Analysis of Metavolcanic Rocks from the Vicinity of Fort Bragg, North Carolina: Comparing the Results Obtained by Neutron Activation Analysis, X-ray Fluorescence Analysis, and Inductively Coupled Plasma-Mass Spectrometry

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1. Introduction

We report on the results of a two-year chemical characterization project to describe the sources of metavolcanic rocks in the vicinity of Fort Bragg, North Carolina. During the summer of 2002, a total of 50 metavolcanic rock specimens from quarries in the Fort Bragg and the surrounding area were submitted to the Archaeometry Lab at the University of Missouri Research Reactor Center (MURR) for chemical analysis by instrumental neutron activation analysis (INAA). Based on the compositional data for 33 elements and the spatial proximity between quarries, the Fort Bragg lithic samples were subdivided into five distinct compositional groups and three other possible groups (Speakman and Glascock, 2002). Although there were hints of other possible subgroups, the numbers of samples present in the database were insufficient to justify further subdivision of the samples.

As a followup to the initial project, 20 additional quarry samples and 10 artifacts were also submitted to the Archaeometry Lab. In addition to performing INAA on the thirty new samples, the customer requested that all 80 of the samples be analyzed by two additional techniques available to the Archaeometry Lab – X-ray fluorescence (XRF) spectrometry and inductively coupled plasma-mass spectrometry (ICP-MS). In this report, we describe the analytical procedures employed, provide a comprehensive listing of the data collected by each analytical method, compare the results between methods, and examine the subgroup structure of the compositional data set for archaeological application.

2. Background

As part of a multi-faceted project, the Archaeometry Laboratory at MURR was contracted to conduct INAA, XRF, and ICP-MS on a collection of metavolcanic rocks recovered from the Fort Bragg region of North Carolina. The purpose of this project was to provide an indication of the range of compositional variability and differences between the metavolcanic rocks found in the region. The 80 samples submitted for analysis are described in Table 1. There were 9 artifacts from Fort Bragg and 71 source samples from quarries located in seven counties surrounding the Fort Bragg military installation (Figure 1). One generalized quarry location, Uwharries 1, was sampled somewhat more intensively (n=25) in order to assess inter-group variability. Other quarry groups were sampled less intensively in order to maximize the number of quarries that could be sampled and permitting compositional variability across a larger spatial area to be assessed.

3. Sample Preparation

The rock samples and artifacts were ground into powders by Brent Miller at the University of North Carolina at Chapel Hill using an aluminum-oxide shatter box. The samples were then shipped to MURR in powdered form. Although about three grams of powder were requested for each sample to conduct the three analytical procedures, not all of the samples had this amount of material available. The original sample material was subdivided into aliquots of 350 mg for

INAA, 150 mg for ICP-MS, and the remainder (i.e., typically 2.5 grams) for XRF.

a. Sample preparation, irradiation, and measurement by INAA

Approximately 350 mg aliquots of rock powder were placed in glass vials and oven-dried at 105 degrees C for 24 hours before weighing. Portions weighing 150 mg each were weighed into clean 2/5-dram polyvials used for short irradiations at MURR. At the same time, a sample weighing 200 mg was weighed into the clean high-purity quartz vials used for long irradiations at MURR. Along with the unknown samples, a number of reference standards made from SRM-1633a (coal fly ash) and SRM-688 (basalt rock) were similarly prepared, as were quality control samples (i.e., standards treated as unknowns) made from SRM-278 (obsidian rock) and Ohio Red Clay.

Neutron activation analysis of geological and archaeological samples at MURR, which consists of two irradiations and a total of three gamma counts, constitutes a superset of the procedures used at most other laboratories (Glascock 1992; Neff 1992, 2000). As discussed in detail by Glascock (1992), a short irradiation is carried out through the pneumatic tube irradiation system. Samples in the polyvials are sequentially irradiated, two at a time, for five seconds at a neutron flux of 8×10^{13} n/cm^2/s. The 720-second count generally yields gamma spectra containing peaks for nine short-lived elements aluminum (Al), barium (Ba), calcium (Ca), dysprosium (Dy), potassium (K), manganese (Mn), sodium (Na), titanium (Ti), and vanadium (V). The samples encapsulated in quartz vials are subjected to a 24-hour irradiation at a neutron flux of 5×10^{13} n/cm^2/s. This long irradiation is analogous to the single irradiation utilized at most other laboratories. After the long irradiation, samples decay for seven days, they are counted for 1,800 seconds (the "middle count") on a high-resolution germanium detector coupled to an automatic sample changer. The middle count generally yields data for seven medium half-life elements, namely arsenic (As), lanthanum (La), lutetium (Lu), neodymium (Nd), samarium (Sm), uranium (U), and ytterbium (Yb). After an additional three- or four-week decay, a final count of 9,000 seconds is carried out on each sample. The latter measurement usually reports data for 17 long half-life elements, including cerium (Ce), cobalt (Co), chromium (Cr), cesium (Cs), europium (Eu), iron (Fe), hafnium (Hf), nickel (Ni), rubidium (Rb), antimony (Sb), scandium (Sc), strontium (Sr), tantalum (Ta), terbium (Tb), thorium (Th), zinc (Zn), and zirconium (Zr). Ratios of the decay-corrected counts per second per unit weight of the unknowns to the standards are used to calculate concentrations.

The NAA data from the two irradiations and three counts (a total of 33 elements) were tabulated with EXCEL and stored in a dBase file along with the descriptive information available for each sample. Table I presents the NAA data in parts per million of the element with missing values (i.e., not detected) indicated by the presence of zeroes (i.e., 0.0).

b. Sample preparation and measurement by XRF

The sample aliquots designated for XRF were used to make loss-on-ignition (LOI) measurements prior to preparation of the samples for XRF spectroscopy. The samples in glass vials were dried for 24 hours in an oven at 105 degrees C before they were transferred into clean pre-weighed crucibles recorded with weights recorded to the nearest 0.0001 gram. After cooling the samples for 30 minutes, the total weight of the sample and crucible were also recorded. The crucible and sample were placed in a furnace operating at 500 degrees C for a period of four hours. The crucible and sample were removed and placed in a dessicator to fully cool. About two hours later, the crucible and ashed sample were reweighed. The percentage of LOI was then calculated.

The ashed samples were then mixed in equal parts with SpectroCertified X-Ray Mix Binding Powder Cat. No. 600 from Chemplex Industries. Mixing was performed on a Spex 8000 Mixer/Mill using a mixing time of 15 minutes. The blended mixtures of sample and binding powder were poured into 32mm aluminum planchets with a stainless steel pellet die and placed under 25 tons of pressure. The Spectro X-Lab 2000 spectrometer produces chemical analyses of geological materials using the energy-dispersive x-ray fluorescence spectrometry (ED-XRF) based on polarized or near monochromatic x-rays for optimal sample excitation. The X-Lab 2000 spectrometer used to perform these analyses incorporates an end-window x-ray tube that can be focused on various secondary targets to produce polarized x-rays. Using the combination of different targets, typical detection limits for the light elements (Si, Al, Mg, and Na) are in the range of 25-50 ppm. Limits of detection for the heavy elements are in the 1-5 ppm range. The Spectro X-lab 2000 spectrometer was factory calibrated using a number of international rock standards (Korotev 1996).

The recommended amount of rock sample to mix powder for proper measurement on the Spectro X-Lab 2000 is about 5.0 grams. However, several of the samples were limited to about only 0.5 grams of sample (i.e., total mass of 1.0 grams). The light mass samples made necessary development of a separate correction method after they were measured on the XRF. An experiment was conducted using a series of samples made by mixing USGS Rock Standard RGM-1 Rhyolite in equal parts with the binding powder (i.e., 0.5, 1.0, 1.5, 2.0, and 2.5 grams each of sample and binding powder). The USGS rock samples were measured under the same conditions as the unknowns in this study. A correction to normalize the data from the USGS rock samples to a total of 100% minus LOI was found to be successful for all elements except Barium. Barium concentrations were always high, and by calculating the ratio of the normalized USGS RGM-1 rock to the certified value for USGS RGM-1 an acceptable correction factor was determined for Barium.

The ED-XRF measurements resulted in data for 21 elements, namely Na, Mg, Al, Si, K, Ca, Ti, Mn, Fe, Cu, Zn, Ga, Rb, Sr, Y, Zr, Nb, Ba, Pb, Th, and U. The data were tabulated with EXCEL and with the major elements converted to percent oxides and the trace elements listed in parts per million. The XRF results are listed in Table 2 of this report.

c. Sample preparation and measurement by ICP-MS

The rock samples from Fort Bragg were analyzed by ICP-MS to determine the rare-earth elements present in the rocks with high precision. The third aliquot was weighed whole into a precleaned Teflon digestion vessel. Fisher brand Optima grade nitric acid (1 ml) and Fisher brand TraceMetal grade hydrofluouric acid (3 ml) were added. The vessels were sealed and samples were heated in a microwave digestion system. After digestion, the vessels were cooled to room temperature before opening. A second microwave cycle was then performed in which a solution of Aldrich brand 99.999% boric acid (4%, 30 ml) was added to the vessels. The vessels were resealed and heated again in the microwave. Vessel blanks containing only the digestion reagents were similarly prepared in order to check for analyte backgrounds. Quality control samples made from USGS RGM-1 rhyolite and NIST SRM-278 obsidian rock were also digested along with the unknown samples to provide accuracy checks.

The digested samples were transferred with rinsing (18.2 MΩ DI H_2O) to precleaned Nalgene bottles. These digestates were then diluted by a factor of 10 for ICP analysis, and an internal standard of Indium was added to the diluted samples. Linearity standards made from diluted commercial High-Purity Standard stock solutions, were prepared to calibrate the ICP-MS. The internal standard of In was also added to all linearity standards. Standards were re-analyzed repeatedly throughout the analytical run to ensure continuous correct instrument response. Vessel backgrounds were found to be insignificant in comparison to the analyte levels in the samples. Table 3 lists the results for the 14 REEs (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, and Lu) along with the data for Hf, Ta, and Th with all values reported in parts per million of the element. Note that some elements are reported by measurement of more than one isotope (Nd143 and Nd146; Gd156 and Gd157). The agreement is excellent.

Comparison of the INAA, XRF, and ICP-MS data in Tables 2-4 finds excellent agreement throughout. The INAA data cover a wider range of elements than either XRF or ICP-MS. XRF permitted measurement of several elements not possible by INAA, including Si, Cu, Ga, Y, and Nb. Although ICP-MS is more laborious, four REE elements (Pr, Ho, Er, and Tm) not possible by INAA or XRF were also measured. For the purpose of archaeological interpretation, we will only discuss the INAA data during the remainder of this report.

4. Quantitative Analysis of the Chemical Data

The INAA analyses at MURR determined concentration for 33 elements. However, a few elements, especially As, Cr, Ni, and V were below detection in half or more of the samples. Ba and Sr are also missing for samples from specific quarries (i.e., Chatham, Uwharrie 1). Treatment of missing values for small groups can be difficult and, as a consequence, these six elements were deleted from consideration during statistical analysis. Analysis was subsequently carried out on base-10 logarithms of concentrations for the 27 element data. Use of log concentrations instead of raw data compensates for differences in magnitude between major elements, such as iron, on one hand and trace elements, such as the rare earth or lanthanide elements (REEs), on the other hand. Transformation to base 10 logarithms also yields a more nearly normal distribution for many trace elements.

The primary goal of quantitative analysis of the chemical data is to recognize compositionally homogeneous groups within the analytical database. Based on the "provenance postulate"

(Weigand, Harbottle, and Sayre 1977), such groups are assumed to represent geographically restricted sources or source zones. The location of sources or source zones may be inferred by comparing the unknown groups to knowns (source raw materials) or by indirect means. Such indirect means include the "criterion of abundance" (Bishop, Rands, and Holley 1982) or arguments based on geological and sedimentological characteristics (e.g., Steponaitis, Blackman, and Neff 1996).

Principal components analysis (PCA) is one of the techniques that can be used to identify patterns (i.e., subgroups) in compositional data. PCA provides new reference axes that are arranged in decreasing order of variance subsumed. The data can be displayed on combinations of these new axes, just as they can be displayed relative to the original elemental concentration axes. PCA can be used in a pure pattern-recognition mode, i.e., to search for subgroups in an undifferentiated data set, or in a more evaluative mode, i.e., to assess the coherence of hypothetical groups suggested by other archaeological criteria. Generally, compositional differences between specimens can be expected to be larger for specimens in different groups than for specimens in the same group, and this implies that groups should be detectable as distinct areas of high point density on plots of the first few components.

One strength of PCA, discussed by Baxter (1992) and Neff (1994), is that it can be applied as a simultaneous R- and Q-mode technique, with both variables (elements) and objects (individual analyzed samples) displayed on the same set of principal component reference axes. The two-dimensional plot of element coordinates on the first two principal components is generally the best possible two-dimensional representation of the correlation or variance-covariance structure in the data: small angles between vectors from the origin to variable coordinates indicate strong positive correlation; angles close to 90^{o} indicate no correlation; and angles close to 180^{o} indicate negative correlation. Likewise, the plot of object coordinates is the best two-dimensional representation of Euclidean relations among the objects in log-concentration space (if the PCA was based on the variance-covariance matrix) or standardized log-concentration space (if the PCA was based on the correlation matrix). Displaying objects and variables on the same plots makes it possible to observe the contributions of specific elements to group separation and to the distinctive shapes of the various groups. Such plots are often called "biplot" in reference to the simultaneous plotting of objects and variables. The variable interrelationships inferred from a biplot can be verified directly by inspection of bivariate elemental concentration plots (note that a bivariate plot of elemental concentrations is not a "biplot").

Whether a group is discriminated easily from other groups can be evaluated visually in two dimensions or statistically in multiple dimensions. A metric known as Mahalanobis distance (or generalized distance) makes it possible to describe the separation between groups or between individual points and groups on multiple dimensions. The Mahalanobis distance of a specimen from a group centroid (Bieber et al. 1976; Bishop and Neff 1989; Neff 2001; Harbottle 1976;

$$D^2_{y,X} = [y - \overline{X}]^t I_X [y - \overline{X}] \quad (1)$$

Sayre 1975) is:

where y is 1 x m array of logged elemental concentrations for the individual point of interest, X is the n x m data matrix of logged concentrations for the group to which the point is being compared with $\bar{X}$ being its 1 x m centroid, and I_x is the inverse of the m x m variance-covariance matrix of group X. Because Mahalanobis distance takes into account variances and covariances in the multivariate group it is analogous to expressing distance from a univariate mean in standard deviation units. Like standard deviation units, Mahalanobis distances can be converted into probabilities of group membership for each individual specimen (e.g., Bieber et al. 1976; Bishop and Neff 1989; Harbottle 1976). For relatively small sample sizes, it is appropriate to base probabilities on Hotelling's T^2, which is the multivariate extension of the univariate Student's t test.

With small groups, Mahalanobis distance-based probabilities of group membership may fluctuate dramatically depending on whether or not each specimen is assumed to be a member of the group to which it is being compared. Harbottle (1976) calls this phenomenon "stretchability" in reference to the tendency of an included specimen to stretch the group in the direction of its own location in the elemental concentration space. This problem can be circumvented by cross-validation (or "jackknifing"), that is, by removing each specimen from its presumed group before calculating its own probability of membership (Baxter 1994; Leese and Main 1994). This is a conservative approach to group evaluation that may sometimes exclude true group members. All probabilities discussed below are cross-validated.

In this study, several of the group sizes are smaller than the total number of variates, and this places a further constraint on use of Mahalanobis distance: with more variates than objects, the group variance-covariance matrix is singular thus rendering calculation of I_x (and D^2 itself) impossible. Dimensionality of the groups therefore must be reduced somehow. One approach to dimensionality reduction would be to eliminate elements considered irrelevant or redundant. The problem with this approach is that the investigator’s preconceptions about which elements should best discriminate sources may not be valid; it also squanders one of the major strengths of INAA, namely its capability to determine a large number of elements simultaneously. An alternative approach to dimensionality reduction, used here, is to calculate Mahalanobis distances not with log concentrations but with scores on principal components extracted from the variance-covariance or correlation matrix of the complete data set. This approach entails only the assumption, entirely reasonable in light of the above discussion of PCA, that most group-separating differences should be visible on the largest several components. Unless a data set is highly complex, with numerous distinct groups, using enough components to subsume 90% of total variance in the data may be expected to yield Mahalanobis distances that approximate Mahalanobis distances in the full elemental concentration space.

5. **Results and Conclusions**

After eliminating the elements with too many missing values mentioned earlier (i.e., As, Cr, Ni, Sr, U, and V), the NAA data were converted to logarithms. An RQ-mode PCA transformation of the 80 specimen rhyolite dataset was performed using the variance-covariance matrix of the logged data. The calculated eigenvalues are listed in Table 5 where one notes that the first seven components subsume at least 90% of the variance in the dataset and the first 15 components subsume more than 99% of the variance. From the biplots in Figures 2 and 3 showing the samples and element vectors for the first three PCs, it is noted that the first PC is dominated by enrichment of the transition metals Co, Fe, Mn, and Ca, and dilution of Ta and Th and the alkali elements K and Rb. The second PC is dominated by enrichment of Ba and dilution of Sb and the REEs. The third PC shows enrichment of Na and dilution of K, Rb, Ba, and Cs.

Based on the elemental data and spatial proximity between quarries, the 71 source samples from the Fort Bragg area were subdivided into the eight chemical groups shown in Figures 2 and 3. The chemical groups are Uwharrie 1, Uwharrie 2, Chatham 2, Chatman 1+3, Cape Fear, Durham, Orange, and Person. Due to their overall similarity, the source samples from the quarries at Chatham 1 and Chatham 3 were combined to create the group named Chatham 1+3 and sample FBL039 was removed from the Cape Fear group because it was found to be an extreme outlier relative to the five remaining samples. Figures 4 through 8 illustrate the basic data structure for the analyzed source samples and group assignments and also show the artifact data projected against the source groups.

The Uwharrie 1 group is statistically the most valid of the groups, a consequence of the number of samples having membership in the group. Additional analyses of source specimens from this quarry would not be likely to affect the overall basic structure of this group. According to Mahalanobis distance calculations for samples in the Uwharrie 1 group membership probabilities based on the first 15 PCs are greater than one percent for all members of this group (except FBL013 and FBL014). The results are shown in Table 6.

A comparison of specimens from the other compositional groups to Uwharrie 1 shown in Table 7 illustrates that with the exception of the Orange group all other chemical groups have low probabilities of overlap with Uwharrie 1. Due to the limited numbers of samples in the individual groups (ranging from 5 to 10 samples), we are unable to perform the same test to differentiate between the other quarries. Due to their overall similarity, the source samples from the quarries at Chatham 1 and Chatham 3 were combined to create the group named Chatham 1+3.

As shown in Figures 4 and 5, the rhyolite specimens exhibit some significant patterns in geochemistry. Three distinct clusters are present with Chatham 2 and Cape Fear groups well separated from the remaining compositional groups on the basis of Hf, Ta, and Zr. The Chatham 2 source samples are an intermediate metavolcanic rock and the Cape Fear specimens are largely greenstone. Sample FBL039 was removed from the Cape Fear group, because it was found to be an extreme outlier relative to the five remaining samples. Both groups are small but compositionally very homogeneous. Although it is unlikely that additional samples from these quarries would have much affect on the basic structure of the database, the analysis of additional specimens would enable more rigorous testing. From Figures 4 and 5, it is obvious that both Chatham 2 and Cape Fear can be excluded as possible sources for the nine artifacts in this study.

In Figures 6 through 8, the artifacts are projected against the remaining six chemical groups. Examination of the plots suggests that Uwharrie 1 is the most probable source for all of the artifacts except FBL073 and FBL075. The latter pair of artifacts have greater likelihood of belonging to the Chatham 1+3 or Person sources. We support this observation by calculating the Mahalanobis distance probabilities shown in Table 8 where the probabilities of the artifacts relative to the Uwharrie 1 source were determined using 99% of the variance in the database. Probabilities are high for FBL074, FBL076, and FBL077 to belong to the Uwharrie 1 group. Samples FBL072, FBL078, FBL079, and FBL080 have modest probabilities of membership. The extremely low probabilities for FBL073 and FBL075 suggest they are from a different quarry.

Table 9 lists the standard deviations and means for each of the compositional groups based on their INAA data.

6. Acknowledgements

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Figure Captions

Figure 1: Map of the Fort Bragg vicinity showing quarry locations and compositional groups identified in the study.

Figure 2: Biplot derived from PCA of the variance-covariance matrix of the Fort Bragg lithic data showing PC1 versus PC2. Vectors connect the origin with element coordinates. Ellipses represent 90% confidence level for membership in the groups.

Figure 3: Biplot derived from PCA of the variance-covariance matrix of the Fort Bragg lithic data showing PC1 versus PC3. Vectors connect the origin with element coordinates. Ellipses represent 90% confidence level for membership in the groups.

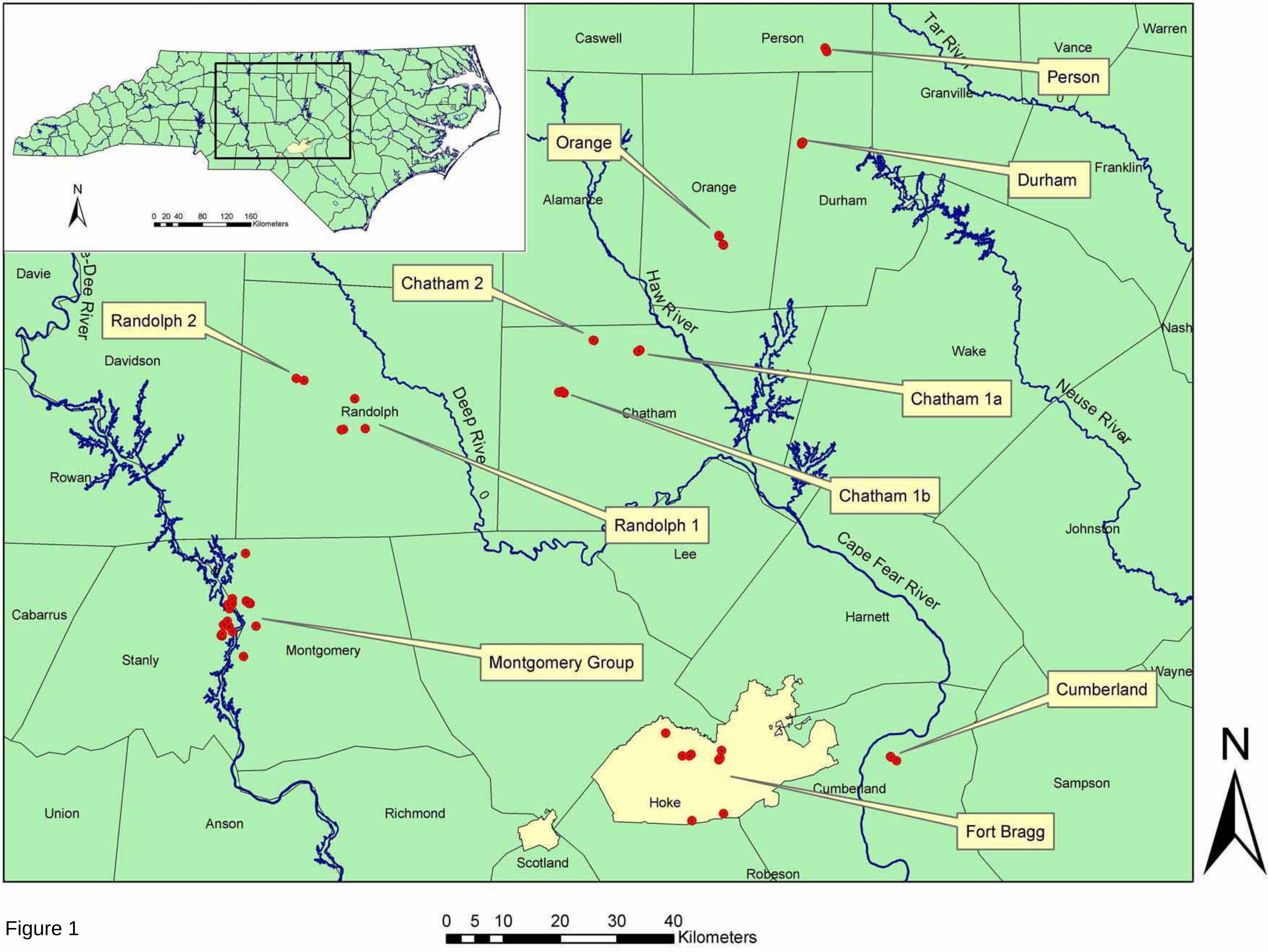
Figure 4: Bivariate plot of lanthanum versus zirconium base-10 logged concentrations for the Fort Bragg lithic groups. Ellipses represent 90% confidence level for membership in the groups. Artifacts labels are shown beside each bold plus (+) symbol.

Figure 5: Bivariate plot of hafnium versus tantalum base-10 logged concentrations for the Fort Bragg lithic groups. Ellipses represent 90% confidence level for membership in the groups. Artifacts labels are shown beside each bold plus (+) symbol.

Figure 6: Bivariate plot of europium versus rubidium base-10 logged concentrations for six of the Fort Bragg lithic groups. Ellipses represent 90% confidence level for membership in the groups. Artifacts labels are shown beside each bold plus (+) symbol.

Figure 7: Bivariate plot of iron versus tantalum base-10 logged concentrations for six of the Fort Bragg lithic groups. Ellipses represent 90% confidence level for membership in the groups. Artifacts labels are shown beside each bold plus (+) symbol.

Figure 8: Bivariate plot of cesium versus thorium base-10 logged concentrations for six of the Fort Bragg lithic groups. Ellipses represent 90% confidence level for membership in the groups. Artifacts labels are shown beside each bold plus (+) symbol.



Caswell
Person
Warren
Vance
Person
Granville
Tar River
Orange
Durham
Franklin
Alamance
Orange
Durham
Davie
e-Dee River
Chatham 2
Haw River
Nash
Randolph 2
Davidson
Wake
Chatham 1a
Randolph
Deep Rive
Chatham
Neuse River
Rowan
Chatham 1b
Randolph 1
Johnston
Lee
Cape Fear River
Cabarrus
Harnett
Stanly
Montgomery
Montgomery Group
Wayne
Cumberland
Sampson
Cumberland
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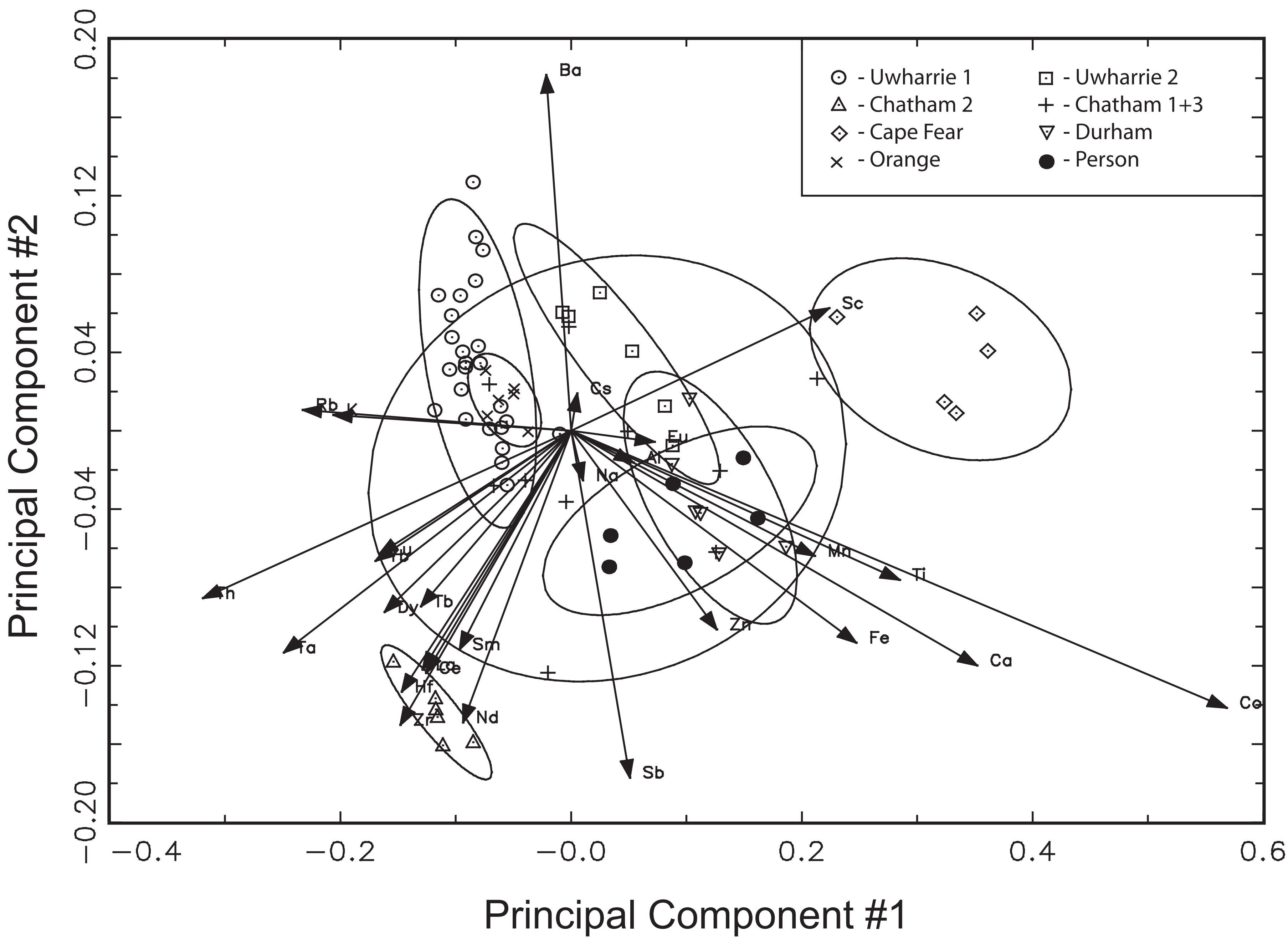
0 5 10 20 30 40
Kilometers

Figure 1


- Uwharrie 1
- Uwharrie 2
- Chatham 2
- Chatham 1+3
- Cape Fear
- Durham
- Orange
- Person
Principal Component #1
Principal Component #2
Ba
Sc
Cs
Rb
K
Eu
Al
Na
Mn
Ti
Zn
Fe
Ca
Ce
Sb
Nd
Sm
Hf
Zr
Tb
Dy
Ta
Th
0.20
0.12
0.04
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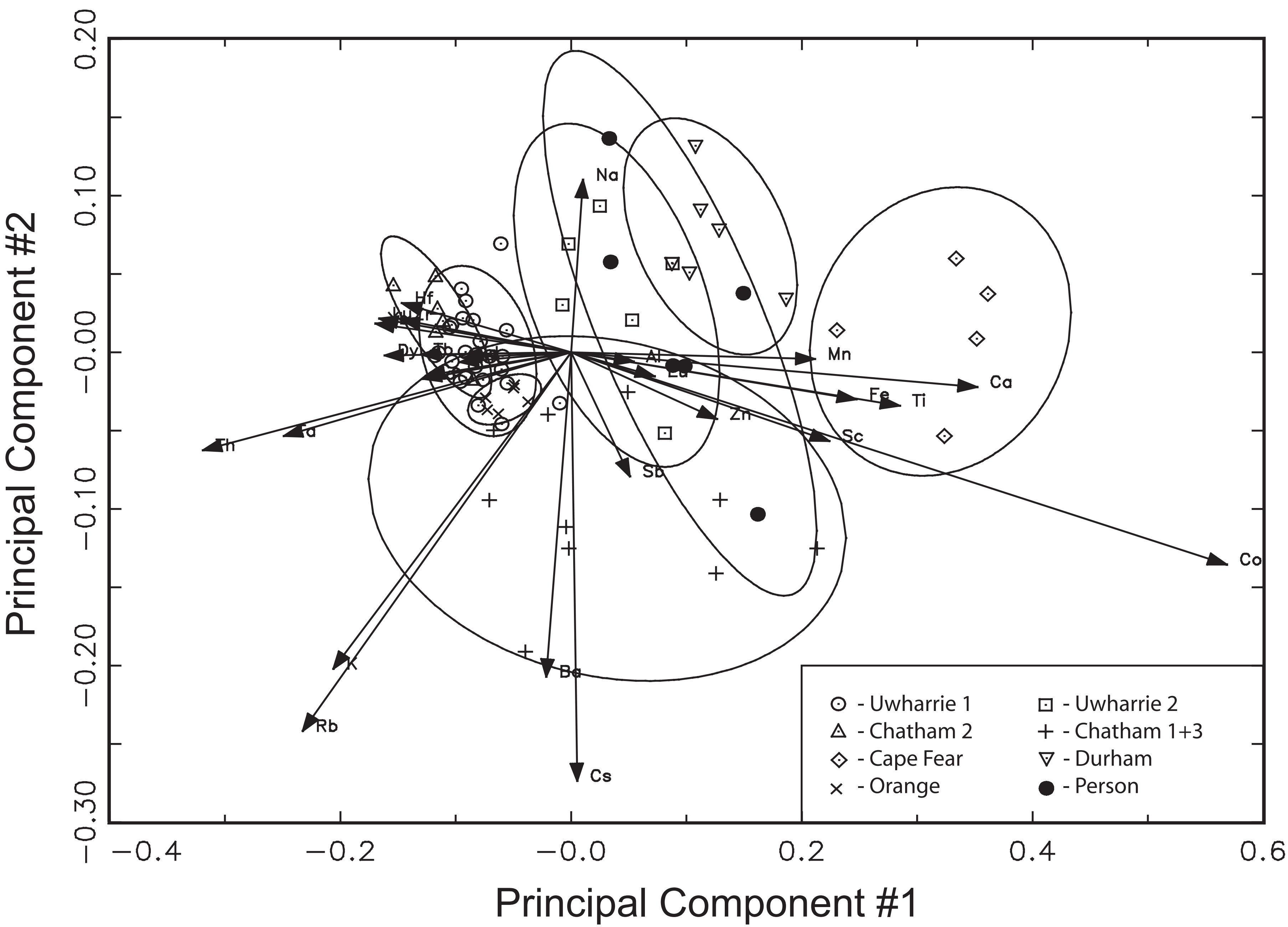
−0.12
−0.20
−0.4
−0.2
−0.0
0.2
0.4
0.6

Figure 2


Principal Component #2
Principal Component #1
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0.10
−0.00
−0.10
−0.20
−0.30
−0.4
−0.2
−0.0
0.2
0.4
0.6
Na
Mn
Al
Eu
Ca
Fe
Ti
Zn
Sc
Co
Sb
Hf
Dy
Tb
Th
Ta
K
Rb
Ba
Cs
- Uwharrie 1
- Uwharrie 2
- Chatham 2
- Chatham 1+3
- Cape Fear
- Durham
- Orange
- Person

Figure 3

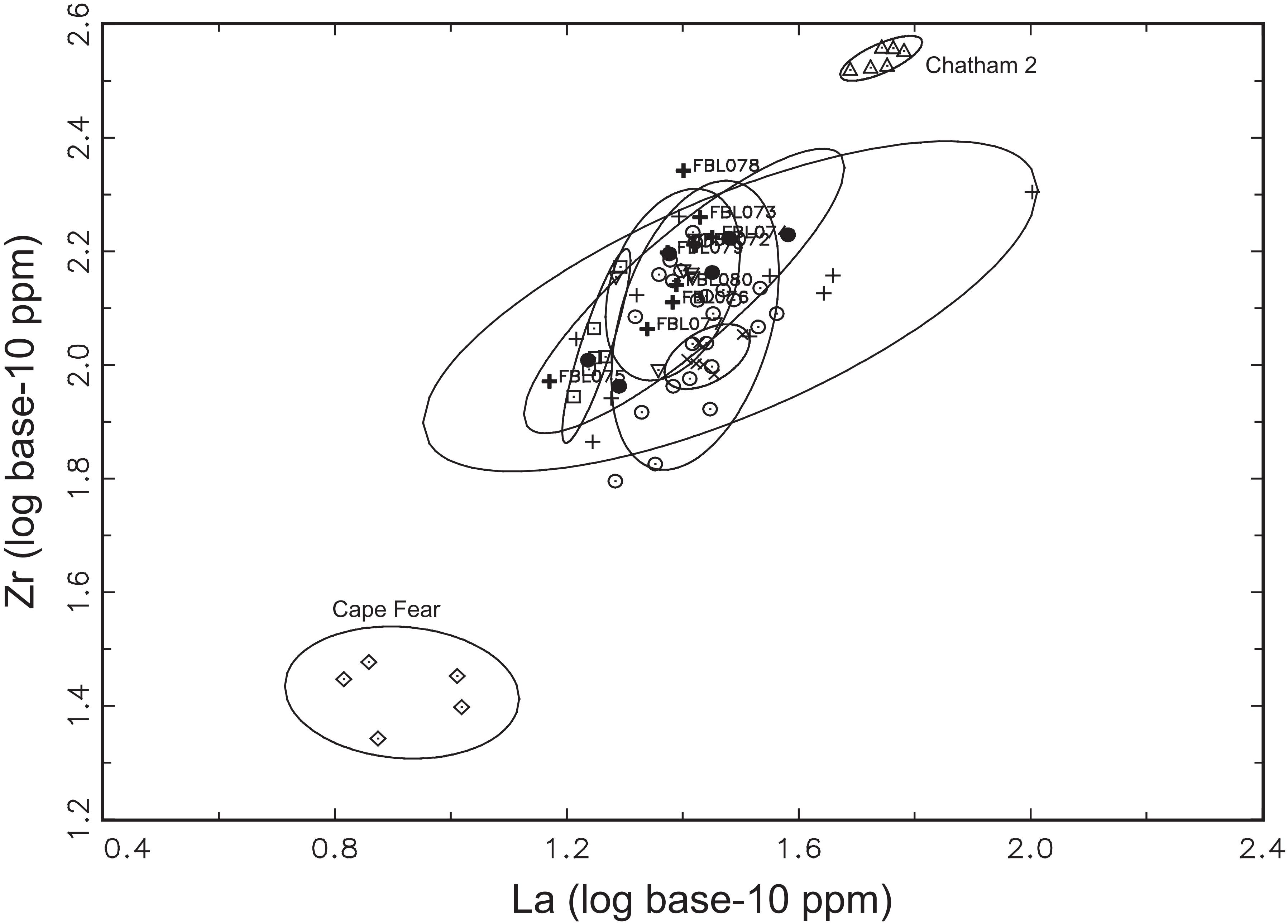

Chatham 2
FBL078
FBL073
FBL072
FBL079
FBL080
FBL076
FBL075
Cape Fear
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
Zr (log base-10 ppm)
0.4
0.8
1.2
1.6
2.0
2.4
La (log base-10 ppm)

Figure 4

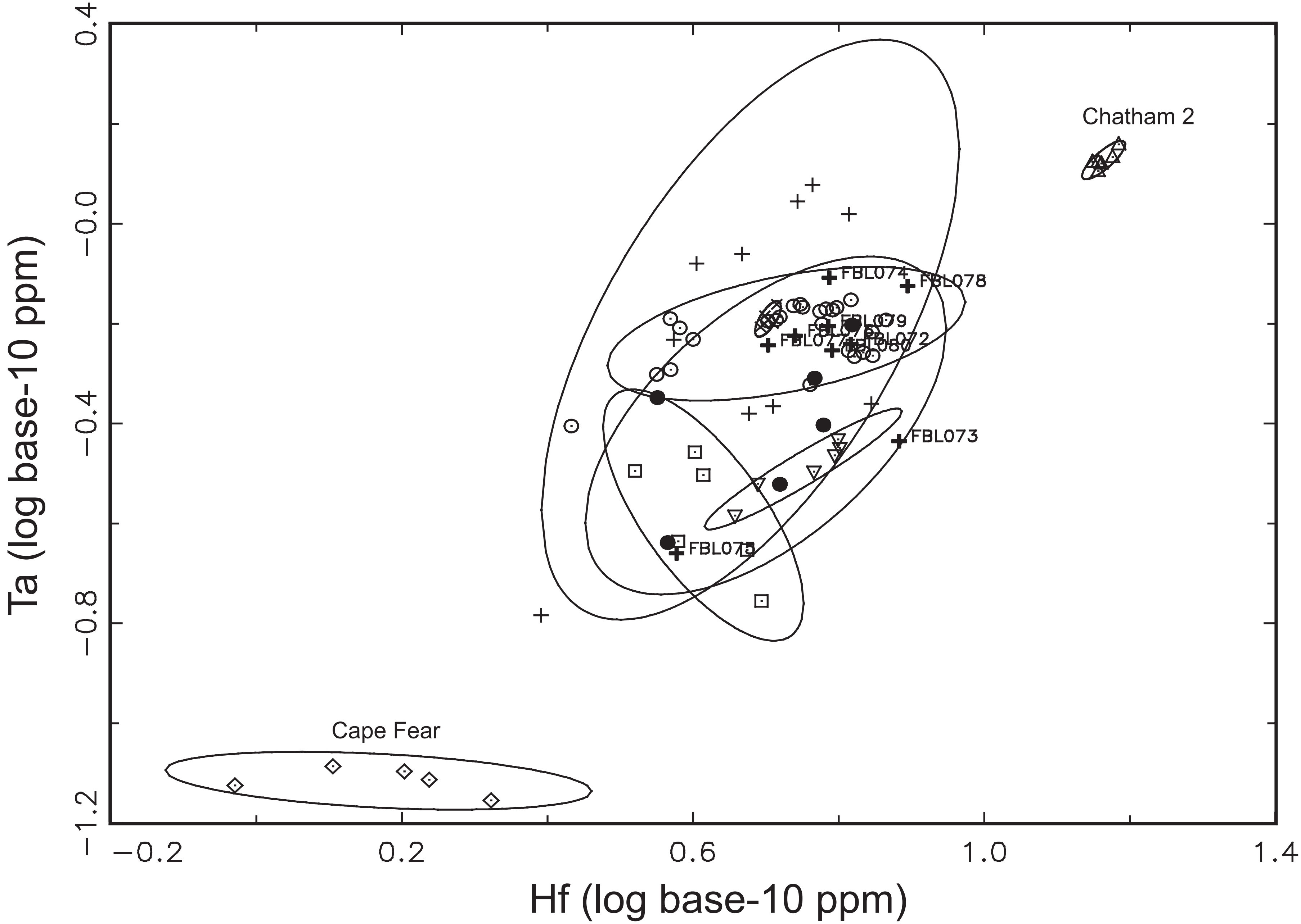
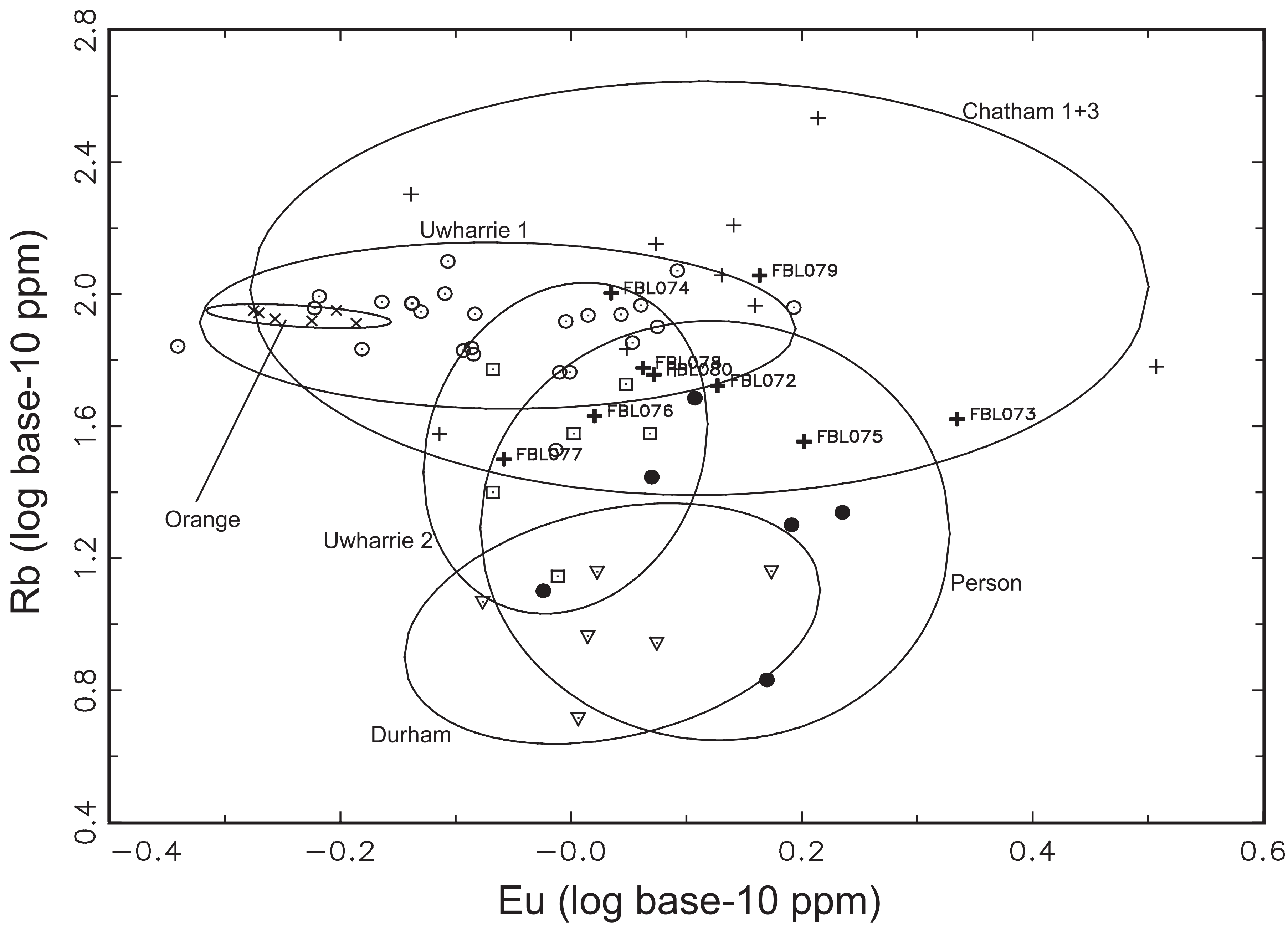

Chatham 2
Cape Fear
FBL074
FBL078
FBL079
FBL072
FBL073
FBL075
0.4
-0.0
-0.4
-0.8
-1.2
-0.2
0.2
0.6
1.0
1.4
Ta (log base-10 ppm)
Hf (log base-10 ppm)

Figure 5



Chatham 1+3
Uwharrie 1
Uwharrie 2
Orange
Durham
Person
FBL079
FBL074
FBL078
FBL080
FBL072
FBL076
FBL077
FBL073
FBL075
2.8
2.4
2.0
1.6
1.2
0.8
0.4
−0.4
−0.2
−0.0
0.2
0.4
0.6
Rb (log base-10 ppm)
Eu (log base-10 ppm)

Figure 6

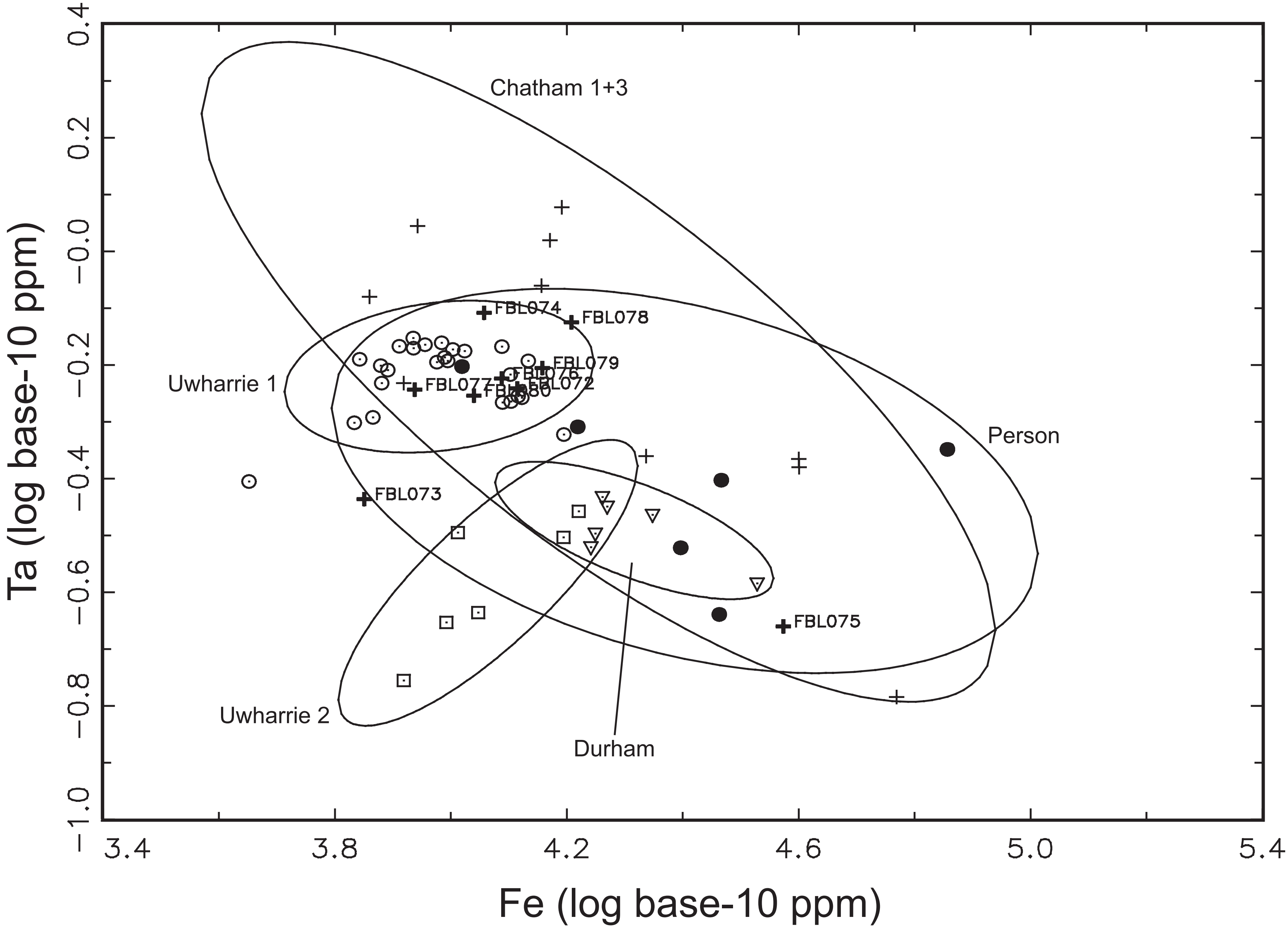

Chatham 1+3
FBL074
FBL078
FBL079
FBL076
FBL072
FBL077
FBL080
Uwharrie 1
Person
FBL073
FBL075
Uwharrie 2
Durham
0.4
0.2
-0.0
-0.2
-0.4
-0.6
-0.8
-1.0
Ta (log base-10 ppm)
3.4
3.8
4.2
4.6
5.0
5.4
Fe (log base-10 ppm)

Figure 7

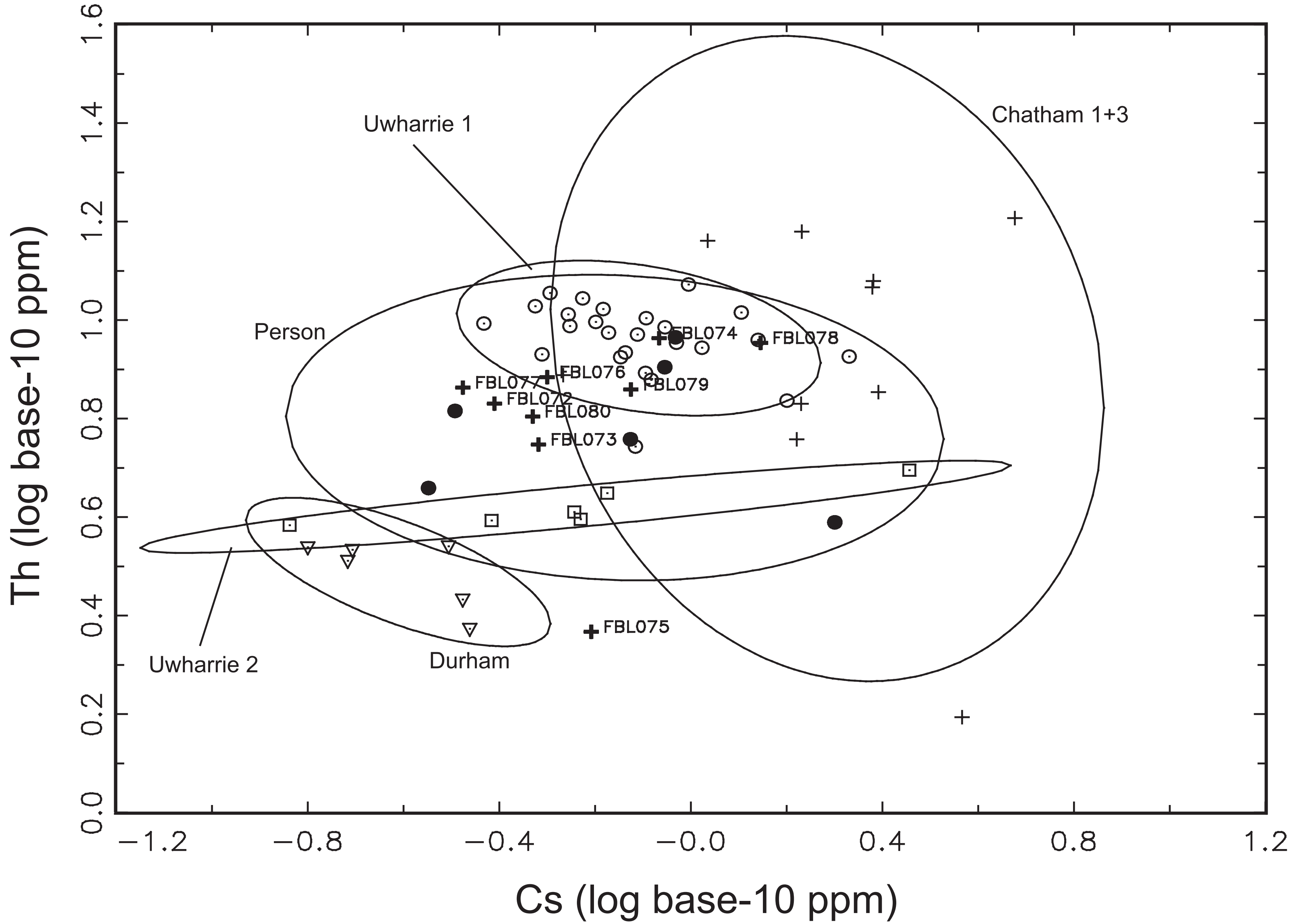

Th (log base-10 ppm)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
−1.2
−0.8
−0.4
−0.0
0.4
0.8
1.2
Cs (log base-10 ppm)
Chatham 1+3
Uwharrie 1
Person
Uwharrie 2
Durham
FBL074
FBL078
FBL076
FBL079
FBL077
FBL072
FBL080
FBL073
FBL075

Figure 8

Table 1. Descriptions of rock specimens from Fort Bragg, North Carolina.

anid	Sample ID	RD1 Group	INAA1 Group	RD2 Group	Locality	Site Name	Site Number	Northing	Easting
FBL001	HD-18A	Uwharries Eastern	Uwharrie 1	Montgomery 2b	Shingletrap Mt.	Shingletrap Mt.	31Mg554	3917872	587452
FBL002	HD-18A*	Uwharries Eastern	Uwharrie 1	Montgomery 2b	Shingletrap Mt.	Shingletrap Mt.	31Mg554	3918056	587342
FBL003	HD-18B	Uwharries Eastern	Uwharrie 1	Montgomery 2b	Shingletrap Mt.	Shingletrap Mt.	31Mg554	3918363	586781
FBL004	HD-18B*	Uwharries Eastern	Uwharrie 1	Montgomery 2b	Shingletrap Mt.	Shingletrap Mt.	31Mg554	3918121	586929
FBL005	HD-19	Uwharries Eastern	Uwharrie 1	Montgomery 2b	Sugarloaf West	Sugarloaf West	31St68	3914124	582758
FBL006	HD-21	Uwharries Eastern	Uwharrie 1	Montgomery 2b	Sugarloaf Mt.	Sugarloaf Mt.	31St66	3913852	583741
FBL007	HD-22	Uwharries Eastern	Uwharrie 1	Montgomery 2b	Hattaway Mt.	Hattaway Mt.	31St67	3914765	583453
FBL008	HD-4A	Uwharries Western	Uwharrie 1	Montgomery 3	Falls Dam	Falls Dam		3916984	583805
FBL009	HD-8	Uwharries Western	Uwharrie 1	Montgomery 3	Wolf Den Mt.	Wolf Den 639	31Mg639	3918067	584251
FBL010	HD-9*	Uwharries Western	Uwharrie 1	Montgomery 3	Wolf Den Mt.	Wolf Den 639	31Mg639	3917939	584300
FBL011	HD-10	Uwharries Western	Uwharrie 1	Montgomery 3	Wolf Den Mt.	Wolf Den 117	31Mg117	3918742	584316
FBL012	HD-10*	Uwharries Western	Uwharrie 1	Montgomery 3	Wolf Den Mt.	Wolf Den 117	31Mg117	3918742	584316
FBL013	HD-13	Uwharries Western	Uwharrie 1	Montgomery 3	Wolf Den Mt.	Wolf Den 640	31Mg640	3917723	583542
FBL014	HD-31	Uwharries Western	Uwharrie 1	Montgomery 3	Montgomery NW	31Mg641	31Mg641	3926732	586632
FBL015	HD-20	Uwharries Southern	Uwharrie 1	Montgomery 2a	Morrow Mt.	Morrow Mt.	31St18	3912209	582492
FBL016	HD-24	Uwharries Southern	Uwharrie 1	Montgomery 2a	Tater Top Mt.	Tater Top Mt.	31St64	3912917	584354
FBL017	HD-54	Uwharries Southern	Uwharrie 1	Montgomery 2a	Morrow Mt.	Morrow Mt.	31St18	3912252	582362
FBL018	HD-55	Uwharries Southern	Uwharrie 1	Montgomery 2a	Morrow Mt.	Morrow Mt.	31St18	3912421	582459
FBL019	HD-56	Uwharries Southern	Uwharrie 1	Montgomery 2a	Morrow Mt.	Morrow Mt.	31St18	3912560	582554
FBL020	HD-25B3	Uwharries Asheboro	Uwharrie 2	Randolph 1	Asheboro S	31Rd37	31Rd37	3948533	603523
FBL021	HD-33	Uwharries Asheboro	Uwharrie 2	Randolph 2	Carraway Mt.	Carraway Mt.	31Rd854/1201	3957237	596949
FBL022	HD-34	Uwharries Asheboro	Uwharrie 2	Randolph 2	Tater Head Mt.	Tater Head Mt.	31Rd855/1202	3957598	595573
FBL023	HD-38	Uwharries Asheboro	Uwharrie 2	Randolph 1	Dave's Mt.	Dave's Mt.		3954020	605891
FBL024	HD-66	Uwharries Asheboro	Uwharrie 2	Randolph 1	Asheboro S	31Rd37	31Rd37	3948601	603912
FBL025	HT-A	Uwharries Southeast	Uwharrie 1	Montgomery 1	Horse Trough Mt.	Horse Trough Mt.	31Mg378/379	3908577	586311
FBL026	HT-B	Uwharries Southeast	Uwharrie 1	Montgomery 1	Horse Trough Mt.	Horse Trough Mt.	31Mg378/379	3908577	586311
FBL027	Ch729-A	Chatham County	Chatham 1	Chatham 1a	Pittsboro	Joe Moylan Quarry	31Ch729	3962336	655804
FBL028	Ch729-B	Chatham County	Chatham 1	Chatham 1a	Pittsboro	Joe Moylan Quarry	31Ch729	3962336	655804
FBL029	Ch729-C	Chatham County	Chatham 1	Chatham 1a	Pittsboro	Joe Moylan Quarry	31CH729	3962336	655804
FBL030	Ch729-D	Chatham County	Chatham 1	Chatham 1a	Pittsboro	Joe Moylan Quarry	31Ch729	3962336	655804
FBL031	Ch741-A	Chatham County	Chatham 2	Chatham 2	Silk Hope	Chestnut Hill Quarry	31Ch741	3964340	647964
FBL032	Ch741-B	Chatham County	Chatham 2	Chatham 2	Silk Hope	Chestnut Hill Quarry	31Ch741	3964340	647964
FBL033	Ch741-C	Chatham County	Chatham 2	Chatham 2	Silk Hope	Chestnut Hill Quarry	31Ch741	3964340	647964
FBL034	Ch741-E	Chatham County	Chatham 2	Chatham 2	Silk Hope	Chestnut Hill Quarry	31Ch741	3964340	647964
FBL035	ChRR-F	Chatham County	Chatham 3	Chatham 1b	Siler City	Rocky River 1		3955002	642790
FBL036	ChRR-R	Chatham County	Chatham 3	Chatham 1b	Siler City	Rocky River 2		3955158	642626
FBL037	ChRR-T	Chatham County	Chatham 3	Chatham 1b	Siler City	Rocky River 3		3955297	642445
FBL038	Ch427	Chatham County	Chatham 3	Chatham 1b	Siler City	31Ch427	31Ch427	3955164	641835
FBL039	400-1	Cape Fear	Cape Fear	Cumberland	Cumberland NE	31Cd400	31Cd400	3890907	700336
FBL040	400-2	Cape Fear	Cape Fear	Cumberland	Cumberland NE	31Cd400	31Cd400	3890907	700336
FBL041	400-3	Cape Fear	Cape Fear	Cumberland	Cumberland NE	31Cd400	31Cd400	3890907	700336
FBL042	424-1	Cape Fear	Cape Fear	Cumberland	Cumberland NE	31Cd424	31Cd424	3890818	700408
FBL043	PCQ-A	Person County	Person	Person	Person SE	Powerline Quarry	31Pr115	4015567	688965
FBL044	PCQ-B	Person County	Person	Person	Person SE	Powerline Quarry	31Pr115	4015567	688965
FBL045	PCQ-C	Person County	Person	Person	Person SE	Powerline Quarry	31Pr115	4015567	688965

Table 1. Descriptions of rock specimens from Fort Bragg, North Carolina.

anid	Sample ID	RD1 Group	INAA1 Group	RD2 Group	Locality	Site Name	Site Number	Northing	Easting
FBL046	PCQ-D	Person County	Person	Person	Person SE	Powerline Quarry	31Pr115	4015567	688965
FBL047	DUR-A	Durham County	Durham	Durham	Durham NW	Cains Chapel Quarry	31Dh703	3999181	684723
FBL048	DUR-B	Durham County	Durham	Durham	Durham NW	Cains Chapel Quarry	31Dh703	3999181	684723
FBL049	QNWD-C	Durham County	Durham	Durham	Durham NW	Cains Chapel Quarry	31Dh703	3999181	684723
FBL050	QNWD-D	Durham County	Durham	Durham	Durham NW	Cains Chapel Quarry	31Dh703	3999181	684723
FBL051	Mg222	Uwharries Southeast	Uwharrie 1	Montgomery 1	Lick Mt.	USS Ranger Quarry	31Mg222	3913923	588488
FBL052	Mg222b	Uwharries Southeast	Uwharrie 1	Montgomery 1	Lick Mt.	USS Ranger Quarry	31Mg222	3913923	588488
FBL053	HFLK-1	Uwharries Southeast	Uwharrie 1	Montgomery 1	Lick Mt.	USS Ranger Quarry	31Mg222	3913923	588488
FBL054	HFLK-2	Uwharries Southeast	Uwharrie 1	Montgomery 1	Lick Mt.	USS Ranger Quarry	31Mg222	3913923	588488
FBL055	Rd852	Uwharries Asheboro	Uwharrie 2	Randolph 1	Asheboro S	Northhampton Rd. Quarry	31Rd852	3948745	607738
FBL056	Ch729-5	Chatham County	Chatham 1	Chatham 1a	Pittsboro	Joe Moylan Quarry	31Ch729	3962589	656168
FBL057	Ch729-6	Chatham County	Chatham 1	Chatham 1a	Pittsboro	Joe Moylan Quarry	31Ch729	3962454	655975
FBL058	Ch741-5	Chatham County	Chatham 2	Chatham 2	Silk Hope	Chestnut Hill Quarry	31Ch741	3964275	648050
FBL059	Ch741-6	Chatham County	Chatham 2	Chatham 2	Silk Hope	Chestnut Hill Quarry	31Ch741	3964353	647937
FBL060	ORNG-1	Orange County	Orange	Orange	Chapel Hill	Bald Mt. Quarry		3982716	670171
FBL061	ORNG-2	Orange County	Orange	Orange	Chapel Hill	Bald Mt. Quarry		3982672	670133
FBL062	ORNG-3	Orange County	Orange	Orange	Chapel Hill	Bald Mt. Quarry		3982816	670076
FBL063	ORNG-4	Orange County	Orange	Orange	Chapel Hill	31Or549	31Or549	3981131	670883
FBL064	ORNG-5	Orange County	Orange	Orange	Chapel Hill	31Or549	31Or549	3981195	670815
FBL065	ORNG-6	Orange County	Orange	Orange	Chapel Hill	31Or549	31Or549	3981171	670810
FBL066	DUR-5	Durham County	Durham	Durham	Durham NW	Cains Chapel Quarry	31Dh703	3998905	684667
FBL067	DUR-6	Durham County	Durham	Durham	Durham NW	Cains Chapel Quarry	31Dh703	3999235	684872
FBL068	PCQ-5	Person County	Person	Person	Person SE	Powerline Quarry	31Pr115	4015213	689130
FBL069	PCQ-6	Person County	Person	Person	Person SE	Powerline Quarry	31Pr115	4015889	688827
FBL070	402	Cape Fear	Cape Fear	Cumberland	Cumberland NE	31Cd402	31Cd402	3890184	701416
FBL071	424-4	Cape Fear	Cape Fear	Cumberland	Cumberland NE	31Cd424	31Cd424	3890818	700408
FBL072	31Hk100	Fort Bragg	Fort Bragg	Fort Bragg	Fort Bragg	31Hk100	31Hk100	3890370	670080
FBL073	31Hk148	Fort Bragg	Fort Bragg	Fort Bragg	Fort Bragg	31Hk148	31Hk148	3890600	670270
FBL074	31Hk173	Fort Bragg	Fort Bragg	Fort Bragg	Fort Bragg	31Hk173	31Hk173	3891970	670560
FBL075	31Hk182	Fort Bragg	Fort Bragg	Fort Bragg	Fort Bragg	31Hk182	31Hk182	3891290	665200
FBL076	31Hk224	Fort Bragg	Fort Bragg	Fort Bragg	Fort Bragg	31Hk224	31Hk224	3895060	660730
FBL077	31Hk737	Fort Bragg	Fort Bragg	Fort Bragg	Fort Bragg	31Hk737	31Hk737	3891053	664850
FBL078	31Hk999	Fort Bragg	Fort Bragg	Fort Bragg	Fort Bragg	31Hk999	31Hk999	3880860	670910
FBL079	31Hk1408	Fort Bragg	Fort Bragg	Fort Bragg	Fort Bragg	31Hk1408	31Hk1408	3879599	665320
FBL080	Flat Creek	Fort Bragg	Fort Bragg	Fort Bragg	Fort Bragg	Flat Creek		3891062	663638

Table 1. Descriptions of rock specimens from Fort Bragg, North Carolina.

anid	Sample ID	Sample Description	SGM Code	SGM Description	Formation	Artifact Type	Period
FBL001	HD-18A	plag-qtz phyric rhyolite	CZfv	Felsic metavolcanic rock	Tillery		
FBL002	HD-18A*	plag-qtz phyric rhyolite	CZfv	Felsic metavolcanic rock	Tillery		
FBL003	HD-18B	plag-qtz phyric rhyolite	CZfv	Felsic metavolcanic rock	Tillery		
FBL004	HD-18B*	plag-qtz phyric rhyolite	CZfv	Felsic metavolcanic rock	Tillery		
FBL005	HD-19	plag-qtz phyric rhyolite	CZfv	Felsic metavolcanic rock	Tillery		
FBL006	HD-21	plag-qtz phyric rhyolite	CZfv	Felsic metavolcanic rock	Tillery		
FBL007	HD-22	plag-qtz phyric rhyolite	CZfv	Felsic metavolcanic rock	Tillery		
FBL008	HD-4A	plag-phyric rhyolite	CZfv	Felsic metavolcanic rock	Cid		
FBL009	HD-8	plag-phyric rhyolite	CZfv	Felsic metavolcanic rock	Cid		
FBL010	HD-9*	plag-phyric rhyolite	CZfv	Felsic metavolcanic rock	Cid		
FBL011	HD-10	plag-phyric rhyolite	CZfv	Felsic metavolcanic rock	Cid		
FBL012	HD-10*	plag-phyric rhyolite	CZfv	Felsic metavolcanic rock	Cid		
FBL013	HD-13	plag-phyric rhyolite	CZfv [near CZmv1]	Felsic metavolcanic rock	Cid		
FBL014	HD-31	plag-phyric rhyolite	CZmv1	Mafic metavolcanic rock	Cid		
FBL015	HD-20	aphyric rhyolite	CZfv	Felsic metavolcanic rock	Tillery		
FBL016	HD-24	aphyric rhyolite	CZmd1	Metamudstone and meta-argillite	Tillery		
FBL017	HD-54	aphyric rhyolite	CZfv	Felsic metavolcanic rock	Tillery		
FBL018	HD-55	aphyric rhyolite	CZfv	Felsic metavolcanic rock	Tillery		
FBL019	HD-56	aphyric rhyolite	CZfv	Felsic metavolcanic rock	Tillery		
FBL020	HD-25B3	felsic tuff and breccia	CZmv	Mafic metavolcanic rock	Uwharrie		
FBL021	HD-33	felsic tuff and breccia	CZmd1	Metamudstone and meta-argillite	Tillery		
FBL022	HD-34	felsic tuff and breccia	CZfv	Felsic metavolcanic rock	Tillery		
FBL023	HD-38	felsic tuff and breccia	CZfv1	Felsic metavolcanic rock	Uwharrie		
FBL024	HD-66	felsic tuff and breccia	CZmv	Mafic metavolcanic rock	Uwharrie		
FBL025	HT-A	plag-qtz phyric felsite	CZfv1	Felsic metavolcanic rock	Uwharrie		
FBL026	HT-B	plag-phyric felsite	CZfv1	Felsic metavolcanic rock	Uwharrie		
FBL027	Ch729-A	felsic aphanite/mudstone	CZmd	Metamudstone and meta-argillite			
FBL028	Ch729-B	laminated metamudstone	CZmd	Metamudstone and meta-argillite			
FBL029	Ch729-C	laminated metamudstone	CZmd	Metamudstone and meta-argillite			
FBL030	Ch729-D	felsic metasandstone	CZmd	Metamudstone and meta-argillite			
FBL031	Ch741-A	purple spherulitic felsite	CZiv [near CZfv]	Intermediate metavolcanic rock			
FBL032	Ch741-B	purple felsic breccia	CZiv [near CZfv]	Intermediate metavolcanic rock			
FBL033	Ch741-C	dark gray aphanite	CZiv [near CZfv]	Intermediate metavolcanic rock			
FBL034	Ch741-E	dark purple/black breccia	CZiv [near CZfv]	Intermediate metavolcanic rock			
FBL035	ChRR-F	dark gray lam metamudstone	CZmd	Metamudstone and meta-argillite			
FBL036	ChRR-R	plag±qtz phyric dacite	CZmd	Metamudstone and meta-argillite			
FBL037	ChRR-T	fine green felsic tuff	CZmd	Metamudstone and meta-argillite			
FBL038	Ch427	v fine metasandst/siltstone	CZmd	Metamudstone and meta-argillite			
FBL039	400-1	white musc+gar aplite	Kc	Cape Fear Formation	Cape Fear		
FBL040	400-2	dk green metass/hornfels	Kc	Cape Fear Formation	Cape Fear		
FBL041	400-3	greenstone or metasandstone	Kc	Cape Fear Formation	Cape Fear		
FBL042	424-1	v fine greenstone (?)	Kc	Cape Fear Formation	Cape Fear		
FBL043	PCQ-A	green metamudstone (?)	CZfv	Felsic metavolcanic rock			
FBL044	PCQ-B	aphyric dark gray felsite	CZfv	Felsic metavolcanic rock			
FBL045	PCQ-C	green felsite	CZfv	Felsic metavolcanic rock			

Table 1. Descriptions of rock specimens from Fort Bragg, North Carolina.

anid	Sample ID	Sample Description	SGM Code	SGM Description	Formation	Artifact Type	Period
FBL046	PCQ-D	metamudstone/metasiltstone	CZfv	Felsic metavolcanic rock			
FBL047	DUR-A	dk green fragmental rock	CZfv	Felsic metavolcanic rock			
FBL048	DUR-B	dk gray aphyric felsite	CZfv	Felsic metavolcanic rock			
FBL049	QNWD-C	gray aphyric felsite	CZfv	Felsic metavolcanic rock			
FBL050	QNWD-D	pale green felsite	CZfv	Felsic metavolcanic rock			
FBL051	Mg222	plag-phyric rhyolite	CZfv1	Felsic metavolcanic rock	Uwharrie		
FBL052	Mg222b	plag-phyric rhyolite	CZfv1	Felsic metavolcanic rock	Uwharrie	quarry flake	unknown
FBL053	HFLK-1	qtz-plag phyric rhyolite	CZfv1	Felsic metavolcanic rock	Uwharrie		
FBL054	HFLK-2	plag-phyric rhyolite	CZfv1	Felsic metavolcanic rock	Uwharrie		
FBL055	Rd852	fine fl-banded plag-phyric metadacite	CZfv1	Felsic metavolcanic rock	Uwharrie		
FBL056	Ch729-5	metamudstone/metasiltstone	CZmd	Metamudstone and meta-argillite			
FBL057	Ch729-6	metamudstone/metasiltstone	CZmd	Metamudstone and meta-argillite			
FBL058	Ch741-5	volcanic breccia	CZiv	Intermediate metavolcanic rock			
FBL059	Ch741-6	volcanic breccia	CZiv [near CZfv]	Intermediate metavolcanic rock			
FBL060	ORNG-1	plag-qtz phyric rhyolite	CZfv	Felsic metavolcanic rock			
FBL061	ORNG-2	plag-qtz phyric rhyolite	CZfv	Felsic metavolcanic rock			
FBL062	ORNG-3	plag-qtz phyric rhyolite	CZfv	Felsic metavolcanic rock			
FBL063	ORNG-4	plag-qtz phyric rhyolite	PzZg [near CZfv]	Metamorphosed gabbro and diorite			
FBL064	ORNG-5	plag-qtz phyric rhyolite	PzZg [near CZfv]	Metamorphosed gabbro and diorite			
FBL065	ORNG-6	plag-qtz phyric rhyolite	PzZg [near CZfv]	Metamorphosed gabbro and diorite			
FBL066	DUR-5	volc metasandstone	CZfv	Felsic metavolcanic rock			
FBL067	DUR-6	volc metasandstone	CZfv	Felsic metavolcanic rock			
FBL068	PCQ-5	v fine aphyric felsic volc	CZfv	Felsic metavolcanic rock			
FBL069	PCQ-6	fine metasandstone	CZfv	Felsic metavolcanic rock			
FBL070	402	meta-andesite/greenstone	Kc	Cape Fear Formation	Cape Fear		
FBL071	424-4	metagabbro/greenstone	Kc	Cape Fear Formation	Cape Fear		
FBL072	31Hk100	v fine plag-phyric felsic metavolc				Savannah River point	Late Archaic
FBL073	31Hk148	qtz-plag phyric metavolcanic				Savannah River point	Late Archaic
FBL074	31Hk173	qtz-plag phyric metavolcanic				Savannah River point	Late Archaic
FBL075	31Hk182	meta-andesite				Savannah River point	Late Archaic
FBL076	31Hk224	aphyric felsic metavolcanic				Savannah River point	Late Archaic
FBL077	31Hk737	metasiltstone/metasandstone				Savannah River point	Late Archaic
FBL078	31Hk999	qtz-plag phyric fl-banded metadacite				Savannah River point	Late Archaic
FBL079	31Hk1408	xtal-poor plag-phyric tuff				Savannah River point	Late Archaic
FBL080	Flat Creek	xtal-poor plag-phyric tuff				Savannah River point	Late Archaic

Table 2. Element concentrations in ppm measured by INAA for metavolcanic rocks from the vicinity of Ft. Bragg, North Carolina

anid	As (ppm)	La (ppm)	Lu (ppm)	Nd (ppm)	Sm (ppm)	U (ppm)	Yb (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)
FBL001	0.00	34.2	0.915	29.9	8.00	2.74	6.15	68.6	0.482	0.00	0.673
FBL002	0.00	29.5	1.077	28.1	7.66	2.94	7.10	63.3	0.283	0.00	0.559
FBL003	0.00	36.5	1.216	29.9	9.44	1.91	8.38	75.9	0.570	0.00	0.633
FBL004	1.44	20.8	0.887	20.7	6.23	2.57	6.03	46.4	0.307	0.00	1.275
FBL005	18.47	33.9	1.149	35.8	9.54	1.94	7.93	74.9	0.334	0.77	0.989
FBL006	0.00	30.8	1.161	27.3	8.17	2.97	7.56	65.7	0.348	0.00	0.369
FBL007	0.00	27.5	0.800	21.2	6.37	1.69	5.25	47.9	0.377	0.00	0.773
FBL008	1.56	26.4	1.038	29.7	8.04	2.59	7.19	59.5	0.544	0.00	1.054
FBL009	0.00	24.9	0.970	23.8	7.58	2.22	6.61	55.7	0.571	0.00	2.139
FBL010	0.77	23.9	1.071	19.6	7.42	2.54	6.97	54.0	0.626	0.00	0.730
FBL011	0.00	26.1	1.029	22.8	7.73	2.39	7.01	57.8	0.811	0.00	0.883
FBL012	1.94	27.5	1.069	26.3	8.24	2.36	7.16	61.0	0.733	0.00	0.807
FBL013	0.00	22.8	0.965	24.4	6.43	1.67	6.14	51.3	0.644	0.00	0.489
FBL014	0.00	24.1	0.779	24.5	6.86	1.84	5.29	52.2	0.575	0.00	1.587
FBL015	0.00	28.3	0.804	21.9	6.39	3.32	5.60	60.6	0.299	0.00	0.508
FBL016	0.00	26.1	0.928	23.3	6.58	3.87	6.22	56.0	0.314	0.00	0.656
FBL017	0.00	27.6	0.861	23.2	6.67	3.08	6.22	59.8	0.377	0.00	0.594
FBL018	0.00	25.8	0.894	25.9	6.01	2.86	5.89	54.6	0.345	0.00	0.555
FBL019	0.00	26.6	0.833	23.7	6.71	2.26	5.62	57.4	0.256	0.00	0.474
FBL020	0.00	18.5	0.473	15.7	4.32	1.04	3.16	37.9	3.372	5.48	2.859
FBL021	6.54	17.6	0.711	16.7	5.05	0.83	4.61	37.7	0.426	0.00	0.589
FBL022	2.36	19.6	0.733	21.9	5.63	0.83	4.79	42.5	0.571	0.00	0.384
FBL023	0.00	16.3	0.557	17.2	4.21	1.06	3.63	33.0	0.574	0.00	0.145
FBL024	0.00	17.7	0.530	18.6	5.10	1.39	3.47	39.0	1.826	0.00	0.669
FBL025	0.00	28.2	0.636	19.0	5.58	2.27	4.27	59.0	0.362	0.65	0.933
FBL026	0.00	28.0	0.613	25.1	5.47	1.30	4.29	58.0	0.413	0.00	1.381
FBL027	15.27	16.5	0.586	22.5	6.55	2.78	4.22	55.6	0.780	2.56	2.394
FBL028	0.00	44.0	0.528	46.3	9.00	3.98	4.06	92.9	2.105	3.90	4.750
FBL029	0.00	35.4	0.557	38.7	7.32	2.46	4.31	76.6	2.933	11.46	2.404
FBL030	0.00	100.6	0.794	89.2	17.67	2.64	6.25	148.0	2.735	6.09	1.705
FBL031	3.94	55.3	1.172	65.1	12.37	4.35	7.95	124.3	0.551	1.85	0.593
FBL032	2.69	53.0	1.135	59.0	12.43	3.83	8.10	123.1	0.381	1.87	0.372
FBL033	0.00	60.5	1.217	64.9	12.97	4.34	8.31	130.8	0.333	1.00	0.352
FBL034	0.00	56.6	1.191	63.5	13.93	3.80	8.11	124.6	0.452	1.88	0.372
FBL035	5.61	20.9	0.380	18.4	5.34	1.53	2.78	46.5	9.781	21.43	1.663
FBL036	2.67	24.7	0.394	18.1	4.76	4.38	2.88	51.7	4.205	2.82	0.541
FBL037	14.13	32.8	0.485	35.9	6.82	2.65	3.15	67.8	13.137	19.73	1.699
FBL038	11.28	17.6	0.234	19.0	4.28	0.00	1.42	33.5	22.908	5.28	3.683
FBL039	0.00	12.8	0.695	16.2	4.23	1.47	4.93	33.9	0.283	0.00	0.220
FBL040	0.00	10.4	0.357	13.5	5.44	0.00	2.60	25.3	24.188	0.00	0.430

Table 2. Element concentrations in ppm measured by INAA for metavolcanic rocks from the vicinity of Ft. Bragg, North Carolina

anid	As (ppm)	La (ppm)	Lu (ppm)	Nd (ppm)	Sm (ppm)	U (ppm)	Yb (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)
FBL041	0.00	10.3	0.290	14.6	4.40	0.00	1.88	25.5	9.059	0.00	0.711
FBL042	10.84	7.2	0.273	7.4	2.68	0.00	1.86	14.9	28.417	113.54	1.455
FBL043	10.09	38.1	0.495	28.0	6.68	4.57	3.08	69.8	4.056	0.00	0.928
FBL044	0.00	23.8	0.680	34.7	8.30	2.17	4.36	61.0	2.238	2.27	0.748
FBL045	13.92	28.2	0.405	26.9	5.43	3.91	2.68	57.0	3.559	0.00	0.882
FBL046	6.18	19.5	0.306	20.7	4.15	1.81	1.89	40.1	7.905	5.75	0.283
FBL047	0.00	19.3	0.389	14.5	4.05	0.00	2.58	41.8	3.386	2.21	0.334
FBL048	3.16	26.1	0.501	29.9	5.64	1.21	3.25	57.2	6.411	3.37	0.000
FBL049	0.00	26.4	0.438	28.5	5.32	1.43	3.04	57.1	3.228	2.05	0.312
FBL050	2.74	26.0	0.464	38.0	5.34	1.59	3.04	56.0	3.032	2.54	0.192
FBL051	0.00	22.5	0.467	19.5	3.83	2.27	3.03	44.7	0.314	0.73	0.827
FBL052	0.00	19.2	0.343	17.4	2.97	1.44	2.26	37.0	0.176	0.00	0.766
FBL053	0.00	24.2	0.502	21.6	4.16	2.06	3.23	48.3	0.380	0.00	0.714
FBL054	0.55	21.3	0.447	21.4	3.87	1.80	3.03	42.3	0.398	0.00	0.804
FBL055	0.00	17.3	0.381	23.7	4.23	1.11	2.69	36.9	1.845	0.00	0.571
FBL056	1.75	18.9	0.492	20.3	4.16	3.14	2.96	41.3	2.589	3.74	2.462
FBL057	0.00	45.6	1.206	47.3	8.67	3.82	8.32	92.5	2.398	2.67	1.084
FBL058	6.28	57.9	1.151	73.0	12.83	3.56	8.16	129.7	0.860	1.24	0.376
FBL059	1.97	48.8	1.046	114.4	11.85	4.81	7.34	112.4	1.630	2.66	0.604
FBL060	2.53	25.5	0.596	28.5	5.97	2.49	4.02	58.4	0.683	4.38	0.766
FBL061	3.66	26.8	0.657	31.7	6.12	2.88	4.31	58.4	0.917	1.74	0.862
FBL062	3.58	26.5	0.601	33.8	6.10	2.71	4.26	56.1	0.836	6.43	0.729
FBL063	3.56	28.4	0.668	33.6	6.44	2.55	4.68	63.0	0.523	35.42	1.142
FBL064	1.79	27.3	0.654	30.6	6.28	3.07	4.44	59.7	0.456	2.82	1.156
FBL065	1.84	31.9	0.790	41.7	7.58	2.64	5.31	71.7	0.602	10.40	1.149
FBL066	0.00	25.2	0.461	27.1	4.81	1.58	2.99	54.3	3.642	3.07	0.159
FBL067	9.17	22.8	0.424	27.8	5.17	1.15	2.80	48.2	10.474	12.86	0.345
FBL068	3.66	30.2	0.707	47.0	6.89	2.11	4.52	69.6	1.598	2.64	0.322
FBL069	13.86	17.2	0.448	23.9	4.76	4.37	2.53	44.1	21.915	204.81	1.997
FBL070	0.00	7.5	0.123	17.1	2.53	0.00	0.96	18.0	35.801	42.69	0.526
FBL071	2.49	6.5	0.203	10.1	2.37	0.00	1.34	14.2	26.717	64.96	0.757
FBL072	0.00	26.2	0.891	31.4	6.98	1.53	6.25	56.5	0.169	0.91	0.389
FBL073	0.00	26.9	0.905	40.8	9.30	1.92	6.07	55.1	0.064	3.32	0.480
FBL074	0.00	28.2	0.569	30.6	5.77	2.93	3.80	59.4	0.364	3.58	0.858
FBL075	0.00	14.8	0.448	31.1	5.15	0.00	2.89	34.8	4.703	2.32	0.619
FBL076	0.00	24.1	0.613	20.9	5.12	1.76	4.24	51.1	0.948	2.56	0.501
FBL077	0.00	21.8	0.535	21.8	4.70	2.16	3.65	45.4	0.487	1.27	0.334
FBL078	1.94	25.2	0.585	26.9	5.48	2.63	4.10	54.4	1.454	2.13	1.396
FBL079	0.00	23.6	0.724	27.3	5.93	2.10	4.63	51.2	0.454	5.08	0.749
FBL080	0.00	24.5	0.842	30.9	6.69	1.39	5.74	53.6	0.087	0.00	0.467

Table 2. Element concentrations in ppm measured by INAA for metavolcanic rocks from the vicinity of Ft. Bragg, North Carolina

anid	Eu (ppm)	Fe (ppm)	Hf (ppm)	Ni (ppm)	Rb (ppm)	Sb (ppm)	Sc (ppm)	Sr (ppm)	Ta (ppm)	Tb (ppm)	Th (ppm)
FBL001	1.105	10566	5.95	0.00	86.8	0.132	5.06	65.7	0.668	1.246	9.43
FBL002	1.034	8614	6.07	0.00	86.4	0.065	5.27	0.0	0.675	1.273	9.72
FBL003	1.236	12241	6.27	0.00	117.9	0.071	5.71	44.7	0.680	1.655	9.91
FBL004	0.820	8607	6.56	0.00	68.8	0.080	4.25	0.0	0.704	1.119	10.36
FBL005	0.659	8146	5.63	0.00	68.2	0.187	5.22	0.0	0.681	1.531	11.81
FBL006	0.977	10076	6.19	0.00	58.0	0.076	5.36	71.5	0.672	1.367	9.84
FBL007	0.777	7567	5.98	0.00	100.5	0.058	3.99	38.0	0.629	0.945	9.35
FBL008	1.188	12697	7.03	0.00	79.7	0.528	7.86	0.0	0.544	1.494	8.79
FBL009	1.149	13058	6.51	0.00	92.6	0.657	7.44	75.3	0.557	1.312	8.43
FBL010	0.997	12273	6.63	0.00	58.0	0.156	6.30	0.0	0.542	1.376	8.60
FBL011	0.989	12664	7.01	0.00	82.8	0.136	7.42	67.0	0.607	1.307	9.66
FBL012	1.130	13598	7.33	0.00	71.4	0.192	8.01	0.0	0.642	1.402	10.08
FBL013	0.970	13255	6.81	22.76	33.7	0.119	7.29	0.0	0.552	1.253	8.52
FBL014	1.559	15659	5.76	0.00	91.2	0.186	10.75	136.0	0.476	1.066	6.86
FBL015	0.823	9632	5.59	0.00	65.8	0.135	6.67	57.2	0.690	1.042	11.36
FBL016	0.782	9873	5.18	0.00	125.6	0.095	6.14	36.5	0.641	1.103	10.53
FBL017	0.825	9023	5.47	0.00	87.3	0.166	6.75	40.0	0.685	1.121	11.07
FBL018	0.727	9459	5.04	0.00	93.8	0.127	6.05	53.6	0.638	1.043	10.26
FBL019	0.807	9760	5.24	0.00	67.5	0.120	6.46	51.6	0.651	1.090	10.67
FBL020	0.855	16609	4.00	0.00	59.2	0.212	9.66	213.7	0.349	0.732	4.96
FBL021	1.115	8288	4.94	0.00	53.4	0.143	5.83	176.8	0.176	0.837	3.94
FBL022	1.170	9823	4.73	0.00	37.9	0.030	4.25	167.4	0.222	0.849	3.92
FBL023	0.855	11136	3.80	0.00	25.1	0.090	6.70	89.2	0.231	0.620	3.83
FBL024	0.974	15647	4.11	0.00	14.0	0.272	10.45	196.7	0.314	0.781	4.46
FBL025	0.685	6959	3.70	0.00	94.8	0.159	4.18	25.4	0.645	0.804	8.99
FBL026	0.728	7783	3.82	0.00	93.8	0.311	4.24	38.3	0.618	0.757	9.12
FBL027	1.185	7240	4.02	0.00	142.1	0.900	5.26	72.8	0.832	0.946	11.65
FBL028	1.637	15541	5.81	0.00	342.0	0.235	7.80	105.1	1.196	1.171	16.12
FBL029	1.383	14319	4.65	0.00	161.6	0.278	8.47	346.2	0.870	0.965	12.00
FBL030	3.216	14813	6.51	0.00	60.4	0.260	8.01	405.1	1.046	2.374	15.12
FBL031	0.495	20571	14.47	0.00	125.5	0.549	2.27	75.0	1.320	1.858	12.85
FBL032	0.370	19301	14.35	0.00	86.5	0.546	1.49	116.1	1.275	1.732	12.33
FBL033	0.379	19342	15.00	0.00	115.6	0.221	1.23	71.2	1.360	1.874	13.16
FBL034	0.481	18815	14.34	0.00	111.2	0.634	2.02	82.8	1.329	1.897	12.81
FBL035	1.231	39870	4.75	0.00	59.2	0.211	14.02	188.2	0.417	0.660	5.73
FBL036	0.769	21699	7.00	0.00	37.7	0.311	7.51	56.3	0.436	0.542	7.73
FBL037	1.350	39828	5.13	0.00	114.0	0.407	14.66	495.0	0.431	0.750	6.76
FBL038	1.118	58740	2.46	0.00	68.3	0.192	19.34	251.7	0.164	0.499	1.56
FBL039	0.482	3876	6.80	0.00	88.8	0.159	4.60	64.9	0.683	0.759	10.17
FBL040	1.754	86274	2.10	0.00	0.0	0.085	34.94	409.4	0.000	0.938	0.42

Table 2. Element concentrations in ppm measured by INAA for metavolcanic rocks from the vicinity of Ft. Bragg, North Carolina

anid	Eu (ppm)	Fe (ppm)	Hf (ppm)	Ni (ppm)	Rb (ppm)	Sb (ppm)	Sc (ppm)	Sr (ppm)	Ta (ppm)	Tb (ppm)	Th (ppm)
FBL041	1.297	55005	1.73	0.00	34.3	0.136	9.55	340.5	0.077	0.500	0.44
FBL042	0.856	71010	1.60	0.00	33.2	1.455	34.18	365.1	0.000	0.597	0.38
FBL043	1.552	29253	6.01	0.00	20.0	0.460	9.99	682.0	0.395	0.740	9.22
FBL044	1.718	16551	5.85	0.00	21.8	0.319	8.03	189.2	0.491	1.070	5.73
FBL045	1.174	24916	5.24	0.00	27.9	0.448	8.72	669.9	0.301	0.605	8.02
FBL046	0.946	29026	3.67	0.00	12.6	0.452	9.73	316.2	0.230	0.569	4.56
FBL047	0.838	17432	4.89	21.22	11.7	0.266	5.93	238.4	0.301	0.476	2.71
FBL048	1.186	22284	6.23	0.00	0.0	0.528	8.36	443.2	0.344	0.666	3.42
FBL049	1.053	18595	6.33	0.00	14.4	0.173	7.00	296.1	0.356	0.583	3.47
FBL050	1.034	17739	5.83	0.00	9.2	0.395	6.95	448.8	0.319	0.602	3.25
FBL051	0.599	6808	3.55	0.00	90.9	0.109	3.85	41.2	0.499	0.672	7.56
FBL052	0.456	4486	2.71	0.00	69.5	0.173	3.08	39.7	0.394	0.522	5.54
FBL053	0.741	7596	3.98	0.00	88.7	0.155	4.38	30.6	0.586	0.724	8.40
FBL054	0.605	7339	3.71	0.00	98.5	0.108	4.03	43.6	0.511	0.748	7.81
FBL055	1.005	10273	3.31	0.00	37.9	0.121	9.30	74.1	0.320	0.689	4.07
FBL056	0.726	8292	3.74	0.00	200.4	0.206	7.23	55.7	0.586	0.598	7.14
FBL057	1.444	8760	5.54	0.00	92.3	0.125	6.67	83.9	1.108	1.392	14.48
FBL058	0.409	17963	15.30	0.00	105.4	0.622	1.43	98.9	1.441	2.121	13.36
FBL059	0.446	18053	14.08	0.00	151.0	0.366	1.79	119.0	1.329	1.983	12.18
FBL060	0.554	8236	4.99	0.00	84.1	0.265	4.81	74.5	0.631	1.024	7.34
FBL061	0.626	9315	5.13	0.00	89.4	0.385	5.59	71.1	0.632	1.086	7.39
FBL062	0.596	8333	4.93	0.00	83.1	0.294	5.08	77.7	0.622	0.999	7.40
FBL063	0.536	7721	5.00	0.00	87.7	0.208	5.09	50.3	0.654	1.114	7.70
FBL064	0.531	8252	5.05	0.00	89.2	0.408	5.32	27.9	0.642	1.087	7.69
FBL065	0.651	8734	5.19	0.00	81.7	0.284	5.98	72.6	0.690	1.286	8.18
FBL066	1.014	18253	6.29	0.00	5.2	0.216	7.55	199.7	0.370	0.646	3.46
FBL067	1.491	33733	4.55	0.00	14.5	0.411	13.23	304.1	0.260	0.712	2.36
FBL068	1.478	10444	6.58	0.00	6.8	0.326	5.92	199.7	0.627	1.038	6.54
FBL069	1.280	71816	3.56	79.67	48.5	0.657	34.80	187.5	0.448	0.714	3.88
FBL070	0.983	76532	1.27	0.00	10.4	0.139	26.10	821.4	0.000	0.231	1.17
FBL071	0.927	72599	0.93	0.00	17.4	0.169	29.88	519.4	0.000	0.395	0.20
FBL072	1.339	13005	6.55	0.00	52.8	0.132	8.56	82.7	0.574	1.425	6.76
FBL073	2.160	7083	7.63	0.00	41.8	0.196	8.60	189.8	0.366	1.702	5.59
FBL074	1.083	11402	6.12	0.00	100.6	0.324	8.42	102.6	0.779	0.911	9.18
FBL075	1.592	37429	3.77	0.00	35.8	0.109	17.61	410.2	0.219	0.808	2.33
FBL076	1.048	12233	5.49	0.00	42.7	0.165	7.77	108.9	0.597	0.887	7.65
FBL077	0.874	8658	5.04	0.00	31.6	0.079	6.78	59.6	0.571	0.841	7.28
FBL078	1.154	16125	7.84	0.00	59.9	0.358	8.76	104.7	0.750	0.943	8.98
FBL079	1.456	14377	6.10	0.00	113.8	0.348	9.71	187.8	0.623	1.233	7.22
FBL080	1.179	10949	6.18	0.00	57.0	0.172	8.04	141.2	0.557	1.379	6.36

Table 2. Element concentrations in ppm measured by INAA for metavolcanic rocks from the vicinity of Ft. Bragg, North Carolina

anid	Zn (ppm)	Zr (ppm)	Al (ppm)	Ba (ppm)	Ca (ppm)	Dy (ppm)	K (ppm)	Mn (ppm)	Na (ppm)	Ti (ppm)	V (ppm)
FBL001	33.6	136.6	59100	489	6549	7.15	24508	457	25157	512	0.0
FBL002	47.5	135.4	59308	525	2932	7.65	24150	261	28468	525	0.0
FBL003	68.5	123.2	55545	678	3104	9.53	27509	520	22641	0	0.0
FBL004	10.6	121.6	57835	423	1550	6.65	16164	231	31515	840	0.0
FBL005	47.8	116.7	56623	539	1759	9.32	21535	121	28626	697	0.0
FBL006	47.3	130.1	56734	494	2583	7.94	17156	391	29613	388	0.0
FBL007	32.4	132.2	57026	597	1611	5.21	30127	231	22069	250	0.0
FBL008	53.3	164.6	52836	407	4680	8.01	20215	267	24118	963	0.0
FBL009	53.0	146.5	53169	400	3246	7.91	24900	383	22277	611	0.0
FBL010	55.9	152.8	50935	401	2992	7.84	15226	375	25496	621	0.0
FBL011	29.8	171.1	53158	431	3952	7.77	23540	276	26848	742	0.0
FBL012	25.9	165.8	58339	445	4210	8.37	18128	257	29628	811	0.0
FBL013	28.3	144.3	49152	160	1155	7.04	10094	361	30491	543	0.0
FBL014	68.4	140.7	57970	434	6927	5.65	20241	598	25771	1628	0.0
FBL015	29.7	123.2	58537	539	2195	6.07	19271	366	27518	405	0.0
FBL016	44.9	109.0	54460	577	1490	6.64	26182	419	24297	488	0.0
FBL017	39.4	109.2	57168	618	3905	6.61	23203	342	26253	227	0.0
FBL018	32.2	94.6	56790	489	4165	6.15	22677	319	26344	604	0.0
FBL019	41.3	130.0	52519	410	2801	5.89	17043	391	27528	362	0.0
FBL020	44.7	103.3	60464	365	14304	3.53	14289	508	18753	1564	16.1
FBL021	38.7	116.0	52405	452	4946	4.11	17888	549	25923	1068	0.0
FBL022	29.1	148.9	50454	346	7386	4.12	13015	669	26230	821	0.0
FBL023	17.0	87.9	54050	363	8840	4.16	12607	657	28949	812	0.0
FBL024	56.8	102.9	62021	184	15773	4.30	7032	717	31059	1051	15.3
FBL025	22.1	99.3	62386	770	1806	5.23	33986	290	28354	465	0.0
FBL026	44.3	83.7	65645	671	3486	5.43	31839	322	29353	0	0.0
FBL027	27.5	111.1	51989	914	3689	6.52	37353	168	12784	585	7.8
FBL028	61.9	133.7	70548	2227	4989	7.15	71471	770	5014	1690	18.7
FBL029	62.3	143.5	56465	655	5369	6.05	38205	795	14478	1307	29.4
FBL030	57.6	201.7	66402	353	12323	13.31	11410	768	31596	699	21.7
FBL031	60.4	361.8	57578	0	3071	11.39	35505	412	24096	1131	0.0
FBL032	37.7	334.0	63252	60	5624	11.19	26501	399	31046	0	0.0
FBL033	89.4	356.9	59389	0	1845	11.65	32870	279	29276	874	0.0
FBL034	64.9	336.4	63136	0	4927	12.10	32981	544	29146	879	6.1
FBL035	92.8	132.7	83851	1131	13888	4.02	25179	1014	22975	3238	89.0
FBL036	42.0	182.7	75278	828	4024	2.80	28334	334	38000	1971	26.5
FBL037	71.2	112.3	74748	1279	35134	4.59	35925	873	8300	3582	101.2
FBL038	86.7	73.3	87090	1328	13871	2.38	31143	1341	35286	3463	179.2
FBL039	19.1	134.5	63978	320	0	6.10	37453	40	27030	727	0.0
FBL040	146.8	0.0	82900	256	48585	4.25	818	1776	25652	7918	243.7

Table 2. Element concentrations in ppm measured by INAA for metavolcanic rocks from the vicinity of Ft. Bragg, North Carolina

anid	Zn (ppm)	Zr (ppm)	Al (ppm)	Ba (ppm)	Ca (ppm)	Dy (ppm)	K (ppm)	Mn (ppm)	Na (ppm)	Ti (ppm)	V (ppm)
FBL041	75.4	28.4	94277	273	10340	2.47	11139	1274	44556	3477	24.6
FBL042	91.0	0.0	89104	280	58865	2.36	12309	1922	23959	3661	259.6
FBL043	81.3	169.5	83047	515	16354	4.18	9596	749	43278	2716	27.4
FBL044	73.6	156.9	64209	110	2480	6.50	5211	566	38521	1367	20.6
FBL045	55.5	145.4	73416	592	8826	3.21	8887	651	39301	2141	0.0
FBL046	65.5	91.8	51954	305	8433	2.53	9222	599	26434	2498	65.3
FBL047	48.1	143.0	66960	520	8315	2.79	11351	730	36839	1225	21.4
FBL048	56.7	142.7	78294	0	13242	3.67	0	638	49802	2042	27.8
FBL049	48.6	166.1	75135	403	9211	3.78	9174	653	41342	1735	16.1
FBL050	35.9	144.9	72955	282	18885	3.45	5310	697	40445	2055	21.8
FBL051	31.9	66.9	53794	552	1172	3.91	28770	214	24816	653	0.0
FBL052	32.1	62.5	38510	427	936	3.13	22129	208	14578	563	0.0
FBL053	35.7	91.7	63095	645	0	4.29	32483	259	27398	0	0.0
FBL054	36.1	82.5	50377	651	886	3.85	34205	231	17440	1153	0.0
FBL055	54.4	98.2	64480	329	5957	3.79	16361	528	33681	1090	0.0
FBL056	54.6	87.3	48259	832	2631	3.28	50612	296	4461	1688	17.7
FBL057	32.4	143.7	70645	713	3767	8.31	31451	430	32691	395	0.0
FBL058	96.3	360.9	61579	0	4179	11.52	36008	461	27084	770	0.0
FBL059	113.5	330.8	62459	0	5471	11.60	47395	380	19168	1228	17.0
FBL060	38.8	102.4	65927	696	4689	5.65	26954	315	29242	0	0.0
FBL061	38.7	109.2	66979	575	5697	6.18	29384	308	28648	857	0.0
FBL062	30.4	100.6	66395	666	5187	5.63	29862	254	28313	545	0.0
FBL063	21.1	96.2	60983	703	4469	7.08	31500	155	27046	871	0.0
FBL064	38.4	100.1	61265	725	5009	6.54	33868	332	22503	753	0.0
FBL065	33.0	113.2	67536	800	4124	7.17	32105	213	29063	0	0.0
FBL066	61.4	146.8	73194	109	7413	3.29	5006	689	47941	1553	20.5
FBL067	74.3	97.9	88249	255	26574	3.76	7980	1090	40746	3762	85.9
FBL068	39.7	167.3	57826	68	6300	6.03	2287	294	37734	1292	21.7
FBL069	266.4	102.0	67095	611	6374	3.39	25529	473	34699	2261	25.3
FBL070	98.4	0.0	96748	0	66052	1.07	2287	1776	16410	5064	289.2
FBL071	92.5	0.0	97330	174	70819	1.83	7767	1192	15144	4543	284.8
FBL072	34.4	162.8	63172	418	2782	8.04	13349	616	35648	403	0.0
FBL073	26.2	181.9	67261	529	7818	9.70	21093	518	34937	1034	0.0
FBL074	43.8	167.8	65232	569	9864	5.34	27843	339	28020	699	0.0
FBL075	98.8	93.5	76656	275	29474	4.05	13916	1329	31086	5166	62.0
FBL076	53.6	128.9	58324	422	0	5.04	17291	685	33849	1138	0.0
FBL077	45.0	115.6	60946	381	850	4.69	16837	309	35927	516	0.0
FBL078	48.7	219.7	67281	385	9685	5.42	20888	488	32147	1492	0.0
FBL079	20.0	157.7	72850	682	11852	5.93	35191	825	26406	868	0.0
FBL080	49.1	138.3	66680	517	14391	7.95	18451	611	28134	0	0.0

Table 3. Element concentrations measured by XRF for metavolcanic rocks from the vicinity of Ft. Bragg, North Carolina.

anid	LOI (%)	Na20 (%)	MgO (%)	Al2O3 (%)	SiO2 (%)	K2O (%)	CaO (%)	TiO2 (%)	MnO (%)	Fe2O3 (%)	Cu (ppm)	Zn (ppm)	Ga (ppm)
FBL001	0.083	5.88	0.000	13.26	74.23	3.484	0.8667	0.1198	0.0693	1.5846	2.8	41.6	16.2
FBL002	0.124	6.38	0.000	12.96	75.36	3.321	0.2868	0.1145	0.0350	1.1844	3.1	57.4	14.8
FBL003	0.288	4.95	0.000	13.37	74.59	3.887	0.3954	0.1192	0.0747	1.7775	4.8	69.7	17.3
FBL004	0.034	7.22	0.000	13.29	75.55	2.427	0.2586	0.1098	0.0318	1.2161	1.7	12.1	16.1
FBL005	-0.074	6.57	0.000	12.51	76.20	2.862	0.2204	0.0888	0.0181	1.2047	5.0	50.6	17.6
FBL006	-0.244	7.05	0.000	12.70	75.68	2.234	0.2810	0.1126	0.0567	1.5487	4.2	49.3	16.1
FBL007	0.133	5.05	0.000	11.30	78.18	3.946	0.1672	0.1142	0.0305	1.0263	2.1	40.8	9.9
FBL008	0.209	5.52	0.183	11.47	77.70	2.664	0.5864	0.1564	0.0356	1.7471	5.7	61.3	14.3
FBL009	0.310	5.21	0.241	11.66	76.93	3.279	0.4434	0.1578	0.0517	1.8468	5.2	57.1	14.0
FBL010	0.291	5.88	0.392	11.37	77.44	2.190	0.3062	0.1526	0.0515	1.8007	7.9	70.3	12.0
FBL011	0.332	5.81	0.171	13.06	75.04	2.985	0.4302	0.1631	0.0367	1.8685	6.0	27.7	15.7
FBL012	0.484	6.96	0.277	13.06	73.68	2.604	0.4904	0.1780	0.0370	1.9382	5.3	27.9	17.5
FBL013	0.295	7.61	0.223	11.38	76.91	1.442	0.1865	0.1474	0.0526	1.8732	0.0	31.5	14.3
FBL014	0.341	5.74	0.383	15.14	71.42	3.191	1.0300	0.2335	0.0962	2.3953	5.2	75.8	18.9
FBL015	0.508	6.62	0.097	12.43	75.82	2.673	0.3572	0.1178	0.0497	1.2768	4.5	29.2	12.3
FBL016	-0.124	5.79	0.226	13.43	74.88	3.926	0.2351	0.1007	0.0625	1.4276	4.9	42.3	16.1
FBL017	0.295	5.89	0.000	12.90	75.89	3.169	0.3699	0.1089	0.0539	1.3827	4.2	44.4	13.2
FBL018	0.269	6.05	0.000	12.73	75.90	3.176	0.4632	0.1040	0.0442	1.4605	4.8	34.5	14.5
FBL019	0.221	6.11	0.000	12.35	76.57	2.421	0.3538	0.1038	0.0617	1.5878	10.9	45.6	16.0
FBL020	0.245	3.50	0.684	14.76	73.33	2.438	1.8233	0.2925	0.0773	2.7422	15.2	57.3	12.9
FBL021	0.303	5.62	0.424	12.73	75.42	2.801	0.8004	0.2317	0.0751	1.3753	3.0	48.2	10.3
FBL022	0.222	4.31	0.268	13.35	75.12	2.615	1.3203	0.2811	0.1240	2.0429	24.4	50.2	21.9
FBL023	0.166	4.92	0.091	11.64	78.60	1.359	1.1540	0.1856	0.0798	1.7190	2.0	20.1	14.0
FBL024	0.184	5.97	0.461	12.00	75.60	0.722	1.9274	0.2168	0.0788	2.3007	2.5	46.8	14.8
FBL025	0.322	4.55	0.000	12.30	76.21	4.387	0.2199	0.1266	0.0402	1.2554	10.0	28.9	12.9
FBL026	0.305	5.42	0.000	12.73	75.87	3.836	0.5397	0.1151	0.0454	1.1734	7.1	41.6	11.6
FBL027	0.494	2.49	0.322	10.39	79.67	4.618	0.5354	0.1696	0.0215	1.0791	4.0	33.4	9.1
FBL028	0.483	0.54	0.891	13.84	71.66	8.624	0.6038	0.2890	0.0988	2.2037	4.2	56.9	18.0
FBL029	0.641	2.59	0.804	11.22	76.51	4.617	0.7217	0.2926	0.0984	2.0260	10.7	53.8	14.3
FBL030	0.402	5.81	0.853	13.13	74.00	1.438	1.6343	0.3180	0.0980	2.1754	9.0	37.7	16.6
FBL031	0.204	5.41	0.099	12.02	74.47	4.122	0.3570	0.2009	0.0439	2.6870	4.1	68.2	17.0
FBL032	0.238	6.80	0.061	12.57	73.70	3.181	0.6985	0.1681	0.0439	2.4577	2.5	40.2	19.0
FBL033	0.232	6.06	0.091	12.41	73.81	3.946	0.3122	0.1639	0.0308	2.4347	3.2	103.5	19.6
FBL034	0.210	5.70	0.117	12.44	74.02	3.808	0.5301	0.1793	0.0646	2.5356	2.0	79.4	16.2
FBL035	1.176	3.75	3.021	16.76	63.85	3.224	1.8767	0.6200	0.1205	5.4675	21.0	67.0	18.3
FBL036	0.300	8.13	0.379	14.44	70.11	3.171	0.5505	0.3241	0.0372	2.7163	14.2	47.5	12.4
FBL037	0.834	1.43	2.499	14.73	65.32	4.531	4.6353	0.6367	0.1045	5.4385	59.2	75.6	18.2
FBL038	1.281	6.28	3.334	17.59	57.36	3.277	1.6458	0.7078	0.1660	8.0967	120.3	91.4	17.8
FBL039	0.229	4.58	0.000	13.95	75.85	4.707	0.0502	0.1526	0.0070	0.5355	4.2	20.4	17.6
FBL040	1.704	4.85	5.054	15.93	52.84	0.556	5.9895	1.3581	0.2080	11.8456	15.3	117.8	19.2
FBL041	1.840	5.69	5.588	20.27	54.50	1.208	1.5661	0.7413	0.1696	8.6345	9.7	99.4	14.3

Table 3. Element concentrations measured by XRF for metavolcanic rocks from the vicinity of Ft. Bragg, North Carolina.

anid	LOI (%)	Na20 (%)	MgO (%)	Al2O3 (%)	SiO2 (%)	K2O (%)	CaO (%)	TiO2 (%)	MnO (%)	Fe2O3 (%)	Cu (ppm)	Zn (ppm)	Ga (ppm)
FBL042	1.444	4.48	7.591	17.59	49.32	1.338	7.3508	0.6803	0.2285	9.4170	196.2	86.4	15.5
FBL043	0.787	9.07	1.949	16.11	64.53	1.005	2.0666	0.5892	0.0913	3.8764	5.3	72.2	15.9
FBL044	0.713	7.59	0.878	12.32	75.02	0.560	0.3180	0.2846	0.0657	2.2337	5.2	66.3	14.6
FBL045	0.856	7.79	1.278	14.81	68.78	1.097	1.2377	0.5258	0.0763	3.3633	4.3	63.6	10.6
FBL046	0.654	5.20	1.451	10.08	75.67	1.038	1.1717	0.4712	0.0715	3.8333	20.3	59.2	10.2
FBL047	0.642	7.18	1.253	12.37	73.45	1.144	0.8967	0.3162	0.0903	2.3509	16.1	51.1	12.3
FBL048	0.595	9.83	1.154	15.20	68.00	0.040	1.6969	0.3737	0.0757	2.9183	15.2	60.9	13.2
FBL049	0.593	8.39	1.080	13.88	70.87	1.194	1.1670	0.3534	0.0766	2.4593	3.3	53.3	10.3
FBL050	0.523	8.40	0.682	13.91	70.49	0.710	2.5056	0.3571	0.0803	2.3322	3.9	39.8	14.3
FBL051	0.312	4.35	0.000	11.19	79.21	3.480	0.1779	0.1117	0.0290	1.1887	4.7	38.1	7.7
FBL052	0.384	2.51	0.051	6.91	86.41	2.737	0.1528	0.0857	0.0296	0.7751	11.2	39.1	6.1
FBL053	0.273	4.57	0.000	12.25	77.40	3.516	0.1980	0.1070	0.0410	1.3318	3.5	36.3	9.1
FBL054	0.361	1.78	0.000	10.93	80.98	3.687	0.1344	0.0974	0.0350	1.5066	6.6	45.7	7.6
FBL055	0.425	6.84	0.409	12.41	75.79	1.813	0.7372	0.2402	0.0578	1.4947	15.4	39.5	8.9
FBL056	0.598	0.44	0.482	10.20	80.14	6.474	0.2812	0.2818	0.0375	1.2684	50.8	52.7	11.9
FBL057	0.494	6.21	0.555	13.31	73.60	3.557	0.4470	0.1990	0.0506	1.2894	5.8	30.4	10.1
FBL058	0.263	5.76	0.129	12.41	74.19	4.029	0.5296	0.1779	0.0563	2.4903	5.2	96.1	20.1
FBL059	0.276	4.07	0.413	13.46	72.70	5.634	0.6688	0.1945	0.0489	2.5977	10.9	114.9	16.2
FBL060	0.273	6.12	0.096	12.83	75.43	3.418	0.6291	0.1240	0.0360	1.1665	3.0	37.2	13.4
FBL061	0.430	6.32	0.178	13.16	74.37	3.424	0.7703	0.1340	0.0368	1.3119	5.3	36.3	14.5
FBL062	0.382	6.18	0.091	13.07	74.79	3.461	0.6557	0.1236	0.0283	1.1689	4.1	25.5	13.9
FBL063	0.282	5.77	0.153	12.51	76.29	3.591	0.4604	0.0981	0.0179	1.0737	2.8	18.4	11.9
FBL064	0.630	4.64	0.188	12.87	75.35	4.032	0.6781	0.1118	0.0413	1.1773	5.2	36.0	13.5
FBL065	0.289	6.15	0.250	13.46	74.00	3.642	0.5630	0.1077	0.0285	1.2442	4.7	29.7	17.2
FBL066	0.484	8.24	0.901	14.80	70.51	0.536	1.1654	0.4154	0.0869	3.0956	34.7	71.8	16.2
FBL067	1.135	6.67	2.497	15.89	63.09	1.226	3.4280	0.6767	0.1290	4.8699	17.2	72.3	16.7
FBL068	0.451	7.96	0.621	11.02	77.36	0.299	0.7528	0.2455	0.0352	1.5539	13.3	36.9	8.1
FBL069	0.480	6.89	0.536	13.33	72.13	2.699	0.7144	0.3803	0.0561	2.4524	9.0	38.2	10.8
FBL070	1.334	2.90	8.083	18.84	47.87	0.367	8.8655	0.9673	0.2086	10.6005	30.9	84.7	20.7
FBL071	1.872	2.71	6.089	18.12	49.69	1.032	8.7490	0.9117	0.1459	10.1513	27.1	74.2	16.9
FBL072	0.428	6.98	0.000	12.42	75.54	1.757	0.5730	0.1345	0.0665	2.0896	5.4	30.6	14.9
FBL073	0.486	7.17	0.216	13.04	73.98	2.309	0.8804	0.2152	0.0690	1.5076	9.8	28.0	23.0
FBL074	0.397	6.76	0.225	12.92	73.40	3.332	1.0884	0.1615	0.0409	1.7036	4.2	43.9	9.5
FBL075	1.089	5.38	2.645	15.59	63.06	1.540	3.8232	0.8575	0.1532	5.4919	4.7	90.4	19.1
FBL076	0.546	7.32	0.394	12.58	74.26	1.973	0.5412	0.2270	0.0858	1.9630	5.7	60.8	11.9
FBL077	0.412	7.29	0.106	12.05	77.01	1.736	0.0742	0.1447	0.0382	1.3417	2.6	43.9	11.3
FBL078	0.226	5.96	0.174	12.89	74.19	2.281	1.2817	0.2884	0.0580	2.5405	0.0	48.1	14.1
FBL079	0.374	5.29	0.451	14.33	71.10	4.125	1.5660	0.2600	0.0985	2.4181	4.5	19.3	16.8
FBL080	0.226	6.72	0.143	12.21	74.16	2.531	1.5529	0.1220	0.0691	1.6950	3.4	34.9	20.6

Table 3. Element concentrations measured by XRF for metavolcanic rocks from the vicinity of Ft. Bragg, North Carolina.

anid	Rb (ppm)	Sr (ppm)	Y (ppm)	Zr (ppm)	Nb (ppm)	Ba (ppm)	Pb (ppm)	Th (ppm)	U (ppm)
FBL001	90.2	53.7	59.1	187.6	9.1	568.8	20.4	8.6	3.2
FBL002	84.3	39.0	58.2	170.1	5.6	529.5	20.3	10.3	3.3
FBL003	120.0	59.9	79.5	187.1	7.4	746.0	17.6	10.9	4.2
FBL004	70.6	31.2	54.4	186.1	8.7	476.6	11.5	12.0	4.4
FBL005	67.8	39.8	69.3	146.6	7.3	486.3	21.3	12.9	3.9
FBL006	61.1	54.6	77.4	193.2	7.4	658.8	18.2	11.2	3.6
FBL007	97.0	45.6	41.3	149.1	6.0	616.0	7.7	10.2	3.7
FBL008	80.8	66.1	69.4	228.7	4.7	388.8	14.3	9.3	2.7
FBL009	86.2	69.8	63.3	200.7	5.5	406.6	11.3	8.2	4.0
FBL010	56.0	36.4	64.3	219.1	4.7	431.2	26.8	8.9	4.7
FBL011	91.0	61.4	71.3	249.1	2.6	529.1	12.1	10.6	2.3
FBL012	70.1	55.2	71.7	216.8	6.9	402.2	15.3	12.8	3.2
FBL013	36.6	18.3	60.8	234.3	3.3	246.6	16.2	11.7	5.8
FBL014	101.0	126.4	58.3	235.2	3.4	647.9	37.5	8.1	2.3
FBL015	60.3	54.5	45.0	140.9	5.6	505.3	10.2	12.0	2.3
FBL016	128.6	37.1	60.8	144.6	5.7	579.1	15.5	10.3	3.6
FBL017	92.8	68.9	61.2	172.8	5.4	729.7	25.7	12.8	4.9
FBL018	100.8	59.9	62.6	157.5	4.5	598.4	14.4	13.2	4.8
FBL019	79.0	64.5	64.8	178.3	5.8	662.3	14.8	14.1	4.2
FBL020	69.3	203.8	37.0	161.1	1.7	564.8	21.0	9.6	3.2
FBL021	57.2	194.3	47.7	213.5	4.5	570.0	10.4	4.5	0.0
FBL022	66.5	295.9	76.8	360.5	9.7	1083.4	19.6	8.0	4.7
FBL023	31.5	128.5	42.3	180.6	4.5	707.6	8.0	3.9	3.3
FBL024	13.8	214.8	34.9	160.7	3.1	268.8	14.9	4.3	1.7
FBL025	120.1	46.5	52.1	152.2	13.3	1163.2	16.2	14.9	7.3
FBL026	107.1	54.2	46.1	133.7	9.2	917.6	25.3	11.4	5.5
FBL027	141.0	64.5	47.5	124.7	10.6	990.3	10.7	14.6	5.1
FBL028	338.4	108.5	44.3	181.0	16.2	2303.1	26.8	17.1	5.7
FBL029	165.6	145.8	44.4	162.5	9.7	738.3	21.9	12.9	3.3
FBL030	71.8	389.5	124.9	300.1	16.3	548.9	26.7	21.3	6.9
FBL031	117.6	66.9	70.5	540.3	18.3	78.0	24.3	13.6	6.3
FBL032	77.5	90.7	68.5	507.5	17.2	45.3	18.1	13.4	5.5
FBL033	103.8	47.6	71.8	538.3	17.7	39.7	21.2	13.1	2.3
FBL034	107.8	85.3	77.2	566.1	16.6	70.9	23.7	13.0	3.9
FBL035	57.1	188.6	24.6	161.0	3.7	875.1	13.2	5.6	0.0
FBL036	35.3	71.1	22.5	222.5	3.7	584.1	13.6	7.2	4.0
FBL037	107.0	399.3	28.7	167.3	2.9	985.0	16.7	7.4	0.0
FBL038	70.8	254.0	15.8	75.4	0.0	1180.9	9.2	1.1	0.0
FBL039	87.8	44.7	44.8	168.2	7.4	301.3	23.9	11.8	2.3
FBL040	8.0	378.2	23.8	60.0	0.0	198.4	5.1	0.0	0.0
FBL041	34.7	371.0	20.2	54.6	0.0	418.9	4.6	0.0	0.0

Table 3. Element concentrations measured by XRF for metavolcanic rocks from the vicinity of Ft. Bragg, North Carolina.

anid	Rb (ppm)	Sr (ppm)	Y (ppm)	Zr (ppm)	Nb (ppm)	Ba (ppm)	Pb (ppm)	Th (ppm)	U (ppm)
FBL042	29.0	324.2	15.5	36.4	0.0	233.2	7.3	0.0	0.0
FBL043	17.2	583.7	31.6	208.7	4.1	438.2	10.5	8.6	5.2
FBL044	14.9	164.4	43.2	195.8	4.8	105.9	16.2	3.9	2.1
FBL045	22.3	565.8	25.9	180.2	3.0	500.1	7.0	6.3	2.3
FBL046	11.8	277.7	18.6	116.2	1.8	286.2	11.0	3.2	3.9
FBL047	9.8	235.7	21.1	159.5	1.2	435.9	13.9	2.4	0.0
FBL048	1.3	383.4	28.7	209.5	2.9	44.2	17.6	2.7	1.8
FBL049	13.1	278.9	27.4	213.6	1.9	374.2	8.7	2.9	2.9
FBL050	7.8	377.9	27.4	197.3	1.7	272.4	10.8	2.6	1.4
FBL051	106.5	71.1	34.2	121.9	5.6	730.4	13.7	10.4	0.0
FBL052	83.7	48.1	32.1	107.8	3.6	618.8	18.3	8.2	6.5
FBL053	111.0	56.3	41.5	159.6	6.7	785.9	13.8	10.7	3.4
FBL054	129.9	65.3	44.4	157.7	4.5	1160.3	23.9	12.5	5.8
FBL055	35.9	92.5	29.0	115.6	2.4	414.5	17.9	3.6	2.3
FBL056	201.1	42.4	25.9	105.8	6.4	676.5	22.2	6.1	4.8
FBL057	89.6	86.7	67.8	152.3	10.9	689.5	4.2	14.6	3.0
FBL058	104.6	75.7	75.2	579.7	15.8	58.9	21.0	14.4	3.3
FBL059	155.0	99.3	68.3	559.8	15.4	111.3	22.8	13.3	3.5
FBL060	80.8	76.7	39.9	126.9	4.8	498.8	11.8	6.3	2.2
FBL061	88.1	82.9	42.1	138.6	8.0	512.7	11.5	7.5	2.2
FBL062	80.5	81.8	38.1	122.0	5.3	521.0	9.8	7.5	3.4
FBL063	86.7	47.5	43.9	118.0	5.3	547.8	10.3	7.4	2.9
FBL064	85.2	41.4	41.5	120.1	5.3	544.6	10.2	6.4	3.0
FBL065	80.4	74.6	51.7	143.5	5.9	605.0	9.4	7.3	2.5
FBL066	7.2	220.6	34.1	278.3	4.2	163.2	8.6	3.1	2.9
FBL067	15.4	304.6	27.3	164.8	3.4	382.6	8.9	2.1	0.0
FBL068	6.9	190.0	42.4	240.8	6.1	140.4	7.6	6.2	2.1
FBL069	39.3	88.1	22.4	167.3	0.0	558.3	18.8	6.4	1.6
FBL070	8.8	633.0	6.5	39.4	0.0	102.5	17.8	0.0	0.0
FBL071	14.1	505.7	10.1	22.8	0.0	155.4	6.1	0.0	0.0
FBL072	69.8	126.8	84.7	264.1	4.0	722.4	11.0	9.6	8.0
FBL073	80.0	311.8	117.4	382.2	0.0	1214.4	18.2	12.8	5.2
FBL074	112.4	113.6	46.3	226.0	7.4	706.0	17.4	10.3	2.0
FBL075	35.1	409.9	35.3	138.5	1.4	506.4	9.8	0.0	0.0
FBL076	54.1	158.6	54.7	239.2	8.0	696.9	19.0	10.5	4.6
FBL077	33.0	65.7	40.7	181.0	4.7	459.6	9.3	7.8	4.4
FBL078	72.4	121.0	49.6	383.1	9.1	578.0	22.2	15.7	3.5
FBL079	151.3	253.1	68.4	302.2	8.0	1048.7	21.6	12.4	0.0
FBL080	66.1	175.4	69.3	227.5	3.6	707.9	12.4	11.3	3.5

Table 4. Element concentrations in ppm measured by ICP-MS for metavolcanic rocks from the vicinity of Ft. Bragg, North Carolina.

anid	La 139	Ce 140	Pr 141	Nd 143	Nd 146	Sm 147	Eu 153	Gd 156	Gd 157	Tb 159	Dy 163	Ho 165	Er 166	Tm 169
FBL001	34.4	66.3	8.31	32.5	32.6	7.72	1.180	8.73	8.39	1.44	9.16	1.96	5.87	0.906
FBL002	33.0	67.7	8.62	33.5	34.0	8.22	1.241	9.99	9.19	1.69	10.90	2.42	7.45	1.239
FBL003	36.4	73.3	9.19	36.3	36.4	9.05	1.277	10.93	10.14	1.83	11.92	2.59	7.91	1.196
FBL004	24.2	52.5	6.62	26.7	26.3	6.96	0.970	8.29	8.07	1.46	9.49	2.06	6.20	0.998
FBL005	35.0	73.5	9.44	38.0	38.0	9.06	0.699	10.45	9.58	1.73	11.05	2.39	7.15	1.094
FBL006	34.4	71.7	9.16	36.1	36.5	9.09	1.164	10.54	9.86	1.84	11.96	2.71	8.31	1.348
FBL007	27.8	46.4	7.39	28.4	28.1	6.30	0.830	6.43	5.95	1.05	6.24	1.46	4.51	0.724
FBL008	27.9	60.5	7.81	32.8	32.2	8.14	1.321	9.74	9.22	1.63	10.83	2.39	7.21	1.138
FBL009	27.6	59.4	7.70	31.5	31.4	8.07	1.281	9.59	9.16	1.66	10.91	2.40	7.36	1.146
FBL010	24.2	53.1	6.90	28.7	28.2	7.25	1.043	8.32	7.91	1.42	9.16	2.09	6.53	1.018
FBL011	29.3	64.0	8.42	33.9	34.1	8.58	1.258	10.31	9.84	1.81	11.74	2.61	7.94	1.261
FBL012	28.8	62.1	8.03	33.0	32.6	8.25	1.182	9.86	9.26	1.68	10.99	2.43	7.36	1.130
FBL013	23.5	52.3	6.87	28.2	28.0	7.15	1.033	7.91	7.88	1.40	9.16	2.01	6.16	0.989
FBL014	25.4	53.4	6.87	28.5	28.3	6.73	1.623	7.60	7.04	1.23	7.46	1.71	5.18	0.798
FBL015	30.0	62.4	7.78	30.2	30.5	7.13	0.896	8.52	7.66	1.36	8.62	1.87	5.72	0.907
FBL016	27.0	55.7	6.81	26.7	26.7	6.40	0.859	7.65	7.06	1.27	8.46	1.90	5.83	0.914
FBL017	29.1	60.3	7.47	29.4	29.1	7.00	0.876	8.05	7.46	1.33	8.81	1.97	5.93	0.930
FBL018	26.9	55.4	6.83	26.8	26.4	6.23	0.790	7.25	7.09	1.24	8.33	1.87	5.73	0.904
FBL019	27.8	57.6	7.08	27.6	27.5	6.65	0.888	7.68	7.07	1.27	8.11	1.80	5.41	0.831
FBL020	19.5	39.6	4.91	19.3	19.3	4.32	0.914	4.74	4.32	0.73	4.62	0.99	2.97	0.453
FBL021	18.9	41.3	5.43	22.7	22.4	5.55	1.328	6.45	5.95	1.09	7.06	1.60	4.91	0.820
FBL022	19.9	42.8	5.57	23.1	23.2	5.28	1.238	6.01	5.59	0.99	5.95	1.41	4.45	0.698
FBL023	15.3	31.1	3.99	16.7	16.3	3.94	0.860	4.41	4.08	0.71	4.60	1.03	3.14	0.486
FBL024	18.9	40.8	5.35	22.3	22.1	5.07	1.094	5.53	5.10	0.88	5.47	1.21	3.55	0.548
FBL025	31.6	63.7	7.75	29.0	28.7	6.10	0.809	6.70	6.23	1.07	6.64	1.50	4.62	0.724
FBL026 Rep 1	28.1	55.8	6.64	25.0	24.5	5.41	0.748	5.79	5.26	0.88	5.61	1.22	3.74	0.575
FBL026 Rep 2	28.3	56.1	6.63	25.1	24.9	5.31	0.743	5.98	5.25	0.88	5.55	1.23	3.77	0.577
FBL027	18.2	60.8	7.06	29.0	28.3	7.24	1.387	7.96	7.34	1.23	7.79	1.71	5.10	0.755
FBL028	47.0	94.6	11.74	44.7	44.8	9.89	1.715	9.75	9.08	1.46	8.36	1.67	4.56	0.634
FBL029	35.2	74.2	9.27	35.2	35.3	7.27	1.428	6.85	6.68	1.11	6.70	1.37	4.05	0.604
FBL030	174.2	240.0	22.98	86.8	86.6	17.31	3.351	16.95	17.11	2.68	14.97	2.90	7.67	1.035
FBL031	57.3	209.7	16.10	62.8	62.5	13.65	0.529	12.64	12.72	2.14	12.94	2.71	8.08	1.248
FBL032	58.5	268.9	17.14	65.7	66.4	14.66	0.465	13.12	13.54	2.36	14.41	3.08	9.07	1.420
FBL033	63.4	266.0	17.60	68.1	67.6	14.40	0.422	13.38	13.95	2.35	14.35	3.06	9.22	1.452
FBL034	58.7	211.9	16.36	64.0	63.9	13.82	0.500	12.98	13.00	2.18	13.14	2.77	8.17	1.244
FBL035	22.1	48.4	6.21	24.9	25.0	5.44	1.334	5.56	5.21	0.81	4.43	0.99	2.89	0.430
FBL036	25.8	51.8	6.15	23.1	22.8	4.48	0.798	3.97	3.98	0.63	3.79	0.81	2.49	0.378
FBL037	35.4	73.4	9.18	36.5	36.3	7.34	1.463	7.49	6.86	1.02	5.96	1.26	3.63	0.540
FBL038	18.7	36.5	4.85	21.0	21.0	4.57	1.223	4.46	4.24	0.60	3.40	0.67	1.93	0.265
FBL039 Rep 1	12.9	33.8	4.17	15.9	15.7	3.98	0.494	3.99	3.79	0.71	4.65	1.03	3.30	0.522
FBL039 Rep 2	13.6	35.5	4.47	16.8	16.5	4.13	0.500	3.85	3.42	0.62	3.79	0.82	2.66	0.453
FBL040	11.9	31.7	4.92	23.6	23.3	6.23	2.081	6.63	6.38	1.02	6.26	1.29	3.55	0.513

Table 4. Element concentrations in ppm measured by ICP-MS for metavolcanic rocks from the vicinity of Ft. Bragg, North Carolina.

anid	La 139	Ce 140	Pr 141	Nd 143	Nd 146	Sm 147	Eu 153	Gd 156	Gd 157	Tb 159	Dy 163	Ho 165	Er 166	Tm 169
FBL041	10.8	27.0	3.88	17.7	17.4	4.24	1.327	4.33	4.06	0.63	3.57	0.71	1.92	0.274
FBL042	7.9	18.9	2.64	12.1	11.8	3.07	1.004	3.60	3.53	0.59	3.69	0.79	2.31	0.330
FBL043	38.9	70.2	8.65	33.7	33.6	6.76	1.678	6.83	6.19	0.92	5.27	1.12	3.27	0.494
FBL044	26.0	65.1	9.18	37.8	37.5	8.76	1.943	8.96	8.12	1.31	7.57	1.59	4.66	0.737
FBL045	30.2	58.1	6.96	27.3	27.0	5.53	1.308	5.31	4.88	0.76	4.40	0.93	2.81	0.432
FBL046	21.3	43.0	5.38	21.2	21.2	4.61	1.091	4.26	3.98	0.64	3.76	0.78	2.30	0.344
FBL047	19.9	42.0	5.29	20.4	20.2	3.96	0.883	3.90	3.62	0.57	3.43	0.75	2.27	0.358
FBL048	27.6	59.0	7.67	29.5	29.3	5.88	1.320	5.90	5.23	0.84	5.11	1.09	3.34	0.528
FBL049 Rep 1	28.3	60.2	7.57	29.1	29.0	5.63	1.214	5.46	4.89	0.78	4.65	1.00	3.10	0.491
FBL049 Rep 2	28.1	60.7	7.58	29.2	29.3	5.74	1.212	5.35	4.81	0.76	4.73	1.01	3.13	0.493
FBL050	26.4	55.9	7.04	27.0	26.8	5.25	1.096	4.65	4.62	0.74	4.30	0.92	2.83	0.440
FBL051	21.8	43.5	5.13	19.2	18.9	4.16	0.632	4.63	4.18	0.73	4.65	1.02	3.15	0.505
FBL052	20.8	39.6	4.49	16.3	16.4	3.33	0.499	3.55	3.36	0.55	3.66	0.76	2.34	0.368
FBL053	24.6	48.4	5.60	20.6	20.9	4.48	0.786	4.82	4.34	0.73	4.32	1.04	3.26	0.522
FBL054	26.1	51.3	6.05	22.8	22.5	4.73	0.680	4.88	4.65	0.79	4.95	1.12	3.37	0.551
FBL055	17.4	36.9	4.71	19.2	19.2	4.33	1.036	4.84	4.46	0.71	4.35	0.94	2.78	0.410
FBL056	20.6	43.8	5.61	20.7	20.5	4.46	0.796	4.49	4.16	0.71	4.31	0.98	3.18	0.535
FBL057	46.8	93.3	11.54	43.6	43.6	9.32	1.559	9.69	8.56	1.51	10.17	2.41	8.36	1.445
FBL058	59.1	136.6	16.63	64.5	64.3	13.75	0.416	12.57	12.72	2.16	13.12	2.76	8.16	1.246
FBL059	51.3	191.6	15.03	58.9	58.8	13.00	0.472	11.99	12.15	2.08	12.36	2.61	7.61	1.174
FBL060	26.8	60.2	7.19	28.7	28.6	6.38	0.585	6.75	6.18	1.06	6.85	1.41	4.14	0.637
FBL061	25.7	55.7	6.86	27.5	27.3	6.21	0.644	6.77	6.30	1.07	6.78	1.44	4.34	0.671
FBL062	28.0	58.5	7.61	30.0	29.9	6.68	0.665	7.20	6.60	1.14	7.16	1.57	4.67	0.745
FBL063	28.8	61.2	7.68	30.2	30.0	6.60	0.546	7.04	6.40	1.11	6.99	1.47	4.50	0.702
FBL064	29.6	64.0	8.18	32.0	32.4	7.28	0.583	7.43	6.83	1.14	7.08	1.62	4.78	0.748
FBL065	33.7	73.3	9.22	36.8	37.0	8.27	0.702	9.02	8.25	1.39	8.62	1.85	5.43	0.839
FBL066	27.4	58.9	7.37	28.3	28.1	5.43	1.181	5.36	4.81	0.78	4.72	1.03	3.18	0.511
FBL067	23.9	50.9	6.60	26.9	27.3	5.57	1.633	5.74	5.22	0.81	4.90	1.04	3.05	0.458
FBL068 Rep 1	31.5	70.2	9.14	35.7	35.7	7.35	1.593	7.11	6.42	1.05	6.16	1.49	4.65	0.715
FBL068 Rep 2	31.0	69.3	9.03	35.6	35.4	7.33	1.559	7.09	6.46	1.06	6.23	1.47	4.62	0.717
FBL069	25.7	46.8	5.56	21.3	20.9	4.23	1.015	3.74	3.78	0.57	3.41	0.70	2.12	0.331
FBL070	8.0	19.1	2.66	11.9	12.1	2.80	1.038	2.55	2.44	0.36	2.02	0.39	1.12	0.154
FBL071	6.6	15.6	2.13	9.8	9.6	2.50	0.949	2.83	2.66	0.42	2.49	0.52	1.46	0.207
FBL072	27.8	59.8	7.92	32.3	32.4	8.17	1.549	9.68	8.95	1.65	10.71	2.35	7.13	1.102
FBL073	28.4	57.2	9.37	42.2	42.0	10.49	2.418	11.51	10.89	1.82	11.03	2.34	6.74	0.990
FBL074	28.7	59.3	7.26	27.8	27.3	5.85	1.136	6.37	5.72	0.96	5.81	1.23	3.72	0.572
FBL075	16.4	38.1	5.47	24.5	24.6	6.00	1.887	6.49	6.15	0.98	5.93	1.28	3.64	0.533
FBL076	33.1	66.2	8.10	30.1	29.9	6.55	0.867	7.16	6.58	1.17	7.48	1.65	5.01	0.819
FBL077	22.6	47.3	5.81	22.7	22.9	4.95	0.918	4.89	4.38	0.71	4.29	0.96	3.26	0.536
FBL078	25.7	54.1	6.55	25.2	25.2	5.69	1.214	6.25	5.82	0.98	6.06	1.34	4.01	0.625
FBL079	24.8	53.5	6.80	27.5	27.4	6.34	1.570	7.36	6.84	1.18	7.60	1.70	5.04	0.765
FBL080	25.5	54.2	6.94	29.0	28.9	6.97	1.242	8.28	7.82	1.37	8.73	1.93	5.82	0.899

Table 4. Element concentrations in ppm measured by ICP-MS for metavolcanic rocks from the vicinity of Ft. Bragg, North Carolina.

anid	Yb172	Lu 175	Hf 178	Ta 181	Th 232
FBL001	6.12	0.951	5.60	0.670	10.26
FBL002	8.35	1.373	7.26	0.886	12.99
FBL003	7.91	1.224	5.74	0.708	9.74
FBL004	6.57	1.063	7.21	0.869	12.59
FBL005	7.29	1.137	5.56	0.754	12.76
FBL006	8.86	1.457	7.46	0.931	13.75
FBL007	5.05	0.802	5.66	0.694	10.00
FBL008	7.31	1.148	6.97	0.669	10.15
FBL009	7.44	1.161	6.87	0.663	10.70
FBL010	6.80	1.086	6.25	0.593	8.87
FBL011	8.41	1.338	8.31	0.851	13.59
FBL012	7.41	1.158	7.07	0.724	11.11
FBL013	6.57	1.024	6.14	0.582	9.45
FBL014	5.17	0.801	5.89	0.515	7.73
FBL015	6.04	0.977	6.47	0.860	13.86
FBL016	5.99	0.949	5.37	0.695	11.43
FBL017	6.23	1.001	6.08	0.809	13.18
FBL018	6.09	0.952	5.19	0.638	11.41
FBL019	5.60	0.877	5.52	0.745	12.19
FBL020	2.91	0.464	3.11	0.428	5.42
FBL021	5.42	0.895	5.88	0.234	5.25
FBL022	4.80	0.778	5.05	0.227	4.50
FBL023	3.23	0.487	2.49	0.235	3.87
FBL024	3.59	0.537	3.56	0.383	5.43
FBL025	4.96	0.820	4.79	0.857	12.49
FBL026 Rep 1	3.82	0.598	3.65	0.661	9.06
FBL026 Rep 2	3.83	0.601	3.64	0.647	9.13
FBL027	4.63	0.688	4.45	1.110	15.17
FBL028	3.86	0.567	5.94	1.412	19.32
FBL029	3.81	0.565	3.95	0.865	12.74
FBL030	6.06	0.857	4.85	1.129	16.27
FBL031	8.18	1.262	15.46	1.536	14.75
FBL032	9.03	1.461	18.17	1.752	17.17
FBL033	9.26	1.473	17.72	1.673	16.39
FBL034	8.04	1.226	14.69	1.438	13.55
FBL035	2.74	0.412	4.16	0.500	6.54
FBL036	2.67	0.412	5.24	0.443	8.47
FBL037	3.61	0.580	5.50	0.581	8.90
FBL038	1.62	0.258	2.47	0.162	2.16
FBL039 Rep 1	3.58	0.557	6.45	0.828	11.82
FBL039 Rep 2	3.09	0.503	6.69	0.845	12.37
FBL040	3.27	0.483	1.92	0.106	0.35

Table 4. Element concentrations in ppm measured by ICP-MS for metavolcanic rocks from the vicinity of Ft. Bragg, North Carolina.

anid	Yb172	Lu 175	Hf 178	Ta 181	Th 232
FBL041	1.66	0.217	0.85	0.085	0.54
FBL042	2.22	0.319	1.27	0.045	0.45
FBL043	3.28	0.521	6.34	0.430	10.50
FBL044	4.94	0.807	7.19	0.614	7.38
FBL045	2.81	0.470	5.84	0.403	9.65
FBL046	2.41	0.369	4.31	0.298	6.17
FBL047	2.56	0.412	5.11	0.317	3.16
FBL048	3.58	0.599	7.12	0.419	4.43
FBL049 Rep 1	3.44	0.568	7.49	0.449	4.46
FBL049 Rep 2	3.44	0.565	7.29	0.428	4.36
FBL050	3.01	0.487	5.92	0.343	3.59
FBL051	3.45	0.554	3.80	0.653	9.89
FBL052	2.52	0.400	2.71	0.441	6.56
FBL053	3.41	0.562	3.75	0.637	9.46
FBL054	3.64	0.590	3.75	0.561	10.42
FBL055	2.60	0.392	2.57	0.340	4.55
FBL056	3.58	0.599	4.37	0.725	9.53
FBL057	8.93	1.365	5.00	1.219	16.84
FBL058	8.25	1.254	14.99	1.449	14.44
FBL059	7.69	1.192	14.98	1.471	14.19
FBL060	4.26	0.668	4.87	0.705	8.64
FBL061	4.39	0.694	4.56	0.660	7.95
FBL062	4.82	0.788	5.24	0.748	9.57
FBL063	4.65	0.722	4.58	0.682	8.12
FBL064	5.00	0.813	5.90	0.844	10.77
FBL065	5.58	0.880	5.42	0.800	9.93
FBL066	3.61	0.596	7.61	0.431	4.65
FBL067	2.95	0.471	4.41	0.308	2.97
FBL068 Rep 1	4.82	0.759	6.79	0.698	7.33
FBL068 Rep 2	4.85	0.758	6.82	0.716	7.37
FBL069	2.23	0.349	4.40	0.278	7.40
FBL070	0.97	0.155	0.75	0.075	1.42
FBL071	1.24	0.184	0.75	0.039	0.26
FBL072	7.06	1.097	6.09	0.726	9.19
FBL073	6.55	1.033	5.21	0.430	6.82
FBL074	3.60	0.541	4.29	0.803	9.99
FBL075	3.46	0.525	3.98	0.259	3.25
FBL076	5.47	0.869	10.24	1.663	16.37
FBL077	3.88	0.652	5.45	0.713	8.83
FBL078	4.11	0.642	7.22	0.789	9.82
FBL079	5.07	0.786	6.24	0.686	8.78
FBL080	5.83	0.908	5.41	0.587	6.93

Table 5. Principal Components Analysis Based on the File: L-ALL

Date: 12/24/04

Simultaneous R-Q Factor Analysis Based on Variance-Covariance Matrix for all 80 samples in this study (FBL001-FBL080).

Eigenvalues and Percentage of Variance Explained:

	Eigenvalue	%Variance	Cum. %Var.
1	1.1227	51.6149	51.6149
2	0.2816	12.9448	64.5597
3	0.2687	12.3538	76.9135
4	0.1020	4.6914	81.6050
5	0.0907	4.1691	85.7740
6	0.0744	3.4201	89.1941
7	0.0499	2.2946	91.4888
8	0.0370	1.6996	93.1884
9	0.0293	1.3467	94.5350
10	0.0229	1.0507	95.5858
11	0.0194	0.8908	96.4766
12	0.0160	0.7343	97.2109
13	0.0149	0.6863	97.8973
14	0.0110	0.5059	98.4031
15	0.0090	0.4161	98.8192
16	0.0068	0.3112	99.1304
17	0.0053	0.2455	99.3759
18	0.0042	0.1912	99.5670
19	0.0032	0.1483	99.7153
20	0.0018	0.0805	99.7958
21	0.0016	0.0722	99.8680
22	0.0009	0.0413	99.9093
23	0.0008	0.0375	99.9467
24	0.0005	0.0245	99.9712
25	0.0003	0.0145	99.9857
26	0.0002	0.0081	99.9939
27	0.0001	0.0061	100.0000

Table 6. Mahalanobis distance probabilities of specimens in Uwharrie 1 belonging to the Uwharrie 1.

Date: 1/05/05

Groups are:

1 PC-U1 Uwharrie 1 group

Variables used:

PC01	PC02	PC03	PC04	PC05	PC06	PC07
PC08	PC09	PC10	PC11	PC12	PC13	PC14
PC15						

Percent Variance explained by these variables: >99%

Probabilities are jackknifed for specimens included in each group.

The following specimens are in the file **Uwharrie 1**

	Probabilities:
ID. NO.	PC-U1
FBL001	16.259
FBL002	55.101
FBL003	20.157
FBL004	4.879
FBL005	1.858
FBL006	90.923
FBL007	34.740
FBL008	86.592
FBL009	45.329
FBL010	12.279
FBL011	94.411
FBL012	94.736
FBL013	0.231
FBL014	0.612
FBL015	84.734
FBL016	64.795
FBL017	63.901
FBL018	66.801
FBL019	89.434
FBL025	87.153
FBL026	37.897
FBL051	95.755
FBL052	3.543
FBL053	79.296
FBL054	56.695

Table 7. Mahalanobis distance probabilities of other source samples compared to Uwharrie 1.

Date: 1/05/05

Groups are:

1	PC-U1	Uwharrie 1 group

Variables used:

PC01	PC02	PC03	PC04	PC05	PC06	PC07
PC08	PC09	PC10	PC11	PC12	PC13	PC14
PC15						

Percent Variance explained by these variables: >99%

Probabilities are jackknifed for specimens included in each group.

The following specimens are in the file **Uwharrie 2**

Probabilities:

ID. NO.	PC-U1
FBL020	0.404
FBL021	0.138
FBL022	0.587
FBL023	0.045
FBL024	0.991
FBL055	1.164

The following specimens are in the file **Chatham 2**

Probabilities:

ID. NO.	PC-U1
FBL031	0.000
FBL032	0.000
FBL033	0.000
FBL034	0.000
FBL058	0.000
FBL059	0.000

The following specimens are in the file **Chatham 1+3**

Probabilities:

ID. NO.	PC-U1
FBL027	0.177
FBL028	0.000
FBL029	0.016
FBL030	0.001
FBL035	0.035
FBL036	0.039
FBL037	0.005
FBL038	0.001
FBL056	0.009
FBL057	0.155

The following specimens are in the file **Cape Fear**

Probabilities:

ID. NO.	PC-U1
FBL040	0.000
FBL041	0.000
FBL042	0.000

FBL070	0.000
FBL071	0.000

The following specimens are in the file **Durham**

Probabilities:	
ID. NO.	PC-U1
FBL047	0.017
FBL048	0.026
FBL049	0.084
FBL050	0.032
FBL066	0.041
FBL067	0.016

The following specimens are in the file **Orange**

Probabilities:	
ID. NO.	PC-U1
FBL060	45.135
FBL061	42.825
FBL062	51.821
FBL063	63.075
FBL064	74.721
FBL065	80.739

The following specimens are in the file **Person**

Probabilities:	
ID. NO.	PC-U1
FBL043	0.009
FBL044	1.518
FBL045	0.020
FBL046	0.025
FBL068	0.032
FBL069	0.012

Table 8. Mahalanobis distance probabilities of artifacts belonging to the group Uwharrie 1.

Date: 1/05/05

Groups are:

1	PC-U1	Uwharrie 1 group

Variables used:

PC01	PC02	PC03	PC04	PC05	PC06	PC07
PC08	PC09	PC10	PC11	PC12	PC13	PC14
PC15						

Percent Variance explained by these variables: >99%

Probabilities are jackknifed for specimens included in each group.

The following specimens are in the file **ARTIFACTS**

	Probabilities:
ID. NO.	PC-U1
FBL072	3.287
FBL073	0.006
FBL074	27.184
FBL075	0.041
FBL076	37.415
FBL077	20.243
FBL078	1.536
FBL079	5.457
FBL080	1.163

Table 9. Means and standard deviations for the rhyolite compositional groups in this study as determined by NAA.

Element	Uwharrie1 (n=25) s.d.	Uwharrie2 (n=6) s.d.	Chatham2 (n=6) s.d.	Chatham 1+3 (n=10) s.d.	Cape Fear (n=5) s.d.	Durham (n=6) s.d.	Orange (n=6) s.d.	Person (n=6) s.d
La (ppm)	26.7 ± 4.2	17.8 ± 1.1	55.4 ± 4.1	35.7 ± 25.2	8.4 ± 1.8	24.3 ± 2.8	27.7 ± 2.2	26.2 ± 7.7
Lu (ppm)	0.858 ± 0.239	0.564 ± 0.137	1.152 ± 0.059	0.566 ± 0.269	0.249 ± 0.089	0.446 ± 0.038	0.661 ± 0.07	0.507 ± 0.158
Nd (ppm)	24.2 ± 4.2	19.0 ± 3.2	73.3 ± 20.6	35.6 ± 22.1	12.5 ± 3.8	27.6 ± 7.6	33.3 ± 4.6	30.2 ± 9.4
Sm (ppm)	6.64 ± 1.67	4.76 ± 0.59	12.73 ± 0.71	7.46 ± 3.97	3.48 ± 1.37	5.06 ± 0.56	6.42 ± 0.60	6.04 ± 1.54
Yb (ppm)	5.78 ± 1.63	3.72 ± 0.82	7.99 ± 0.34	4.04 ± 1.97	1.73 ± 0.62	2.95 ± 0.23	4.50 ± 0.45	3.18 ± 1.05
Ce (ppm)	56.5 ± 9.3	37.8 ± 3.1	124.1 ± 6.6	70.6 ± 34.0	19.6 ± 5.5	52.4 ± 6.2	61.2 ± 5.6	56.9 ± 12.6
Co (ppm)	0.43 ± 0.16	1.44 ± 1.15	0.70 ± 0.49	6.36 ± 6.99	24.84 ± 9.82	5.03 ± 2.95	0.67 ± 0.18	6.88 ± 7.69
Cs (ppm)	0.85 ± 0.40	0.87 ± 0.99	0.45 ± 0.12	2.24 ± 1.23	0.78 ± 0.40	0.27 ± 0.09	0.97 ± 0.20	0.86 ± 0.62
Eu (ppm)	0.895 ± 0.246	0.996 ± 0.13	0.43 ± 0.052	1.406 ± 0.696	1.163 ± 0.371	1.103 ± 0.22	0.582 ± 0.05	1.358 ± 0.28
Fe (ppm)	9909 ± 2676	11963 ± 3370	19008 ± 968	22910 ± 17360	72284 ± 11336	21339 ± 6321	8432 ± 540	30334 ± 21627
Hf (ppm)	5.51 ± 1.27	4.15 ± 0.60	14.59 ± 0.46	4.96 ± 1.35	1.53 ± 0.44	5.69 ± 0.78	5.05 ± 0.10	5.15 ± 1.27
Rb (ppm)	82.9 ± 19.6	37.9 ± 16.9	115.9 ± 21.5	127.8 ± 91.2	23.8 ± 11.8	11.0 ± 3.9	85.9 ± 3.3	22.9 ± 14.5
Sb (ppm)	0.172 ± 0.139	0.145 ± 0.087	0.49 ± 0.163	0.312 ± 0.22	0.397 ± 0.592	0.331 ± 0.135	0.307 ± 0.076	0.444 ± 0.123
Sc (ppm)	5.83 ± 1.73	7.70 ± 2.47	1.70 ± 0.40	9.90 ± 4.52	26.93 ± 10.35	8.17 ± 2.60	5.31 ± 0.42	12.87 ± 10.85
Ta (ppm)	0.608 ± 0.079	0.269 ± 0.068	1.342 ± 0.056	0.709 ± 0.35	0.077 ± 0.005	0.325 ± 0.04	0.645 ± 0.025	0.415 ± 0.141
Tb (ppm)	1.119 ± 0.293	0.751 ± 0.088	1.911 ± 0.131	0.99 ± 0.565	0.532 ± 0.264	0.614 ± 0.082	1.1 ± 0.101	0.789 ± 0.215
Th (ppm)	9.31 ± 1.43	4.20 ± 0.44	12.78 ± 0.46	9.83 ± 4.75	0.53 ± 0.37	3.11 ± 0.47	7.62 ± 0.32	6.32 ± 2.04
Zn (ppm)	39.7 ± 13.7	40.1 ± 15.2	77.0 ± 27.6	58.9 ± 21.3	100.8 ± 27.1	54.2 ± 13.2	33.4 ± 7.0	97.0 ± 84.3
Zr (ppm)	121.4 ± 29.8	109.6 ± 21.3	346.8 ± 14.5	132.2 ± 39.4	26.7 ± 3.2	140.2 ± 22.5	103.6 ± 6.3	138.8 ± 33.7
Al (ppm)	55640 ± 5324	57312 ± 5749	61232 ± 2284	68527 ± 12938	92072 ± 6069	75798 ± 7137	64847 ± 2936	66258 ± 11079
Ba (ppm)	511 ± 127	340 ± 88	67 ± 8	1026 ± 515	246 ± 49	314 ± 156	694 ± 74	367 ± 241
Ca (ppm)	2843 ± 1643	9534 ± 4486	4186 ± 1483	9969 ± 9902	50932 ± 24188	13940 ± 7499	4862 ± 558	8128 ± 4617
Dy (ppm)	6.53 ± 1.69	4.00 ± 0.29	11.57 ± 0.31	5.84 ± 3.28	2.40 ± 1.18	3.46 ± 0.38	6.38 ± 0.68	4.31 ± 1.61
K (ppm)	23411 ± 6230	13532 ± 3766	35210 ± 6863	36108 ± 15997	6864 ± 5154	7764 ± 2671	30612 ± 2411	10122 ± 8068
Mn (ppm)	324 ± 106	605 ± 87	413 ± 88	679 ± 366	1588 ± 331	750 ± 170	263 ± 69	555 ± 157
Na (ppm)	25864 ± 3909	27432 ± 5168	26636 ± 4362	20559 ± 13100	25145 ± 11777	42853 ± 4957	27469 ± 2554	36661 ± 5724
Ti (ppm)	616 ± 309	1068 ± 273	976 ± 194	1862 ± 1198	4933 ± 1790	2062 ± 890	757 ± 151	2046 ± 590