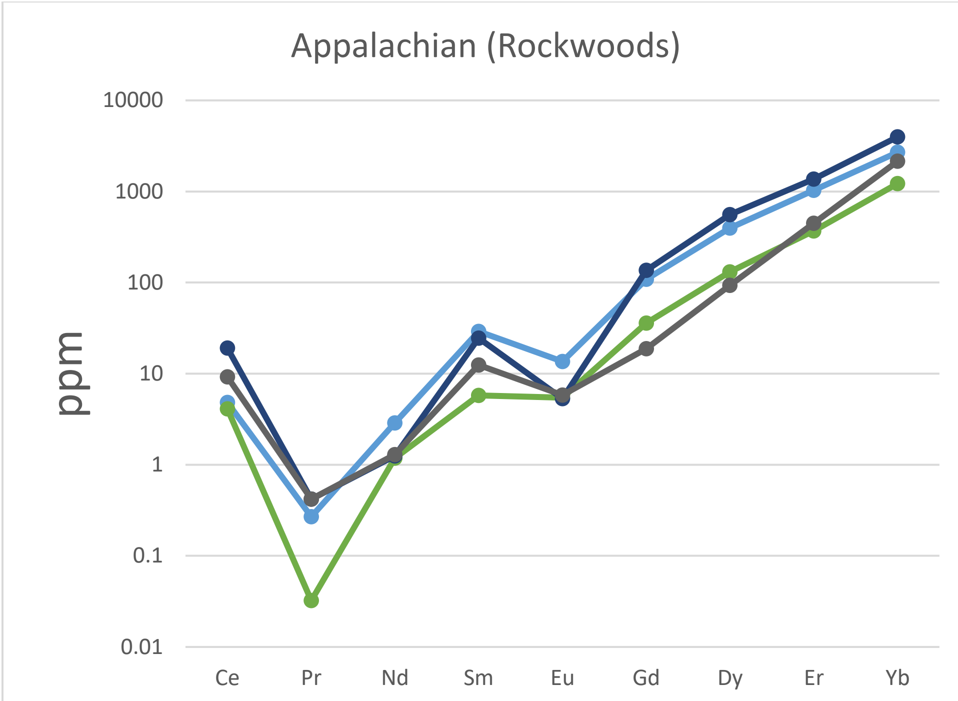
10000
1000
100
10
1
0.1
0.01
ppm
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb
Western Cordillera (Dunn Road)
10000
1000
100
10
1
0.1
ppm
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb



Western Cordillera (Dexter)
ppm
10000
1000
100
10
1
0.1
0.01
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb



Western Cordillera (Ridge Meadows)
ppm
10000
1000
100
10
1
0.1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Appalachian (Rockwoods)
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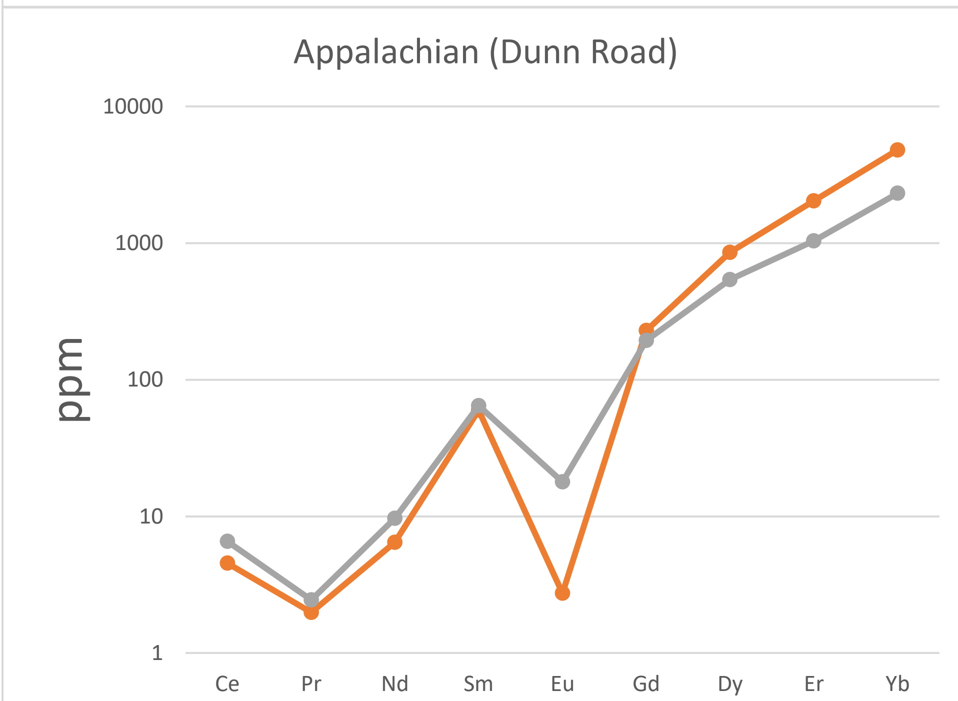
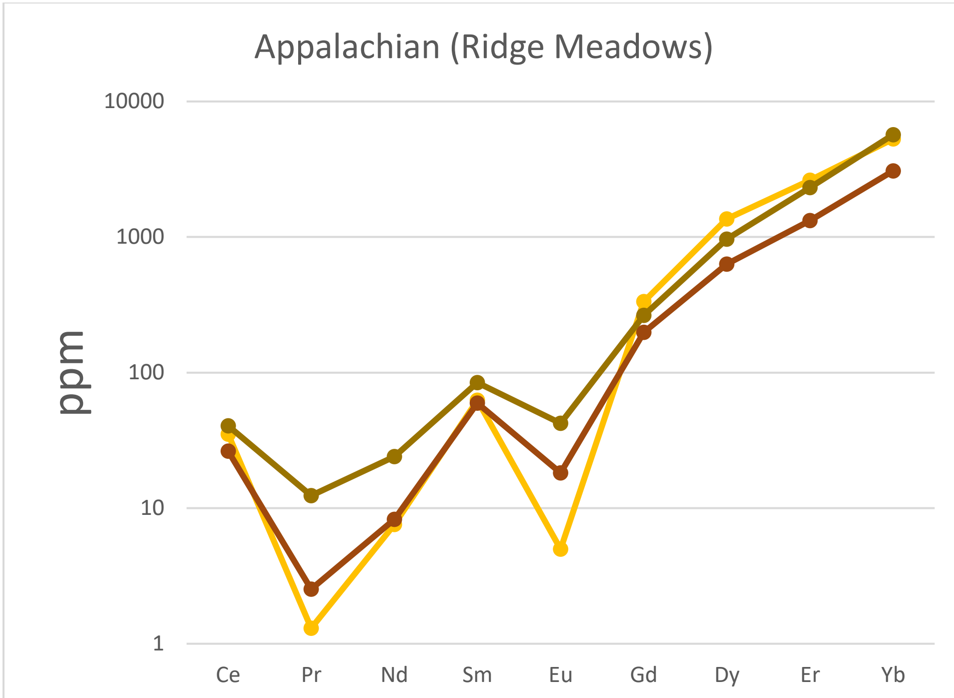
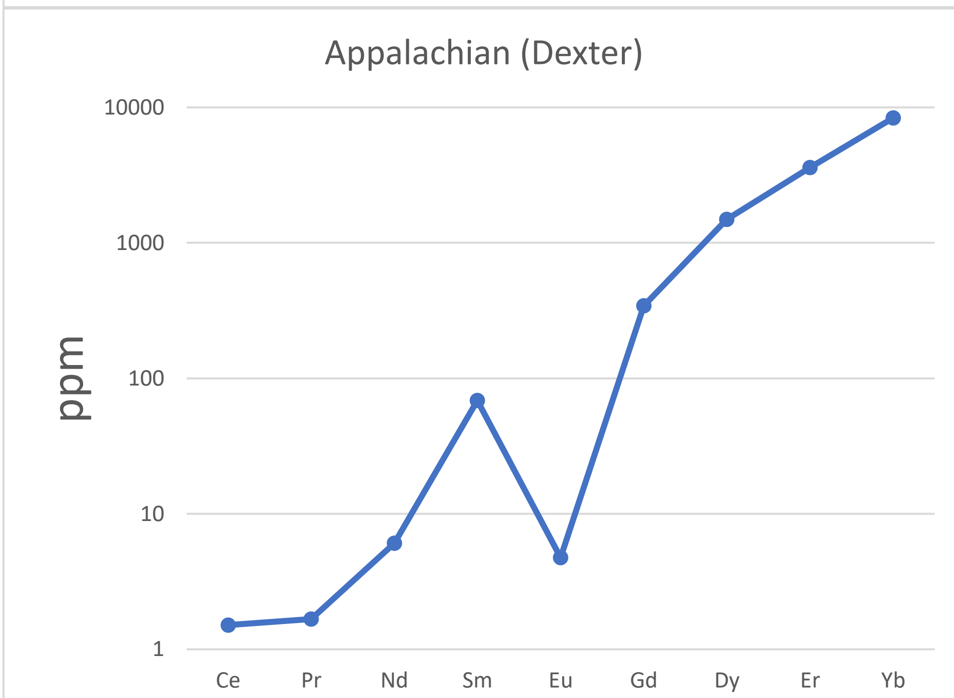
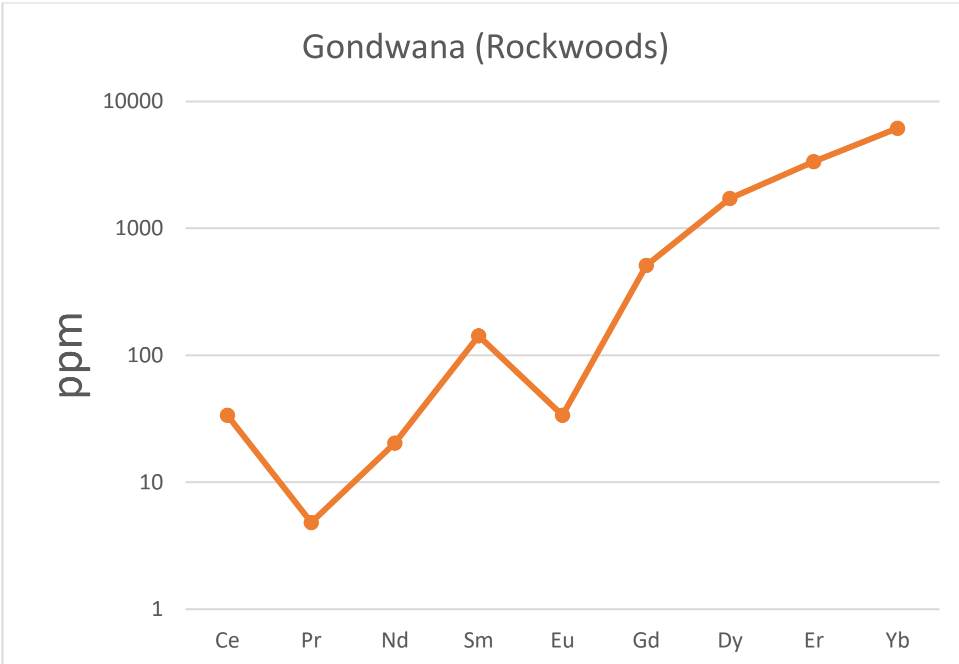
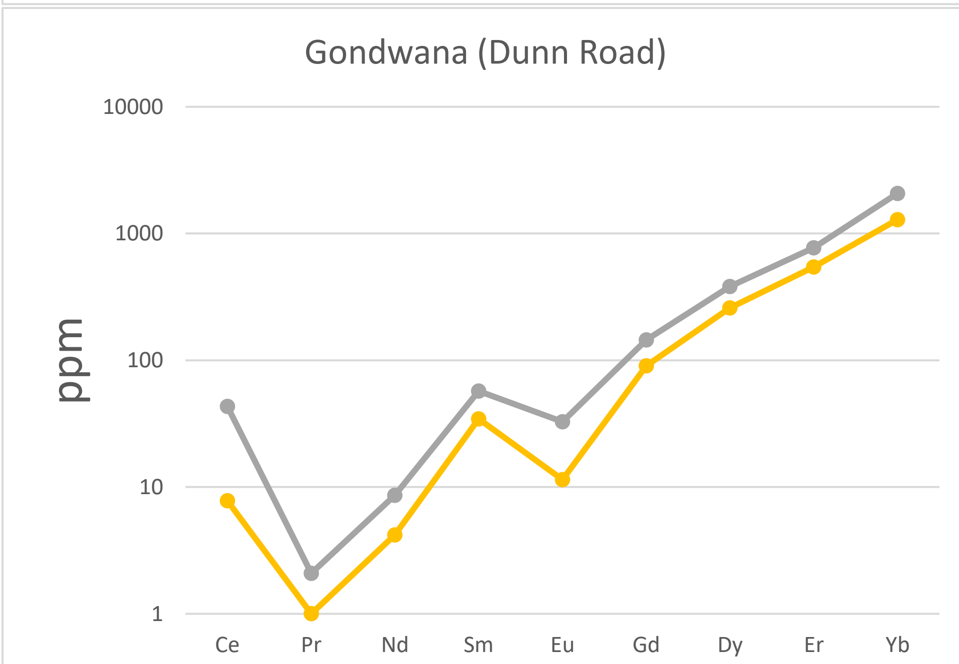
100
10
1
0.1
0.01
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb

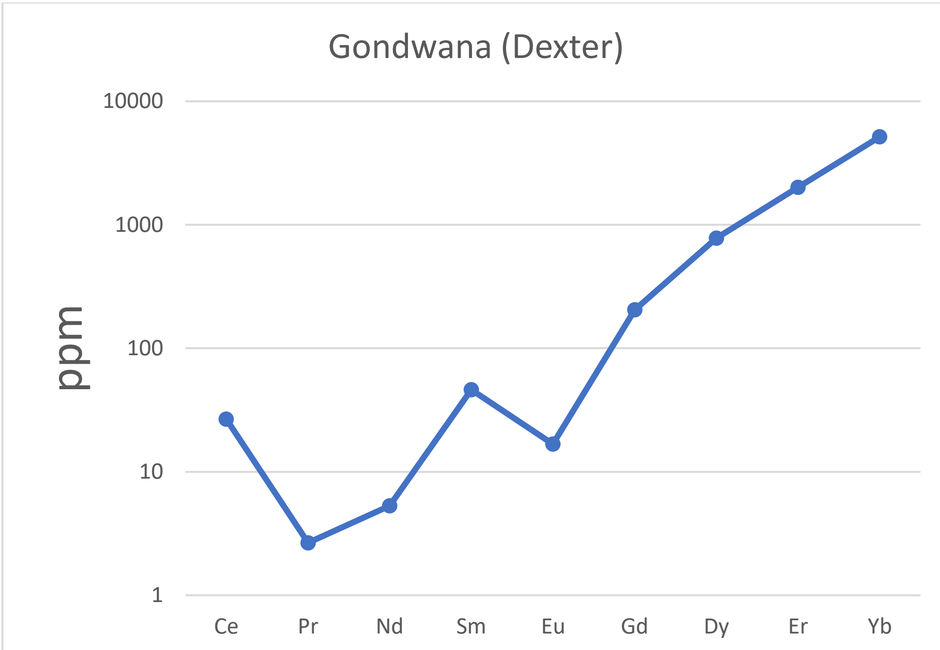

Appalachian (Dunn Road)
ppm
10000
1000
100
10
1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb

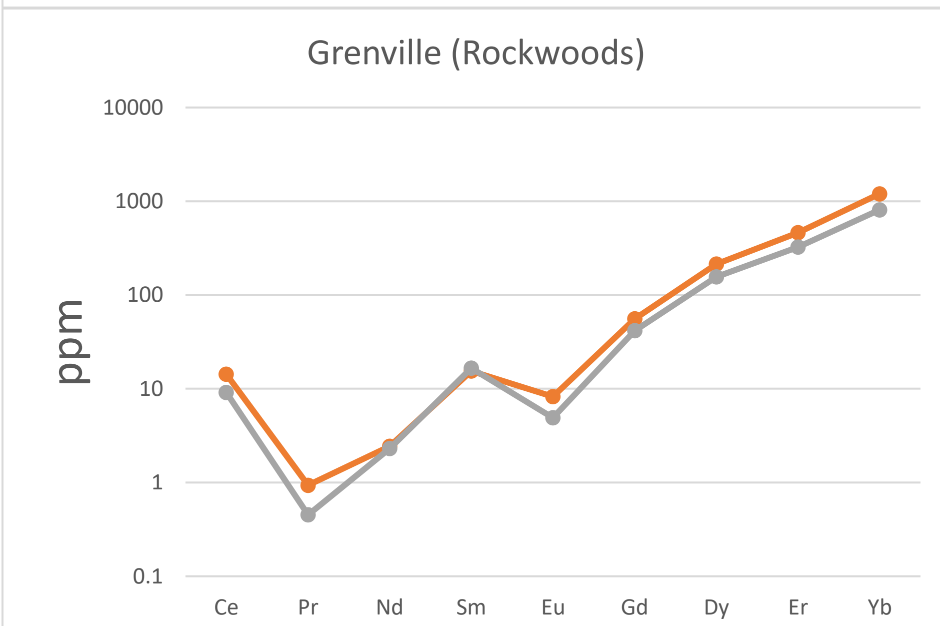

Appalachian (Ridge Meadows)
ppm
10000
1000
100
10
1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb

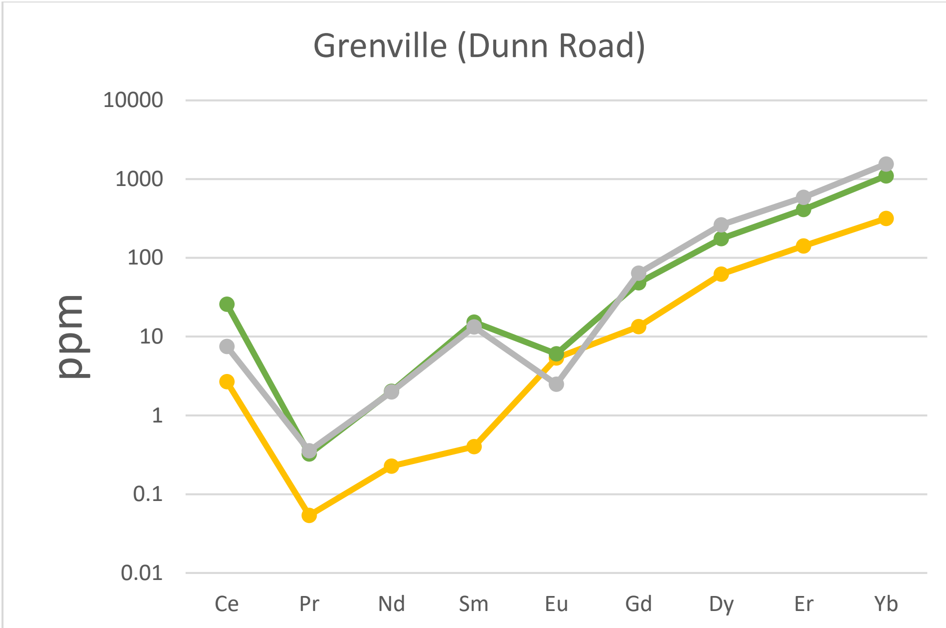

Appalachian (Dexter)
ppm
10000
1000
100
10
1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb

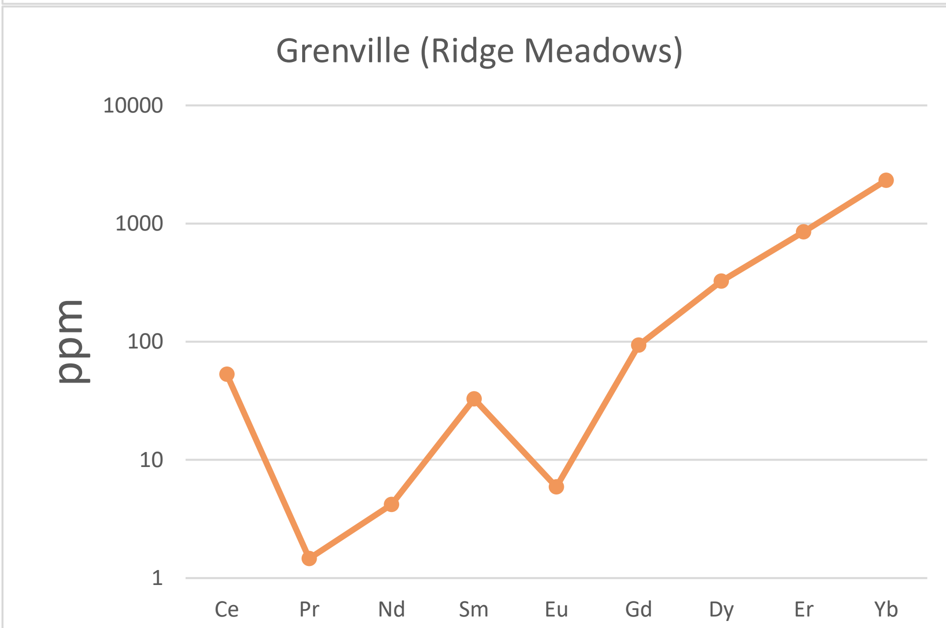

Gondwana (Rockwoods)
ppm
10000
1000
100
10
1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb

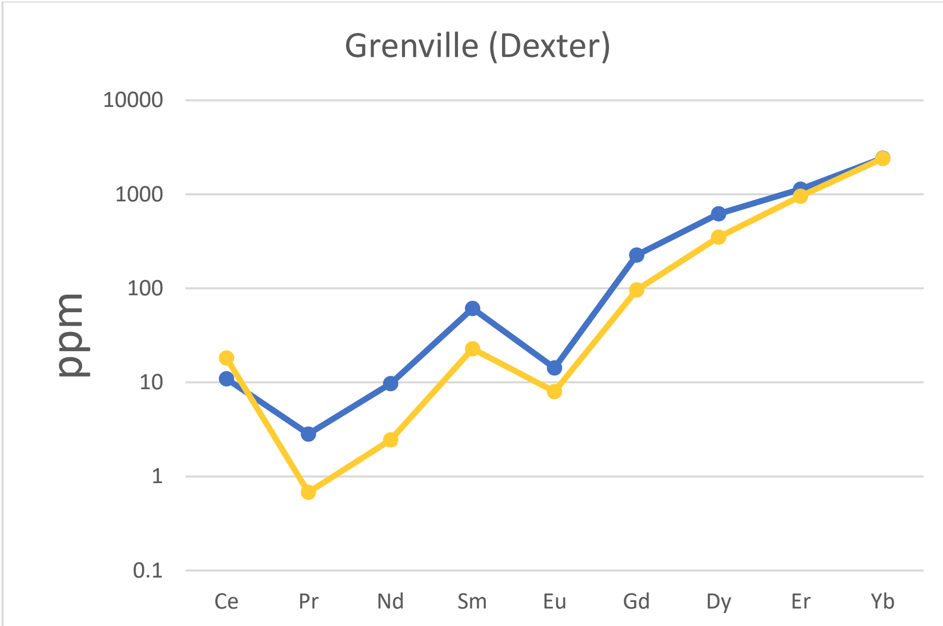

Gondwana (Dunn Road)
ppm
10000
1000
100
10
1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Gondwana (Dexter)
ppm
10000
1000
100
10
1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Grenville (Rockwoods)
ppm
10000
1000
100
10
1
0.1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Grenville (Dunn Road)
ppm
10000
1000
100
10
1
0.1
0.01
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Grenville (Ridge Meadows)
ppm
10000
1000
100
10
1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Grenville (Dexter)
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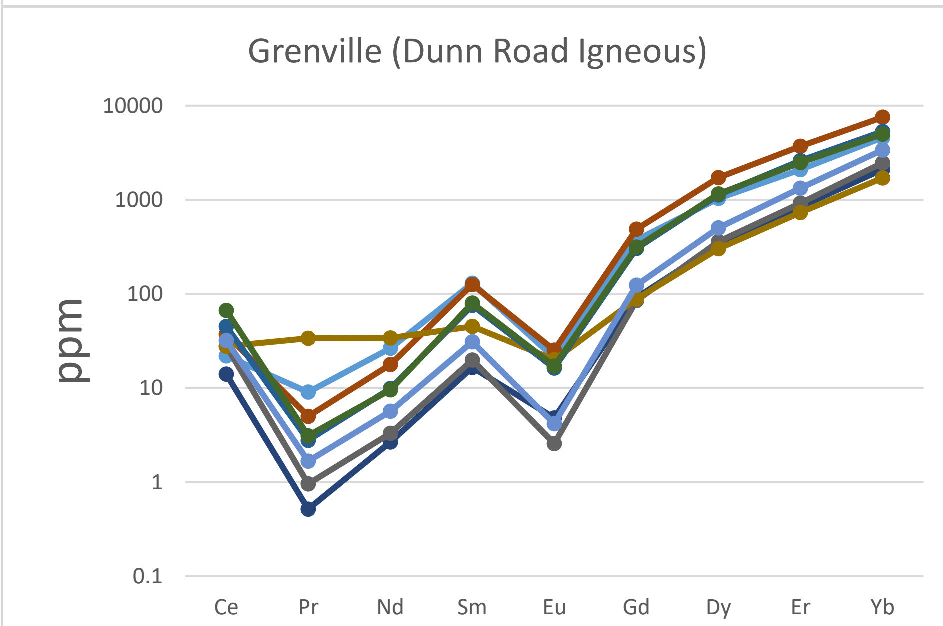
1000
100
10
1
0.1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Grenville (Dunn Road Igneous)
ppm
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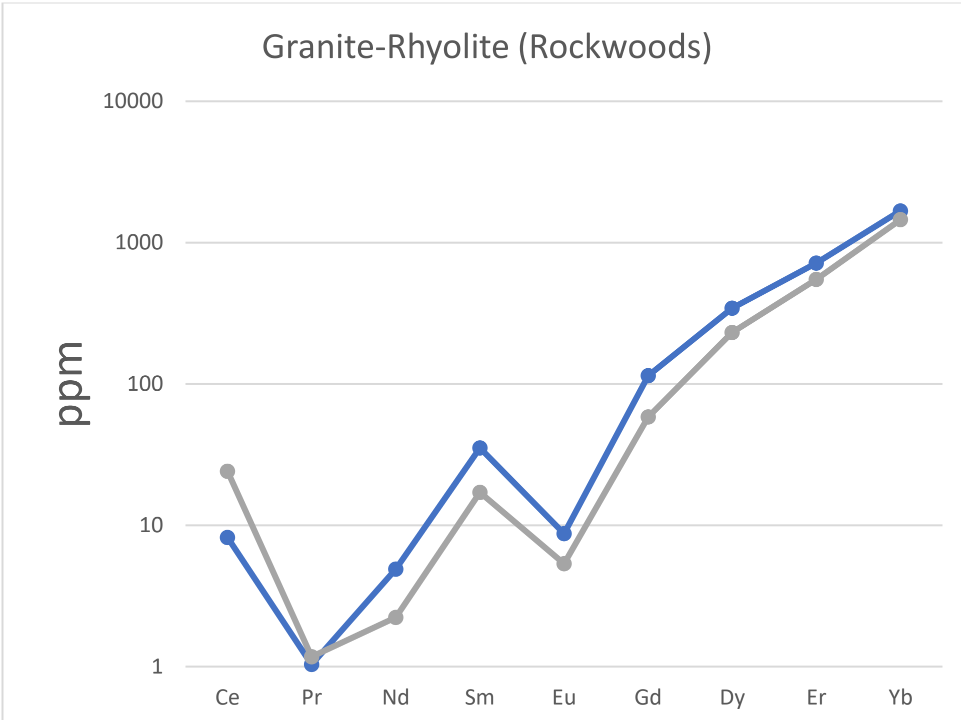
1000
100
10
1
0.1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Granite-Rhyolite (Rockwoods)
ppm
10000
1000
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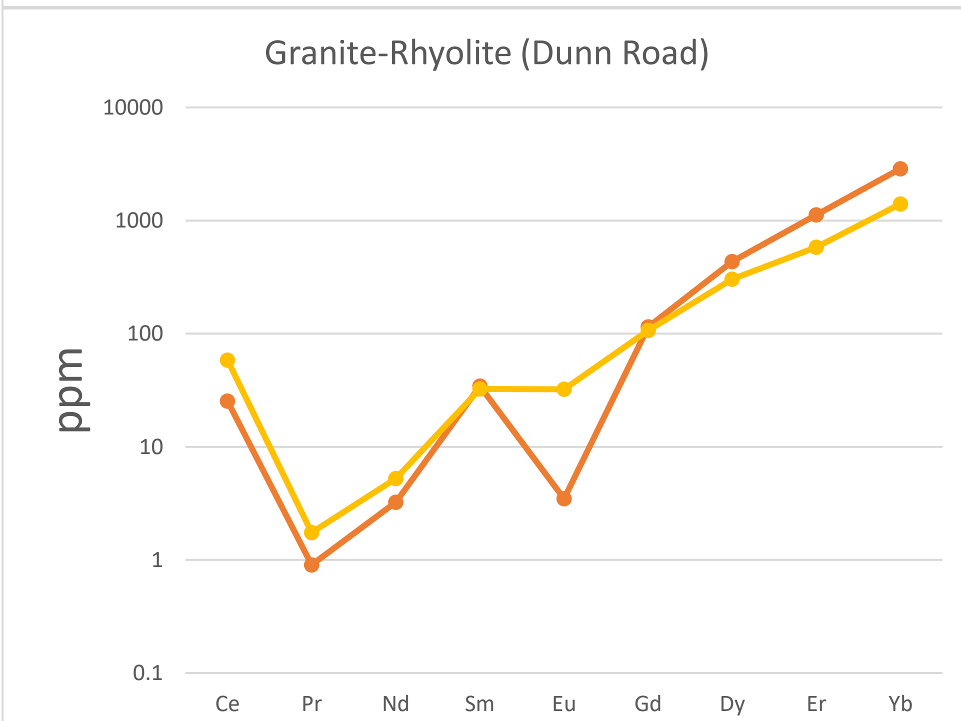
10
1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Granite-Rhyolite (Dunn Road)
ppm
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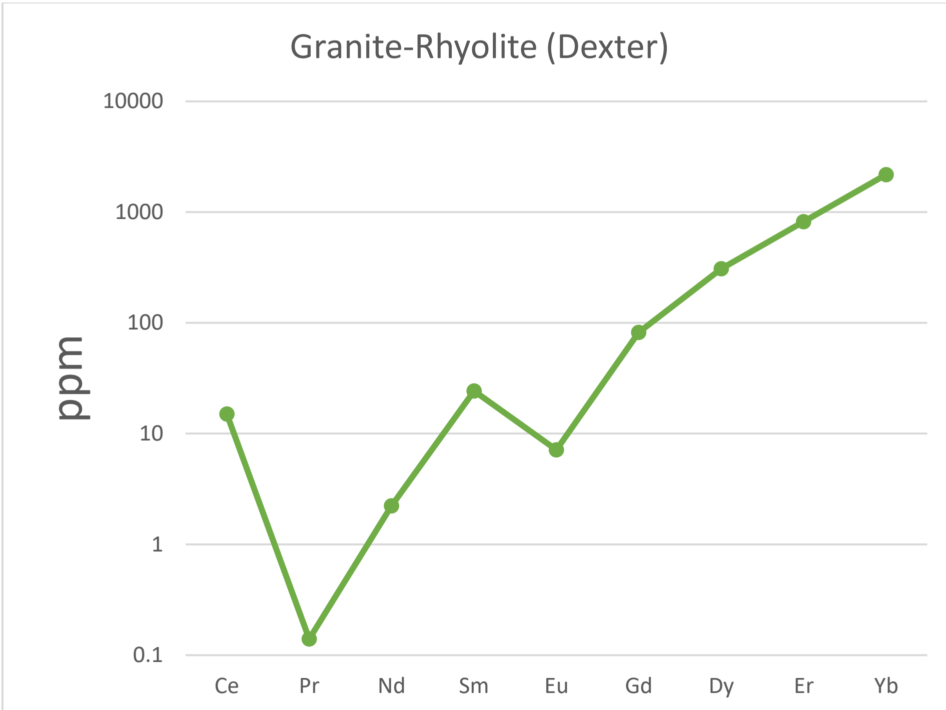
1000
100
10
1
0.1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Granite-Rhyolite (Dexter)
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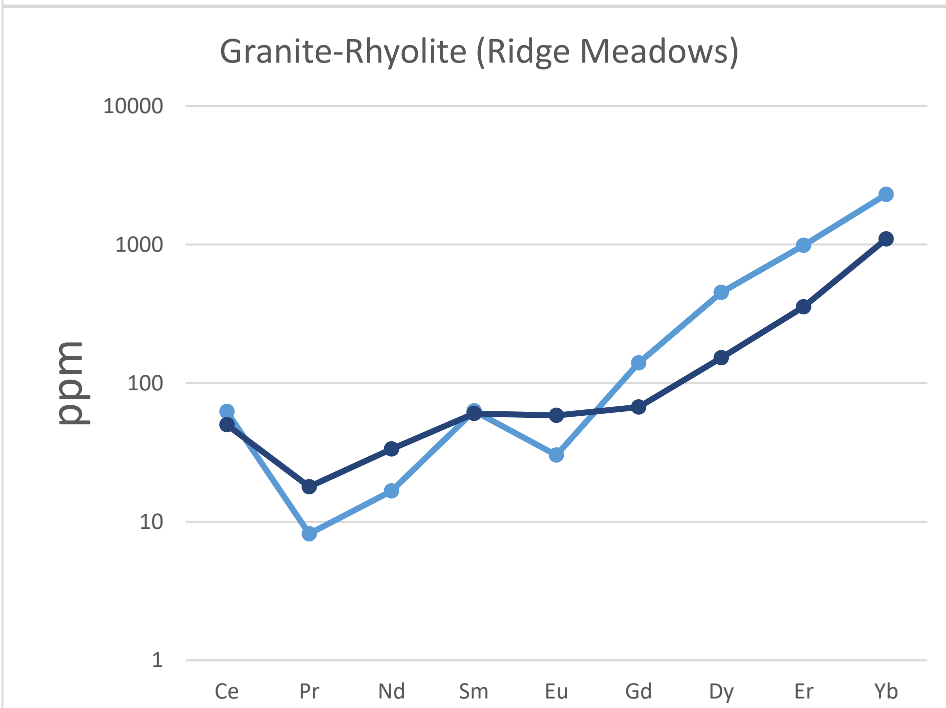
1000
100
10
1
0.1
ppm
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Granite-Rhyolite (Ridge Meadows)
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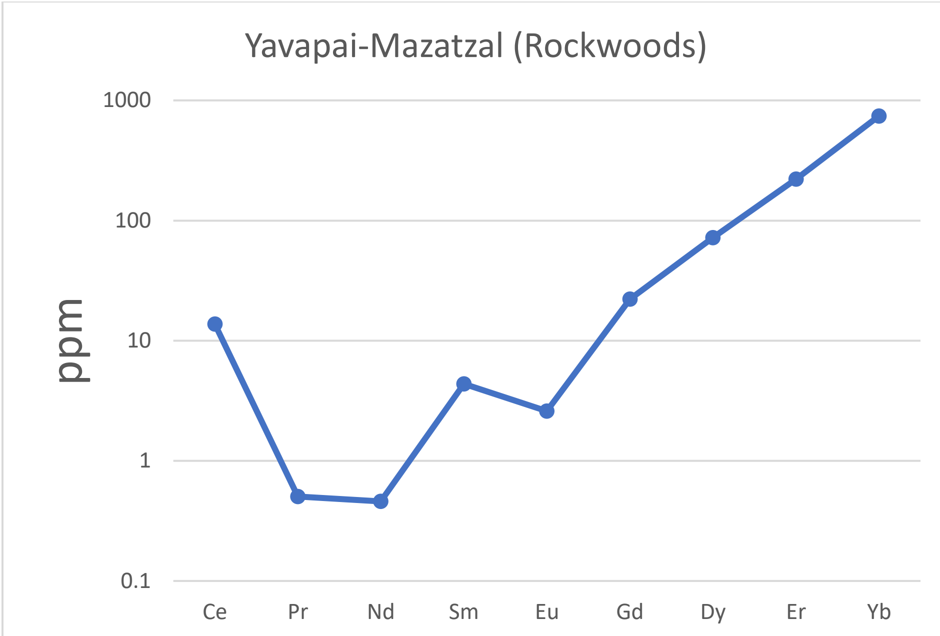
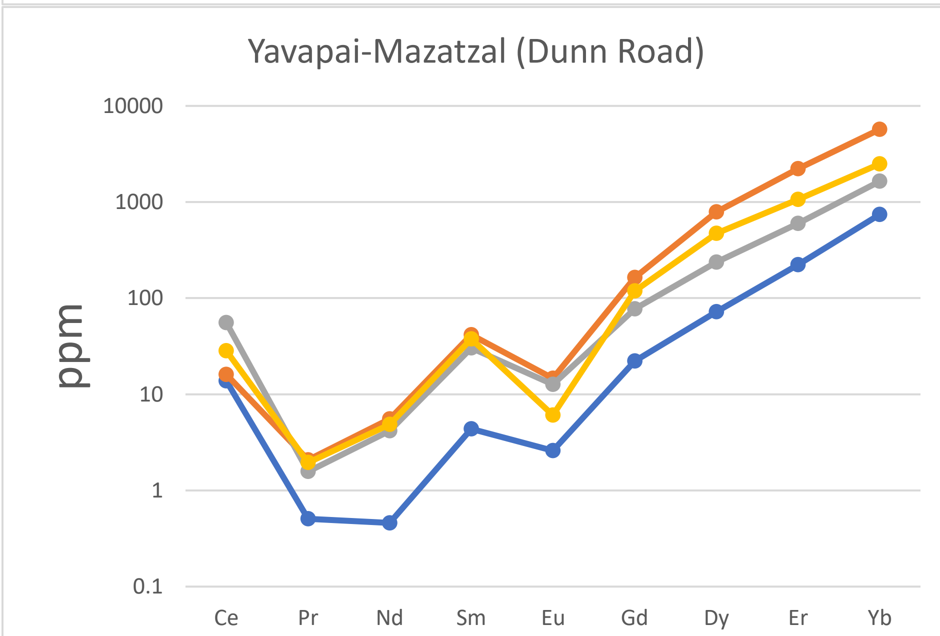
1000
100
10
1
ppm
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Yavapai-Mazatzal (Rockwoods)
ppm
1000
100
10
1
0.1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Yavapai-Mazatzal (Dunn Road)
ppm
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1000
100
10
1
0.1
Ce
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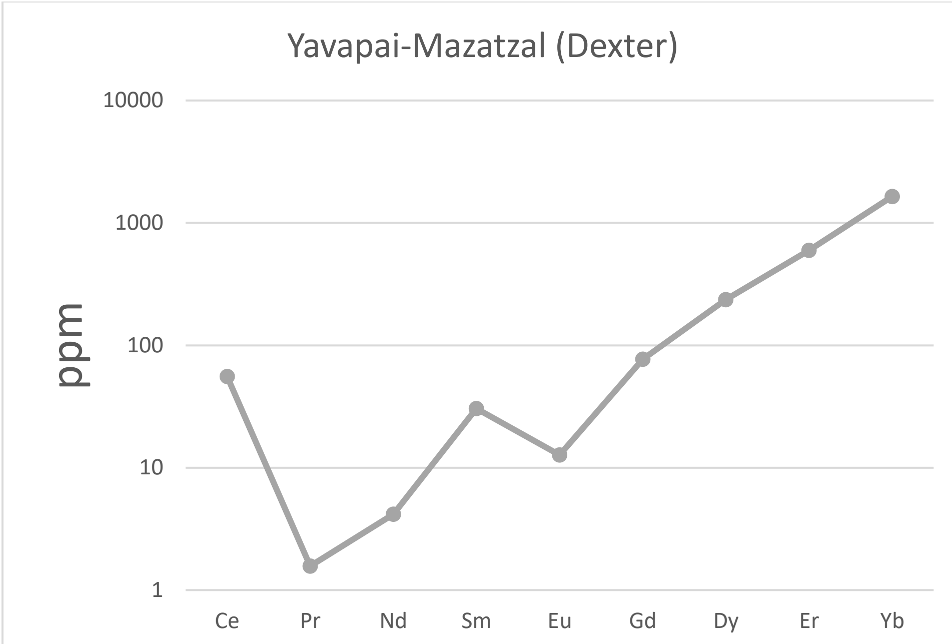
Nd
Sm
Eu
Gd
Dy
Er
Yb


Yavapai-Mazatzal (Dexter)
ppm
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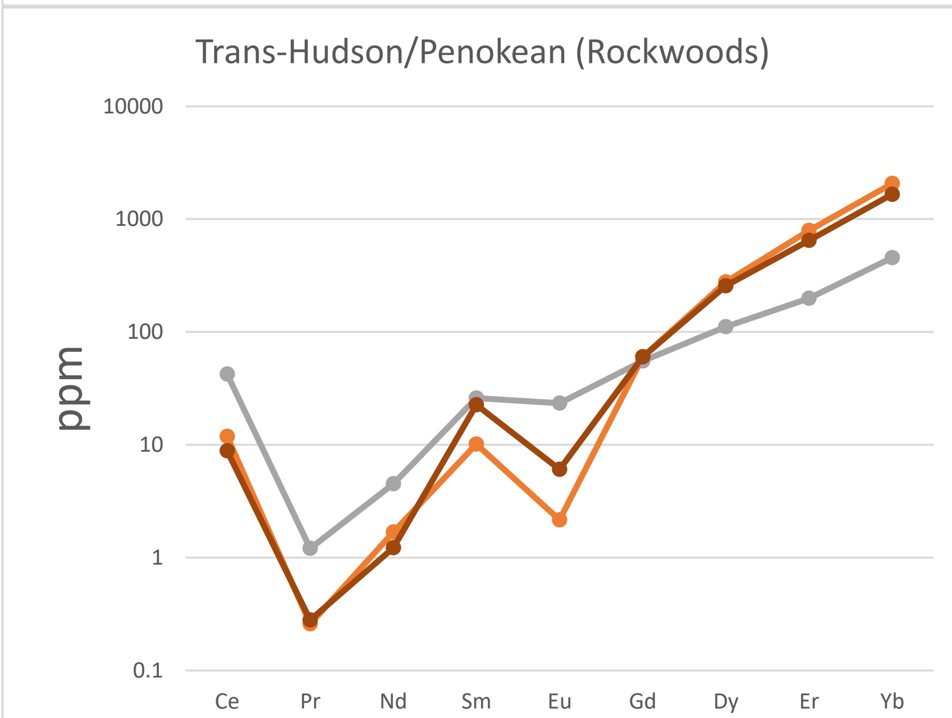
1000
100
10
1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Trans-Hudson/Penokean (Rockwoods)
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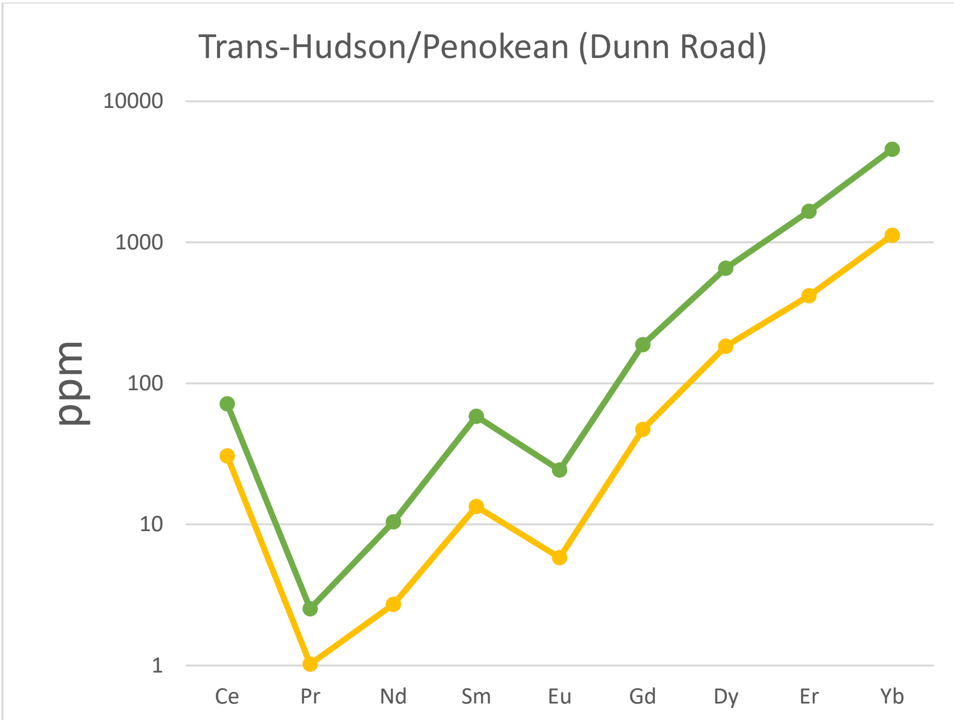
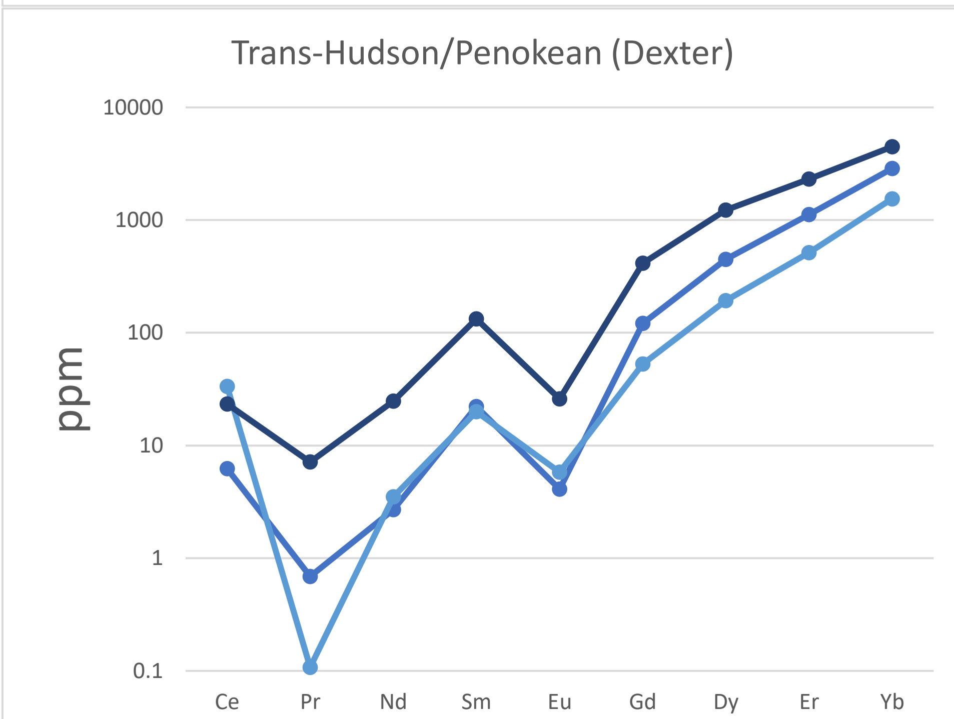
1000
100
10
1
0.1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Trans-Hudson/Penokean (Dunn Road)
ppm
10000
1000
100
10
1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Trans-Hudson/Penokean (Dexter)
ppm
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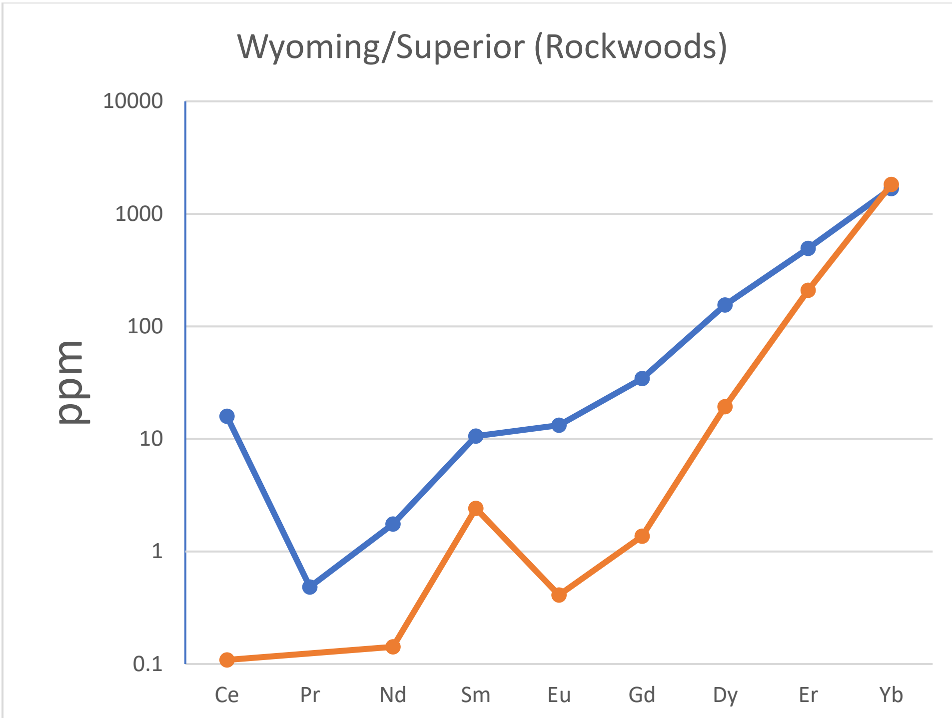
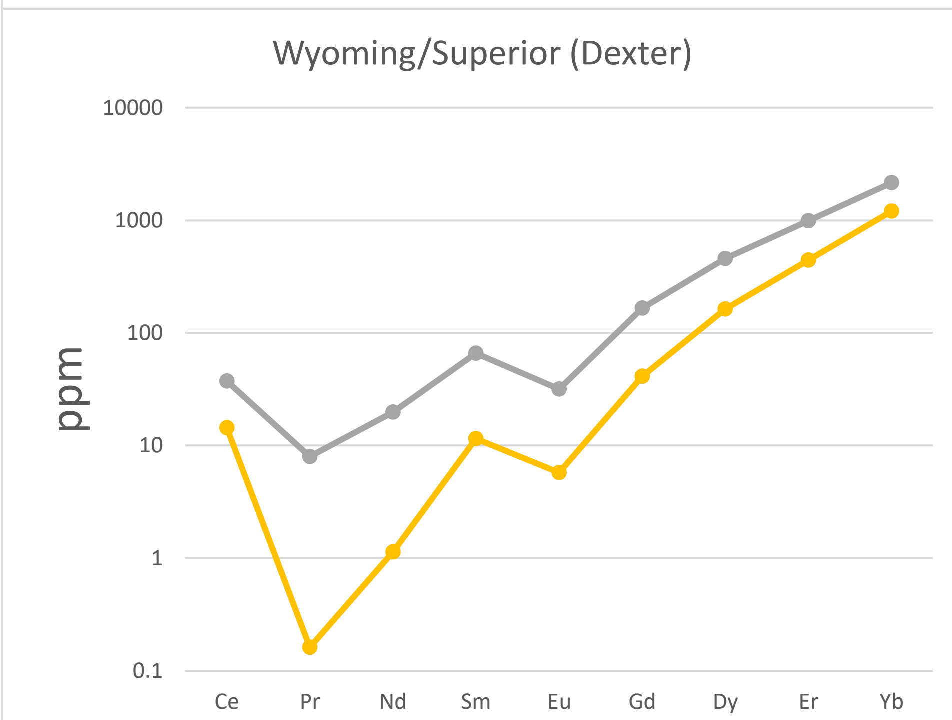
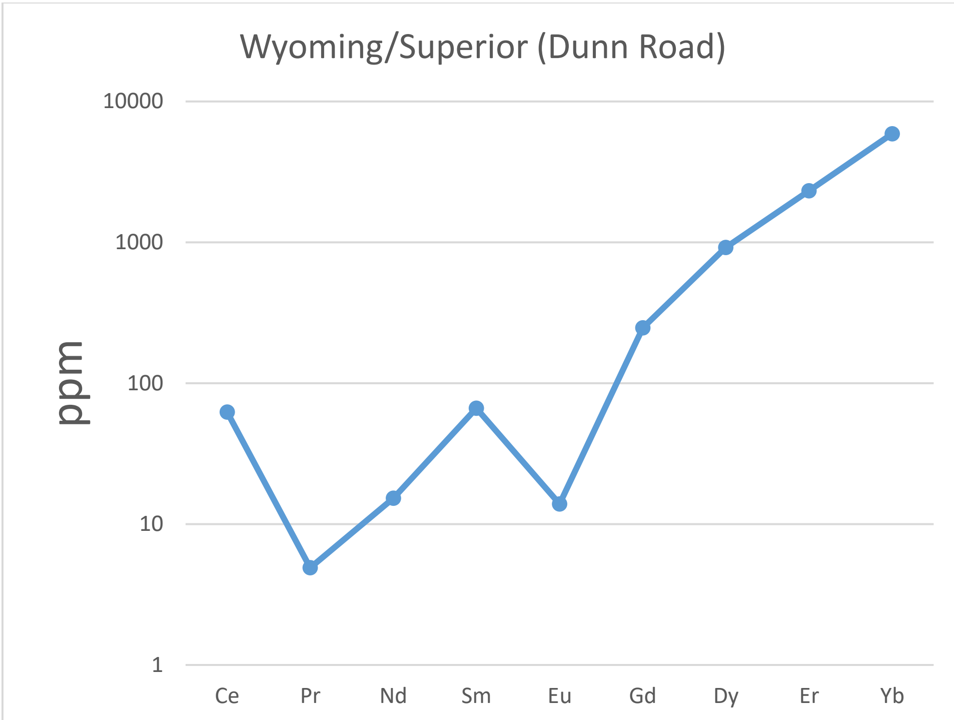
1000
100
10
1
0.1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Wyoming/Superior (Rockwoods)
ppm
10000
1000
100
10
1
0.1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Wyoming/Superior (Dexter)
ppm
10000
1000
100
10
1
0.1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb


Wyoming/Superior (Dunn Road)
ppm
10000
1000
100
10
1
Ce
Pr
Nd
Sm
Eu
Gd
Dy
Er
Yb