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Reinterpreting the stratigraphy of the Florissant Fossil Beds National Monument through correlation by magnetic susceptibility and geochemical comparison

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by

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Undergraduate honors thesis under the direction of

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ABSTRACT

In the summer of 2012, samples were collected for stratigraphic analysis from the Late Eocene lacustrine Florissant Formation at Florissant Fossil Beds National Monument, Colorado. The formation has informally been divided into six units—the lower shale, lower mudstone, middle shale, caprock conglomerate, upper shale, and upper pumice conglomerate. Because of the discontinuous and isolated nature of many of the volcanic mudstone and shale exposures at the Monument, lithostratigraphic correlation has been difficult for previous researchers. The primary objective of this study was to characterize and interpret the stratigraphy based on correlation using magnetic susceptibility (χ) and geochemical data. Thermomagnetic susceptibility (κ) also proved to be a useful correlation aid.

The two sections that were analyzed displayed remarkable similarities and were easily correlated due to the high-resolution sampling in this study. They correlated especially well through the middle shale unit; however, the caprock conglomerate that appeared in one section was virtually absent from the other, but its stratigraphic location is suggested by magnetic susceptibility data. Both sections include a portion of the upper shale, but not the complete sequence.

This study also presents two scenarios supported by time-series for depositional duration and sedimentation rate for the lake beds. The precise stratigraphy that has been produced will be useful for all future studies of the Florissant Formation, and due to its temporal proximity to the Eocene-Oligocene boundary, may even be beneficial to understanding terrestrial response to climate change.

1. Introduction

At the time of one of Earth's most significant climate transitions in geological history, a small stream-filled valley near present-day Florissant, Colorado, became isolated by volcanic eruptions from the nearby Thirtynine Mile volcanic field (Fig. 1). This created a dam that allowed ancient Lake Florissant to form. Estimated to be late Eocene in age, the unique lake shale beds that subsequently developed consist primarily of volcanic ash fallout and clay formed from alteration of volcanic ash. Microbial mats of diatoms cooperated with the clay to preserve one of the most diverse and abundant fossil records in the world (McLeroy and Anderson, 1966; Harding and Chant, 2000; Wingate and Nichols, 2001; O'Brien et al., 2008). Lake Florissant provides an environment where excellent preservation has protected over 1500 species of fossil

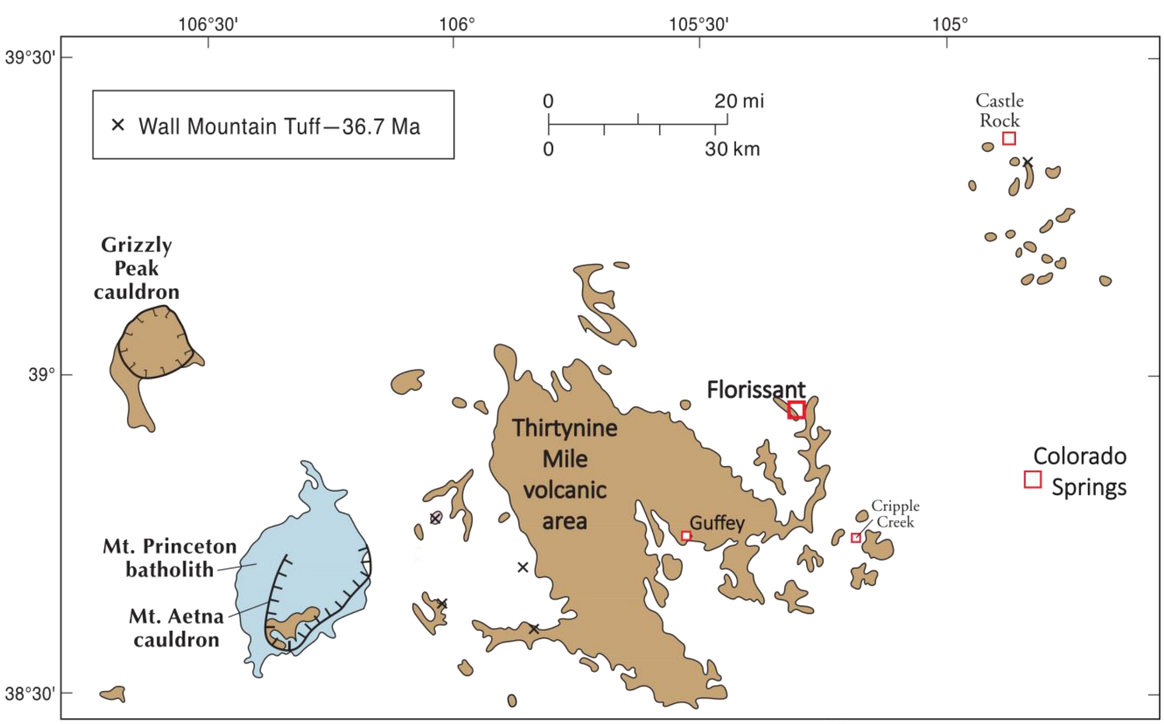

Fig. 1: Map of potential sources of volcanic material relative to Florissant Fossil Beds National Monument. [Image modified from McIntosh and Chapin, 2004]

insects and spiders, and hundreds of fossilized flora, leaves, fruit, and pollen, as well as the impressive petrified Sequoia tree stumps for which the monument is known (Wingate and Nichols 2001, Veatch and Meyer 2008).

The dendritic shape of ancient Lake Florissant reflects its previous stream geometry (Fig. 2). The streams originated after emplacement of the Wall Mountain Tuff at 36.7 Ma. Two generations of Lake Florissant are believed to have been formed from these streams (Evanoff et al., 2001; McIntosh and Chapin, 2004). Several studies have been published on the stratigraphy of the Florissant Formation, and a basic stratigraphic

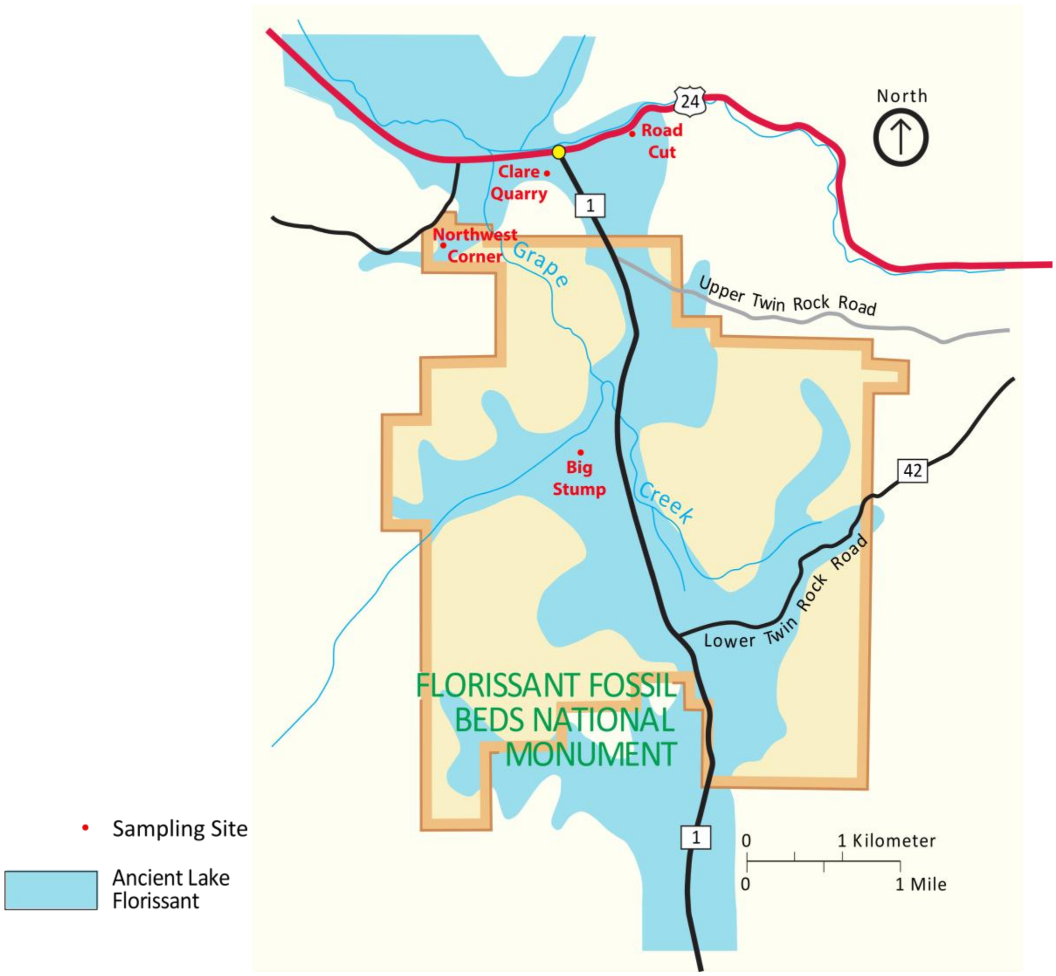

Fig. 2: Map of Florissant Fossil Beds National Monument. Park boundaries outlined in brown, location of ancient Lake Florissant in blue, and sampling locations marked in red. [Image modified from National Park Service]

column (Fig. 3; Evanoff, 1994, 2001) depicts the lacustrine shale deposits as being comprised of three different units, lower, middle, and upper shale, each separated by capping volcanic units. In the earliest lake, the lower shale unit was likely formed due to obstruction of streams by a lahar dam to the southwest. Once sediments filled the lake, streams covered the valley again, only to be dammed once more by a violent volcanic mudflow from the southwest that buried nearby trees to form the petrified forest (McLeroy and Anderson, 1966; Evanoff et al., 2001; Wingate and Nichols, 2001). After this massive lahar, lake shale deposition resumed, forming the middle shale, although these sediments were riddled with ash deposits as well as eroded and redeposited volcanic material from the nearby still-active volcanic center. This second lake generation was covered once more when an eruption produced a thick, pumiceous lahar, the caprock conglomerate, which entered parts of the lake and was deposited on the bottom (Meyer, 2003; Meyer et al., 2004). After this, lake deposition continued for a short time, forming the upper shale unit. Lake Florissant was finally filled by an outwash event of large pumice clasts (Evanoff et al. 2001; Wingate and Nichols, 2001).

Evanoff et al. (2001) identify the Big Stump location as middle shale, and claim that the Northwest Corner contains both the upper and middle shale units, with no caprock conglomerate separating the shale units.

The importance of understanding the Florissant Formation lies in its unique depositional setting, paleontological diversity, and its temporal proximity to the Eocene-Oligocene boundary. Understanding the stratigraphy is essential, but the non-uniform and discontinuous volcanic beds are so complicated that traditional lithologic correlation between exposures in the Monument may be misleading, resulting in misidentification of units. Additionally, the lack of radiometric age dates for units below the caprock conglomerate makes estimation of the depositional time frame nearly impossible. The use of both low field, mass-specific magnetic susceptibility (χ) and geochemical analysis as correlation tools provides the potential to resolve uncertainties in identification of the different exposures. Thermomagnetic susceptibility (κ) may also be useful in correlation, and this is tested here. Time-series analysis of the χ data can provide rough estimates of depositional duration and sediment accumulation rates. As this is an ongoing study, three sections from different areas of the Monument have been collected and at least one remains to be collected. This paper serves to examine the relationship between the Big Stump and Northwest Corner sections (Fig. 2).

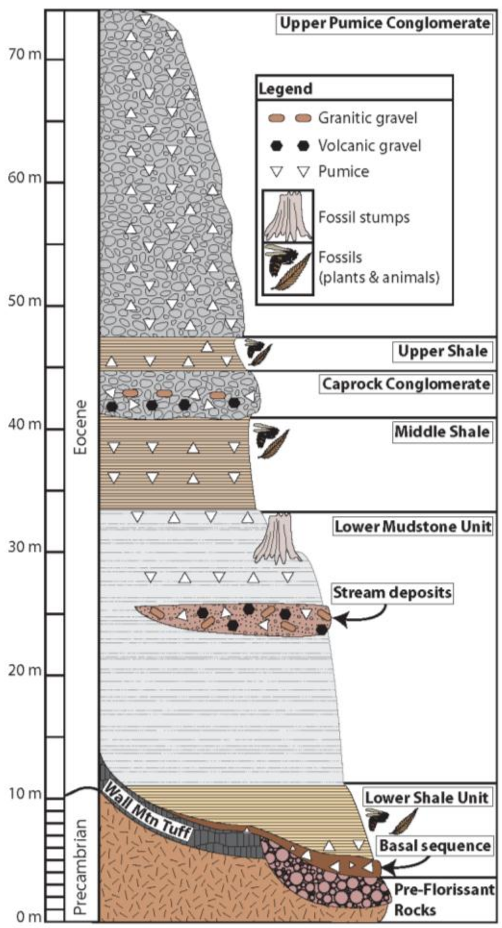

Fig. 3: Basic stratigraphic column for the Florissant Formation as depicted by Evanoff. [Image source: National Park Service]

2. Previous Work

Previous estimates for the age of the Florissant Formation have been made by relative age comparison of its fossil plants with those of the nearby Antero Formation and Thirtynine Mile volcanics (MacGinitie, 1953), and recently by linking the mammalian fauna from Florissant to those of other late Eocene localities (Lloyd et al. 2008). Very few radiometric age dating studies have been conducted for Florissant stratigraphy. The first published date was acquired through K/Ar analysis of sanidine (Epis and Chapin, 1974; 1975), which yielded an estimate of 34.9 Ma when adjusted to modern-day constants (Steiger and Jaeger 1977). Evanoff et al. (2001) produced the first comprehensive examination of radiometric age dates for Florissant locales. Using single-crystal $^{40}Ar/^{39}Ar$ analyses of sanidine from pumice found in the debris flow deposits of the upper sections of the Florissant Formation, Evanoff et al. (2001) determined a unimodal distribution with a mean age of 34.07±0.10 Ma. While this result appears to constrain Florissant's depositional age to latest Eocene, the range of values produced in the study suggests otherwise. The sixty-six individual sanidine crystals yielded ages from 33.64±0.22 Ma to 34.53±0.15 Ma. Such a range is inclusive of the currently accepted Eocene-Oligocene boundary age at 33.9±0.20 Ma (Gradstein et al. 2012). The range encompasses even the 33.714 Ma boundary age proposed by Jovane et al. (2006, 2007) that is based on orbital tuning.

Several eruptive sources for the pumice and ash of the Florissant Formation have been proposed. Evanoff et al. (2001) cited the Grizzly Peak and Mount Aetna calderas (Fig. 1) as potential sources, as well as eruptions of local rhyolite domes near Florissant.

However, the sanidines of the Antero Tuff from the Mount Aetna caldera are slightly younger (33.78±0.09 Ma) than those of the Florissant Formation. The sanidines from the Grizzly Peak Caldera ignimbrites are too old (34.31±0.09 Ma), and no rhyolitic domes have been found near Florissant that lie within the appropriate age range. Therefore, Evanoff et al. (2001) suggested that the pumice of the Florissant Formation might be a result of an early Mount Aetna eruption, a late Grizzly Peak eruption, or that the pumice might be sourced from rhyolitic domes that were once present but have since been eroded or covered. Conversely, Meyer et al. (2004) advocated the Guffey volcanic center as a potential source of appropriate age in close proximity to Lake Florissant.

The dated bounding units of the Florissant Formation represent a 2 myr difference. The unit that lies just below the Florissant Formation, the Wall Mountain Tuff, is dated at 36.7 Ma (McIntosh and Chapin, 2004), while the uppermost pumice conglomerate is dated at 34.9 Ma (Evanoff et al., 2001). Despite this large difference, McLeroy and Anderson (1966) estimated a rough depositional time frame of 2500 to 5000 years based on the thickness of annual laminae in the paper shales.

In an unpublished study supervised by Evanoff and Doi (1992), the authors correlated between sections using magnetic susceptibility. However, they sampled at low resolutions, varying between 0.1 to 0.2 m. While correlation by magnetic susceptibility showed potential, the study was inconclusive due to the authors' suspicion that the insufficient sampling interval was causing important variations in the data to be missed.

3. Methods

3.1. Field sampling

For this study, samples were collected from two locations, the Big Stump and the Northwest Corner (Fig. 2). These sections were carefully cleared of cover and cleaned with scrapers and brushes to ensure sampling of fresh outcrop. The three dominant lithologies present in the sections were paper shale, fine-grained volcanic ash deposits (mudstone), and pumice conglomerate caprock. Different lithologies were sampled at different resolutions, because volcanic material was assumed to be instantaneously deposited. Samples were collected at ~1 cm intervals for shale, ~5 cm intervals for mudstone, and ~20 cm intervals for caprock. Strike and dip was measured at different locations across the monument. Dips were extremely shallow and strike directions varied.

3.2. Laboratory measurements of χ

χ (in m^3/kg) is an indicator of the concentration and composition of the magnetizable materials in a sample, not its magnetic polarity, so oriented samples are not required (Ellwood et al., 2008). χ measurements for samples from the Big Stump and the Northwest Corner sections were taken using the Williams susceptibility bridge at LSU and reported in terms of sample mass. χ measurements are reported in this paper, along with lithologies, for the Big Stump (Fig. 4) and the Northwest Corner sections (Fig. 5).

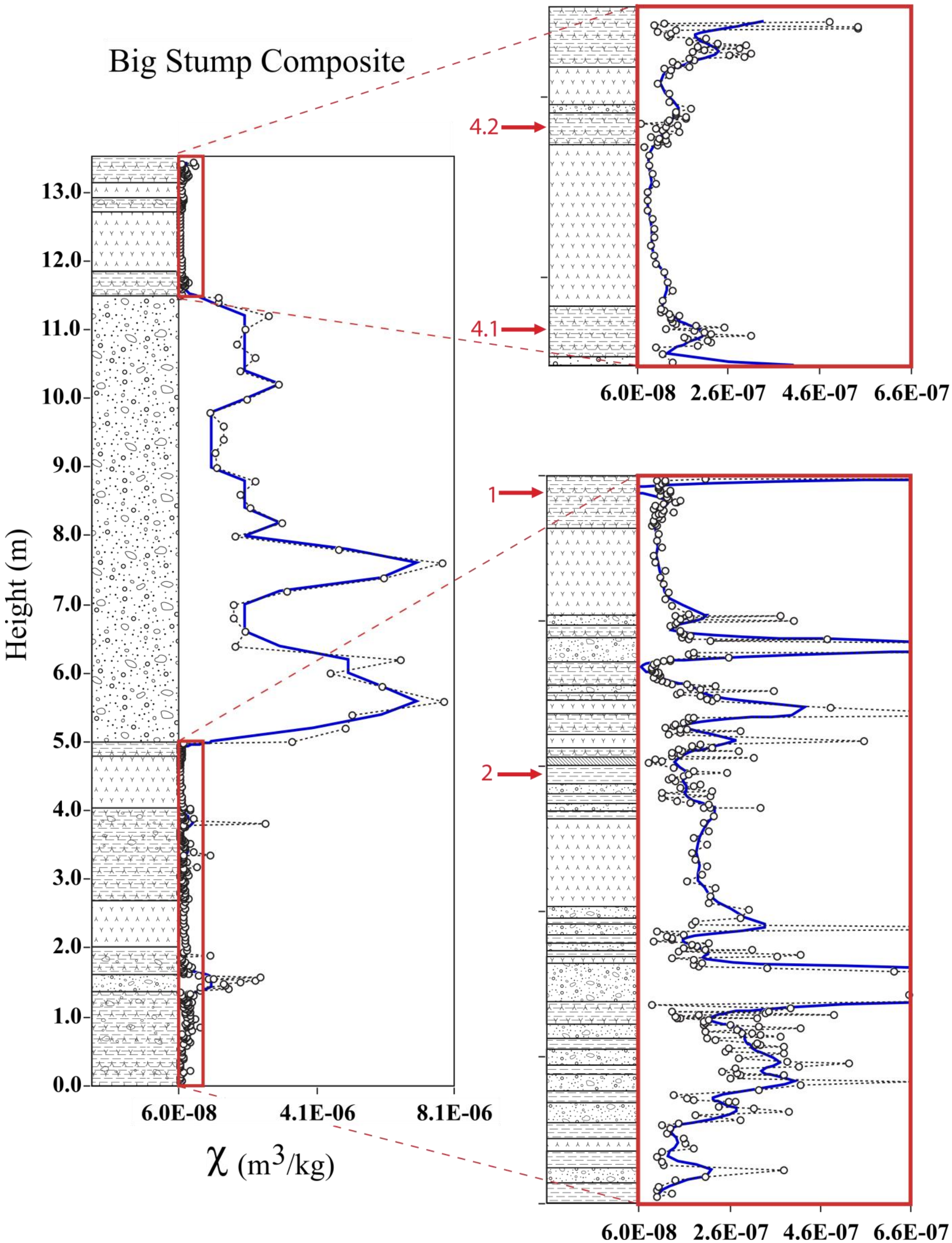

Fig. 4: Big Stump composite magnetic susceptibility (χ) results with lithologic logs. Insets are provided for clarity. Lithologic symbols used are defined in Fig. 5. Red numbers with arrows indicate locations at which pollen samples have been taken for analysis.

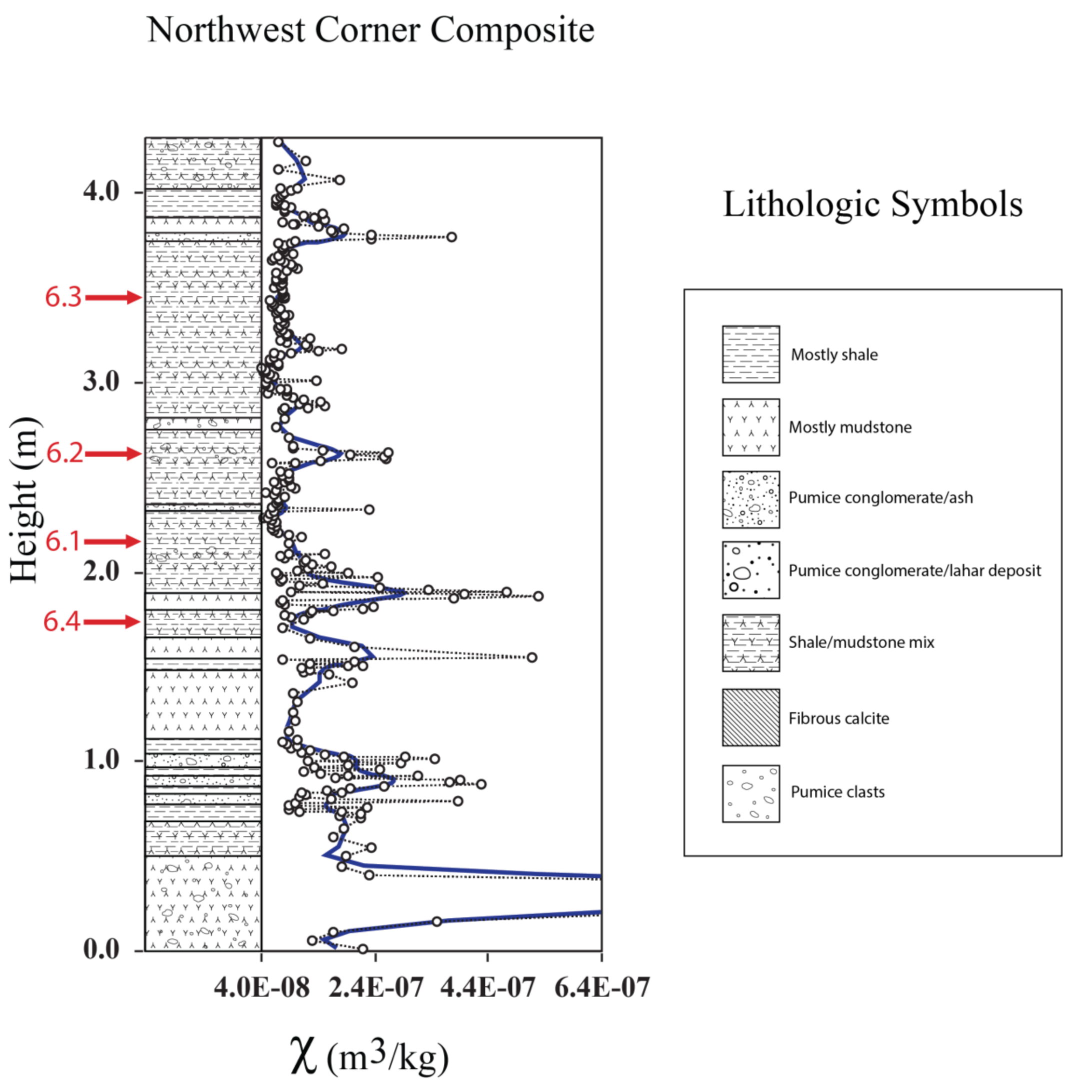

Fig. 5: Northwest Corner composite magnetic susceptibility (χ) results with lithologic log. Lithologic symbols used are defined in the key. Red numbers with arrows indicate locations at which pollen samples have been taken for analysis.

3.3. Thermomagnetic susceptibility measurements (κ)

Thermomagnetic susceptibility *(κ)* measurements were performed on selected samples (Fig. 6) from both sections using the KLY-3S Kappa Bridge at LSU. The measurement is performed by heating a sample to 700°C, while simultaneously

measuring κ as the sample responds to the heating and cooling. Results are presented in dimensionless SI units. The curves that are produced are used to characterize the mineral types that are responsible for κ. Paramagnetic minerals display a parabolic-shaped decay at low temperatures (30-200°), while ferrimagnetic minerals show an increase in κ before falling toward the Curie temperature of the mineral responsible for κ (Ellwood et al., 2008; Ellwood et al., 2010b; Ellwood et al., 2013).

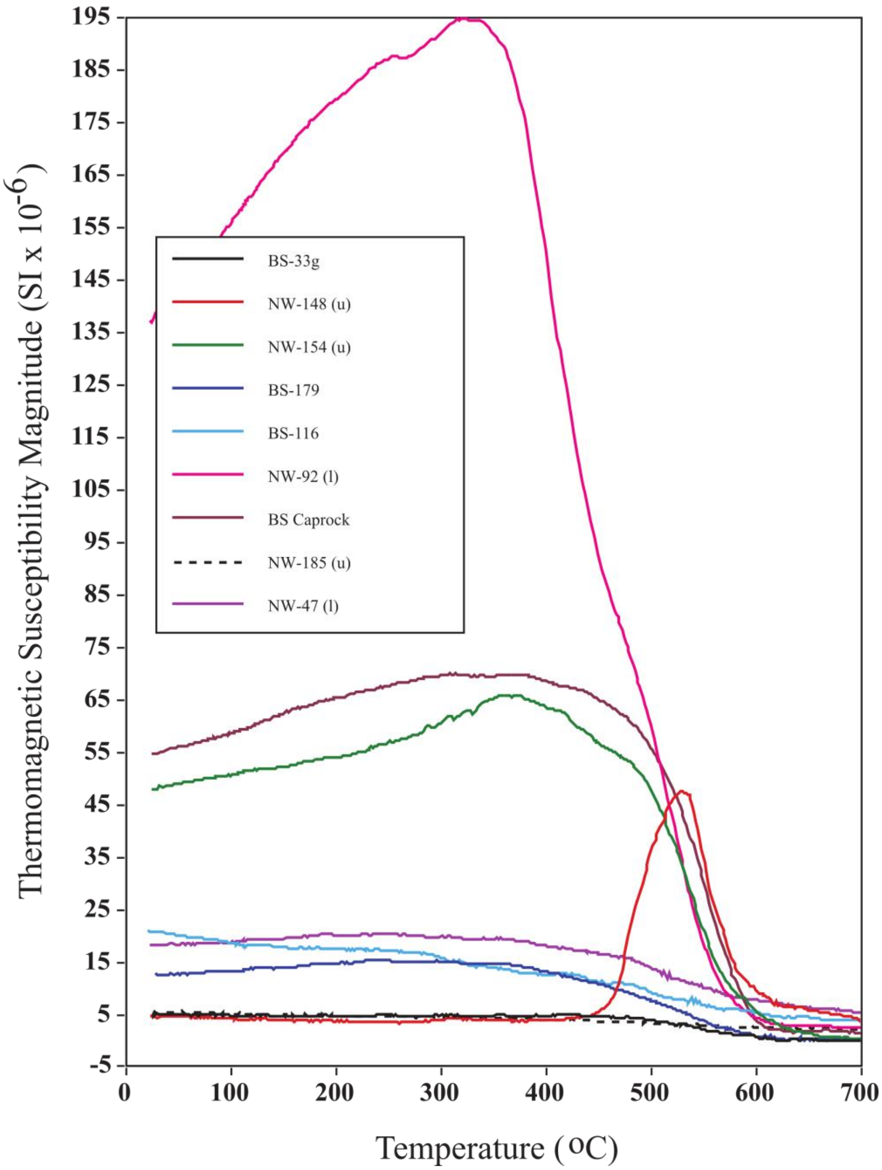

Fig. 6: Thermomagnetic susceptibility (κ) heating results for selected Big Stump (BS) and Northwest Corner (NW) samples.

3.4. Determination of elemental concentrations using X-Ray fluorescence (XRF)

Samples were collected for whole rock inorganic geochemical measurements for the Northwest Corner section and the portion of the Big Stump section below the caprock conglomerate. Using pressed pellet preparation on a Bruker S4 wavelength dispersive X-ray fluorescence spectrometer, elemental concentrations were determined and reported at weight percentage oxides (Al_2O_3, SiO_2, TiO_2, Fe_2O_3, MnO, MgO, CaO, K_2O, Na_2O and P_2O_5) and trace elements at ppm (S, Ba, Be, Ce, Co, Cr, Cs, Cu, Dy, Eu, Er, Ga, Gd, Hf, Ho, La, Lu, Mo, Nb, Nd, Ni, Pr, Rb, Sc, Sm, Sn, Sr, Ta, Tb, Th, Tl, Tm, U, V, W, Y, Yb, Zn and Zr) (Ellwood, et al., 2008).

3.5. Time-series analysis

Time-series analysis was performed on the χ data for the Northwest Corner section. Although the sampling intervals were not consistent for this section, uniform spacing of 1 cm was assumed for this analysis, as this is only intended to roughly estimate depositional time frame and sediment accumulation rate. Spectral power was obtained using Multi-taper (MTM) and Fourier Transform (FT) methods (Ellwood et al., 2013). Determination of the depositional time frame and sediment accumulation rate was estimated for two possible scenarios. The first scenario was based on the assumption that the entire Florissant Formation was deposited in approximately 2 million years, and that the Northwest Corner section only represented half of that time frame (Fig. 7). Evidence of Milankovitch cyclicity (adjusted for 33.9 Ma by the method in Berger et al., 1992)

should be present. The second scenario, presented in Fig. 8, was based on the 5000-year endmember of the potential time frame suggested by McLeroy and Anderson (1966). If the Northwest Corner section represents half of that time frame, the section should contain evidence of solar cycles.

4. Results

4.1. Big Stump section

At the Big Stump location (Fig. 4; N=369), 13.42 m of section were collected. Lithologies are interbedded shale and mudstone, and pumice conglomerate. Shale and mudstone lithologies are typically white to gray and appear to be composed of the same materials, a mixture of clay and volcanic ash, but the distinguishing factor between the lithologies is the fissility and sometimes papery nature of the shale relative to the blocky or even conchoidal fracture of the mudstone. Both the ash beds and the caprock conglomerate are termed pumice conglomerate; these are both white to yellow pumice-rich aggregates. However, the ash beds typically contain more fine-grained pumice clasts than the coarse clasts of the caprock. Pumice clasts found in mudstone units are often inversely graded. Smoothed χ data for the entire section are reported along with a lithologic log in Fig. 4. Insets have been created for the portions of the section above and below the caprock.

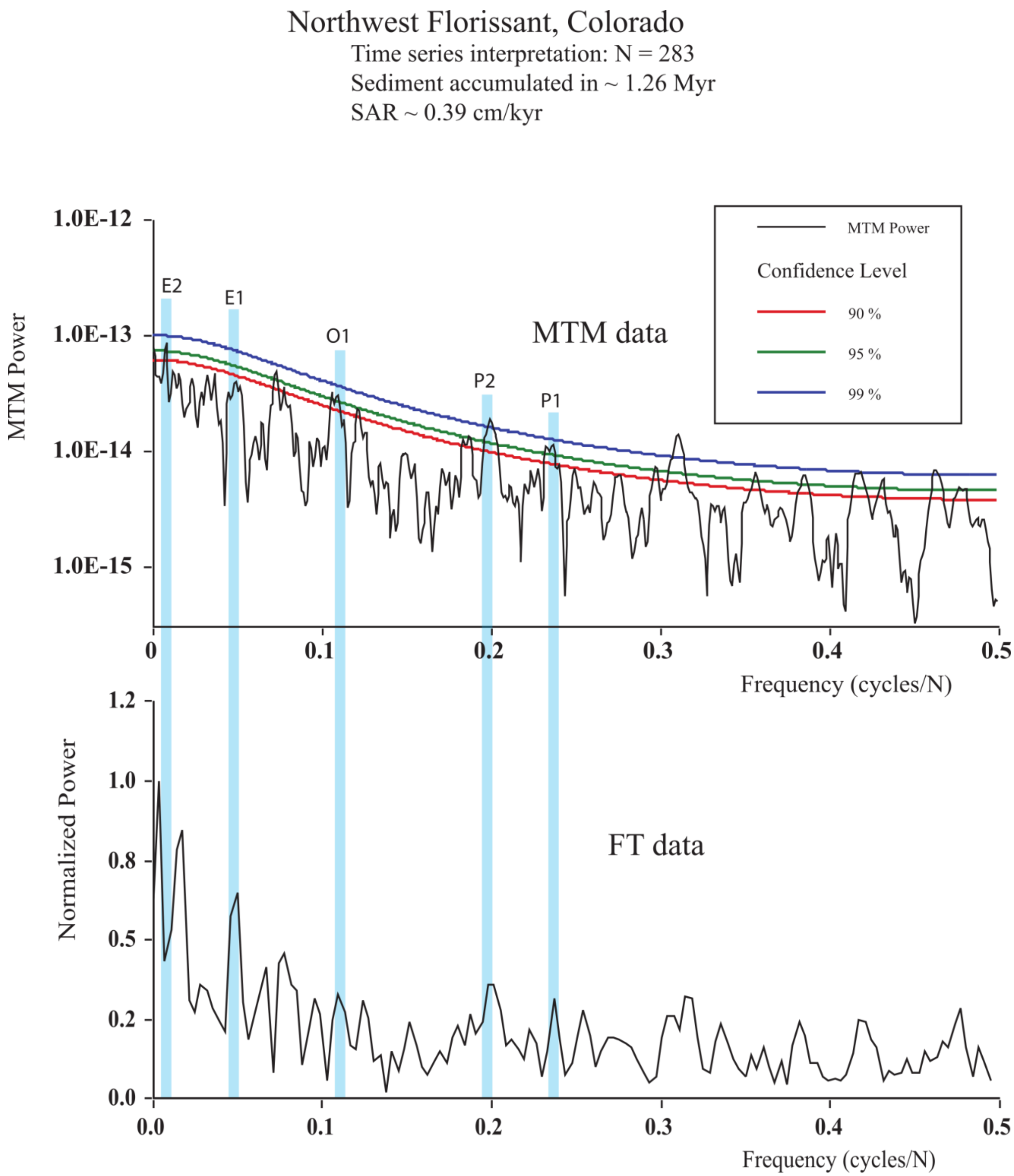

Fig. 7: MTM and FT time-series results with assumed ~2 myr depositional duration for entire Florissant Formation. Analyzed section shown here is interpreted to represent approximately half of that time frame. Interpreted orbital signals are represented by blue bars. [Adjusted for 33.9 Ma by method in Berger et al., 1992]

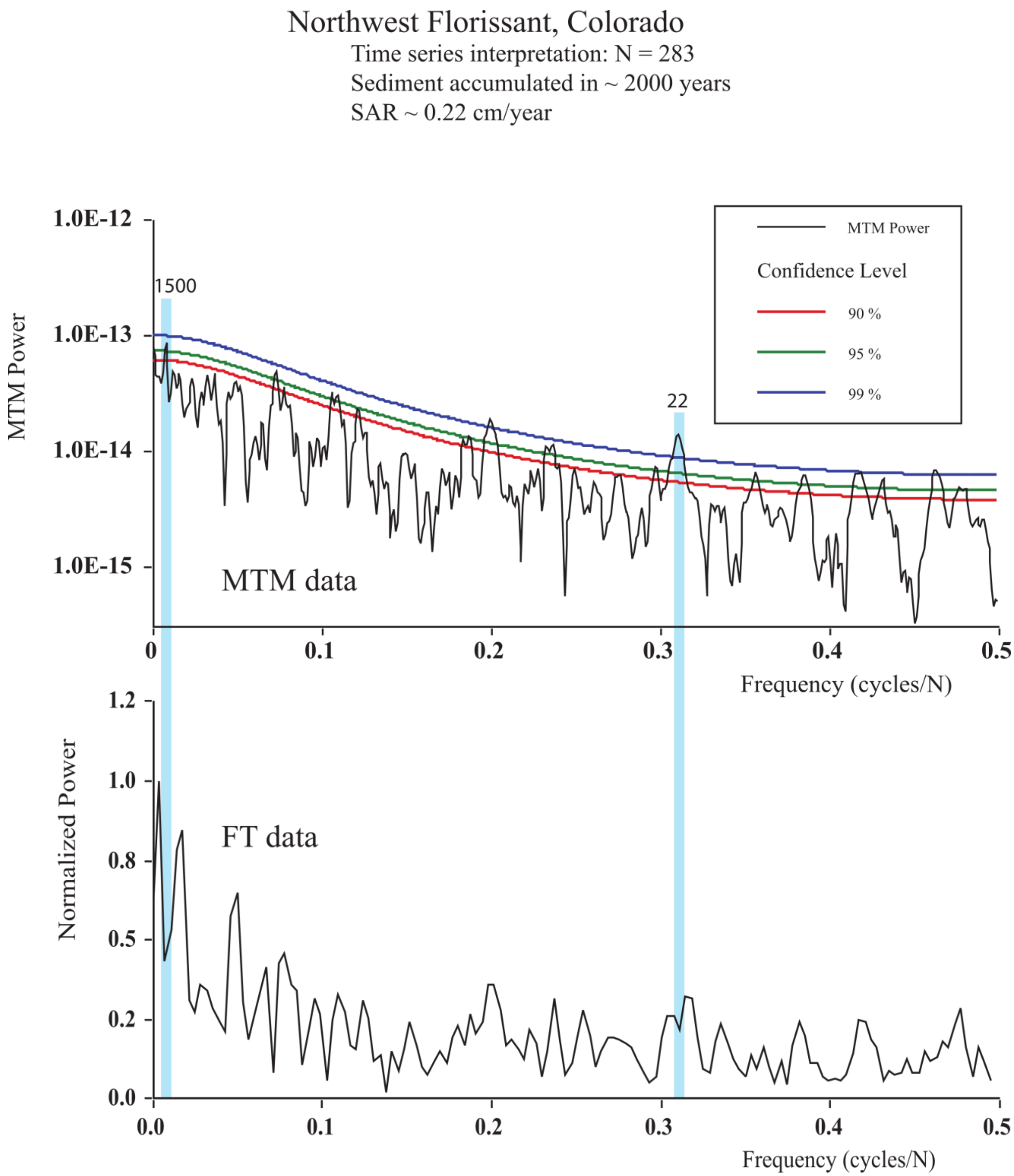

Fig. 8: MTM and FT time-series results with assumed ~5000-year depositional duration for entire Florissant Formation. Analyzed section shown here is interpreted to represent approximately half of that time frame. Interpreted signals are represented by blue bars.

4.2. Northwest Corner section

A 4.27 m section was collected at the Northwest Corner locality (Fig. 5; N=283). Lithologies are interbedded shale and mudstone, and pumice conglomerate. Like the Big Stump section, shale and mudstone is typically white to gray and appears to be composed of the same materials, namely a mixture of clay and volcanic ash. However, the distinguishing factor between the lithologies is the fissility and sometimes papery nature of the shale relative to the blocky or even conchoidal fracture of the mudstones. Contrary to the Big Stump section, the Northwest Corner section appears to have more paper shale, as well as fewer and thinner mudstone and ash layers. Because no caprock appears to be present, pumice conglomerate as used here only refers to the white to yellow, fine-grained ash beds. In some mudstone units, layers of pumice clasts are apparent, but not abundant enough to be considered pumice conglomerate. Some shale strata appear to be slightly cross-bedded.

4.3. Controls on κ of Florissant shale, mudstone, and caprock.

κ measurements (Fig. 6) for both sections display a dominance of ferrimagnetic components, which is evidenced by the decay of every sample to the Curie point for magnetite, 580° C (Ellwood et al., 2010a). Some samples seem to contain paramagnetic minerals, shown by the slight parabolic curvature at the onset of heating, but ultimately decay in a manner resembling ferrimagnetic magnetite (Ellwood et al., 2010b).

4.4. Correlation using chemostratigraphy

The geochemical data for the Northwest Corner section and the portion of the Big Stump section below the caprock was acquired and used to correlate between the two sections (Fig. 9). Four ratios for each section were devised from the elemental concentrations, normalized, lined up with their respective χ data and lithologic logs, and then compared between sections. Eight stratigraphic packages are outlined that appear to correlate well. Additional geochemical comparisons were conducted (Fig. 10) to verify accuracy of correlation (Methods derived from David, 2006; Xu et al., 2010).

4.5. Evaluating depositional duration and sedimentation rate for two scenarios through time-series analysis

The first scenario yielded excellent evidence of Milankovitch E2 (405 kyr) and E1 (100 kyr) eccentricity, O1 (40.15 kyr) obliquity, and P2 (22.73 kyr) and P1 (18.82 kyr) precessional peaks (obliquity and precessional peaks recalculated from Berger et al., 1992). These results returned a sediment accumulation rate of approximately 0.39 cm/kyr, and suggested that sediment accumulated over a period of ~1.3 myr (Fig. 7).

The second scenario yielded strong evidence of a 22-year sunspot cycle, as well as a clear 1,500-year cycle. These results returned a sediment accumulation rate of approximately 0.22 cm/yr, and indicated a depositional time frame of approximately 1,936 years (Fig. 8). Clearly these two scenarios are very different.

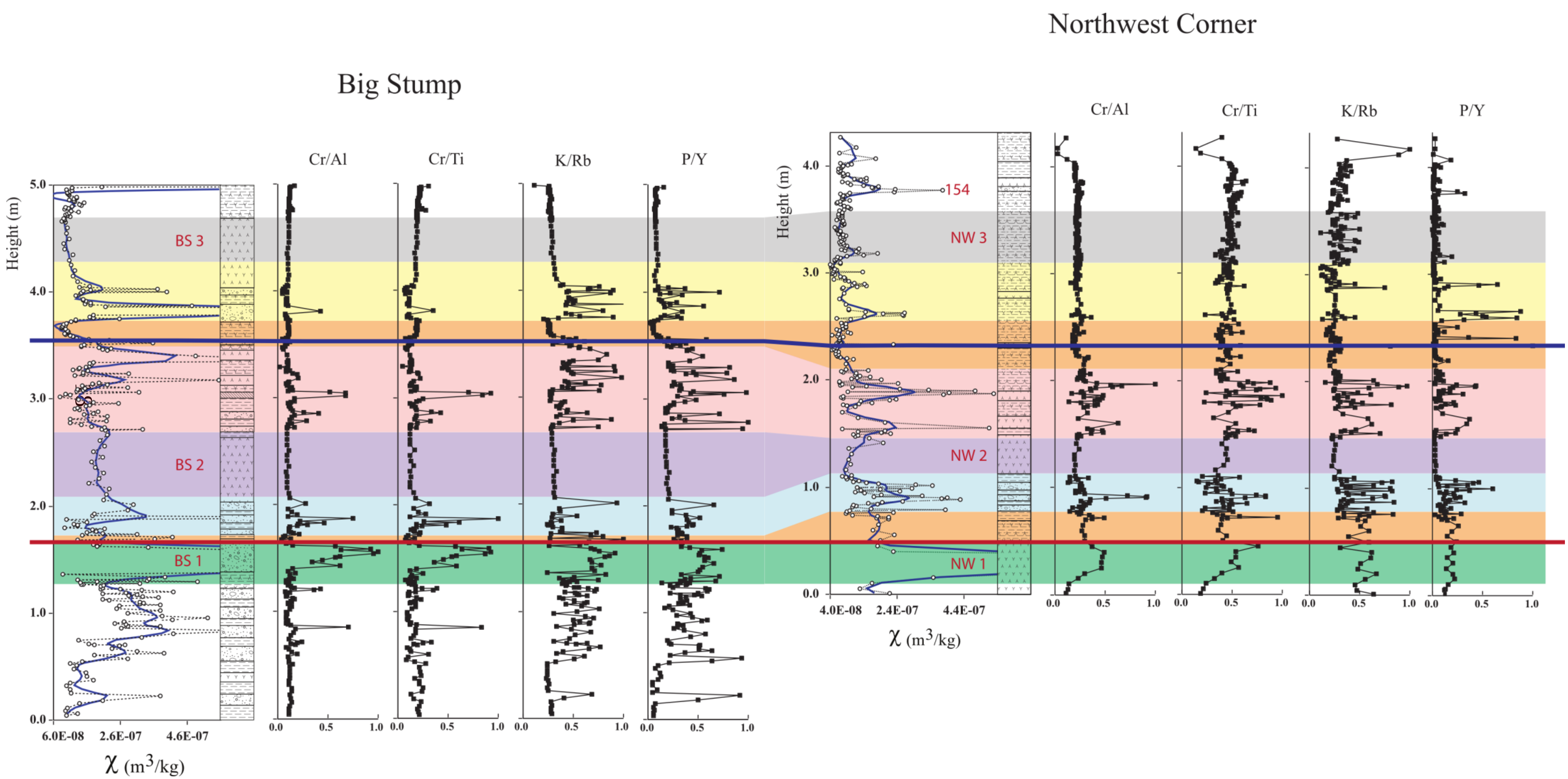

Fig. 9: Chemostratigraphic characterization and correlation of the Big Stump section and the Northwest Corner section. Magnetic susceptibility (χ) data is included, as well as lithologic logs. The solid red line is a tie line, and the blue line represents a significant ash marker bed.

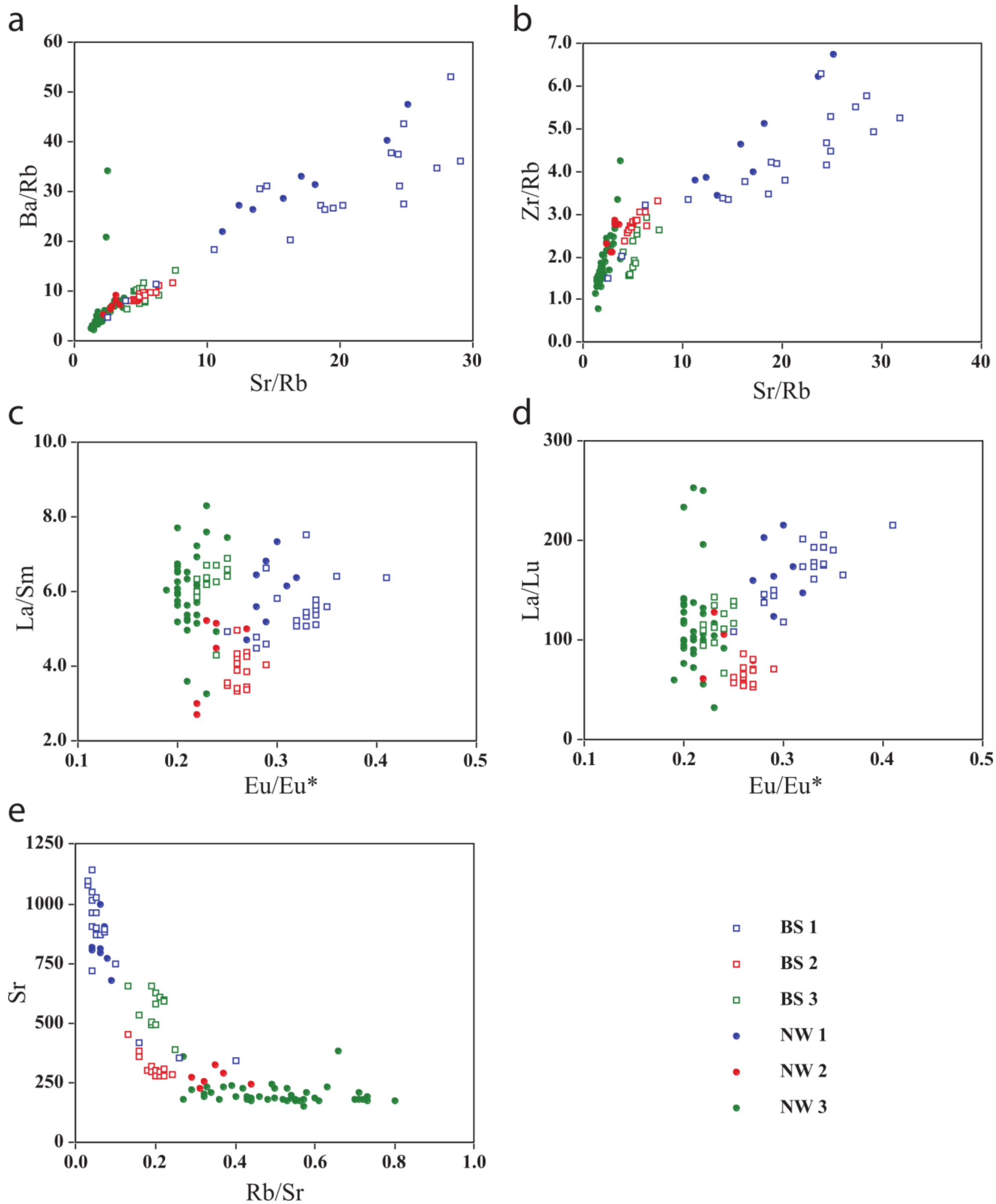

Fig. 10: Trace element ratios for differentiation and correlation of selected units outlined in Fig. 9. BS 1, BS 2, BS 3, NW 1, NW 2, and NW 3 are marked in Fig. 9 in red. **(a)** Plot of Ba/Rb vs. Sr/Rb. **(b)** Plot of Zr/Rb vs. Sr/Rb. **(c)** Plot of La/Sm vs. europium anomaly. **(d)** Plot of La/Lu vs. Europium anomaly. **(e)** Plot of Sr vs. Rb/Sr. [a-d based on methods from David, 2006; e based on method in Xu et al., 2010]

5. Discussion

5.1. Controls on lithology, as suggested by correlation among sections using χ, κ, *and geochemical comparisons*

The high resolution sampling from this study produced a very detailed stratigraphy for parts of the Florissant Formation. The χ plots for each section bear a striking resemblance to one another, allowing tentative correlation of these data sets. However, the introduction of geochemical data as an additional correlation tool provides greater certainty (Fig. 9).

While lithologic correlation is difficult between the two sections, the similarities between the two become more evident when paired with χ plots and chemostratigraphy (Fig. 9). In many instances, mudstone or pumice conglomerate ash layers appear thinner or nonexistent in the Northwest Corner section relative to their counterparts in the Big Stump section, and their association may not have been recognized without the additional tools used here.

The comparisons in Fig. 10 were conducted as additional verification of the correlation of selected packages (identified in Fig. 9). Fig. 10a and Fig. 10b are most useful for identifying the similarity between BS 1 and NW 1. Fig. 10c and Fig. 10d display good differentiation between a BS 1 and NW 1 cluster, a BS 2 and NW 2 cluster, and a BS 3 and NW 3 cluster. Finally, Fig. 10e is useful for linking BS 1 and NW 1, but the behavior of the remaining units may reveal a corollary for weathering intensity. If BS 2 is assumed to be equivalent to NW 2, and BS 3 to NW 3, their separation in Fig. 10e

may be attuned with the theories presented in Xu et al (2010). That is, because Sr is leached more easily than Rb, Sr is likely to be transported in water as dissolved material and eventually deposited in lake sediments. Xu et al. (2010) suggest that Sr is most abundant when farthest from its source. The greater amount of Sr (and in turn, lower Rb/Sr ratios) in the BS units may be an indication that the source of sediment runoff is closer to the NW sections. The result is consistent with the natural direction of stream flow from the north in the Florissant valley (Fig. 2).

Chemostratigraphic correlation becomes difficult toward the upper stratigraphic portion of each section. However, the κ data may be used to tentatively resolve uncertainties. Because no geochemical data were produced for the caprock conglomerate of the Big Stump section, κ measurements must be used to attempt to find its counterpart in the Northwest Corner section. Although the caprock conglomerate is believed to be absent from the Northwest Corner section (Evanoff et al., 2001), it is possible that pumice clasts or other components of the massive lahar may have floated in the ancient lake waters to be deposited at the Northwest Corner section, and if so should record a magnetic signature similar to that of the caprock at the Big Stump section. The κ curve for the caprock sample that was analyzed displays similar behavior and magnitude of κ to sample 154 of the Northwest Corner section (Fig. 6). The slightly paramagnetic nature of the κ curve at the onset of heating for this sample may be explained by the presence of more clay material in sample 154 than is in the caprock sample. While the stratigraphically higher position of sample 185 seemed more likely to display evidence of the caprock, due to the large pumice clasts (shown only in Fig. 5) that it contains, its κ

curve is significantly different from that of the caprock (Fig. 6). Therefore, it is argued here that sample 154 is stratigraphically equivalent to the caprock conglomerate.

Variations between sections regarding stratigraphic package thickness can be explained by a number of controlling factors. The noticeable decrease in volcanic influence on the Northwest Corner section, relative to the Big Stump, can be attributed to source, because the Northwest Corner section is located farther from the proposed sources of volcanic material than is the Big Stump section. Additionally, the orange chemostratigraphic packages in Figure 9 are particularly shale-rich in both sections, but appear to be thicker at the Northwest Corner section. The greater thickness, when associated with the slight cross-bedding observed in the Northwest Corner shale, suggests that the Northwest Corner was impacted more than the Big Stump by detrital debris flows due to closer proximity to an outwash source, perhaps from south-running streams.

5.2. Controls on cyclicity for two scenarios

Given that the time-series data are only intended to produce rough estimates of depositional duration and sedimentation rate, the data spacing used for analysis was adjusted to allow the time-series calculations. Despite the altered sampling interval, the time-series work returned interesting results.

The strong cyclicity found in the χ results is a result of the flux of magnetizable minerals entering the lake. Periods of increased precipitation likely carried large amounts of clay sediments into the lake, driving much of the cyclicity.

The ~2 myr estimate of depositional duration provided the strongest evidence for cyclicity, with 5 instances of correlation between high spectral peak confidence and calculated Milankovitch cycles (Berger et al., 1992). The ~5 kyr scenario returned a potential 22-year sunspot cycle (Mitchell, 1976), as well as a 1500-year cycle. Spectral power at ~1500 years commonly appears in ice cores (Alley et al., 2001) and marine sediment cores (Bond et al., 1997, 2001). Thought to be a stochastically resonant signal, the 1500-year cycle is consistent for at least 110,000 years in the Greenland Ice Core Project (GRIP) core (Alley et al., 2001). It is unknown whether this signal is continuous in records older than 110 ka, or what exactly forces the signal (Bond et al., 1997, 2001; Alley et al., 2001; Braun et al., 2005; Debret et al., 2007; Dima and Lohmann, 2009). By examining Holocene pollen records, Viau et al. (2002) noted vegetation changes across the North American continent that were synchronous with the marine and ice core records. If the Florissant Lake Beds do indeed represent 5,000 total years of deposition, and if the appearance of the 1500-year cycle is real, then the Florissant data may provide evidence that the 1500-year cycle found in younger sediment and ice cores has a greater temporal extent than is currently known. Because the work of Viau et al. (2002) suggested that the effects of the cycle on the marine environment are congruous with those of the terrestrial world, Florissant may record palynological evidence of the ~1500-year cycle as well.

As a result of comparison of the sedimentation rates estimated from this time series work with a modern analog, the ~5000-year scenario is interpreted to best fit the data. Clear Lake in California is a stream-fed lake in a valley amongst an active volcanic province, and is comparable in size to ancient Lake Florissant (Osleger et al., 2008;

Richerson et al., 2008). Because anthropogenic activities since 1927 have caused changes in sediment flux to Clear Lake, cores taken from Clear Lake show a change in calculated sedimentation rate after 1927. The rates from pre-1927 sedimentation range from ~0.063 cm/yr to 0.2 cm/yr, while they spike up to ~2.04 cm/yr after 1927. The estimated sedimentation rate for Florissant according to the ~5000-year scenario was ~0.22 cm/year, which is similar to the upper range of the values generated from pre-1927 Clear Lake (Osleger et al., 2008; Richerson et al., 2008). The sediment accumulation rate estimated from the ~2 myr scenario is slower by three orders of magnitude. This comparison suggests that the ~5000-year scenario may be a more likely depositional duration for Lake Florissant.

6. Conclusions

The results of this study suggest that the Northwest Corner section and the portion of the Big Stump section below the caprock conglomerate represent nearly the same sequence in time. While the Big Stump section represents the entire middle shale unit, the Northwest Corner appears to also represent most of the middle shale, with the addition of ~0.5 m of upper shale. Some minor evidence of the caprock conglomerate seems to be preserved in the Northwest Corner section at ~3.76 m, as demonstrated by κ analysis.

Furthermore, the geochemical work provides insight on potential material provenance of certain deposits. The chemostratigraphic packages used to aid in correlation, that are rich in mudstone and/or pumice conglomerate, tend to be thicker in

the Big Stump section than the Northwest Corner section, indicating that the Big Stump section may be closer to the volcanic source of the ash that appears in these packages. This is consistent with the supposition that the Thirtynine Mile volcanic field, which lies to the southwest of Florissant, provided the volcanic material found in the lake beds. In addition, shale-rich packages appear thicker in the Northwest Corner section relative to the Big Stump section. This, coupled with the higher Sr concentrations at the Big Stump relative to the Northwest Corner (Fig. 10e), indicates that the Northwest Corner section was closer to the clay-laden streams that fed the lake.

Time-series analysis agrees with both the 5000-year depositional duration proposed by McLeroy and Anderson (1966) and the ~2 myr time frame suggested by radiometric dating of bounding volcanic deposits, but comparison of estimated sedimentation rates with those of the modern Clear Lake in California reveals the ~5000-year scenario as a more likely depositional duration. Additionally, radiometric dating of the lower units of the Florissant Formation may help determine which of these very different scenarios is more likely. Analysis of other sections in the area may also be useful.

Although the Florissant Formation is believed to be late Eocene in age, the range of uncertainties for the age dates includes the Eocene–Oligocene boundary age within it. Because the exact age of the Florissant Formation is unclear, pollen samples were taken at selected locations during this study (Fig. 4 and Fig. 5) to be analyzed for any evidence that may tie the Florissant sections into the known Eocene–Oligocene boundary sections in the Southeastern U.S. As yet these results are not available.

High-resolution stratigraphic analyses such as these will be useful for all future studies of the Florissant Formation. The analyses that were done provide interesting insights into material provenance, depositional duration, cyclic variation, and unit classification within the Florissant Formation, and should provide the basis for further investigation of the units at Florissant. Due to its temporal proximity to the Eocene-Oligocene boundary, the Florissant Formation may even be beneficial to understanding terrestrial response to climate change.

7. Future studies

Preliminary studies of the Clare Quarry section have revealed that it may be unsuitable for time-series analysis, due to a large quantity of mudstone and ash deposits. However, there may be sections in the southern parts of the monument that may be more useful, as well as the US 24 Road Cut section at Florissant, Colorado, which has not yet been observed. So far, no continuous section of the entire Florissant Formation has been found.

The acquisition of geochemical data at the Big Stump section through the caprock and above may help resolve correlation uncertainties. In addition, χ, κ, and geochemical analysis of the Clare Quarry section, as well as sampling and analysis of the Road Cut section should be beneficial to further understanding the stratigraphy of the lake beds.

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Appendix I

Big Stump Composite Notes

Sample #	Height (m)	Lithology	Description
96	13.42	Mudstone	Gray, fissile, some visible grains, some paper shale, some iron staining
95	13.41	Mudstone	Gray, fissile, no visible grains, some coarse, some iron staining
94	13.40	Mudstone	Gray, fissile, no visible grains
93	13.39	Mudstone	Gray, fissile, some lithic frags visible, some iron staining
92	13.38	Mudstone	Gray, some lithic frags visible, some iron staining
91	13.37	Mudstone	Gray, some fis w/no visible grains, some not fis w/visible lithic frags & Fe stain
90	13.36	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
89	13.35	Mudstone	Gray, fissile, no visible grains, some iron staining
88	13.34	Mudstone	Gray, fissile, no visible grains, some iron staining
87	13.33	Mudstone	Gray, fissile, no visible grains, some iron staining
86	13.32	Mudstone	Gray, fissile, no visible grains, iron staining
85	13.31	Mudstone	Gray, fissile, no visible grains, iron staining
84	13.30	Mudstone	Gray, no visible grains, iron staining
83	13.29	Mudstone	Fissile, no visible grains, iron staining
82	13.28	Mudstone	Fissile, no visible grains, iron staining
81	13.27	Mudstone	Fissile, no visible grains, iron staining
80	13.26	Paper shale	White, iron staining
79	13.25	Paper shale	White, iron staining
78	13.24	Mudstone	Gray, fissile, no visible grains, iron staining
77	13.23	Mudstone	Very fissile, some paper shale, iron staining
76	13.22	Mudstone	Very fissile, some paper shale, iron staining
75	13.21	Paper shale	White, iron staining
74	13.20	Paper shale	White, iron staining
73	13.19	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
72	13.18	Mudstone	Gray, fissile, no visible grains, some white paper shale
71	13.17	Mudstone	Gray, fissile, no visible grains, some white paper shale
70	13.16	Mudstone	Gray, fissile, no visible grains, some white paper shale
69	13.15	Mudstone	Gray, very fissile, no visible grains, some white paper shale
68	13.12	Mudstone	Gray, fissile, no visible grains
67	13.07	Mudstone	Gray, fissile, no visible grains
66	13.02	Mudstone	Gray, fissile, no visible grains, some iron staining
65	12.97	Mudstone	Gray, fissile, no visible grains
64	12.93	Pumice Conglomerate	Gray, pumice frags up to 1 cm, some iron staining
63	12.92	Mudstone	Gray, fissile, no visible grains, some white paper shale
62	12.91	Mudstone	Gray, fissile, no visible grains, some white paper shale, some fossils
61	12.90	Mudstone	Gray, fissile, no visible grains, some white paper shale
60	12.89	Mudstone	Gray, fissile, no visible grains, some white paper shale
59	12.88	Mudstone	Gray, fissile, no visible grains, some white paper shale, large wood cast
58	12.87	Mudstone	Gray, fissile, no visible grains, some white paper shale
57	12.86	Mudstone	Gray, fissile, no visible grains, some white paper shale
56	12.85	Mudstone	Gray, fissile, no visible grains, some white paper shale
55	12.84	Mudstone	Gray, fissile, no visible grains, some white paper shale
54	12.83	Mudstone	Gray, fissile, no visible grains, some white paper shale
53	12.82	Mudstone	Gray, fissile, no visible grains, some white paper shale
52	12.81	Mudstone	Gray, fissile, no visible grains, some white paper shale
51	12.80	Mudstone	Gray, very fissile, no visible grains, some white paper shale
50	12.79	Mudstone	Gray, very fissile, no visible grains, some white paper shale
49	12.78	Mudstone	Gray, very fissile, no visible grains, some white paper shale
48	12.77	Mudstone	Gray, very fissile, no visible grains, some white paper shale
47	12.76	Mudstone	Gray, very fissile, no visible grains, some white paper shale
46	12.75	Mudstone	Gray, very fissile, no visible grains, some white paper shale
45	12.74	Mudstone	Gray, very fissile, no visible grains, some white paper shale, some iron stain
44	12.73	Paper shale	White, some very fissile gray mudstone with no visible grains, some iron stain
43	12.72	Mudstone	Gray, no visible grains
42	12.67	Mudstone	Gray, fissile, no visible grains

Sample #	Height (m)	Lithology	Description
41	12.62	Mudstone	Gray, no visible grains
40	12.57	Mudstone	Gray, fissile, no visible grains
38	12.47	Mudstone	Gray, fissile, no visible grains
37	12.42	Mudstone	Gray, fissile, no visible grains, some iron staining
36	12.37	Mudstone	Gray, fissile, no visible grains
35	12.32	Mudstone	Gray, fissile, no visible grains, some iron staining
34	12.27	Mudstone	Gray, fissile, no visible grains, some iron staining
33	12.22	Mudstone	Gray, fissile, no visible grains, some iron staining
32	12.17	Mudstone	Gray, fissile, no visible grains, some iron staining
31	12.12	Mudstone	Gray, fissile, no visible grains
30	12.07	Mudstone	Gray, no visible grains
29	12.02	Mudstone	Gray, no visible grains, some iron staining
28	11.97	Mudstone	Gray, fissile, no visible grains, some iron staining
27	11.92	Mudstone	Gray, no visible grains, some iron staining
26	11.87	Mudstone	Gray, fissile, no visible grains, some iron staining
25	11.82	Mudstone	Gray, fissile, no visible grains, some iron staining
24	11.81	Mudstone	Gray, fissile, no visible grains, some iron staining
23	11.80	Mudstone	Gray, fissile, no visible grains, some iron staining
22	11.79	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
21	11.78	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
20	11.77	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
19	11.76	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
18	11.75	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
17	11.74	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
16	11.73	Mudstone	Gray, fissile, no visible grains, some coarse, some wt ppr sh, some Fe staining
15	11.72	Mudstone	Gray, fissile, no visible grains, some coarse, some wt ppr sh, some Fe staining
14	11.71	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
13	11.70	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
12	11.69	Mudstone	Gray, fissile, no visible grains, some white paper shale
11	11.68	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
10	11.67	Mudstone	Gray, fissile, no visible grains, some iron staining, jerosite?
9	11.66	Mudstone	Gray, fissile, no visible grains, some iron staining
8	11.65	Mudstone	Gray, fissile, no visible grains, some iron staining
7	11.64	Mudstone	Gray, fissile, no visible grains, some coarse, some iron staining
6	11.63	Mudstone	Gray, fissile, no visible grains, some iron staining
5	11.62	Mudstone	Gray, fissile, no visible grains, some iron staining
4	11.61	Pumice Conglomerate	White-gray, pumice frags up to 12mm
3	11.57	Pumice Conglomerate	White-gray, pumice frags up to 15mm
2	11.52	Pumice Conglomerate	Gray, pumice frags up to 6mm, extremely iron-rich
1	11.48	Pumice Conglomerate	White-gray, pumice frags up to 6mm
34	11.47	Mudstone	Gray-brown, abundant pumice frags up to 5mm, some vesicles
33	11.39	Mudstone	Gray, abundant pumice frags up to 1 cm, some obsidian flakes
32	11.19	Mudstone	Gray, abundant pumice frags up to 1 cm, some obsidian flakes
31	10.99	Mudstone	Gray, abundant pumice frags up to 1 cm, some obsidian flakes
30	10.79	Pumice conglomerate	Gray, abundant pumice frags up to 4 mm, some obsidian flakes
29	10.59	Pumice conglomerate	Gray, abundant pumice frags up to 2mm, some obsidian, quartz frags
28	10.39	Pumice conglomerate	Gray, abundant pumice frags up to 1mm, some obsidian, quartz frags
27	10.19	Pumice conglomerate	Gray, abundant pumice frags up to 1mm, various lithic frags
26	9.99	Pumice conglomerate	Gray, pumice up to 5mm, lithic frags, bivalve frags
25	9.79	Pumice conglomerate	Gray, abundant pumice, lithic frags, bivalve frags, just below weather surface
24	9.59	Pumice conglomerate	Gray, abundant pumice, lithic frags, bivalve frags
23	9.39	Pumice conglomerate	Gray, abundant pumice, lithic frags, just below event horizon
22	9.19	Pumice conglomerate	Gray, abundant pumice, lithic frags, bivalve frags nearby
21	8.99	Pumice conglomerate	Gray, abundant pumice, lithic frags
20	8.79	Pumice conglomerate	Gray, abundant pumice up to 5 mm, lithic frags, event horizon b/w 19&20
19	8.59	Pumice conglomerate	Gray, abundant pumice, lithic frags, 4mm bivalve frag above
18	8.39	Pumice conglomerate	Gray, abundant pumice, lithic frags

Sample #	Height (m)	Lithology	Description
17	8.19	Pumice conglomerate	Gray, abundant pumice, lithic frags
16	7.99	Pumice conglomerate	Gray, abundant pumice, lithic frags, some fine grained mudstone
14	7.59	Pumice conglomerate	Gray, abundant pumice up to 8mm, lithic frags, iron-rich bands
13	7.39	Pumice conglomerate	Gray, abundant pumice up to 5mm, lithic frags, iron-rich concretions
12	7.19	Pumice conglomerate	Gray, abundant pumice, lithic frags (qtz up to 3 mm), iron-rich bands
11	6.99	Pumice conglomerate	Gray, abundant pumice, lithic frags, iron-rich bands
10	6.79	Pumice conglomerate	Gray, abundant pumice, lithic frags
9	6.59	Pumice conglomerate	Gray, abundant pumice, lithic frags
8	6.39	Pumice conglomerate	Gray, abundant pumice, lithic frags
7	6.19	Pumice conglomerate	Gray, abundant pumice, lithic frags
6	5.99	Pumice conglomerate	Gray, abundant pumice, lithic frags
5	5.79	Pumice conglomerate	Gray, abundant pumice, lithic frags
4	5.59	Pumice conglomerate	Gray, abundant pumice, lithic frags
3	5.39	Pumice conglomerate	Gray, abundant pumice up to 4mm, lithic frags
2	5.19	Pumice conglomerate	Gray, abundant pumice up to 8mm, lithic frags
1	4.99	Pumice conglomerate	Gray, abun. pum. < 4mm, lith frags (qtz <3mm), Fe stain
1	4.98	Paper shale	Brown, iron-rich, sample disintegrated, possibly volcanic
2	4.97	Mudstone	Gray-brown, conchoidal fracture, grains not visible
3	4.96	Mudstone	Gray-brown, conchoidal fracture, some visible grains (pumice frags?)
4	4.95	Mudstone	Gray-brown, conchoidal fracture, grains not visible
5	4.94	Mudstone	Gray-brown, conchoidal fracture, some fossils, grains not visible
6	4.93	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags
7	4.92	Mudstone	Gray-brown, conchoidal fracture, grains not visible
8	4.91	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags
9	4.90	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags
10	4.89	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags
11	4.88	Mudstone	Brown, conchoidal fracture, grains not visible
12	4.87	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags
13	4.86	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags
14	4.85	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags
15	4.84	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags
16	4.83	Mudstone	Brown, conchoidal fracture, some fossils, some pumice frags, top 2mm fissile
17	4.82	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags
18	4.81	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags
19	4.80	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
20	4.79	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
21	4.78	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
22	4.77	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
23	4.76	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
24	4.75	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
25	4.74	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
26	4.73	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
27	4.72	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
28	4.71	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
29	4.70	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
30	4.69	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
31	4.68	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
32	4.67	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
33	4.66	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
33a	4.65	Mudstone	Gray-brown, poor conc fracture, some fossils, abundant pumice frags, resistant
33b	4.60	Mudstone	Bgn 5cm smpls, gray-brown, poor conc fracture, fossils, pumice frags, resistant
33c	4.55	Mudstone	Gray-brown, poor conc fracture, fossils, abundant pumice frags <1cm, resistant
33d	4.50	Mudstone	Gray-brown, poor conc fracture, fossils, abundant pumice frags <1cm, resistant
33e	4.45	Mudstone	Gray-brown, poor conchoidal fracture, fossils, abundant pumice frags, resistant
33f	4.40	Mudstone	Gray-brown, poor conchoidal fracture, fossils, abundant pumice frags, resistant
33g	4.35	Mudstone	Brown, conchoidal fracture, fossils, pumice frags, resistant, iron stain below
33h	4.30	Mudstone	Brown, conchoidal fracture, some fossils, pumice frags, resistant

Sample #	Height (m)	Lithology	Description
33i	4.25	Mudstone	Gray-brown, conchoidal fracture, some fossils, pumice frags, resistant
33j	4.20	Mudstone	Gray-brown, conchoidal fracture, some fossils, pumice frags, resistant
33l	4.10	Mudstone	Gray-brown, conchoidal fracture, some fossils, some pumice frags, resistant
33m	4.05	Mudstone	Gray-brown, conchoidal fracture, some pumice frags, resistant, some iron stain
34	4.04	Paper shale	Gray-brown, fossils, 1 cm below previous
34a	4.03	Pumice conglomerate	Gray-brown, some iron staining, some paper shale, fossils
35	4.02	Mudstone	Gray-brown, fissile, fossils, pumice frags, some iron staining
36	4.01	Mudstone	Gray-brown, fissile, fossils, pumice frags, some iron staining
36a	4.00	Pumice conglomerate	Yellowish, with some mudstone, fossils, pumice and lithic frags, jerosite
37	3.99	Mudstone	Gray-brown, fissile, grains not visible, with some paper shale
38	3.98	Mudstone	Gray-brown, fissile, grains not visible, with some paper shale, fossils
38a	3.97	Mudstone	Gray-brown, fissile, grains not visible, with some paper shale, fossils
38b	3.93	Mudstone	Gray-brown, fissile, grains not visible, fossils, some iron staining
39	3.92	Mudstone	Gray-brown, fissile, grains not visible, fossils, some iron staining
40	3.91	Mudstone	Gray-brown, fissile, grains not visible, fossils, some iron staining
40a	3.90	Pumice conglomerate	Gray-brown-yellow, some mudstone and paper shale
41	3.89	Mudstone	Gray-brown, fissile, with some paper shale, pumice conglomerate, fossils
42	3.88	Mudstone	Gray-brown, fissile, with some paper shale, pumice conglomerate, fossils
42a	3.87	Mudstone	Gray-brown, fissile, some pumice frags, pumice conglomerate, iron stain
43	3.86	Mudstone	Gray-brown, fissile, some pumice conglomerate, iron stain
43a	3.81	Pumice conglomerate	Yellowish, fossils, pumice and lithic frags, 7 cm thick
44	3.78	Mudstone	Gray-brown, fissile, grains not visible, fossils, some iron staining
45	3.77	Mudstone	Gray-brown, fissile, fossils, pumice frags, some iron staining
46	3.76	Mudstone	Gray-brown, fissile, fossils, pumice frags, some iron staining
46a	3.75	Pumice conglomerate	Yellowish, some gray-brown mudstone, some fossils, iron staining
47	3.74	Mudstone	Gray-brown, very fissile, some paper shale, some fossils
48	3.73	Mudstone	Gray-brown, fissile, some paper shale, some pumice frags, iron staining
49	3.72	Mudstone	Gray-brown, fissile, some paper shale, iron staining
50	3.71	Mudstone	Gray-brown, fissile, some pumice frags, some fossils, jerosite
51	3.70	Mudstone	Gray-brown, somewhat fissile, some pumice frags, some fossils, iron staining
52	3.69	Mudstone	Gray-brown, somewhat fissile, some pumice frags, iron staining
53	3.68	Mudstone	Gray-brown, somewhat fissile, some pumice frags, iron staining
54	3.67	Mudstone	Gray-brown, somewhat fissile, some pumice frags, iron staining
55	3.66	Mudstone	Gray-brown, somewhat fissile, some pumice frags, some fossils, iron staining
56	3.65	Mudstone	Gray-brown, somewhat fissile, some pumice frags, some fossils, iron staining
57	3.64	Mudstone	Gray-brown, somewhat fissile, some pumice frags, iron staining
58	3.63	Mudstone	Gray-brown, somewhat fissile, some pumice frags, some fossils, iron staining
59	3.62	Mudstone	Gray-brown, somewhat fissile, some pumice frags, some fossils, iron staining
60	3.61	Mudstone	Gray-brown, somewhat fissile, some pumice frags, some fossils, iron staining
61	3.60	Mudstone	Brown, somewhat fissile, some pumice frags, some fossils, iron staining
62	3.59	Mudstone	Gray-brown, fissile, some pumice frags, some fossils, iron staining
63	3.58	Mudstone	Gray-brown, fissile, some pumice frags, some fossils, iron staining
64	3.57	Mudstone	Gray-brown, fissile, some pumice frags, some fossils, iron staining
65	3.56	Mudstone	Gray-brown, fissile, some pumice frags, some fossils, iron staining
66	3.55	Pumice conglomerate	Yellow-white, fissile, iron staining, some gray-brown paper shale
67	3.54	Mudstone	Gray-brown, fissile, some fossils, iron staining, some paper shale
68	3.53	Mudstone	Gray-brown, fissile, some fossils, iron staining, some paper shale
69	3.52	Mudstone	Gray-brown, fissile, some fossils, iron staining, some pumice conglomerate
70	3.51	Mudstone	Gray-brown, fissile, some fossils, iron staining, some paper shale
71	3.50	Paper shale	Brown, heavy iron staining
71a	3.49	Mudstone	Gray-brown, fissile, some paper shale, iron staining
72	3.48	Mudstone	Gray-brown, fissile, some fossils, pumice frags, iron staining
73	3.47	Paper shale	Gray-brown, some fossils, some pumice conglomerate
74	3.46	Paper shale	Gray-brown, some fossils, some pumice frags, some pumice conglomerate
74a	3.45	Mudstone	Gray-brown, fissile, no visible grains, iron-staining
74b	3.40	Mudstone	Gray-brown, fissile, some fossils, iron staining
74c	3.35	Mudstone	Gray-brown, somewhat fissile, some fossils, iron staining

Sample #	Height (m)	Lithology	Description
75	3.34	Mudstone	Brown, fissile
75a	3.33	Mudstone	Gray-brown, fissile, some fossils, some pumice frags, iron staining
77	3.31	Mudstone	Gray-brown, fissile, some pumice frags
78	3.30	Mudstone	Gray-brown, fissile, some pumice frags, fossils, iron staining
78a	3.29	Mudstone	Gray, no visible grains, iron staining
79	3.28	Paper shale	Gray, very fissile, fossils, some mudstone
80	3.27	Paper shale	Gray, fossils, iron staining
80a	3.26	Mudstone	Gray-brown, fissile, no visible grains, some fossils
81	3.25	Paper shale	Gray, fossils, rough
81a	3.24	Mudstone	Gray, fossils, pumice clasts, some pumice conglomerate, iron staining
82	3.23	Mudstone	Gray-brown, fissile, no visible grains, some iron staining
83	3.22	Paper shale	Gray, fossils, some mudstone, iron staining
83a	3.18	Mudstone	Gray-brown, some pumice conglomerate, iron staining, 6 cm thick
84	3.15	Mudstone	Brown, fissile, fossils, pumice frags, iron staining
85	3.14	Mudstone	Brown, very fissile, fossils, air-filled, iron stained
86	3.13	Mudstone	Brown, very fissile, fossils, pumice frags, air-filled, iron stained
87	3.12	Paper shale	Gray, fossils, iron staining
87a	3.11	Pumice conglomerate	Brown, iron staining
88	3.10	Mudstone	Gray-brown, fissile, fossils, pumice frags, iron staining
89	3.09	Mudstone	Brown, fissile, fossils, pumice frags
89a	3.08	Paper shale	Reddish, fossils, some mudstone, pumice frags, iron staining
90	3.07	Paper shale	Reddish, fossils, iron staining
90a	3.06	Paper shale	Highly altered, reddish-brown, iron-rich, disintegrated
91	3.05	Calcite	White to black, fibrous
92	3.04	Calcite	White to black, fibrous, some white paper shale
93	3.02	Calcite	White to black, fibrous
94	2.99	Paper shale	Brown-red, some fissile mudstone
95	2.97	Paper shale	Brown-red, some fissile mudstone
96	2.96	Paper shale	Brown-red, some fissile mudstone
97	2.95	Mudstone	Gray, fissile, no visible grains, some fossils, some iron staining
98	2.94	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
99	2.92	Mudstone	Gray, fissile, no visible grains, some iron staining
100	2.91	Mudstone	Gray, fissile, no visible grains, abundant fossils, some iron staining
101	2.90	Mudstone	Gray, fissile, no visible grains, abundant fossils, some iron staining
102	2.88	Mudstone	Gray, fissile, no visible grains, abundant fossils, some wt ppr sh, some Fe stain
103	2.87	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
104	2.86	Pumice conglomerate	Yellowish, coarse-grains, pumice, iron staining
105	2.84	Pumice conglomerate	Yellowish, coarse-grains, pumice, some white paper shale, some iron stain
106	2.82	Mudstone	Gray, fissile, no visible grains, abundant fossils, some iron staining, grass blade
107	2.80	Mudstone	Gray, fissile, some coarse grains
108	2.78	Mudstone	Gray, fissile, some coarse grains, some iron staining
109	2.72	Pumice conglomerate	Gray-yellow, fissile, some coarse grains, some white paper shale, iron staining
110	2.76	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
111	2.75	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
112	2.74	Mudstone	Gray, fissile, no visible grains
113	2.72	Mudstone	Gray, conchoidal fracturing, some iron staining
114	2.71	Mudstone	Gray, conchoidal fracturing
115	2.66	Mudstone	Gray, conchoidal fracturing
116	2.61	Mudstone	Gray, conchoidal fracturing
117	2.56	Mudstone	Gray, conchoidal fracturing
118	2.51	Mudstone	Gray, conchoidal fracturing
119	2.46	Mudstone	Gray, conchoidal fracturing
120	2.41	Mudstone	Gray, conchoidal fracturing
121	2.36	Mudstone	Gray, conchoidal fracturing
122	2.31	Mudstone	Gray, conchoidal fracturing
123	2.26	Mudstone	Gray, conchoidal fracturing
124	2.21	Mudstone	Gray, conchoidal fracturing

Sample #	Height (m)	Lithology	Description
125	2.16	Mudstone	Gray, conchoidal fracturing
126	2.11	Mudstone	Gray, conchoidal fracturing, some iron staining
128	2.01	Pumice conglomerate	White-yellow, coarse-grained, some iron staining
129	1.96	Paper shale	Brown-red, some fissile mudstone, some iron staining
130	1.93	Paper shale	Brown-red, some fissile mudstone, some fossils, some iron staining
131	1.91	Paper shale	Brown-red, some fissile mudstone, some fossils, some iron staining
132	1.89	Pumice conglomerate	White-yellow, coarse-grained, some iron staining, some brown paper shale
133	1.87	Mudstone	Gray, fissile, no visible grains
134	1.85	Mudstone	Gray, fissile, no visible grains, some white paper shale
135	1.83	Mudstone	White-gray, fissile, coarse-grained, thin 3mm fibrous calcite bed
136	1.82	Mudstone	White-gray, fissile, coarse-grained, some fibrous calcite
137	1.81	Mudstone	White-gray, fissile, coarse-grained, some paper shale, some fibrous calcite
138	1.80	Paper shale	White-gray, some mudstone, some iron staining, some fibrous calcite
139	1.79	Paper shale	Brown-red, some fissile mudstone, iron staining
140	1.78	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
141	1.77	Mudstone	Gray, fissile, no visible grains, some iron staining
142	1.76	Mudstone	Gray, fissile, no visible grains, some iron staining
143	1.75	Mudstone	Gray, fissile, no visible grains, some iron staining
144	1.74	Pumice conglomerate	White-yellow, coarse-grained, some iron staining, some gray paper shale
145	1.73	Paper shale	Brown-red, some white coarse-grained ash, iron staining
146	1.71	Mudstone	White-gray, fissile, coarse-grained, some gray paper shale, some iron stain
147	1.70	Mudstone	White-gray, fissile, coarse-grained, some gray paper shale, some iron stain
148	1.69	Paper shale	Brown-red, iron staining
149	1.67	Mudstone	White-gray, fissile, coarse-grained, some gray paper shale, some iron stain
150	1.65	Mudstone	White-gray, fissile, coarse-grained, some fine gry-brn mudstone, some Fe stain
151	1.64	Mudstone	Brown, conchoidal fracturing, no visible grains, some interbedded ash, Fe stain
152	1.62	Mudstone	Brown, conchoidal fracturing, no visible grains, some interbedded ash, Fe stain
153	1.61	Pumice conglomerate	White-yellow, coarse-grained, some fine-grained gray mudstone, iron staining
154	1.59	Pumice conglomerate	White-yellow, coarse-grained, some fine-grained gray mudstone, iron staining
155	1.58	Pumice conglomerate	White-yellow, coarse-grained, iron staining
156	1.56	Pumice conglomerate	White-yellow, coarse-grained, iron staining
157	1.54	Pumice conglomerate	Gray-brown, coarse-grained, iron staining
158	1.52	Pumice conglomerate	White-gray-brown, coarse-grained, pumice up to 1cm, some iron staining
159	1.51	Pumice conglomerate	White-gray-brown, coarse-grained, pumice up to 1cm, some iron staining
160	1.49	Pumice conglomerate	White-gray-brown, coarse-grained, pumice up to 1cm, some iron staining
161	1.46	Pumice conglomerate	Yellow-brown-red, coarse-grained, iron staining
162	1.43	Pumice conglomerate	Gray-yellow, coarse-grained ash, iron staining
163	1.40	Pumice conglomerate	Gray-yellow, coarse-grained ash, iron staining
165	1.38	Pumice conglomerate	Gray-yellow, coarse-grained ash, some fine-grained brown mudstone, Fe stain
166	1.36	Mudstone	Dark brown, fissile, no visible grains, some iron staining
167	1.34	Mudstone	Gray-yellow, fissile, coarse-grained ash, some ppr sh, some fossils, Fe stain
168	1.32	Mudstone	Gray, fissile, coarse-grained ash, some brown fine-grained mudstone, Fe stain
169	1.31	Mudstone	Gray, fissile, no visible grains, some white paper shale, some fossils, Fe stain
170	1.30	Mudstone	Gray, fissile, coarse-grained ash, some fine-grained fissile mudstone, Fe stain
171	1.30	Mudstone	Gray, fissile, coarse-grained ash, some iron staining
172	1.29	Paper shale	Gray, some fossils, iron staining
173	1.28	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
174	1.28	Pumice conglomerate	Gray, fissile, crs-grnd ash, some fn-grnd fissile mdrk, some fossils, some Fe stain
175	1.27	Mudstone	Gray, fissile, no visible grains, some wt ppr sh, some crs-grnd ash, some Fe stain
176	1.27	Pumice conglomerate	White, crs-grnd ash, some dk brn fis mdrk, some wt pr sh, some fossils, Fe stain
177	1.26	Mudstone	Gray, fissile, no visible grains, some wt ppr sh, some fossils, some iron staining
178	1.25	Mudstone	Gray, fissile, no visible grains, some fossils, some iron staining
179	1.24	Mudstone	Gray, fissile, no visible grains, some fossils, some iron staining
180	1.23	Pumice conglomerate	Gray, fissile, coarse-grained ash, some fine-grnd fis mdrk, some ppr sh, Fe stain
181	1.22	Mudstone	Gray, fissile, med-grained ash, some ppr sh, some fossils, some iron staining
182	1.22	Mudstone	Gray, crs-grnd ash, some vry fn-grnd brn mdrk, white paper shale, iron staining
183	1.20	Pumice conglomerate	Gray-yellow, crs-grnd ash, some very fn-grnd brown mudstone, some iron stain

Sample #	Height (m)	Lithology	Description
184	1.19	Mudstone	Gray, fissile, med-grained ash, some ppr sh, some fossils, some iron staining
185	1.18	Mudstone	Gray, fissile, no visible grains, some med-grained ash, some iron staining
187	1.17	Mudstone	Gray, fissile, coarse-grained ash, some paper shale, some fossils, some Fe stain
188	1.16	Mudstone	Gray, fissile, coarse-grained ash, some paper shale, some fossils, some Fe stain
189	1.15	Mudstone	Gray, fissile, med-grained ash, some ppr sh, some fossils, some iron staining
190	1.13	Paper shale	Dark brown, some med-grained ash, some fossils, some iron staining
191	1.12	Mudstone	Dark brn, fissile, no visible grains, some crs ash, some wt ppr sh, some Fe stain
192	1.10	Mudstone	Gray, fissile, med-grained ash, some ppr sh, some fossils, some iron staining
193	1.09	Mudstone	Gray, fissile, med-grained ash, some ppr sh, some fossils, some iron staining
194	1.09	Pumice conglomerate	Gray-yellow, med-grained ash, some paper shale, some fossils, some Fe stain
195	1.08	Pumice conglomerate	White-yellow, coarse-grnd ash, some paper shale, some fossils, some Fe stain
196	1.07	Pumice conglomerate	Gray, med-grained ash, some paper shale, some fossils, some Fe stain
197	1.05	Pumice conglomerate	Gray-yellow, coarse-grained ash, some paper shale, some iron staining
198	1.03	Pumice conglomerate	Gray-yellow, coarse-grained ash, some paper shale, some iron staining
199	1.00	Mudstone	Dark brn, fissile, no visible grains, some crs ash, some wt ppr sh, some Fe stain
200	0.98	Pumice conglomerate	Gray-yellow, med-grained ash, some paper shale, some iron staining
201	0.96	Pumice conglomerate	Dark brown, med-grained ash, some white paper shale, some iron staining
202	0.94	Pumice conglomerate	White-yellow, coarse-grained ash, iron staining
203	0.92	Mudstone	Gray-yellow, crs-grnd ash, some vry fn-grnd dk brn mdrk, some ppr sh, Fe stain
204	0.90	Mudstone	Wt-yellow, med-grnd ash, some vry fn-grnd dk brn mdrk, some ppr sh, Fe stain
205	0.89	Mudstone	Gray, fissile, med-grained ash, some paper shale, some fossils, some Fe stain
206	0.88	Mudstone	Gray-yellow, crs-grnd ash, some vry fn-grnd dk brn mdrk, some ppr sh, Fe stain
207	0.88	Mudstone	Drk brn, fissile, no visible grains, crs-grnd ash, some paper shale, Fe staining
208	0.86	Pumice conglomerate	Wt-yellow, crs-grnd ash, some vry fn-grnd dk brn mdrk, some ppr sh, Fe stain
209	0.84	Pumice conglomerate	White-yellow, coarse-grained ash, some paper shale, iron staining
210	0.81	Pumice conglomerate	Wt-yellow, crs-grnd ash, some vry fn-grnd dk brn mdrk, some ppr sh, Fe stain
211	0.78	Mudstone	Gray-brown, very fine grained, coarse-grained, some paper sh, some Fe stain
212	0.75	Mudstone	Dark brown, fissile, no visible grains, some med ash, some ppr sh, some Fe stain
213	0.72	Mudstone	Wt-yellow, med-grnd ash, some vry fn-grnd dk brn mdrk, some ppr sh, Fe stain
214	0.71	Mudstone	Gray, crs-grnd ash, some vry fn-grnd brn mdrk, white paper shale, iron staining
215	0.70	Mudstone	Wt-gray, crs-grnd ash, some vry fn-grnd brn mdrk, white paper shale, Fe stain
216	0.69	Pumice conglomerate	Wt-yellow, crs-grnd ash, some vry fn-grnd dk brn mdrk, some ppr sh, Fe stain
217	0.67	Pumice conglomerate	Wt-yellow, crs-grnd ash, some vry fn-grnd dk brn mdrk, some ppr sh, Fe stain
218	0.65	Pumice conglomerate	Wt-yellow, crs-grnd ash, some vry fn-grnd dk brn mdrk, some ppr sh, Fe stain
219	0.63	Pumice conglomerate	Wt-yellow, crs-grnd ash, some vry fn-grnd dk brn mdrk, some ppr sh, Fe stain
220	0.61	Mudstone	Gray, fissile, no visible grains, some white paper shale, some fossils, Fe stain
221	0.58	Mudstone	White-gray, coarse-grained ash, some very fine grained gray mudstone, Fe stain
222	0.55	Pumice conglomerate	White-yellow, coarse-grained ash, some very fn grnd gray mudstone, Fe stain
223	0.53	Mudstone	Dark brown, fissile, no visible grains, some crs ash, some wt ppr sh, Fe stain
224	0.51	Altered shale	Brown, some very fine grained conchoidally fracturing mudstone, iron staining
225	0.48	Altered shale	Brown, iron staining
226	0.44	Altered shale	Brown, iron staining
227	0.41	Altered shale	Brown, iron staining
228	0.38	Altered shale	Brown, iron staining
229	0.35	Altered shale	Brown
230	0.32	Altered shale	Brown
231	0.29	Altered shale	Brown, iron staining
232	0.26	Altered shale	Brown, iron staining
233	0.23	Pumice conglomerate	Brown, fissile, no visible grains, some med ash, some ppr shale, iron staining
234	0.19	Pumice conglomerate	Brown, fissile, no visible grains, some med ash, some ppr shale, iron staining
235	0.16	Altered shale	Brown
236	0.12	Altered shale	Brown, some fossils, iron staining
237	0.09	Altered shale	Brown
238	0.06	Altered shale	Brown
239	0.04	Altered shale	Brown

Appendix II
Northwest Corner Composite Notes

Sample #	Height (m)	Lithology	Description
185	4.27	Pumice conglomerate	White, coarse grained
184	4.17	Pumice conglomerate	White, coarse grained
183	4.12	Pumice conglomerate	White, coarse grained
182	4.07	Pumice conglomerate	Yellow, some gray mudstone with no visible grains
181	4.03	Mudstone	Gray-dark gray, no visible grains
180	4.02	Mudstone	Gray, fissile, no visible grains, some iron staining
179	4.01	Mudstone	Gray, fissile, no visible grains, some iron staining
178	4.00	Mudstone	Gray, fissile, iron nodules up to 4 mm
177	3.99	Shale	White-gray, fissile, no visible grains
176	3.98	Shale	Gray, fissile, no visible grains
175	3.97	Shale	Gray, fissile, no visible grains
174	3.96	Shale	Gray, fissile, no visible grains
173	3.95	Shale	Gray, fissile, no visible grains
172	3.94	Shale	Gray, fissile, no visible grains
171	3.93	Shale	Gray, fissile, no visible grains
170	3.92	Shale	Gray, fissile, no visible grains
169	3.91	Shale	Gray, fissile, no visible grains
168	3.90	Shale	Gray, fissile, no visible grains
167	3.89	Shale	Gray, fissile, no visible grains
166	3.88	Mudstone	White-gray, fissile, coarse-grained
165	3.87	Mudstone	Gray, fissile, no visible grains, some white paper shale
164	3.86	Mudstone	Gray, conchoidal fracturing, no visible grains, some white paper shale
163	3.85	Mudstone	Gray, fissile, no visible grains
162	3.84	Mudstone	White-gray, fissile, coarse-grained
161	3.83	Mudstone	White-gray, fissile, coarse-grained
160	3.82	Mudstone	White-gray, fissile, coarse-grained
159	3.81	Mudstone	White-gray, fissile, coarse-grained
158	3.80	Mudstone	White-gray, fissile, coarse-grained
157	3.79	Mudstone	White-gray, fissile, coarse-grained
156	3.78	Mudstone	White-gray, fissile, coarse-grained
155	3.77	Pumice conglomerate	Yellow, coarse-grained, some iron staining
154	3.76	Pumice conglomerate	Yellow, coarse-grained, some iron staining
153	3.75	Paper shale	White, some gray mudstone with no visible grains
152	3.74	Paper shale	White, some gray mudstone with no visible grains
151	3.73	Paper shale	White, some gray mudstone with no visible grains
150	3.72	Paper shale	White, some gray mudstone with no visible grains
149	3.71	Mudstone	Gray, fissile, no visible grains, some white paper shale
148	3.70	Mudstone	Gray, fissile, no visible grains
147	3.69	Mudstone	Gray, no visible grains, some white paper shale
146	3.68	Mudstone	Gray, fissile, no visible grains
145	3.67	Paper shale	White, some gray mudstone with no visible grains
144	3.66	Paper shale	White, some gray mudstone with no visible grains
143	3.65	Paper shale	White, some gray mudstone with no visible grains
142	3.64	Paper shale	White, some gray mudstone with no visible grains
141	3.63	Paper shale	White, some gray mudstone with no visible grains
140	3.62	Paper shale	White, some gray mudstone with no visible grains
139	3.61	Paper shale	White, some gray mudstone with no visible grains
138	3.60	Paper shale	White, some gray mudstone with no visible grains
137	3.59	Paper shale	White, some gray mudstone with no visible grains
136	3.58	Paper shale	White, some gray mudstone with no visible grains
135	3.57	Mudstone	Gray, fissile, no visible grains
134	3.56	Paper shale	White, some gray mudstone with no visible grains
133	3.55	Paper shale	White, some gray mudstone with no visible grains
132	3.54	Mudstone	Gray, fissile, no visible grains
131	3.53	Paper shale	White, some gray mudstone with no visible grains
130	3.52	Mudstone	Gray, very fissile, no visible grains, some white paper shale
129	3.51	Mudstone	Gray, very fissile, no visible grains, some white paper shale
128	3.50	Mudstone	Gray, very fissile, no visible grains, some white paper shale
127	3.49	Mudstone	Gray, very fissile, no visible grains, some white paper shale

Sample #	Height (m)	Lithology	Description
126	3.48	Mudstone	Gray, very fissile, no visible grains, some white paper shale
125	3.47	Mudstone	Gray, very fissile, no visible grains, some white paper shale
124	3.46	Mudstone	Gray, fissile, no visible grains, some white paper shale
123	3.45	Mudstone	Gray, fissile, no visible grains, some white paper shale
122	3.44	Mudstone	Gray, fissile, no visible grains, some white paper shale
121	3.43	Paper shale	White, some gray mudstone with no visible grains
120	3.42	Paper shale	White, some gray mudstone with no visible grains, some iron staining
119	3.41	Paper shale	White, some gray mudstone with no visible grains
118	3.40	Paper shale	White, some gray mudstone with no visible grains, some iron staining
117	3.39	Paper shale	White, some gray mudstone with no visible grains, some iron staining
116	3.38	Mudstone	White-gray, fissile, no visible grains, some white paper shale
115	3.37	Paper shale	White, some gray mudstone with no visible grains
114	3.36	Mudstone	Gray, fissile, no visible grains, some white paper shale
113	3.35	Mudstone	Gray, fissile, no visible grains, some white paper shale
112	3.34	Paper shale	White, some gray mudstone with no visible grains
111	3.33	Mudstone	White-gray, fissile, no visible grains, some white paper shale
110	3.32	Mudstone	White-gray, fissile, no visible grains, some white paper shale
109	3.31	Mudstone	Gray, conchoidal fracturing, no visible grains, some white paper shale
108	3.30	Paper shale	White, some gray mudstone with no visible grains
107	3.29	Paper shale	White, some gray mudstone with no visible grains, some iron staining
106	3.28	Mudstone	White-gray, fissile, no visible grains, some white paper shale, some iron staining
105	3.27	Mudstone	White-gray, fissile, no visible grains, some white paper shale
104	3.26	Mudstone	White-gray, fissile, no visible grains, some white paper shale, iron staining
103	3.25	Mudstone	White-gray, fisisle, no visible grains, some white paper shale, iron staining
102	3.24	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
101	3.23	Mudstone	Gray, no visible grains, conchoidal fracturing, some iron staining
100	3.22	Mudstone	Gray, no visible grains, conchoidal fracturing, some iron staining
99	3.21	Mudstone	Gray, fissile, no visible grains, some iron staining
98	3.20	Mudstone	Gray, fissile, no visible grains, some iron staining
97	3.19	Mudstone	Gray, fissile, no visible grains, some iron staining
96	3.18	Mudstone	Gray, fissile, no visible grains, iron staining
95	3.17	Mudstone	Gray, fissile, no visible grains, some iron staining
94	3.16	Mudstone	Gray, fissile, no visible grains, some white paper shale, some iron staining
93	3.15	Paper shale	White, some gray mudstone with no visible grains, some iron staining
92	3.14	Mudstone	Gray, fissile, no visible grains, some white paper shale
91	3.13	Paper shale	White, some gray mudstone with no visible grains
90	3.12	Paper shale	White, some gray mudstone with no visible grains
89	3.11	Paper shale	White, some iron staining
88	3.10	Mudstone	Gray, no visible grains, conchoidal fracturing
87	3.09	Mudstone	Gray, no visible grains
86	3.08	Paper shale	White, some gray mudstone with no visible grains, some iron staining
85	3.07	Paper shale	White, some iron staining
84	3.06	Paper shale	White, some gray mudstone with no visible grains
83	3.05	Paper shale	White, some gray mudstone with no visible grains
82	3.04	Paper shale	White, some gray mudstone with no visible grains
81	3.03	Paper shale	White, some gray mudstone with no visible grains
80	3.02	Paper shale	White, some gray mudstone with no visible grains, some iron staining
79	3.01	Paper shale	White, some gray mudstone with no visible grains, some iron staining
78	3.00	Paper shale	White, some gray mudstone with no visible grains
77	2.99	Paper shale	White, some gray mudstone with no visible grains
76	2.98	Mudstone	White, very fissile, some paper shale
75	2.97	Mudstone	White, very fissile, some paper shale
74	2.96	Paper shale	White, some gray mudstone with no visible grains, some iron staining
73	2.95	Mudstone	Gray, fissile, no visible grains, white paper shale
72	2.94	Mudstone	Gray, very fissile, no visible grains, some paper shale
71	2.93	Mudstone	White, fissile, some paper shale
70	2.92	Paper shale	White, disintegrated, could be fissile mudstone
69	2.91	Mudstone	White, disintegrated, some gray mudstone, some iron staining
68	2.90	Mudstone	Gray, fissile, no visible grains, some disent. white p. sh., some iron staining
67	2.89	Paper shale	White, disintegrated, some gray mudstone, some iron staining
66	2.88	Paper shale	White, disintegrated, some gray mudstone, some iron staining

Sample #	Height (m)	Lithology	Description
65	2.87	Mudstone	Gray, very fissile, no visible grains, some paper shale
64	2.86	Mudstone	Gray, very fissile, no visible grains, some paper shale
63	2.85	Mudstone	Gray, fissile, some pumice frags, some iron staining
62	2.81	Mudstone	Gray, fissile, some paper shale
61	2.76	Mudstone	White, fissile, some paper shale
60	2.71	Mudstone	Gray, fissile, some pumice frags
59	2.66	Mudstone	Gray, fissile, no visible grains, some paper shale
58	2.65	Mudstone	Gray, fissile, no visible grains, some paper shale
57	2.64	Mudstone	Gray, fissile, some paper shale, some iron staining
56	2.63	Mudstone	Gray, fissile, some paper shale, iron staining
55	2.62	Mudstone	White, fissile, some paper shale, iron staining
54	2.61	Mudstone	White, fissile, some paper shale, iron staining
53	2.60	Mudstone	White, fissile, some paper shale, iron staining
52	2.59	Mudstone	White, fissile, some paper shale, iron staining
51	2.58	Mudstone	White, fissile, some paper shale, iron staining
50	2.57	Mudstone	Gray, some pumice frags
49	2.53	Mudstone	Gray, fissile, no visible grains, some paper shale
48	2.52	Mudstone	White, fissile, some paper shale
47	2.51	Mudstone	White, fissile, some paper shale
46	2.50	Mudstone	White, fissile, some paper shale
45	2.49	Mudstone	White-gray, fissile, some paper shale
44	2.48	Mudstone	Gray, no visible grains
43	2.47	Mudstone	White, fissile, some paper shale
42	2.46	Mudstone	White, very fissile, some paper shale
41	2.45	Mudstone	Gray, no visible grains
40	2.44	Mudstone	Gray, no visible grains
39	2.43	Mudstone	White, very fissile, some paper shale
38	2.42	Mudstone	White, very fissile, some paper shale
37	2.41	Mudstone	White, very fissile, some paper shale, cephalopod
36	2.40	Mudstone	White, very fissile, some paper shale
35	2.39	Mudstone	White, very fissile, some paper shale
34	2.38	Mudstone	White, very fissile, some paper shale
33	2.37	Mudstone	White, very fissile, some paper shale
32	2.36	Mudstone	White, very fissile, some paper shale
31	2.35	Mudstone	White, very fissile, some paper shale, some carbonization
30	2.34	Mudstone	White, very fissile, some paper shale
29	2.33	Pumice conglomerate	Yellow-gray, coarse-grained, fissile, jerosite?
28	2.32	Mudstone	White-gray, very fissile, some paper shale
27	2.31	Mudstone	White, very fissile, some paper shale
26	2.30	Mudstone	White, very fissile, some paper shale
25	2.29	Mudstone	White, very fissile, some paper shale
24	2.28	Mudstone	White, very fissile, some paper shale
23	2.27	Mudstone	White, very fissile, some paper shale
22	2.26	Mudstone	White, very fissile, some paper shale
21	2.25	Mudstone	White, very fissile, some paper shale
20	2.24	Mudstone	White, very fissile, some paper shale
19	2.23	Mudstone	White, very fissile, some paper shale
18	2.22	Mudstone	White, very fissile, some paper shale
17	2.21	Mudstone	White, very fissile, some paper shale
16	2.20	Mudstone	Yellow-gray, fissile, jerosite?
15	2.19	Mudstone	Yellow, fissile, jerosite?
14	2.15	Mudstone	White, fissile, no visible grains, some fossils
13	2.10	Mudstone	Gray, pumice up to 5 mm, some mudstone
12	2.09	Mudstone	White-gray, fissile, no visible grains, some fossils
11	2.08	Mudstone	White-gray, fissile, no visible grains, some fossils
10	2.07	Mudstone	White-gray, fissile, no visible grains, some fossils
9	2.06	Mudstone	White, fissile, no visible grains, some fossils
8	2.05	Mudstone	White-gray, fissile, no visible grains, some fossils
7	2.04	Mudstone	White-gray, fissile, no visible grains, some fossils
6	2.03	Mudstone	White-gray, fissile, no visible grains, some fossils
5	2.02	Mudstone	White-gray, fissile, no visible grains, some fossils

Sample #	Height (m)	Lithology	Description
4	2.01	Mudstone	White-gray, fissile, no visible grains, some fossils
3	2.00	Mudstone	White-gray, fissile, no visible grains, some fossils
2	1.99	Mudstone	White-gray, fissile, no visible grains
1	1.98	Paper shale	White, some mudstone
1	1.97	Mudstone	Gray, coarse-grained, fissile, some white paper shale
2	1.96	Paper shale	White-gray, some mudstone with no visible grains
3	1.95	Paper shale	White-gray, some mudstone with no visible grains
4	1.94	Mudstone	Gray, coarse-grained, fissile, some white paper shale
5	1.93	Mudstone	Gray, fissile, some white paper shale, more coarse-grained at base
6	1.92	Mudstone	Gray, coarse-grained, fissile, abundant pumice fragments
7	1.91	Mudstone	Gray, coarse-grained, fissile, abundant pumice fragments
8	1.90	Mudstone	Gray, coarse-grained, fissile, abundant pumice fragments
9	1.89	Mudstone	Gray, fissile, no visible grains, some paper shale
10	1.88	Mudstone	Gray, coarse-grained, fissile, abundant pumice fragments
11	1.87	Mudstone	Gray, coarse-grained, fissile, abundant pumice fragments
12	1.86	Mudstone	Gray, coarse-grained, fissile, abundant pumice frags, some paper shale
13	1.85	Paper shale	White-gray, some mudstone with no visible grains
14	1.84	Paper shale	White
15	1.83	Paper shale	White, some mudstone with no visible grains
16	1.82	Mudstone	Gray, coarse-grained, fissile, some white paper shale
17	1.81	Mudstone	Gray, coarse-grained, fissile, some white paper shale
18	1.80	Mudstone	Gray, coarse-grained, fissile, some white paper shale
19	1.79	Mudstone	Gray, coarse-grained, fissile, some white paper shale
20	1.78	Mudstone	Gray, coarse-grained, fissile, some white paper shale
21	1.77	Mudstone	Gray, coarse-grained, fissile, some white paper shale
22	1.76	Mudstone	Gray, fissile, no visible grains, some white paper shale
23	1.75	Mudstone	White-gray, very fissile, some white paper shale
24	1.70	Mudstone	White-gray, very fissile, some white paper shale
25	1.65	Mudstone	Gray, coarse-grained, some very fissile, some white paper shale
26	1.60	Mudstone	Gray, coarse-grained, some very fissile, some white paper shale
27	1.55	Mudstone	Gray, coarse-grained, fissile
28	1.54	Mudstone	Gray, very fissile, no visible grains, some white paper shale
29	1.53	Mudstone	Gray, coarse-grained, fissile, some white paper shale
30	1.52	Mudstone	Gray, coarse-grained, fissile, some very fissile with no visible grains
31	1.51	Mudstone	Gray, coarse-grained, fissile, some very fissile with no visible grains
32	1.50	Mudstone	Gray, coarse-grained, fissile, some very fissile with no visible grains
33	1.49	Mudstone	Gray, coarse-grained, fissile, some very fissile with no visible grains
34	1.48	Mudstone	Gray, coarse-grained, fissile, some very fissile with no visible grains
35	1.47	Mudstone	Gray, coarse-grained, fissile, some very fissile with no visible grains
36	1.46	Mudstone	Gray, coarse-grained, abundant pumice fragments
37	1.41	Mudstone	Gray, coarse-grained, fissile, abundant pumice frags
38	1.36	Mudstone	Gray, no visible grains, concoidal fracturing
39	1.31	Mudstone	Gray, no visible grains, concoidal fracturing
40	1.26	Mudstone	Gray, no visible grains, concoidal fracturing
41	1.21	Mudstone	Gray, no visible grains, fissile
42	1.16	Mudstone	Gray, no visible grains, fissile
43	1.11	Mudstone	Gray, no visible grains, fissile
44	1.10	Paper shale	Gray, no visible grains, very fissile
45	1.09	Paper shale	Gray, no visible grains, very fissile
46	1.08	Paper shale	Gray, no visible grains, very fissile
47	1.07	Paper shale	White, some gray fissile mudstone with no visible grains
48	1.06	Mudstone	Gray, no visible grains, very fissile, some white paper shale
49	1.05	Mudstone	Gray, some visible grains, fissile, some white paper shale
50	1.04	Mudstone	Gray, no visible grains, fissile, iron staining
51	1.03	Mudstone	Gray, no visible grains, fissile, iron staining
52	1.02	Pumice conglomerate	Gray, some coarse grains, fissile, some iron staining
53	1.01	Pumice conglomerate	Gray, some coarse grains, fissile, some iron staining
54	1.00	Pumice conglomerate	Gray, some coarse grains, fissile, some paper shale, some iron staining
55	0.99	Pumice conglomerate	Gray, fissile, some coarse-grains
56	0.98	Mudstone	Gray, no visible grains, fissile
57	0.97	Mudstone	Gray, no visible grains, fissile

Sample #	Height (m)	Lithology	Description
58	0.96	Mudstone	Gray, no visible grains, fissile, some white paper shale
59	0.95	Paper shale	White, some iron staining
60	0.94	Paper shale	White, some iron staining
61	0.93	Mudstone	Gray, no visible grains, fissile
62	0.92	Mudstone	Gray, some visible grains, fissile
63	0.91	Mudstone	Gray, no visible grains, fissile
64	0.90	Pumice conglomerate	White-gray, coarse-grained, abundant pumice frags
65	0.89	Pumice conglomerate	White-gray, coarse-grained, abundant pumice frags
66	0.88	Pumice conglomerate	White-gray, coarse-grained, abundant pumice frags
67	0.87	Mudstone	White-gray, some coarse grains, some pumice frags
68	0.86	Mudstone	White-gray, some coarse grains, some pumice frags
69	0.85	Mudstone	White-gray, some coarse grains, some pumice frags
70	0.84	Mudstone	White-gray, some coarse grains, some pumice frags
71	0.83	Paper shale	White, some gray fissile mudstone with no visible grains
72	0.82	Paper shale	White, some gray fissile mudstone with no visible grains
73	0.81	Paper shale	White, some gray fissile mudstone with no visible grains
74	0.80	Paper shale	White, some gray fissile mudstone with no visible grains
75	0.79	Pumice conglomerate	White-gray, some coarse grains, some pumice frags
76	0.78	Paper shale	White
77	0.77	Paper shale	White
78	0.76	Mudstone	Gray, no visible grains, fissile, some iron staining
79	0.75	Paper shale	White
80	0.74	Paper shale	White, some white-gray very fissile mudstone with no visible grains
81	0.73	Paper shale	Gray, no visible grains, fissile, some white-gray paper mudstone
82	0.72	Paper shale	Gray, no visible grains, very fissile, some mudstone, some iron staining
83	0.71	Paper shale	White-gray, some white-gray fissile mudstone with no visible grains
84	0.70	Mudstone	Gray, some coarse grains, some pumice fragments, some white-gray paper shale
85	0.65	Mudstone	Gray, some coarse grains, some pumice fragments, some white-gray paper shale
86	0.60	Mudstone	Gray, some coarse grains, some pumice fragments, some white-gray paper shale
87	0.55	Mudstone	Gray, some coarse grains, some pumice fragments, some white-gray paper shale
88	0.50	Mudstone	Gray, some coarse grains, some pumice fragments, some white-gray paper shale
89	0.45	Mudstone	Gray, some coarse grains, some pumice fragments
90	0.40	Mudstone	Gray, some coarse grains, some pumice fragments
91	0.35	Mudstone	Gray, some coarse grains, some pumice fragments
92	0.30	Mudstone	Gray, some coarse grains, some pumice fragments
93	0.25	Mudstone	Gray, some coarse grains, some pumice fragments
94	0.20	Mudstone	Gray, some coarse grains, some pumice fragments
95	0.15	Mudstone	Gray, some coarse-grains, some pumice frags, some iron
96	0.10	Mudstone	Gray, some coarse grains, some pumice fragments
97	0.05	Mudstone	Gray, some coarse grains, some pumice fragments
98	0.01	Mudstone	Gray, some coarse grains, some pumice fragments

Appendix III
Big Stump Composite Magnetic Susceptibility (χ) Data

Sample #	Height (m)	Mass (g)	χ (m3/kg)	Standard Deviation (m3/kg)
96	13.42	10.055	4.80E-07	6.69E-10
95	13.41	10.657	1.18E-07	7.05E-10
94	13.40	10.234	9.73E-08	1.13E-09
93	13.39	10.340	5.44E-07	1.12E-09
92	13.38	10.629	5.45E-07	2.38E-10
91	13.37	10.349	1.44E-07	4.17E-10
90	13.36	10.138	1.04E-07	7.44E-10
89	13.35	10.133	1.35E-07	4.93E-10
88	13.34	6.839	1.28E-07	1.33E-09
87	13.33	10.008	1.31E-07	1.00E-09
86	13.32	10.299	2.12E-07	0.00E+00
85	13.31	10.145	1.76E-07	6.72E-10
84	13.30	10.764	2.38E-07	9.55E-10
83	13.29	10.079	3.00E-07	7.63E-10
82	13.28	10.415	1.93E-07	8.57E-10
81	13.27	10.445	2.85E-07	2.45E-10
80	13.26	10.452	2.07E-07	4.27E-10
79	13.25	8.685	1.83E-07	5.73E-10
78	13.24	10.510	3.10E-07	6.45E-10
77	13.23	10.281	2.62E-07	9.99E-10
76	13.22	10.179	2.96E-07	5.04E-10
75	13.21	10.131	1.75E-07	2.55E-10
74	13.20	10.274	1.84E-07	6.64E-10
73	13.19	10.365	1.39E-07	8.34E-10
72	13.18	10.305	1.49E-07	4.19E-10
71	13.17	10.035	1.73E-07	4.45E-10
70	13.16	10.296	1.19E-07	9.74E-10
69	13.15	8.865	1.35E-07	7.48E-10
68	13.12	10.237	1.32E-07	2.44E-10
67	13.07	10.436	1.04E-07	7.22E-10
66	13.02	10.237	1.29E-07	7.33E-10
65	12.97	10.311	1.29E-07	6.42E-10
64	12.93	10.278	1.79E-07	4.34E-10
63	12.92	10.399	1.46E-07	4.15E-10
62	12.91	10.037	1.45E-07	7.46E-10
61	12.90	10.390	1.44E-07	8.65E-10
60	12.89	10.031	1.67E-07	2.57E-10
59	12.88	10.014	1.66E-07	2.58E-10
58	12.87	10.086	1.32E-07	6.56E-10
57	12.86	10.040	1.25E-07	8.64E-10
56	12.85	10.119	6.85E-08	6.62E-10
55	12.84	5.382	1.47E-07	8.14E-10
54	12.83	10.494	1.24E-07	4.77E-10
53	12.82	9.265	1.01E-07	1.09E-09
52	12.81	4.834	1.14E-07	1.89E-09
51	12.80	3.342	1.52E-07	1.32E-09
50	12.79	5.889	1.23E-07	1.14E-09
49	12.78	6.102	9.16E-08	1.10E-09
48	12.77	4.636	1.09E-07	1.65E-09
47	12.76	5.243	1.23E-07	9.67E-10
46	12.75	5.816	1.04E-07	1.31E-09
45	12.74	10.726	1.27E-07	4.66E-10

Sample #	Height (m)	Mass (g)	χ (m3/kg)	Standard Deviation (m3/kg)
44	12.73	5.655	1.06E-07	8.98E-10
43	12.72	10.165	7.39E-08	6.59E-10
42	12.67	10.149	8.51E-08	4.98E-10
41	12.62	10.674	8.49E-08	6.25E-10
40	12.57	10.167	9.28E-08	8.94E-10
39	12.52	10.430	1.01E-07	8.35E-10
38	12.47	10.866	8.21E-08	8.37E-10
37	12.42	10.641	8.47E-08	4.74E-10
36	12.37	10.193	8.17E-08	9.91E-10
35	12.32	10.135	9.33E-08	8.97E-10
34	12.27	10.036	9.63E-08	1.00E-09
33	12.22	10.679	9.82E-08	4.08E-10
32	12.17	10.585	9.12E-08	6.30E-10
31	12.12	10.135	9.66E-08	7.46E-10
30	12.07	10.247	1.02E-07	8.85E-10
29	12.02	10.519	1.21E-07	4.76E-10
28	11.97	10.116	1.25E-07	6.55E-10
27	11.92	10.576	1.38E-07	6.24E-10
26	11.87	10.255	1.16E-07	8.47E-10
25	11.82	10.478	1.11E-07	8.63E-10
24	11.81	10.187	1.19E-07	7.38E-10
23	11.80	10.141	1.13E-07	6.55E-10
22	11.79	8.527	1.30E-07	8.84E-10
21	11.78	7.833	1.53E-07	3.20E-10
20	11.77	3.852	1.33E-07	1.32E-09
19	11.76	7.108	1.33E-07	0.00E+00
18	11.75	6.206	1.37E-07	7.05E-10
17	11.74	8.315	1.44E-07	7.98E-10
16	11.73	9.871	1.90E-07	6.91E-10
15	11.72	10.392	2.50E-07	8.91E-10
14	11.71	10.404	1.24E-07	0.00E+00
13	11.70	10.071	1.86E-07	6.77E-10
12	11.69	10.060	2.07E-07	4.43E-10
11	11.68	10.456	2.22E-07	8.52E-10
10	11.67	10.061	3.11E-07	6.74E-10
9	11.66	10.468	1.62E-07	8.88E-10
8	11.65	10.267	1.70E-07	6.65E-10
7	11.64	10.409	2.15E-07	6.54E-10
6	11.63	6.992	2.20E-07	9.42E-10
5	11.62	9.997	1.94E-07	6.82E-10
4	11.61	10.401	9.95E-08	8.72E-10
3	11.57	10.118	1.17E-07	4.96E-10
2	11.52	10.517	1.38E-07	0.00E+00
1	11.48	10.113	1.11E-07	6.57E-10
34	11.47	5.933	1.19E-06	1.53E-09
33	11.39	5.468	1.19E-06	4.61E-10
32	11.19	6.303	2.66E-06	1.00E-09
31	10.99	5.796	1.97E-06	1.27E-09
30	10.79	5.130	1.72E-06	1.68E-09
29	10.59	5.212	2.27E-06	1.63E-09
28	10.39	4.776	1.85E-06	1.88E-09
27	10.19	4.700	2.96E-06	1.86E-09
26	9.99	6.050	2.03E-06	1.76E-09
25	9.79	6.696	9.87E-07	1.88E-09

Sample #	Height (m)	Mass (g)	χ (m3/kg)	Standard Deviation (m3/kg)
24	9.59	6.034	1.33E-06	7.18E-10
23	9.39	4.703	1.34E-06	1.61E-09
22	9.19	4.102	1.11E-06	1.07E-09
21	8.99	6.306	1.16E-06	1.05E-09
20	8.79	6.098	2.28E-06	3.98E-10
19	8.59	5.272	1.85E-06	2.05E-09
18	8.39	5.486	2.12E-06	1.79E-09
17	8.19	5.589	3.08E-06	1.13E-09
16	7.99	6.540	1.69E-06	1.51E-09
15	7.79	4.945	4.71E-06	9.30E-10
14	7.59	2.738	7.71E-06	2.55E-09
13	7.39	3.069	6.05E-06	3.36E-09
12	7.19	5.854	3.18E-06	1.46E-09
11	6.99	3.527	1.64E-06	1.43E-09
10	6.79	5.116	1.65E-06	2.24E-09
9	6.59	3.422	1.99E-06	3.37E-09
8	6.39	6.298	1.71E-06	1.79E-09
7	6.19	3.442	6.53E-06	2.01E-09
6	5.99	4.451	4.45E-06	1.40E-09
5	5.79	3.763	5.99E-06	2.13E-09
4	5.59	2.785	7.78E-06	3.34E-09
3	5.39	4.531	5.10E-06	4.16E-09
2	5.19	4.637	4.91E-06	1.72E-09
1	4.99	4.797	3.37E-06	1.80E-09
1	4.98	10.785	2.06E-07	6.31E-10
2	4.97	9.398	1.16E-07	7.07E-10
3	4.96	10.381	1.01E-07	4.20E-10
4	4.95	10.476	1.17E-07	6.33E-10
5	4.94	8.839	1.11E-07	5.70E-10
6	4.93	10.376	1.03E-07	6.41E-10
7	4.92	8.737	1.02E-07	5.78E-10
8	4.91	10.196	1.04E-07	8.89E-10
9	4.90	10.832	1.07E-07	6.95E-10
10	4.89	4.780	1.29E-07	1.06E-09
11	4.88	6.660	1.29E-07	7.58E-10
12	4.87	7.458	1.21E-07	5.86E-10
13	4.86	9.371	1.08E-07	7.11E-10
14	4.85	10.168	1.22E-07	9.86E-10
15	4.84	10.610	1.24E-07	7.07E-10
16	4.83	10.429	1.52E-07	6.31E-10
17	4.82	10.184	1.38E-07	4.25E-10
18	4.81	7.432	1.45E-07	1.22E-09
19	4.80	10.384	1.15E-07	2.42E-10
20	4.79	10.409	9.68E-08	4.84E-10
21	4.78	10.370	1.06E-07	6.41E-10
22	4.77	10.272	9.34E-08	8.84E-10
23	4.76	10.459	1.13E-07	4.80E-10
24	4.75	10.324	1.35E-07	4.19E-10
25	4.74	10.009	1.09E-07	1.00E-09
26	4.73	10.075	1.02E-07	1.26E-15
27	4.72	10.120	9.61E-08	6.59E-10
28	4.71	10.432	1.02E-07	4.17E-10
29	4.70	10.013	1.10E-07	8.69E-10
30	4.69	10.131	9.12E-08	6.58E-10

Sample #	Height (m)	Mass (g)	χ (m3/kg)	Standard Deviation (m3/kg)
31	4.68	10.053	9.32E-08	8.69E-10
32	4.67	10.433	9.37E-08	2.41E-10
33	4.66	10.244	8.71E-08	9.85E-10
33a	4.65	10.080	9.77E-08	4.33E-10
33b	4.60	10.247	1.02E-07	2.45E-10
33c	4.55	10.199	9.83E-08	6.53E-10
33d	4.50	10.225	1.09E-07	2.46E-10
33e	4.45	10.587	9.20E-08	8.24E-10
33f	4.40	10.487	9.54E-08	7.20E-10
33g	4.35	10.236	1.19E-07	2.45E-10
33h	4.30	10.556	1.07E-07	9.52E-10
33i	4.25	10.062	1.13E-07	9.98E-10
33j	4.20	10.337	1.25E-07	7.26E-10
33k	4.15	10.075	1.19E-07	7.47E-10
33l	4.10	10.340	1.33E-07	8.71E-10
33m	4.05	10.614	1.68E-07	2.43E-10
34	4.04	10.556	1.38E-07	7.09E-10
34a	4.03	10.791	3.73E-07	2.36E-10
35	4.02	10.441	1.73E-07	8.90E-10
36	4.01	10.429	1.50E-07	6.31E-10
36a	4.00	10.305	4.01E-07	6.55E-10
37	3.99	10.075	1.44E-07	8.93E-10
38	3.98	10.170	1.40E-07	6.49E-10
38a	3.97	10.028	1.27E-07	4.32E-10
38b	3.93	10.683	1.50E-07	1.78E-15
39	3.92	10.313	1.50E-07	4.83E-10
40	3.91	10.080	1.58E-07	4.27E-10
40a	3.90	9.710	1.73E-07	4.60E-10
41	3.89	10.393	1.56E-07	2.39E-10
42	3.88	10.310	1.71E-07	5.00E-10
42a	3.87	10.180	4.75E-07	2.50E-10
43	3.86	10.262	2.17E-07	6.63E-10
43a	3.81	10.457	2.56E-06	1.51E-09
44	3.78	10.651	1.80E-07	6.40E-10
45	3.77	10.209	1.68E-07	5.05E-10
46	3.76	5.244	1.79E-07	9.61E-10
46a	3.75	10.751	2.58E-07	9.55E-10
47	3.74	10.176	1.27E-07	8.87E-10
48	3.73	7.391	1.28E-07	1.36E-09
49	3.72	10.222	1.13E-07	4.91E-10
50	3.71	10.496	9.98E-08	6.34E-10
51	3.70	10.327	9.10E-08	6.46E-10
52	3.69	10.356	9.56E-08	7.29E-10
53	3.68	10.082	8.92E-08	7.51E-10
54	3.67	10.874	8.70E-08	6.13E-10
55	3.66	10.169	8.63E-08	8.60E-10
56	3.65	10.262	9.56E-08	4.91E-10
57	3.64	10.256	1.02E-07	8.84E-10
58	3.63	10.186	1.04E-07	4.94E-10
59	3.62	10.043	1.06E-07	4.34E-10
60	3.61	10.095	9.31E-08	9.99E-10
61	3.60	10.061	9.81E-08	5.01E-10
62	3.59	10.506	1.10E-07	4.78E-10
63	3.58	10.581	1.20E-07	2.37E-10

Sample #	Height (m)	Mass (g)	χ (m3/kg)	Standard Deviation (m3/kg)
64	3.57	10.330	1.31E-07	6.40E-10
65	3.56	10.126	1.67E-07	6.74E-10
66	3.55	10.423	2.28E-07	7.40E-10
67	3.54	10.493	1.73E-07	7.37E-10
68	3.53	10.448	1.97E-07	7.39E-10
69	3.52	10.133	3.58E-07	5.04E-10
70	3.51	10.204	1.52E-07	9.76E-10
71	3.50	10.041	1.43E-07	1.49E-09
71a	3.49	10.010	1.43E-07	6.60E-10
72	3.48	10.056	1.96E-07	9.24E-10
73	3.47	10.527	2.34E-07	8.46E-10
74	3.46	10.230	2.09E-07	8.72E-10
74a	3.45	10.382	2.21E-07	6.56E-10
74b	3.40	10.504	4.85E-07	7.25E-10
74c	3.35	10.575	9.62E-07	4.68E-10
75	3.34	10.124	1.79E-07	8.82E-10
75a	3.33	10.090	1.68E-07	2.56E-10
76	3.32	10.542	1.74E-07	7.34E-10
77	3.31	10.103	1.69E-07	6.75E-10
78	3.30	10.480	1.59E-07	6.51E-10
78a	3.29	10.483	1.38E-07	2.38E-10
79	3.28	10.340	1.36E-07	7.25E-10
80	3.27	10.305	1.18E-07	8.77E-10
80a	3.26	10.688	1.64E-07	8.70E-10
81	3.25	8.392	1.51E-07	0.00E+00
81a	3.24	10.199	2.85E-07	5.03E-10
82	3.23	10.146	1.50E-07	2.46E-10
83	3.22	10.093	1.26E-07	2.48E-10
83a	3.18	10.538	5.56E-07	4.16E-10
84	3.15	10.189	1.97E-07	1.66E-09
85	3.14	10.181	1.78E-07	9.13E-10
86	3.13	10.332	2.21E-07	6.59E-10
87	3.12	10.341	1.46E-07	4.17E-10
87a	3.11	10.254	2.82E-07	6.62E-10
88	3.10	10.314	1.55E-07	4.18E-10
89	3.09	10.269	1.34E-07	4.21E-10
89a	3.08	10.481	1.51E-07	6.28E-10
90	3.07	10.011	1.31E-07	2.50E-10
90a	3.06	10.091	3.15E-07	1.02E-09
91	3.05	10.189	9.70E-08	1.24E-09
92	3.04	10.517	1.12E-07	1.19E-09
93	3.02	10.724	8.07E-08	9.42E-10
94	2.99	9.989	1.36E-07	5.00E-10
95	2.97	6.632	1.81E-07	1.36E-09
96	2.96	7.135	2.54E-07	9.56E-10
97	2.95	5.539	1.69E-07	1.37E-09
98	2.94	2.659	1.57E-07	2.53E-09
99	2.92	5.138	1.34E-07	2.26E-09
100	2.91	7.154	1.24E-07	1.62E-09
101	2.90	8.152	1.38E-07	1.07E-09
102	2.88	6.613	1.95E-07	3.79E-10
103	2.87	4.549	1.79E-07	2.55E-09
104	2.86	10.304	1.52E-07	4.18E-10
105	2.84	7.579	2.21E-07	9.01E-10

Sample #	Height (m)	Mass (g)	χ (m3/kg)	Standard Deviation (m3/kg)
106	2.82	10.016	1.10E-07	1.09E-09
107	2.80	10.840	2.19E-07	6.28E-10
108	2.78	10.319	1.11E-07	2.43E-10
109	2.72	10.163	3.28E-07	6.66E-10
110	2.76	6.725	1.44E-07	1.35E-09
111	2.75	10.573	1.74E-07	2.44E-10
112	2.74	5.883	2.13E-07	8.52E-10
113	2.72	9.975	2.04E-07	9.31E-10
114	2.71	10.754	2.17E-07	4.78E-10
115	2.66	10.509	2.23E-07	9.79E-10
116	2.61	10.233	2.01E-07	9.07E-10
117	2.56	10.025	2.13E-07	1.12E-09
118	2.51	10.707	1.81E-07	7.22E-10
119	2.46	10.152	2.09E-07	9.14E-10
120	2.41	10.768	1.76E-07	2.28E-09
121	2.36	10.350	1.86E-07	1.09E-09
122	2.31	10.123	2.11E-07	6.73E-10
123	2.26	10.781	1.98E-07	6.32E-10
124	2.21	10.504	1.65E-07	9.82E-10
125	2.16	10.105	2.27E-07	6.73E-10
126	2.11	10.333	2.19E-07	7.47E-10
127	2.06	10.344	2.12E-07	8.62E-10
128	2.01	10.748	3.01E-07	1.09E-09
129	1.96	6.149	2.83E-07	1.11E-09
130	1.93	10.708	1.84E-07	4.17E-10
131	1.91	4.738	1.77E-07	2.67E-09
132	1.89	10.238	9.54E-07	1.11E-09
133	1.87	9.152	9.94E-08	9.55E-10
134	1.85	8.880	1.60E-07	2.81E-10
135	1.83	7.947	1.22E-07	6.34E-10
136	1.82	4.359	1.32E-07	2.67E-09
137	1.81	4.536	1.32E-07	2.02E-09
138	1.80	8.753	9.35E-08	1.32E-09
139	1.79	9.984	2.13E-07	1.12E-09
140	1.78	10.272	1.77E-07	1.15E-09
141	1.77	6.343	1.89E-07	1.37E-09
142	1.76	10.089	1.60E-07	6.52E-10
143	1.75	10.138	2.07E-07	2.54E-10
144	1.74	10.340	3.10E-07	8.58E-10
145	1.73	6.464	1.46E-07	1.78E-15
146	1.71	6.819	4.17E-07	1.13E-09
147	1.70	9.555	3.64E-07	5.35E-10
148	1.69	2.410	1.33E-07	3.82E-09
149	1.67	10.286	1.79E-07	9.04E-10
150	1.65	10.182	2.00E-07	5.06E-10
151	1.64	10.334	1.80E-07	6.60E-10
152	1.62	10.188	1.90E-07	9.12E-10
153	1.61	8.191	3.44E-07	1.09E-09
154	1.59	10.152	6.24E-07	4.97E-10
155	1.58	8.506	2.43E-06	1.37E-09
156	1.56	9.101	1.06E-06	7.21E-10
157	1.54	10.110	8.95E-07	8.87E-10
158	1.52	10.127	2.26E-06	6.02E-10
159	1.51	10.220	1.85E-06	8.32E-10

Sample #	Height (m)	Mass (g)	χ (m3/kg)	Standard Deviation (m3/kg)
160	1.49	10.171	1.35E-06	9.55E-10
161	1.46	10.800	1.40E-06	3.86E-10
162	1.43	10.093	6.57E-07	1.25E-09
163	1.40	10.368	1.51E-06	1.16E-09
164	1.38	10.427	6.84E-07	6.37E-10
165	1.36	9.984	8.76E-08	5.06E-10
167	1.34	10.067	3.93E-07	1.27E-09
168	1.32	6.892	3.46E-07	9.87E-10
169	1.31	4.024	1.34E-07	2.28E-09
170	1.30	5.534	3.40E-07	1.68E-09
171	1.30	4.393	4.91E-07	1.55E-09
172	1.29	3.479	1.92E-07	2.52E-09
173	1.28	7.812	1.41E-07	1.16E-09
174	1.28	10.138	3.20E-07	5.05E-10
175	1.27	8.083	1.43E-07	1.42E-09
176	1.27	10.102	1.51E-07	8.89E-10
177	1.26	3.559	2.12E-07	2.13E-09
178	1.25	8.640	2.02E-07	1.08E-09
179	1.24	10.431	2.07E-07	7.40E-10
180	1.23	10.180	2.02E-07	9.12E-10
181	1.22	7.997	2.62E-07	1.61E-09
182	1.22	10.238	3.24E-07	7.50E-10
183	1.20	10.218	4.18E-07	1.14E-09
184	1.19	10.092	2.77E-07	9.17E-10
185	1.18	10.080	2.07E-07	6.76E-10
186	1.17	10.118	3.11E-07	6.70E-10
187	1.17	10.305	2.87E-07	7.46E-10
188	1.16	7.191	3.28E-07	1.79E-09
189	1.15	10.049	3.74E-07	4.40E-10
190	1.13	10.228	2.09E-07	5.03E-10
191	1.12	7.456	2.27E-07	1.20E-09
192	1.10	10.187	3.20E-07	1.10E-09
193	1.09	10.135	3.29E-07	7.58E-10
194	1.09	10.104	3.18E-07	1.10E-09
195	1.08	10.122	3.81E-07	2.52E-10
196	1.07	10.149	2.58E-07	9.12E-10
197	1.05	5.444	2.50E-07	4.59E-10
198	1.03	10.253	3.80E-07	9.96E-10
199	1.00	10.163	2.82E-07	5.05E-10
200	0.98	10.773	3.86E-07	9.46E-10
201	0.96	10.397	5.23E-07	6.45E-10
202	0.94	10.366	4.15E-07	1.07E-09
203	0.92	10.331	2.71E-07	8.60E-10
204	0.90	10.324	2.43E-07	9.96E-10
205	0.89	10.072	2.77E-07	5.10E-10
206	0.88	10.401	3.79E-07	6.49E-10
207	0.88	10.244	2.84E-07	1.15E-09
208	0.86	10.288	2.63E-07	4.99E-10
209	0.84	10.104	6.88E-07	1.72E-09
210	0.81	10.070	4.18E-07	9.12E-10
211	0.78	10.025	3.25E-07	2.55E-10
212	0.75	7.827	1.35E-07	5.56E-10
213	0.72	10.541	1.66E-07	1.22E-09
214	0.71	8.523	1.82E-07	8.76E-10

Sample #	Height (m)	Mass (g)	χ (m3/kg)	Standard Deviation (m3/kg)
215	0.70	10.203	2.74E-07	5.03E-10
216	0.69	10.236	2.58E-07	5.02E-10
217	0.67	10.090	2.35E-07	1.02E-09
218	0.65	10.344	3.12E-07	1.13E-09
219	0.63	10.272	3.90E-07	6.57E-10
220	0.61	10.483	1.84E-07	2.46E-10
221	0.58	10.183	2.84E-07	1.01E-09
222	0.55	6.255	1.48E-07	2.02E-09
223	0.53	6.266	1.10E-07	4.04E-10
224	0.51	8.024	1.30E-07	3.13E-10
225	0.48	6.862	1.23E-07	9.74E-10
226	0.44	9.259	1.58E-07	9.33E-10
227	0.41	7.228	1.62E-07	1.25E-09
228	0.38	8.827	1.79E-07	7.46E-10
229	0.35	10.335	1.11E-07	7.29E-10
230	0.32	9.362	9.83E-08	9.33E-10
231	0.29	10.424	1.12E-07	2.41E-10
232	0.26	10.288	1.13E-07	4.88E-10
233	0.23	8.396	3.81E-07	9.15E-10
234	0.19	7.072	2.08E-07	1.27E-09
235	0.16	7.573	1.38E-07	1.15E-09
236	0.12	10.135	1.02E-07	4.96E-10
237	0.09	10.093	9.79E-08	2.50E-10
238	0.06	10.048	1.32E-07	6.59E-10
239	0.04	10.279	1.01E-07	1.12E-09

Appendix IV

Northwest Corner Composite Magnetic Susceptibility (χ) Data

Sample #	Height (m)	Mass (g)	χ (m3/kg)	Standard Deviation (m3/kg)
185	4.27	10.45	7.03E-08	6.41E-10
184	4.17	10.442	1.17E-07	8.31E-10
183	4.12	10.604	6.85E-08	4.77E-10
182	4.07	10.462	1.77E-07	4.27E-10
181	4.03	10.148	7.15E-08	8.99E-10
180	4.02	10.43	1.03E-07	4.82E-10
179	4.01	10.472	9.25E-08	4.17E-10
178	4.00	10.205	7.95E-08	6.55E-10
177	3.99	10.591	7.71E-08	6.31E-10
176	3.98	10.346	7.48E-08	4.89E-10
175	3.97	10.465	6.65E-08	7.26E-10
174	3.96	10.307	7.08E-08	4.91E-10
173	3.95	10.79	6.58E-08	6.21E-10
172	3.94	10.415	6.73E-08	4.21E-10
171	3.93	10.638	8.03E-08	8.56E-10
170	3.92	10.772	9.37E-08	9.35E-10
169	3.91	10.604	8.11E-08	2.38E-10
168	3.90	10.568	8.05E-08	4.14E-10
167	3.89	10.375	1.48E-07	6.35E-10
166	3.88	10.402	1.13E-07	2.41E-10
165	3.87	10.396	1.33E-07	4.16E-10
164	3.86	10.741	1.50E-07	4.63E-10
163	3.85	10.432	7.75E-08	8.39E-10
162	3.84	10.222	9.44E-08	2.46E-10
161	3.83	10.402	1.01E-07	4.19E-10
160	3.82	10.687	1.40E-07	2.33E-10
159	3.81	10.737	1.86E-07	8.31E-10
158	3.80	10.571	1.64E-07	8.80E-10
157	3.79	10.463	1.67E-07	7.39E-10
156	3.78	10.278	2.34E-07	4.33E-10
155	3.77	10.778	3.77E-07	8.53E-10
154	3.76	10.393	2.32E-07	2.47E-10
153	3.75	10.475	1.00E-07	8.66E-10
152	3.74	10.291	7.02E-08	4.26E-10
151	3.73	10.384	9.33E-08	4.20E-10
150	3.72	10.305	7.89E-08	4.25E-10
149	3.71	10.42	7.55E-08	4.20E-10
148	3.70	10.375	7.62E-08	6.45E-10
147	3.69	10.542	7.99E-08	9.58E-10
146	3.68	10.49	9.74E-08	8.31E-10
145	3.67	10.506	7.13E-08	8.34E-10
144	3.66	10.715	6.17E-08	9.46E-10
143	3.65	10.736	5.88E-08	8.18E-10
142	3.64	10.478	7.17E-08	2.41E-10
141	3.63	10.822	8.13E-08	6.17E-10
140	3.62	10.374	9.29E-08	0
139	3.61	10.612	9.72E-08	4.74E-10
138	3.60	10.193	1.02E-07	6.53E-10
137	3.59	10.676	8.31E-08	8.52E-10
136	3.58	10.366	6.69E-08	2.44E-10
135	3.57	10.606	7.54E-08	6.31E-10
134	3.56	10.641	7.78E-08	2.37E-10

Sample #	Height (m)	Mass (g)	χ (m3/kg)	Standard Deviation (m3/kg)
133	3.55	10.536	6.57E-08	8.67E-10
132	3.54	10.288	7.73E-08	2.46E-10
131	3.53	10.382	6.49E-08	8.46E-10
130	3.52	10.794	7.55E-08	6.19E-10
129	3.51	10.627	7.18E-08	6.30E-10
128	3.50	10.358	6.07E-08	6.48E-10
127	3.49	10.593	7.80E-08	4.77E-10
126	3.48	10.33	7.53E-08	6.48E-10
125	3.47	10.527	7.56E-08	8.66E-10
124	3.46	10.779	8.24E-08	7.02E-10
123	3.45	10.812	8.15E-08	9.34E-10
122	3.44	10.187	7.60E-08	2.48E-10
121	3.43	10.003	5.48E-08	6.72E-10
120	3.42	9.907	5.75E-08	9.24E-10
119	3.41	9.726	6.03E-08	6.91E-10
118	3.40	10.809	6.02E-08	9.38E-10
117	3.39	10.661	7.21E-08	4.74E-10
116	3.38	10.589	7.09E-08	6.32E-10
115	3.37	10.746	6.65E-08	6.23E-10
114	3.36	10.699	7.94E-08	8.51E-10
113	3.35	10.362	8.68E-08	4.22E-10
112	3.34	10.8	7.95E-08	2.34E-10
111	3.33	10.476	7.01E-08	8.71E-10
110	3.32	10.609	7.65E-08	4.76E-10
109	3.31	10.648	8.06E-08	4.74E-10
108	3.30	10.397	7.38E-08	8.77E-10
107	3.29	10.428	6.87E-08	4.21E-10
106	3.28	10.324	7.83E-08	7.34E-10
105	3.27	10.461	7.16E-08	4.19E-10
104	3.26	10.341	8.32E-08	8.80E-10
103	3.25	10.322	8.95E-08	4.89E-10
102	3.24	10.34	8.63E-08	8.80E-10
101	3.23	10.416	1.26E-07	7.20E-10
100	3.22	10.086	7.46E-08	2.51E-10
99	3.21	10.376	8.60E-08	6.43E-10
98	3.20	10.448	1.19E-07	2.40E-10
97	3.19	10.22	1.23E-07	2.45E-10
96	3.18	10.411	1.82E-07	6.55E-10
95	3.17	10.342	1.39E-07	4.18E-10
94	3.16	10.694	9.04E-08	9.42E-10
93	3.15	10.492	6.37E-08	4.18E-10
92	3.14	10.374	7.19E-08	8.80E-10
91	3.13	10.628	6.10E-08	6.31E-10
90	3.12	10.472	5.49E-08	4.85E-10
89	3.11	9.867	5.54E-08	6.81E-10
88	3.10	10.607	6.99E-08	8.60E-10
87	3.09	10.338	7.11E-08	4.90E-10
86	3.08	10.351	4.05E-08	6.51E-10
85	3.07	10.533	4.61E-08	7.24E-10
84	3.06	10.052	4.70E-08	9.13E-10
83	3.05	10.11	4.25E-08	1.01E-09
82	3.04	10.326	5.48E-08	4.26E-10
81	3.03	10.212	6.11E-08	6.57E-10
80	3.02	10.406	5.15E-08	6.46E-10

Sample #	Height (m)	Mass (g)	χ (m3/kg)	Standard Deviation (m3/kg)
79	3.01	10.592	1.37E-07	4.08E-10
78	3.00	10.242	4.77E-08	2.48E-10
77	2.99	10.208	4.56E-08	9.97E-10
76	2.98	10.328	5.55E-08	2.46E-10
75	2.97	10.04	7.21E-08	5.04E-10
74	2.96	10.174	8.28E-08	6.57E-10
73	2.95	10.354	8.51E-08	8.79E-10
72	2.94	9.216	5.23E-08	1.10E-09
71	2.93	10.211	8.35E-08	6.54E-10
70	2.92	10.353	9.67E-08	7.30E-10
69	2.91	10.231	1.13E-07	2.45E-10
68	2.90	10.799	1.44E-07	4.61E-10
67	2.89	10.461	1.07E-07	8.66E-10
66	2.88	10.467	1.50E-07	4.76E-10
65	2.87	10.712	1.22E-07	8.42E-10
64	2.86	10.231	7.99E-08	8.90E-10
63	2.85	10.285	7.77E-08	6.50E-10
62	2.81	10.494	8.08E-08	4.81E-10
61	2.76	10.498	6.74E-08	2.41E-10
60	2.71	10.404	8.85E-08	8.40E-10
59	2.66	10.775	9.57E-08	4.67E-10
58	2.65	10.571	9.72E-08	8.25E-10
57	2.64	10.321	1.47E-07	7.24E-10
56	2.63	10.392	2.62E-07	9.88E-10
55	2.62	10.848	1.98E-07	7.12E-10
54	2.61	10.357	2.56E-07	6.56E-10
53	2.60	10.271	2.60E-07	9.01E-10
52	2.59	10.312	1.44E-07	6.40E-10
51	2.58	10.273	5.86E-08	4.94E-10
50	2.57	10.692	1.01E-07	8.48E-10
49	2.53	10.466	7.31E-08	7.25E-10
48	2.52	9.001	8.68E-08	4.87E-10
47	2.51	9.72	7.61E-08	2.60E-10
46	2.50	7.417	8.68E-08	1.23E-09
45	2.49	8.867	8.73E-08	2.85E-10
44	2.48	10.281	7.96E-08	8.51E-10
43	2.47	10.778	6.05E-08	4.07E-10
42	2.46	10.174	6.92E-08	4.98E-10
41	2.45	10.73	9.34E-08	4.69E-10
40	2.44	9.532	1.01E-07	9.53E-10
39	2.43	10.563	6.60E-08	6.34E-10
38	2.42	10.343	4.71E-08	6.51E-10
37	2.41	10.63	6.24E-08	8.26E-10
36	2.40	10.713	7.98E-08	6.24E-10
35	2.39	10.319	6.84E-08	8.50E-10
34	2.38	10.422	6.78E-08	7.29E-10
33	2.37	10.603	6.83E-08	4.78E-10
32	2.36	7.144	6.64E-08	6.17E-10
31	2.35	10.174	7.06E-08	4.98E-10
30	2.34	10.632	5.93E-08	7.16E-10
29	2.33	9.995	2.30E-07	4.46E-10
28	2.32	10.632	6.32E-08	4.77E-10
27	2.31	10.391	5.48E-08	4.89E-10
26	2.30	10.535	6.06E-08	4.81E-10

Sample #	Height (m)	Mass (g)	χ (m3/kg)	Standard Deviation (m3/kg)
25	2.29	10.211	5.04E-08	2.49E-10
24	2.28	10.376	4.49E-08	6.49E-10
23	2.27	10.422	5.66E-08	8.78E-10
22	2.26	10.249	6.59E-08	8.91E-10
21	2.25	10.454	5.74E-08	6.42E-10
20	2.24	10.404	6.55E-08	2.44E-10
19	2.23	10.316	5.92E-08	9.84E-10
18	2.22	10.385	6.35E-08	8.80E-10
17	2.21	10.147	7.14E-08	9.00E-10
16	2.20	10.55	8.98E-08	4.14E-10
15	2.19	10.433	1.10E-07	1.05E-09
14	2.15	10.293	8.79E-08	0
13	2.10	10.444	8.83E-08	8.71E-10
12	2.09	10.454	1.53E-07	8.24E-10
11	2.08	10.375	7.50E-08	1.06E-09
10	2.07	10.576	7.95E-08	4.14E-10
9	2.06	10.495	1.17E-07	8.61E-10
8	2.05	10.361	1.14E-07	4.84E-10
7	2.04	10.41	1.30E-07	6.35E-10
6	2.03	10.431	1.61E-07	4.95E-10
5	2.02	10.273	1.21E-07	0
4	2.01	10.484	1.04E-07	6.34E-10
3	2.00	10.414	1.93E-07	6.54E-10
2	1.99	10.511	6.68E-08	2.41E-10
1	1.98	9.962	6.85E-08	6.73E-10
1	1.97	10.524	2.44E-07	4.23E-10
2	1.96	10.427	7.58E-08	2.42E-10
3	1.95	10.561	7.16E-08	9.58E-10
4	1.94	10.433	1.48E-07	4.13E-10
5	1.93	10.61	1.06E-07	7.10E-10
6	1.92	10.399	2.48E-07	8.91E-10
7	1.91	10.815	3.35E-07	6.48E-08
8	1.90	10.404	4.74E-07	6.46E-10
9	1.89	10.053	9.35E-08	9.04E-10
10	1.88	10.645	3.97E-07	9.58E-10
11	1.87	10.462	5.28E-07	8.73E-10
12	1.86	10.231	3.78E-07	4.99E-10
13	1.85	10.794	7.83E-08	7.02E-10
14	1.84	10.123	7.31E-08	2.50E-10
15	1.83	10.731	7.95E-08	8.48E-10
16	1.82	10.816	2.38E-07	6.28E-10
17	1.81	10.528	2.18E-07	4.89E-10
18	1.80	10.161	1.31E-07	2.46E-10
19	1.79	10.52	1.66E-07	4.25E-10
20	1.78	10.159	1.27E-07	0
21	1.77	10.527	7.93E-08	7.20E-10
22	1.76	10.035	9.03E-08	2.51E-10
23	1.75	10.23	1.16E-07	4.25E-10
24	1.70	10.02	7.69E-08	7.57E-10
25	1.65	10.504	1.25E-07	4.12E-10
26	1.60	10.154	2.03E-07	2.54E-10
27	1.55	10.002	5.16E-07	4.39E-10
28	1.54	10.072	7.65E-08	8.70E-10
29	1.53	10.575	2.04E-07	6.44E-10

Sample #	Height (m)	Mass (g)	χ (m3/kg)	Standard Deviation (m3/kg)
30	1.52	10.795	1.24E-07	6.13E-10
31	1.51	10.157	1.92E-07	2.54E-10
32	1.50	10.046	2.20E-07	8.87E-10
33	1.49	10.307	1.09E-07	4.87E-10
34	1.48	10.509	1.25E-07	6.30E-10
35	1.47	10.344	1.14E-07	2.43E-10
36	1.46	9.992	1.58E-07	8.98E-10
37	1.41	10.431	2.00E-07	4.28E-10
38	1.36	10.64	9.71E-08	7.09E-10
39	1.31	10.629	1.03E-07	4.73E-10
40	1.26	10.221	9.67E-08	9.86E-10
41	1.21	10.587	1.01E-07	6.28E-10
42	1.16	10.372	8.88E-08	4.21E-10
43	1.11	10.498	1.04E-07	8.63E-10
44	1.10	10.168	7.68E-08	4.31E-10
45	1.09	10.121	8.62E-08	4.32E-10
46	1.08	8.982	1.03E-07	4.86E-10
47	1.07	10.47	9.12E-08	2.41E-10
48	1.06	10.066	1.27E-07	2.74E-09
49	1.05	10.469	1.09E-07	9.59E-10
50	1.04	10.019	1.50E-07	9.95E-10
51	1.03	10.468	1.84E-07	2.46E-10
52	1.02	10.264	2.95E-07	8.65E-10
53	1.01	10.73	3.46E-07	2.38E-10
54	1.00	10.277	1.21E-07	8.79E-10
55	0.99	10.037	2.85E-07	6.76E-10
56	0.98	10.423	1.91E-07	6.54E-10
57	0.97	10.099	1.33E-07	8.93E-10
58	0.96	10.281	2.49E-07	6.61E-10
59	0.95	10.299	1.15E-07	6.44E-10
60	0.94	10.509	1.43E-07	4.74E-10
61	0.93	10.507	1.93E-07	0
62	0.92	10.17	3.15E-07	5.04E-10
63	0.91	10.094	1.72E-07	6.76E-10
64	0.90	10.135	3.89E-07	1.01E-09
65	0.89	10.831	3.73E-07	4.71E-10
66	0.88	10.128	4.29E-07	5.03E-10
67	0.87	10.263	2.56E-07	9.02E-10
68	0.86	10.585	1.96E-07	2.51E-15
69	0.85	10.263	1.55E-07	4.20E-10
70	0.84	10.657	1.83E-07	4.84E-10
71	0.83	10.757	1.10E-07	9.33E-10
72	0.82	8.759	1.19E-07	9.95E-10
73	0.81	8.783	1.07E-07	1.15E-09
74	0.80	10.411	1.63E-07	9.91E-10
75	0.79	7.732	3.86E-07	3.32E-10
76	0.78	8.303	9.88E-08	8.05E-10
77	0.77	8.813	8.91E-08	7.59E-10
78	0.76	10.152	2.28E-07	6.70E-10
79	0.75	7.504	8.84E-08	1.17E-09
80	0.74	10.069	1.08E-07	9.98E-10
81	0.73	10.42	1.83E-07	6.54E-10
82	0.72	10.09	2.15E-07	5.10E-10
83	0.71	8.859	1.78E-07	7.43E-10

Sample #	Height (m)	Mass (g)	χ (m3/kg)	Standard Deviation (m3/kg)
84	0.70	10.122	2.14E-07	8.81E-10
85	0.65	10.058	1.86E-07	6.78E-10
86	0.60	10.356	1.68E-07	7.47E-10
87	0.55	10.241	2.32E-07	8.70E-10
88	0.50	9.502	1.89E-07	7.18E-10
89	0.45	10.543	1.83E-07	4.89E-10
90	0.40	10.147	2.30E-07	2.53E-10
91	0.35	10.137	1.14E-06	4.84E-10
92	0.30	10.15	1.83E-06	6.16E-10
93	0.25	10.516	6.64E-07	7.17E-10
94	0.20	10.547	7.08E-07	6.29E-10
95	0.15	10.437	3.49E-07	8.83E-10
96	0.10	10.026	1.66E-07	6.81E-10
97	0.05	10.06	1.29E-07	7.46E-10
98	0.01	10.323	2.18E-07	6.59E-10