1991

Tephrochronology of core E67-126A, northwestern Gulf of Mexico

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Mexico**

Ostergren, Carol Lynn, M.S.

San Jose State University, 1991

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TEPHROCHRONOLOGY
OF CORE E67-126A,
NORTHWESTERN GULF OF MEXICO

A Thesis
Presented to
The Faculty of the Department of Geology
San Jose State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

By
Carol Lynn Ostergren

August, 1991

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ABSTRACT

The objective of this study is to isolate dispersed and macroscopic tephra contained in core E67-126A from the Gulf of Mexico and to correlate them with other widespread tephra and where possible with their eruptive centers. Other objectives included describing the depositional environment at the core site, correlating lithologic material to glacial and interglacial stages, and refining distribution patterns of major late Quaternary volcanic episodes.

A major ash layer at the base of the 310-m-thick core E67-126A is geochemically correlated with the Lava Creek B eruption of the Yellowstone volcanic center (0.620 Ma) on the basis of major- and trace-element analyses. The correlation is further corroborated by biostratigraphy and limited oxygen isotope data. The identification of this ash in core E67-126A allows extension of the Lava Creek B ash into the Gulf of Mexico for the first time.

Four additional dispersed ash zones were detected and analyzed, but variations in major-element chemistry precluded chemical correlation with any of the known major late Quaternary volcanic eruptions of Mexico, Central America, and the western United States. Major-element chemistry and degree of hydration of these samples is consistent with older tephra (Pliocene and older) deposited in an arid environment. Shards contained in the four horizons may be from direct air fall of late Quaternary Plinian eruptions, erosion and transport of older (Pliocene or older) ashes deposited in the western United States, or both. In addition, mixing of tephra from sites both proximal and distal to the Gulf of Mexico may contribute to the variable chemical signature.

A rate of sediment deposition is calculated using the ash layer datum and assuming that present-day sediments are at the core top. The rate of 48.4 cm/1000 yr is among the highest for any ocean basin.

Detailed macroscopic examination of the core and semiquantitative microscopic inspection of core samples taken at approximately 30-cm intervals show that the core is comprised primarily of continuous, massive, virtually featureless grayish-green silty clay. Unconsolidated, sand-rich layers are common in the upper 140 m of the core and reflect low stands of sea level during the late Quaternary. A 60-m-thick sand layer is correlated to the last major glacial advance of late Wisconsinan age.

INTRODUCTION

Scope of the Investigation

The primary objective of this study is to isolate and characterize tephra (both macroscopic layers and dispersed tephra zones) contained in core E67-126A and to correlate them by geochemical and petrographic characteristics with other known tephra layers of the western Gulf of Mexico, as well as to determine the eruptive centers of the tephra. Correlation of tephra allows existing tephrostratigraphy of the Gulf of Mexico to be refined and areal distribution patterns and sedimentary processes in the area to be better understood. Further objectives include determination of degree and type of alteration of shards, general description of lithologic characteristics of the core, recognition of the eustatic effects of glacial/interglacial episodes in core sediments and supporting records, and assessment of the present-day and late Pleistocene depositional environment.

Previous Studies

Chemical correlation of tephra is a valuable tool for providing correlation and age control for both terrestrial and marine sequences (Bramlette and Bradley, 1941; Worzel, 1959; Ewing and others, 1959; Bowles and others, 1973; Drexler and others, 1980; Ledbetter, 1984, 1985; Rabek and others, 1985). Early tephra studies were based on tephra characteristics such as shard morphology, color, shape, and refractive index (Ninkovich and others, 1964; Wilcox, 1965; Ninkovich and Heezen, 1967); chemical correlation by electron microprobe and other analytical techniques came into use in the mid 1960's (Smith and Westgate, 1969; Watkins and others, 1978; Thunell and others, 1979).

Tephrochronology was first applied to the marine environment by Bramlette and Bradley (1941) who correlated ash layers in a large area of the north Atlantic Ocean. Soon after, Kuene and Neeb (1943) examined surface sediments from the 19th-century eruptions of Tambora and Oena-Oena in Indonesia and traced ash as far as 400 km from the source. Development of the piston corer in the late 1940's (Kullenberg, 1947) allowed for major advances in marine stratigraphy, including tephrochronology. The present tephrostratigraphy for the Gulf of Mexico was developed by first establishing a detailed biostratigraphy (Kennett and Huddleston, 1972; Thunell, 1976); ash layers were then assigned ages and named according to their positions within the biostratigraphic zones. Current application of geochemical correlation of tephra now commonly is used in analysis of deep-sea drill cores (Sarna-Wojcicki and others, 1987), and tephra correlations can now be determined by chemical and physical characteristics, rather than by associated biostratigraphy. Consequently, tephra correlations now provide an independent methodology by which biostratigraphy and other chronostratigraphic methods (for example, magnetostratigraphy) can be tested. Recent tephra studies in the Gulf of Mexico (Bowles and others, 1973, Drexler and others, 1980; Ledbetter, 1984, 1985; Rabek and others, 1985) have established a detailed chronology and distribution patterns for volcanic events in the past 300,000 years based on the physical and chemical characteristics of the tephra layers, combined with other chronostratigraphic data.

Location of Core E67-126A

The core studied is located in the northwestern Gulf of Mexico, south of the central part of the United States, at lat 27°42' N. and long 95°37' W. (fig. 1). The core was drilled by the Eureka Company, which was under contract to Shell Oil; the core

Figure 1. Index map of the Gulf of Mexico showing location of core E67-126A.

now belongs to the U.S. Geological Survey. The drill site lies approximately 200 km due east from Corpus Christi, Texas, and depth to the sea floor was recorded at 324.3 m (1064 ft). However, drilled core material at the core repository in Corpus Christi, Texas, began at a sea floor depth of 320.6 m (1052 ft); this discrepancy may be due to the footage that is required to spud the drill bit. The core site lies in the East Breaks area of the northwestern Gulf and is situated on the shelf-slope break and thus probably was influenced by a variety of sedimentary processes during fluctuating sea levels.

Total drilling depth was 310.3 m (1018 ft); total core recovered was approximately 249 m (819 ft), giving a recovery of 81% (see Appendix 1 for driller's log). The core was drilled 17 November, 1967, and was stored at the U.S. Geological Survey core warehouse in Corpus Christi until it was rewrapped and moved (in 1982) to the U.S. Geological Survey office located at Corpus Christi State University in Corpus Christi, Texas (Ronnie Wells, U.S. Geological Survey, oral commun., 1986).

Core Condition

I inspected the core at the U.S. Geological Survey office in Corpus Christi during the week of Feb. 26 to Mar. 2, 1986. Both the archive and sampling sides of the core were examined, and in some cases, both sides appeared to be very extensively sampled. Initial sampling by the U.S. Geological Survey in the summer of 1985 looked to be very sporadic at best; in some cases too much of the core was missing to be able to verify a sample interval; in other cases, both the archive and the sample half were continuous and showed no evidence of sample collection in intervals from 0.5 to 1.0 m. Thus, samples listed in Appendix 2 do not reflect a consistent sampling interval of 30 cm (1 ft).

The condition of the core was the best that could be expected for a core of 19 years age. Both sides of the core were individually wrapped in plastic and stored together in 1-m

(3-ft) sections. The core was completely dried and in some instances the cut surface of the core was covered with a crusty white precipitate (possibly calcium carbonate or calcium sulfate) that precluded easy assessment of the color, lithologic character, and sedimentary features. In those cases, the core surface was scraped with a razor blade and brushed with a soft brush. In zones of unconsolidated sand, much of the material spilled out or mixed during core handling.

Methods

Samples were taken at approximately 0.3-m intervals by U.S. Geological Survey personnel in Corpus Christi, Texas, in 1985. Sample weight ranged from 10 to 100 g depending upon the material available. Samples from the consolidated, clay-rich parts of the core generally consisted of a 4- to 10-cm-long piece of one-half of the core. Sample weight was recorded where possible, and then the sample was disaggregated in a softened water solution. Disaggregated samples were washed on a 38-mm sieve to remove clay and fine silt. The resulting coarse fractions were dried, weighed, and dry sieved to isolate the 38- μ m to 63- μ m fraction. This fraction was examined using a binocular microscope to provide semiquantitative estimates of tephra abundance. The relative abundance scale for semiquantitative estimates of ash is as follows:

NONE	No shards of glass detected
TRACE	3-10 shards (0.5-1.0 percent) or possible shards detected entire sample
RARE	10-12 shards (1.0-3.0 percent) or possible shards detected; all samples rated rare were further examined under the petrographic microscope for verification
COMMON	Approximately 3-5 percent of coarse fraction
ABUNDANT	Approximately 5-50 percent of coarse fraction

LAYER More than approximately 50 percent of coarse fraction

Selected samples that showed rare concentrations of ash (roughly 1-2 percent of the 38-63- μm fraction) were separated using mixtures of light and heavy liquids (methyl iodide and acetone) at the U.S. Geological Survey Tephrochronology Laboratory at Menlo Park, California, to remove heavy detrital minerals, silt, carbonate, and other contaminants. Many of the samples showed possible tephra under plane light, but examination under a petrographic microscope indicated that much of this material is not volcanic glass but clear, angular, and in some cases flat quartz or feldspar grains or anhedral, weathered muscovite. These samples are indicated subsequently as rare (queried) but were not prepared for microprobe analysis after inspection under the petrographic microscope. Glass shards from several of those zones of dispersed tephra also were separated, but numbers of shards were too few to allow further preparation and analysis. These samples were not processed for X-ray fluorescence analysis owing to the small amounts of ash in these zones. Glass shards were analyzed on the electron microprobe for silicon, aluminum, iron, magnesium, manganese, calcium, titanium, sodium, and potassium using 15-Kv excitation potential, 0.010 μa specimen current measured on SiO_2 , and a beam diameter of 10 to 25 μm for 20 seconds. Where possible, 15 or more shards were analyzed to provide a representative population. Oxide totals are low (92.2-93.8 percent) owing to the hydration of glass. Results were recalculated to 100 percent to facilitate comparison on a water-free basis and entered into the computer data base. Best possible matches were drawn on the basis of several different suites of elements; sodium was mostly excluded from the statistical comparisons because of sodium-ion migration during microprobe analysis or sodium loss due to interaction with seawater (Jezek and Noble, 1978). Elements used in selection of possible matches were aluminum, calcium, silicon, titanium, and iron.

Terrestrial pumice and ash samples from major late Cenozoic volcanic sources also were prepared and analyzed by the electron microprobe for comparison. These samples were selected on the basis of proximity of the source area to the core site, estimated large volume of magma, and available age determinations. Major late Quaternary volcanic centers that may have provided ash to the Gulf of Mexico are shown in figure 2. Pumice samples were obtained from the Lake Atitlan volcanic center in Guatemala (W.I. Rose, written commun., 1986), the Sierra La Primavera volcanic center in Jalisco, Mexico (G. Mahood, written commun., 1986), the Los Humeros volcanic center in Puebla, Mexico (G. Mahood, written commun., 1986), and the Long Valley Caldera system in California (C.E. Meyer, oral commun., 1986). In addition, a sample of a widespread ash layer (Y8) present in piston cores from the western Gulf of Mexico that chemically correlates with the Los Chocoyos eruption from Lake Atitlan (Rabek and others, 1985) also was prepared and analyzed. U.S. Geological Survey samples of the Yellowstone family of ashes also were analyzed to facilitate correlation to the unknowns of core E67-126A. The ash layer at depth 280 m (2040 ft) was additionally analyzed by X-ray fluorescence.

Chemical data obtained in this study were compared with data for analyzed samples in the computer data base of the Tephrochronology Project at the U.S. Geological Survey in Menlo Park, California, and best matches were calculated using several different suites of elements. The data base contains more than 2,500 samples of ash from mostly explosive rhyolitic volcanic events of the conterminous western United States. Comparisons were made using the SIMINAL similarity coefficient method (Borchardt and others, 1972; Sarna-Wojcicki and others, 1984). This is given by

$$d_{(A, B)} = \frac{\sum_{i=1}^n R_i}{n}.$$

Figure 2. Map of western United States, Mexico, and Central America showing locations of major late Quaternary volcanic centers.

where

$d_{(A, B)} = d_{(B, A)}$ = similarity coefficient for comparison between sample A,
sample B,

i = element number,

n = number of elements,

$R_i = X_i A / X_i B$ if $X_i B > X_i A$; otherwise $R_i = X_i B / X_i A$,

$X_i A$ = concentration of element i in sample A, and

$X_i B$ = concentration of element i in sample B.

Ratios for each pair of elements compared in two samples were calculated by dividing the lower of a given element concentration by the higher concentration for the same element, thus resulting in a ratio of 1 (for identical concentrations) or less. The resulting ratios for the two samples were then averaged to give a similarity coefficient. For two identical ashes, the similarity coefficient will be 1; similarity coefficients in the 0.97 to 0.99 range are considered good matches for different samples of the same ash when corroborated by additional information such as trace-element analysis, biostratigraphy, oxygen-isotope stratigraphy, or stratigraphic sequence.

TEPHROCHRONOLOGY

Introduction and general results

Geochemical correlation of tephra makes it possible to chemically characterize a sample of volcanic ash, and to correlate it with tephra from other sites. The electron microprobe provides a rapid and generally accurate means of assessing the major-element chemistry. The elements generally measured in these microprobe analyses are sodium, magnesium, aluminum, silicon, potassium, calcium, titanium, manganese, and iron (Sarna-Wojcicki and others, 1984, 1987).

Trace amounts of tephra were detected in nearly every sample in the upper half of the core (fig. 3 and Appendix 2). This most likely reflects the presence of background levels of reworked volcanic glass and does not represent volcanic events. Dispersed tephra that were analyzed by electron microprobe were detected at the following core depths: (1) 37.8 m (1176 ft below sea level); (2) 58.83 m (1245 ft below sea level); (3) 61.57 m (1254 ft below sea level); and (4) 76.5 m (1303 ft below sea level). During the course of the microscope inspection, additional tephra were observed (at depths of 103.63, 107.29, 116.13, 119.78, 124.05, 175.26, 183.49, 187.15, 204.22, 214.27, 273.17, and 279.5 m), but these generally were too low in concentration or appeared to be too highly altered and weathered to analyze chemically.

One 40-cm-thick ash layer and four dispersed ash zones were isolated, and glass shards separated from these were analyzed. Electron microprobe data for both the unknowns of core E67-126A and the possible source ashes are contained in Appendix 3. Best matches calculated by the computer are shown in Appendix 4. Oxide totals range from 92.25 to 94.18 percent; results were recalculated to 100 percent to minimize the effects of variable degrees of hydration (table 1). Low oxide totals are due mostly to the

Ash Content

Figure 3. Abundance of tephra in core E67-126A. N, none; T, trace; R, rare; C, common; A, abundant.

Table 1. Electron microprobe data for tephra from core E67-126A

[Results in weight percent; FeO recalculated to Fe₂O₃. Analyses by C.E. Meyer, U.S. Geological Survey, 1986. Numbers in parentheses are percent standard deviation. Sample numbers correspond to depth, in feet below sea level, as recorded in Appendix 2)

OXIDE	1176	1254	1265	1303	2040	2040	2040
Na ₂ O	2.016 (3.80)	2.506 (3.53)	2.198 (3.69)	2.269 (3.65)	3.171 (3.30)	3.072 (3.02)	3.143 (4.76)
MgO	0.038 (62.19)	0.076 (32.38)	0.067 (36.36)	0.037 (63.64)	0.018 (132.2)	0.028 (80.83)	0.023 (99.11)
Al ₂ O ₃	11.379 (0.86)	11.924 (0.85)	11.720 (0.86)	11.662 (0.86)	11.559 (0.86)	11.488 (0.83)	11.608 (0.85)
SiO ₂	72.186 (0.87)	72.529 (0.87)	72.193 (0.87)	72.259 (0.87)	72.313 (0.87)	72.092 (0.85)	72.721 (0.86)
K ₂ O	5.352 (1.53)	5.335 (1.53)	5.459 (1.52)	5.433 (1.52)	4.545 (1.58)	4.638 (1.53)	4.501 (1.58)
CaO	0.275 (6.04)	0.454 (4.28)	0.407 (4.59)	0.365 (4.94)	0.528 (3.89)	0.544 (3.68)	0.533 (3.85)
TiO ₂	0.109 (34.99)	0.128 (30.68)	0.115 (33.44)	0.103 (36.56)	0.151 (26.96)	0.121 (32.07)	0.120 (33.36)
MnO	0.094 (27.95)	0.071 (35.95)	0.072 (35.65)	0.079 (32.62)	0.047 (1.083)	0.047 (52.12)	0.046 (54.62)
FeO	0.797 (6.23)	0.773 (6.35)	0.746 (6.19)	0.747 (6.49)	1.532 (4.35)	1.557 (4.14)	1.487 (4.38)
Total	92.245	93.796	92.977	92.954	93.864	93.588	94.183
Recalculated to 100 percent							
Average of 3 samples							
Na ₂ O	2.18	2.67	2.36	2.44	3.33		
MgO	0.04	0.08	0.07	0.04	0.02		
Al ₂ O ₃	12.32	12.70	12.59	12.53	12.30		
SiO ₂	78.18	77.26	77.58	77.67	77.08		
K ₂ O	5.80	5.68	5.87	5.84	4.77		
CaO	0.30	0.48	0.44	0.39	0.56		
TiO ₂	0.12	0.14	0.12	0.11	0.13		
MnO	0.10	0.08	0.08	0.08	0.05		
*Fe ₂ O ₃	0.96	0.91	0.89	0.89	1.75		
Total	100.00	100.00	100.00	99.99	99.99		

*Total iron as Fe₂O₃

effects of hydration, which is caused by exposure to water or water vapor over time.

Shards deposited in arid or semiarid regions tend to hydrate to a greater degree (more than 5 percent H₂O) than shards deposited in marine or other environments (Sarna-Wojcicki, written commun., 1991). Water content and any other fluids that may be present could not be measured by the electron microprobe used in this study.

Dispersed Ash Zones

Zones within core E67-126A that contained dispersed glass shards are predominantly featureless greenish- to reddish-gray clay containing variable amounts of sand and biogenic material (fig. 4). Binocular and petrographic examination show that shards are abraded and pitted. Scanning electron micrographs show pitted shard surfaces and ragged dissolution edges (fig. 5A, B). A terrestrial pumice sample of the Faby 37 eruption (fig. 5C) shows typical shard morphology.

Four zones (sample nos. 1176, 1254, 1265, and 1303) were detected with dispersed ash in amounts sufficient for heavy-liquid separation and microprobe analysis; results are shown in table 1. Oxide totals range from 92.2 to 93.8 percent; this degree of hydration suggests that shards were deposited in an arid to semiarid environment. Among the 4 dispersed tephra zones of core E67-126A, silica concentrations are consistent and typical of highly explosive rhyolitic eruptions. Altered shards would likely show increased silica (>78 weight percent; Sarna-Wojcicki, oral commun., 1991); thus, alteration of shards within the four dispersed zones is minimal. Single shard calculations may show variability of chemical compositions and alteration in shards within each sample .

Titanium levels in the range of 0.10 to 0.14 weight percent show an affinity to the Yellowstone ashes and ash from the Coso area as reported by Sarna-Wojcicki and

Figure 4. Photograph of split core showing clay zone at 70.1-78.0-m depth that contains ash sample 1303. This zone is characteristic of massive greenish-gray, clay-rich sections of the core; note lack of sedimentary features. Ruler is 15.25 cm long. Upper left of photograph is at 70.1-m depth; lower right is at 78.8-m depth. Each split section of core is approximately 1 m long.

Figure 5. Scanning electron micrographs of hydrated tephra (A, B) from sample 1303. Note pitted shard surfaces and dissolution edges. Pumice sample of the Faby 37 ash (C) for comparison. Micrograph by Robert Oscarson, U.S. Geological Survey, 1990.

Figure 5.—Continued

others (1984). Calcium levels range from 0.30 to 0.48 weight percent; this variation may reflect calcium levels from different eruptions.

Iron-oxide totals (total iron as Fe_2O_3) in the unknowns range from 0.89 to 0.96 weight percent. Sarna-Wojcicki and others (1987) showed that ash erupted from the Long Valley-Glass Mountain volcanic center (Bishop ash) contains Fe_2O_3 ranging from 0.71 to 0.81 weight percent. Iron concentrations for other recent late Quaternary eruptions reported by Sarna-Wojcicki and others (1987) range from a mean of 1.57 weight percent (for the Lava Creek ash) to 1.91 weight percent (for the Loleta ash). Low iron-oxide totals were noted in a similar study in core E67-113 and are attributed to the release of iron in a reducing (salt diapir) environment (C.L. Brown, oral commun., 1990); however, I have no evidence to suggest that core E67-126A lies within a similar salt-rich setting.

Best matches from the similarity coefficients (Appendix 4) are mostly highly hydrated ashes from a wide variety of sources and ages, most of which do not fit the late Quaternary time frame of these recent sediments. However, the degree of hydration in the four unknowns suggests that these tephra may be older ash that had a long residence in an arid environment before being carried by fluvial systems to the Gulf of Mexico. Similarity coefficients between the unknowns of core E67-126A and the older, hydrated ashes are no greater than 0.977. Sample 1254 shows similar chemistry (similarity coefficient of 0.977) to a white air-fall tuff that may be equivalent to the Peach Springs Tuff (mid- to upper Miocene; Sarna-Wojcicki, oral commun., 1991); no correlation is drawn here, however, owing to the likelihood of shard-to-shard variability within sample 1254.

Similarity coefficients between 0.92-0.96 among the four samples and close proximity of unknowns on the Fe_2O_3 -CaO- $\text{TiO}_2 \times 5$ ternary diagram (fig. 6) and the

Figure 6. Fe_2O_3 - CaO - $\text{TiO}_2 \times 5$ ternary diagram showing unknown ashes of core E67-126A and possible correlative ashes. Electron microprobe data.

Fe_2O_3 -CaO-MgO ternary diagram (fig. 7) suggest that the four unknowns are chemically similar. Three of the four unknowns of core E67-126A correlated with the Faby 37 ash from the Los Humeros volcanic center with similarity coefficients of 0.85 (sample 1176), 0.90 (sample 1254), and 0.91 (sample 1265). The Faby 37 Tuff also plots close to the unknowns on the ternary diagrams. No correlation is drawn here, however, because of low similarity coefficients and lack of supporting evidence.

Lava Creek B Ash

A 3-m-thick ash layer (fig. 8) is present at the base of core E67-126A (301 m below the sea floor). The layer is grayish white in color, which contrasts with the overlying and underlying green to gray sediments. It consists of unconsolidated silt containing little biogenic or sand-sized material (fig. 8). Glass shards within this zone are clear, angular bubble-wall shards that show little evidence of reworking or alteration (fig. 9A, B).

Major-element chemistry determined by the electron microprobe for this ash layer suggests that the tephra was erupted from Yellowstone National Park, a volcanic center in northwestern Wyoming and east-central Idaho (fig. 3). However, more chemical data were needed to differentiate which of three major late Quaternary eruptions produced this ash. The three major eruptions from this center are from youngest to oldest: (1) The Lava Creek B ash bed (formerly the Pearlette type O ash bed) dated at 0.62 Ma (potassium/argon age cited in Christiansen and Blank, 1972; Izett, 1981); (2) The Mesa Falls ash bed (formerly the Pearlette type S ash bed) dated at 1.4 Ma; and (3) the Huckleberry Ridge ash (formerly the Pearlette type B ash bed) dated at about 2.0 Ma.

Major-element chemistry was determined by electron microprobe for three populations of shards as listed in table 1, and these analyses were averaged and entered into the computer base of analyzed tephra layers of the Tephrochronology Project (U.S. Geological

Figure 7. Fe_2O_3 -CaO-MgO ternary diagram showing unknown ashes of core E67-126A and possible correlative ashes. Electron microprobe data.

Figure 8. Photograph of split core containing tephra layer at 301-m depth. Ash content of more than 5 percent of the 38- to 63- μ m fraction are contained in the white layer. Ash contents of less than 5 percent are from the gray zones both above and below the white zone. Upper left corner of photograph is 301-m depth; lower right is 302-m depth.

Figure 9. Scanning electron micrographs of tephra at 300-m depth (A, B). Micrographs by Robert Oscarson, U.S. Geological Survey, 1990.

Survey) for the western United States. Elements used for selection of best matches were aluminium, silicon, calcium, titanium, and iron. Potassium and sodium were excluded from the comparison because of the high mobility of these ions in most natural depositional environments. Manganese and magnesium were excluded because of their very low concentrations. Electron microprobe results are inconclusive in themselves; additional supporting information is needed to substantiate a correlation.

Concentrations of five oxides were determined by energy-dispersive X-ray fluorescence analysis and results are shown in table 2. Chemical data for selected samples of ash from the Yellowstone volcanic center, means, and standard deviations are included in table 3. Graphic representation of ash sample 2040 compared with terrestrial samples and several marine samples of the Lava Creek B and Huckleberry Ridge ashes is shown in figure 10. Potassium and calcium values are depleted in contrast to both the Lava Creek and Huckleberry Ridge terrestrial samples. Lower potassium values are probably due to the glass-sea-water ion exchange (Fisher and Schmincke, 1984). Lower calcium concentrations in the marine tephra may be due to calcite precipitation (Fisher and Schmincke, 1984). These lower values may also be due to the release of the Ca^{2+} during low-temperature alteration as glass is transformed into smectite clay and zeolites (Fisher and Schmincke, 1984); no clays were observed on or within shards, however. Lower calcium values may reflect a mixing of shards from both the initial plinian air fall part of the eruption and the later ignimbrite phase deposited closer to the source and carried downstream by fluvial systems to the depositional site. Single shard variability within the three populations of shards analyzed may show bimodal compositions that would reflect two phases of deposition.

Table 2. X-ray fluorescence data for the 2040 ash

(Analyses by Janet Slate, U.S. Geological Survey, 1986. Lava Creek B (L.C.) and Huckleberry Ridge (H.R.) ash samples listed here were analyzed at the same time as sample 2040 for comparison; samples from the U.S. Geological Survey Tephrochronology Project.

Major-element oxides (in weight percent)				
	2040	L.C.	H.R.	H.R.
K ₂ O	4.43	5.26	5.91	5.25
CaO	0.57	0.62	0.67	0.65
TiO ₂	0.09	0.10	0.11	0.11
MnO	0.04	0.04	0.04	0.05
Fe ₂ O ₃	1.66	1.75	1.84	1.91
Trace elements (in parts per million)				
Rb	231	209	217	205
Sr	5	6	14	12
Y	84	82	86	83
Zr	195	233	237	253
Nb	57	62	54	53

The MnO concentration (0.042 weight percent) correlates more closely with the Lava Creek B ash (mean 0.0414 weight percent) than with the Huckleberry Ridge ash (0.0434 weight percent), although this level falls within the range for both ashes. The Fe₂O₃ concentration (1.66 weight percent) shows a stronger affinity to the Lava Creek B ash (mean 1.70 weight percent) than to the Huckleberry Ridge ash (mean 1.85 weight percent; fig. 10). The concentration of Fe₂O₃ determined by X-ray fluorescence (1.66 weight percent) differs from that determined by electron microprobe (1.75 weight percent); this discrepancy may be due to a variation of shard chemistry, but it does not affect the correlation. The TiO₂ concentration (0.095 weight percent) correlates with

Table 3. Major-element oxide data for selected samples of ashes from Yellowstone volcanic center

(Results in weight percent. $\bar{x}$, mean; sd, standard deviation. Data from U.S. Geological Survey Tephrochronology Project. See Appendix 5 for a list of sample localities. X-ray fluorescence data.)

Sample	K ₂ O	CaO	TiO ₂	MnO	Fe ₂ O ₃
LAVA CREEK B SAMPLES					
CDH-D87-0	5.09	0.64	0.087	0.041	1.65
CDH-D86-11B	5.09	0.61	0.096	0.041	1.71
CDH-D88-23	5.36	0.61	0.087	0.041	1.65
CDH-D88-36	5.87	0.61	0.089	0.040	1.67
TECO-30B1	5.26	0.62	0.100	0.043	1.75
TECO-30C	5.33	0.62	0.103	0.043	1.75
TECO-30D	5.31	0.60	0.100	0.044	1.74
TECO-30F	5.33	0.59	0.100	0.042	1.69
TECO-30G	5.27	0.59	0.100	0.043	1.76
2V-198	5.53	0.63	0.107	0.043	1.70
PICO-133A	5.33	0.63	0.091	0.040	1.70
PICO-133C	5.42	0.60	0.095	0.040	1.70
TA-B1	5.48	0.61	0.095	0.039	1.65
OL768.5-769	4.59	0.60	0.090	0.039	1.54
P5-23	4.59	0.63	0.099	0.042	1.78
2011854	6.56	0.61	0.087	0.041	1.66
$\bar{x}$	5.34	0.614	0.095	0.0414	1.70
sd	0.45	0.015	0.006	0.0015	0.06
HUCKLEBERRY RIDGE SAMPLES					
68W98	5.30	0.66	0.115	0.041	1.75
PICO-157	4.48	0.61	0.105	0.045	1.85
TECO-1	5.79	0.69	0.126	0.046	1.96
TECO-2	5.15	0.65	0.124	0.046	1.91
TECO-12	5.25	0.65	0.111	0.046	1.91
HPA	5.25	0.65	0.111	0.046	1.80
SM-ASH-36	5.10	0.64	0.097	0.043	1.83
DSDP36-46	5.42	0.62	0.119	0.045	1.88
BEAVER-1	5.91	0.67	0.106	0.040	1.84
VA-2-1982	5.84	0.62	0.096	0.040	1.79
$\bar{x}$	5.33	0.642	0.1099	0.0434	1.85
sd	0.44	0.027	0.0109	0.0025	0.06
OTHER YELLOWSTONE ASH					
ARCO-A2-14	4.29	0.53	0.098	0.040	1.50
ALT-1	5.92	0.60	0.19	0.040	1.72

Figure 10. Major-element chemistry for the 2040 ash sample (triangle) plotted against Lava Creek and Huckleberry Ridge data from the U.S. Geological Survey Tephrochronology Project. X-ray fluorescence data. See appendix 5 for sample localities. Data points to right are additional Yellowstone ashes from the marine environment. Bars show one standard deviation.

Figure 10.—Continued

levels in the Lava Creek samples (mean 0.095 weight percent). Detailed diagenetic studies by Summa (1986) showed that these three particular elements, manganese, titanium, and iron, remain generally immobile when ash is deposited in a saline environment. In addition, work by Sarna-Wojcicki and others (1987) showed that diagenetic effects are minor within a marine environment.

Trace elements also were detected with X-ray fluorescence analysis and results are shown in table 2. Chemical data for selected samples of ash from the Yellowstone volcanic center are contained in table 4. Graphic representation of the 2040 ash sample data and the concentrations for terrestrial samples of the Lava Creek B and Huckleberry Ridge ashes are shown in figure 11. The strontium level of 9 parts per million (ppm) is consistent with levels of strontium for both terrestrial and marine samples of the Lava Creek B ashes (mean 6.4 ppm). Studies by Summa (1986) suggest that strontium levels remain consistent between the altered and unaltered tephra of the same source.

Zirconium is depleted in the 2040 ash sample with respect to both the Lava Creek B and Huckleberry Ridge ashes. Work by Summa (1986) that shows abnormal depletion of zirconium in the Lava Creek B ash deposited in a saline environment. Summa (1986) attributes this zirconium depletion to the replacement by hafnium, however I have no evidence to suggest that these shards have been altered. It may be likely, however, that low zirconium levels reflect a mixing of two phases of the eruptive cycle that differ in zirconium content.

The yttrium level (84 ppm) correlates to levels for the Lava Creek B ash (mean 83 ppm; range 77 to 94 ppm) noted by Sarna-Wojcicki (written commun., 1991; fig. 11). The niobium level (57 ppm) coincides more closely with that for the Huckleberry Ridge ash (mean 53.7 ppm; range 53-58 ppm). The rubidium level (224 ppm) is comparable to the highest measured levels for the Lava Creek B ash samples.

Table 4. Trace-element chemistry for selected samples of ashes from Yellowstone volcanic center

(Results in parts per million. $\bar{x}$, mean; sd, standard deviation. Data from U.S. Geological Survey Tephrochronology Project. See appendix 5 for a list of sample localities. X-ray fluorescence data.)

Sample	Rubidium	Strontium	Yttrium	Zirconium	Niobium
LAVA CREEK B SAMPLES					
CDH-D87-0	224	2	83	218	66
CDH-D86-11B	202	1	87	241	65
CDH-D88-23	226	2	94	228	71
CDH-D88-36	212	1	86	229	76
TECO-30B1	204	10	82	231	62
TECO-30C	200	2	78	231	63
TECO-30D	207	9	78	232	58
TECO-30F	214	14	83	221	61
TECO-30G	206	13	82	237	61
2V-198	196	2	77	236	61
PICO-133A	210	2	83	225	64
PICO-133C	204	9	82	230	62
TA-B1	220	10	87	226	67
OL768.5-769	212	11	79	212	62
P5-23	206	4	84	233	62
2011854	214	10	85	223	63
$\bar{x}$	210	6.4	83	228	63.4
sd	8	4.7	4	7.4	3.1
HUCKLEBERRY RIDGE SAMPLES					
68W98	199	5	77	217	55
PICO-157	199	14	83	241	53
TECO-1	189	7	74	253	53
TECO-2	185	25	73	240	46
TECO-12	201	16	83	251	53
HPA	203	17	86	229	56
SM-ASH-36	206	13	84	222	54
DSDP36-46	203	19	84	247	58
BEAVER-1	211	18	86	236	54
VA-2-1982	207	12	85	224	55
$\bar{x}$	200	14.6	82	236	53.7
sd	8	5.8	5	12.7	3.1
OTHER YELLOWSTONE ASH					
ARCO-A2-14	182	12	75	253	57
ALT-1	175	13	64	280	49

Figure 11. Trace-element chemistry for the 2040 ash sample (triangle) plotted against Lava Creek and Huckleberry Ridge data from the U.S. Geological Survey Tephrochronology Project. X-ray fluorescence data. See appendix 5 for sample localities. Data points to right show additional Yellowstone ashes from the marine environment. Bars show one standard deviation.

Trace-element data are inconclusive in themselves; however the strontium level is consistent with that of the Lava Creek, and the zirconium level is consistent with work done by Summa (1986). In addition, the similarity coefficient for the Lava Creek B is higher (0.95) than the similarity coefficient for the Huckleberry Ridge (0.91).

The Lava Creek ash has been reported as far south as south-central Texas (locality 2 of Izett and Wilcox, 1982). It is likely that ash from this eruption cloud traveled as far south as the northwestern Gulf of Mexico; alternatively, high concentrations of ash from both the initial plinian phase and the ignimbrite phase could have been carried into this area of the Gulf by subsequent fluvial processes. Terrestrial drainages both to the north and south of central Texas probably provided conduits for ash to travel to the core site. It is most likely that tephra was deposited by both air fall and subsequent fluvial and offshore depositional processes.

BIOSTRATIGRAPHY AND OXYGEN-ISOTOPE STRATIGRAPHY

Preliminary biostratigraphy of core E67-126A (Robin Ross, written commun., 1986) further supports the geochemical correlation with the 0.62-Ma Lava Creek B ash assigned to the megascopic ash layer at the 301-m depth. Early work in the Gulf of Mexico (Ericson and Wollin, 1968; Kennett and Huddlestun, 1972; and Thunell, 1976) shows that the *Globorotalia menardii* complex is most sensitive to climatic changes in the marine environment and generally is chosen for biostratigraphy because it characterizes certain well-defined faunal zones that are widespread throughout the Caribbean, the Gulf of Mexico, and equatorial Atlantic. This species flourished in the warm interglacial stages so the presence of this species is considered synchronous with interglacial periods; absence of this species denotes glacial advances. The presence-absence approach allows for the Pleistocene to be subdivided into ten climatically controlled zones; six of these are apparent in core E67-126A. Three subspecies of the *G. menardii* were used as paleoclimatic indicators in this study of core E67-126A: *Globorotalia menardii*, *G. menardii tumida*, and *G. menardii flexuosa*. Relative abundances, rather than the strict presence-absence approach, were calculated for this study. This approach has been effectively used in areas marginal to the Gulf where sedimentation rates are very high, as it enables a more accurate placement of zonal boundaries (Kennett and Huddlestun, 1972). Relative abundances of the *G. menardii* group for core E67-126A are plotted in figure 12. These data are plotted against the biostratigraphic zonation of the Upper Pleistocene (zones U through Z) and its relation to the North American glacial stages (from Ericson and Wollin, 1968).

A second method of biostratigraphic zonation applied to core E67-126A confirms the faunal stage boundaries defined by the method described above. The warm-water assemblage *Neogloboquadrina dutertrei*, *Globorotalia menardii*, and *Pulleniatina*

Figure 12. Biostratigraphy for core E67-126A plotted against established biostratigraphy for the Gulf of Mexico. Data from Robin Ross (written commun., 1986). Age assignments from Thunell (1984).

obliquiloculata is plotted against the cool-water assemblage *Globorotalia inflata*, *Globorotalia crassaformis*, and *Globigerina falconesis*, and results in similar zonation and assignment of faunal zones T through Z (fig. 12). These data are plotted against the late Pleistocene paleoclimatic curves developed for the Gulf of Mexico by Kennett and Huddlestun (1972).

The biostratigraphic methods employed here show that the core encompasses the present interglacial period (foram zone Z), the two most recent glacial advances of Wisconsinan glaciation (foram zones Y and W), the Wisconsinan interglacial (foram zone X), the Sangamon interglacial period (foram zone V), and the Illinoian glacial (foram zone U). On the basis of relative abundance of sand in the samples, I suggest that the interval from 0 to 30 m depth coincides with the present-day interglacial period and the sediment between 30 and 90 m depth was deposited during the main Wisconsinan glacial epoch; it may possibly represent the entire Wisconsinan glacial epoch but additional biostratigraphy and oxygen-isotope stratigraphy are needed to confirm this. Discrepancies between the faunal stratigraphy, and oxygen-isotope stratigraphy, and the percentage of sand in the core are not resolved. The Sangamonian interglacial period is difficult to distinguish from the Illinoian glacial period on the basis of sand content, however the biostratigraphy suggests that the lower boundary of the Sangamon (6/7 isotope boundary) lies at the 160-m depth (fig. 12). The lower boundary of the Sangamon interglacial epoch (isotope mid Stage 13) cannot be distinguished owing to the presence of both cold- and warm-water species.

Oxygen-isotope stratigraphy provides an increased level of stratigraphic resolution and this method of study has been widely applied to the Gulf of Mexico in recent years (Williams, 1984, 1988). Fluctuations in the oxygen-isotope ratio ($^{18}\text{O}/^{16}\text{O}$) are a result of fluctuations of terrestrially stored ice volume: calcium carbonate precipitated

by foraminifera during interglacial stages contains a smaller proportion of the heavier isotope (^{18}O ; fig. 13). Conversely, the ^{18}O levels in foraminifera precipitated during glacial stages are higher. Note that the horizontal scale for the $^{18}\text{O}/^{16}\text{O}$ is reversed; this convention was started by early workers and has persisted.

Limited oxygen-isotope stratigraphy (provided by D.F. Williams, written commun., 1987) shown in figure 13 provides additional supportive information for the Lava Creek B age assignment of the 2040 ash sample in core E67-126A. Oxygen-isotope data for the bottommost 100 m was plotted against established biostratigraphic zonation for the Gulf of Mexico. The ash layer lies in the upper part of isotope stage 16, which lies in the foraminifera zone U as established for the Gulf of Mexico (Williams, 1984); foraminifera zone U corresponds to the Illinoian glacial epoch. The approximate age for the 2040 ash layer in core E67-126A based on the position in the oxygen-isotope stratigraphy (fig. 13) here is 610,000 to 620,000 years.

Figure 13. Oxygen-isotope stratigraphy for the lower 100 m of core E67-126A. Dashed line shows position of 2040 ash layer that is correlated to the Lava Creek B eruption. Data from D.F. Williams (written commun., 1987). Age assignments from Williams (1984) in years before present.

DEPOSITIONAL HISTORY

Sediment accumulation rates in the Gulf of Mexico appear to be among the highest of any ocean basin in the world. Rates as high as 250 cm/1,000 yr (8.2 ft/1,000 yr) were reported for the offshore Louisiana coast at depths greater than 200 m (Stude, 1984). Kohl (1984) reported sedimentation rates of 200 cm/1,000 yr and 650 cm/1,000 yr for lower fan facies at Deep Sea Drill Site 618 in the Orca Basin.

An average sedimentation rate for core E67-126A was calculated using the Lava Creek Ash layer as a datum and assuming zero age for the top of the core. The age of the Lava Creek B ash bed is 0.62 Ma (potassium/argon age cited in Christiansen and Blank, 1972; Izett, 1981), and the corresponding sedimentation rate is approximately 48.4 cm/1,000 yr.

Actual sedimentation rates within the Gulf, however, vary significantly due to the water depth fluctuations and distance from shore during glacial and interglacial periods. Glacial periods of relatively low sea-level stands generally are characterized by thick accumulations of coarse to fine sand and shell-rich debris. Sedimentation during glacial epochs generally is very rapid and probably is represented in the core as both the sand-rich intervals and intervals of no recovery, because loose, unconsolidated sand often is not recovered during drilling. Warm, interglacial periods are characterized by massive, clay-rich strata that show little evidence of rapid, turbulent sedimentation processes.

Sand-rich zones of core E67-126A can be roughly correlated with glacial periods when sea level was lower and sediment was being shed off the aerially exposed shelf at a rapid rate (fig. 14). The most extensive sand-rich zone is at a depth of 44-95 m (1183-1365 ft below sea level) and probably represents the main Wisconsinan glacial advance

Figure 14. Depth versus coarse fraction (>10 percent sand) content and biostratigraphy (cold- versus warm-water assemblages) for core E67-126A. Sand-rich area from 40 to 90 m probably corresponds to the main Wisconsinan glacial epoch. Biostratigraphic foraminifera zones from Ericson and Wollin (1968) and Kennett and Huddleston (1972; see fig. 12 for correlation).

(foram zone Y). Geophysical studies by Sutter and Berryhill (1985) show that the area surrounding site E67-126A was a prograding delta during the Wisconsin glacial advance. Thickness isopachs by Sutter and Berryhill (1985; fig. 15) suggest that core E67-126A lies on the east edge of a prograding delta-fan complex that may have been ponded to the north or slowly subsiding to accommodate huge sediment influx. Studies conducted by the U.S. Geological Survey (Shideler, 1986) show that sea level may have dropped as much as 140 m and that approximately 90 km of the shelf may have been exposed to subaerial erosion. Carbonate reefs detected from seismic records (Sutter and Berryhill, 1985) mark the most recent low sea-level stand about 75 km east of the present-day shoreline. Present-day bathymetry (fig. 15) reflects the disruptive and perhaps erosive escarpment-type morphology that developed along the shelf-slope interface during the glacial low stand of sea level. This drop in sea level caused an increase in the amount of material being transported to the depositional site and an increase in proportion of sand.

Figure 15. Detailed bathymetric map of East Breaks area showing core site and late Wisconsin sediment thicknesses suggested by Sutter and Berryhill (1985). Heavy contours are thickness isopachs, in meters, of late Wisconsinan prograding delta-fan complex. Isopachs from minisparker seismic lines from Sutter and Berryhill (1985). Bathymetric contours in meters.

CONCLUSIONS

Four dispersed tephra layers and one macroscopic tephra layer were detected in core E67-126A in sufficient quantities for electron microprobe analyses; the megascopic ash layer also was analyzed by X-ray fluorescence and correlated to the lava Creek B ash of the Yellowstone volcanic center.

The oxide totals show that the four dispersed tephra are hydrated to a degree that suggests deposition in arid to semiarid terrestrial environments (oxide totals 92.2-93.8 weight percent). Because compositions of the ash in the four zones do not match any previously identified ashes, no correlations are drawn with either late Quaternary ashes of Mexican, Central American, or North American origin or to older deposits (Pliocene or older). Silica levels (77.2-78.2 weight percent) are typical, however of highly explosive rhyolitic eruptions and do not suggest alteration after deposition in the marine environment.

The data show that the four dispersed tephra zones are similar, suggesting that shards of diverse compositions may have been deposited simultaneously from a variety of sources. Other factors that may have contributed to the lack of distinct, correlative tephra horizons include bioturbation, disruptive sedimentary processes such as slumping and turbidity currents, dilution owing to high influxes of other material, and mixing of sediment due to core handling. The lack of recognizable late Quaternary tephra horizons expected in the core-site area, such as the widespread Y8 tephra, may be due to minor fluctuations of sea level not identified in the biostratigraphy, or incomplete sampling method. A better sampling method, such as continuous scraping along the entire length of the core, may have revealed discrete tephra zones for this time period.

In addition to the four dispersed tephra zones, a megascopic tephra layer was identified at a depth of 301 m. This tephra layer is correlated to the Lava Creek B eruption of the Yellowstone volcanic center on the basis of four lines of evidence:

1. Major-element chemistry. An average silica level of 77.1 percent is comparable to levels in terrestrial samples of the Yellowstone ashes. Levels of Al_2O_3 , MgO , and TiO_2 determined by electron microprobe also are consistent with Yellowstone levels. X-ray fluorescence data show levels of MnO , Fe_2O_3 , and TiO_2 consistent with samples from the Lava Creek B eruption. The CaO level in the 2040 ash sample is depleted, possibly reflecting a variation in chemistry not seen in terrestrial samples or a bimodal composition resulting from two eruptive phases.
2. Trace-element chemistry. Strontium levels of 9 parts per million are consistent with both marine and terrestrial samples of the Lava Creek B ash. Depletion of zirconium from 236 (mean Lava Creek B) to 194 parts per million in the 2040 ash sample may be attributed to alteration, but more likely to variable shard chemistry resulting from both Plinian and ignimbrite phases of eruption.
3. Biostratigraphy supports a 620,000-yr age for the ash layer.
4. Oxygen-isotope stratigraphy further substantiates a 620,000-yr age for the deposition of the ash.

A sedimentation rate of 48.4 cm/1,000 yr is calculated using the ash layer as a datum and extrapolating to the present day (core top). This rate falls within the range of sedimentation rates for the Gulf of Mexico, which are among the highest of any ocean basin in the world. A 60-m-thick sand-rich layer in the upper part of the core is correlated with the main advance of the Wisconsinan glacial epoch coincident with a prograding delta-fan complex.

The identification of the source of the tephra at the 301-m depth allows extension of the distribution zone of the Lava Creek B ash (from the Yellowstone volcanic center) to the Gulf of Mexico for the first time. Although it is not possible to determine if the ash layer in core E67-126A is the result of primary air fall or redistribution to the upper continental slope by fluvial/marine processes or both, the stratigraphic utility of this tephra layer is important for further work in the Gulf of Mexico.

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APPENDIX 1: DRILLERS LOG

Drillers log for core E67-126A was obtained from the U.S. Geological Survey office in Corpus Christi, Texas. Core was drilled in 1967 by Eureka Co. under contract to Shell Oil.

APPENDIX 1. DRILLERS LOG

Core No.	Cored Interval	Recovery in Feet	Remarks
1	1064-71	7/7	Gray-green clay, soft, forams
2	1071-87	9/16	Gray-green clay, soft, forams
3	1087-1103	8/16	Gray-green clay, soft, forams
4	1103-19	0/16	No recovery
5	1119-35	6/16	Gray-green clay, soft
6	1135-51	4/16	Gray-green clay, soft
7	1151-67	3/16	As above, becoming firm
8	1167-83	15/16	Gray clay, slightly silty, firm
9	1183-99	7/16	1186-90—sand (4') and sandy clay (3') firm
10	1199-1215	11/16	Pure coarse sand contaminated by drill
11	1215-31	5/16	Sandy clay and sand, wood frags (1216)
12	1231-47	14/16	8' sand at top; 6' gray firm clay
13	1247-63	9/16	Gray clay, firm, sand lens at bottom
14	1263-79	2/16	Gray clay, firm, sand lens 6" and 6" sandy silt
15	1279-95	9/16	6' loose sand over 3' gray sandy clay
16	1295-1311	16/16	Med. gray, firm, fine sandy clay
17	1311-27	16/16	As above with carb. material at top
18	1327-43	5/16	Firm medium-gray clay, some fine sand at top
19	1343-59	15/16	As above
20	1359-75	16/16	Firm medium-gray clay, some fine sand throughout, fine sand at top
21	1375-91	15/16	Firm medium gray clay with fine sand
22	1391-1407	16/16	As above, with some sand
23	1407-23	14/16	As above, with 1.5' loose sand near bottom, shell material at bottom

APPENDIX 1. DRILLERS LOG

Core No.	Cored Interval	Recovery in Feet	Remarks
24	1423-39	16/16	Firm medium-gray clay, sand on top
25	1439-55	16/16	As above
26	1455-71	16/16	As above
27	1471-87	16/16	As above
28	1487-1503	16/16	As above
29	1503-19	15/16	As above
30	1519-35	12/16	As above
31	1535-51	16/16	Clay, dark green, firm, massive
32	1551-67	13/16	As above
33	1567-83	16/16	As above
34	1583-99	6/16	As above
35	1599-1615	15/16	As above
36	1615-31	16/16	Clay, dark gray, firm, massive
37	1631-47	13/16	As above
38	1647-63	13/16	As above
39	1663-79	12/16	As above
40	1679-95	16/16	Clay, dark-green to black, firm, silty
41	1595-1711	15/16	Clay, gray-green, firm
42	1711-27	16/16	As above, minor carbonaceous material
43	1727-43	15/16	Clay, green, firm, forams, silty
44	1743-59	15/16	As above
45	1759-75	15/16	As above
46	1775-91	15/16	Clay, green and gray-green, firm, silty
47	1791-1807	14/16	Firm, green, light-brown at 1801'
48	1807-23	15/16	Clay, gray-green to gray, firm, silty
49	1823-39	15/16	As above
50	1839-55	6/16	As above

APPENDIX 1. DRILLERS LOG

Core No.	Cored Interval	Recovery in Feet	Remarks
51	1855-71	16/16	9' red clay at top; 7' gray-green clay, shell fragments
52	1871-87	14/16	Clay, gray-green, silty, firm
53	1887-1903	15/16	As above
54	1903-19	15/16	Clay, gray-green, firm
55	1919-35	15/16	As above
56	1935-51	15/16	As above, but silty in part
57	1951-67	15/16	As above, no silt
58	1967-83	15/16	As above, silty in part
59	1983-99	15/16	As above
60	1999-2015	15/16	As above
61	2015-31	14/16	Clay, green-gray, firm, silty in part
62	2031-47	14/16	As above
63	2047-63	15/16	As above
64	2063-64	1/1	As above
			Logger inoperative, no log

APPENDIX 2: SEMIQUANTITATIVE ASSESSMENT OF ASH ABUNDANCE

Depth in feet is as recorded in the drillers report (Appendix 1) and on boxes that contain core material. Sample preparation by C.L. Ostergren, C. Brown, K. Bork, R. Turnau, and J. Muller. Coarse fraction percentage was obtained by dividing the coarse fraction ($>38\text{ }\mu\text{m}$) in grams by the total sample weight and multiplying by 100. Lithology was determined by visual inspection of the sample before dissolution in softened water, by visual inspection of the core, and by percentage of sand calculated. Samples designated "sand" contain 10 percent or more material larger than $38\text{ }\mu\text{m}$. Ash abundance was determined by examination under a binocular microscope using the semiquantitative estimates outlined in the text. Petrographic inspection of those samples shown as rare? showed that sample contained clear flat quartz or plagioclase or weathered muscovite rather than ash. Samples containing rare or greater amounts of ash were analyzed on the electron microprobe.

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1052	0.0	27.45	0.92	0.03	trace	clay
1053	0.3	36.00	5.18	14.39	trace	sand
1054	0.61	27.73	1.34	5.01	trace	clay
1055	0.91	-----	-----	-----	-----	-----
1056	1.22	-----	-----	-----	-----	-----
1057	1.52	-----	-----	-----	-----	-----
1058	1.83	-----	-----	-----	-----	-----
1059	2.13	-----	-----	-----	-----	-----
1060	2.44	-----	-----	-----	-----	-----
1061	2.74	-----	-----	-----	-----	-----
1062	3.05	-----	-----	-----	-----	-----
1063	3.35	-----	-----	-----	-----	-----
1064	3.66	11.93	0.40	3.31	trace	clay
1065	3.96	13.78	1.16	8.42	trace	clay
1066	4.27	18.90	0.40	2.11	trace	clay
1067	4.57	18.24	5.31	29.11	trace	sand
1068	4.88	22.67	1.41	6.22	trace	clay
1069	5.18	30.99	2.45	7.91	trace	clay
1070	5.48	22.41	1.21	5.40	trace	clay
1071	5.79	27.08	1.23	4.54	trace	clay
1072	6.10	26.09	1.43	5.48	trace	clay
1073	6.40	34.28	2.97	8.66	trace	clay
1074	6.71	27.80	2.32	8.35	trace	clay
1075	7.01	29.93	2.91	9.72	trace	sand
1076	7.32	28.40	2.88	10.14	trace	clay
1077	7.62	27.75	2.61	9.41	trace	sand
1078	7.92	29.17	2.94	10.08	trace	clay
1079	8.23	26.58	2.30	8.62	trace	-----
1080	8.53	-----	-----	-----	-----	-----
1081	8.84	-----	-----	-----	-----	-----
1082	9.14	-----	-----	-----	-----	-----
1083	9.45	-----	-----	-----	-----	-----
1084	9.75	19.82	0.43	2.17	trace	clay
1085	10.06	17.99	0.45	2.50	trace	clay
1086	10.36	10.97	0.32	2.90	trace	clay
1087	10.67	27.63	-----	-----	trace	clay
1088	10.97	19.70	0.91	4.62	trace	clay
1089	11.28	27.13	0.84	3.10	trace	clay
1090	11.58	27.84	0.56	2.03	trace	clay
1091	11.89	30.13	0.65	2.16	trace	clay
1092	12.19	29.40	0.71	2.41	trace	clay
1093	12.50	32.72	0.58	1.77	trace	clay
1094	12.80	29.31	-----	-----	trace	clay
1095	13.11	-----	0.40	-----	trace	clay
1096	13.41	20.66	0.27	1.31	trace	clay
1097	13.72	31.07	0.64	2.05	trace	clay

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1098	14.02	22.65	0.48	2.12	trace	clay
1099	14.33	-----	-----	-----	-----	-----
1100	14.63	-----	-----	-----	-----	-----
1101	14.94	28.84	0.59	2.04	trace	clay
1102	15.24	19.92	0.44	2.21	trace	clay
1103	15.54	31.74	0.56	1.76	trace	clay
1104	15.84	-----	-----	-----	-----	-----
1105	16.15	-----	-----	-----	-----	-----
1106	16.46	-----	-----	-----	-----	-----
1107	16.76	-----	-----	-----	-----	-----
1108	17.07	-----	-----	-----	-----	-----
1109	17.37	-----	-----	-----	-----	-----
1110	17.68	-----	-----	-----	-----	-----
1111	17.98	-----	-----	-----	-----	-----
1112	18.29	-----	-----	-----	-----	-----
1113	18.59	-----	-----	-----	-----	-----
1114	18.90	-----	-----	-----	-----	-----
1115	19.20	-----	-----	-----	-----	-----
1116	19.51	-----	-----	-----	-----	-----
1117	19.81	-----	-----	-----	-----	-----
1118	20.12	-----	-----	-----	-----	-----
1119	20.42	-----	-----	-----	-----	-----
1120	20.73	49.97	0.82	1.64	trace	clay
1121	21.03	24.18	0.43	1.78	trace	clay
1122	21.34	34.22	0.58	1.69	trace	clay
1123	21.64	27.23	0.29	1.07	trace	clay
1124	21.95	24.67	0.24		trace	clay
1125	22.25	33.32	0.59	1.77	trace	clay
1126	22.56	-----	-----	-----	-----	-----
1127	22.86	-----	-----	-----	-----	-----
1128	23.16	-----	-----	-----	-----	-----
1129	23.47	-----	-----	-----	-----	-----
1130	23.77	-----	-----	-----	-----	-----
1131	24.08	-----	-----	-----	-----	-----
1132	24.38	-----	-----	-----	-----	-----
1133	24.69	-----	-----	-----	-----	-----
1134	24.99	15.79	0.16	1.01	trace	clay
1135	25.30	-----	0.82	0.97	trace	clay
1136	25.60	23.74	0.37	1.56	trace	clay
1137	25.91	17.88	0.22	1.23	trace	clay
1138	26.21	39.95	0.55	1.38	trace	clay
1139	26.52	18.19	0.31	1.70	trace	clay
1140	26.82	-----	-----	-----	-----	-----
1141	27.13	-----	-----	-----	-----	-----
1142	27.43	-----	-----	-----	-----	-----
1143	27.74	-----	-----	-----	-----	-----

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1144	28.04	-----	-----	-----	-----	-----
1145	28.35	-----	-----	-----	-----	-----
1146	28.65	-----	-----	-----	-----	-----
1147	28.96	-----	-----	-----	-----	-----
1148	29.26	-----	-----	-----	-----	-----
1149	29.57	-----	-----	-----	-----	-----
1150	29.87	-----	-----	-----	-----	-----
1151	30.18	-----	-----	-----	-----	-----
1152	30.48	-----	-----	-----	-----	-----
1153	30.78	-----	-----	-----	-----	-----
1154	31.09	-----	-----	-----	-----	-----
1155	31.39	-----	-----	-----	-----	-----
1156	31.70	-----	-----	-----	-----	-----
1157	32.00	-----	-----	-----	-----	-----
1158	32.31	-----	-----	-----	-----	-----
1159	32.61	-----	-----	-----	-----	-----
1160	32.92	-----	-----	-----	-----	-----
1161	33.22	-----	-----	-----	-----	-----
1162	33.53	-----	-----	-----	-----	-----
1163	33.83	-----	-----	-----	-----	-----
1164	34.14	-----	-----	-----	-----	-----
1165	34.44	-----	-----	-----	-----	-----
1166	34.75	-----	-----	-----	-----	-----
1167	35.05	-----	-----	-----	-----	-----
1168	35.36	31.73	-----	-----	trace	clay
1169	35.66	37.68	0.50	1.33	trace	clay
1170	35.97	39.91	0.81	2.03	trace	clay
1171	36.27	26.73	0.49	1.83	trace	clay
1172	36.58	57.22	2.33	4.07	trace	clay
1173	36.88	28.01	0.85	3.03	trace	clay
1174	37.19	18.41	0.41	2.23	trace	clay
1175	37.49	47.56	1.56	3.28	trace	clay
1176	37.80	52.36	1.74	3.32	rare	clay
1177	38.10	-----	-----	-----	-----	-----
1178	38.40	-----	-----	-----	-----	-----
1179	38.71	33.12	0.72	2.17	trace	clay
1180	39.01	32.74	0.68	2.08	trace	clay
1181	39.32	35.95	0.37	1.03	trace	clay
1182	39.62	40.08	5.42	13.52	trace	sand
1183	39.93	27.48	1.44	5.24	trace	clay
1184	40.23	44.13	4.27	9.68	trace	clay
1185	40.54	30.64	11.27	36.78	trace	sand
1186	40.84	36.19	5.69	15.72	none	sand
1187	41.15	50.70	30.72	60.59	trace	sand
1188	41.45	31.08	21.82	70.21	trace	sand
1189	41.76	56.21	18.11	32.22	trace	sand

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1190	42.06	34.56	10.32	29.86	trace	sand
1191	42.36	-----	-----	-----	-----	-----
1192	42.67	-----	-----	-----	-----	-----
1193	42.98	-----	-----	-----	-----	-----
1194	43.28	-----	-----	-----	-----	-----
1195	43.59	-----	-----	-----	-----	-----
1196	43.89	-----	-----	-----	-----	-----
1197	44.20	-----	-----	-----	-----	-----
1198	44.50	24.06	22.17	92.18	trace	sand
1199	44.81	31.96	30.50	95.43	trace	sand
1200	45.11	17.95	17.01	94.76	trace	sand
1201	45.42	37.34	35.73	95.69	trace	sand
1202	45.72	34.85	33.39	95.81	trace	sand
1203	46.02	35.46	34.28	96.67	trace	sand
1204	46.33	34.83	33.54	96.29	trace	sand
1205	46.63	10.10	9.07	89.80	trace	sand
1206	46.94	24.90	21.59	86.71	trace	sand
1207	47.24	18.42	17.71	96.15	trace	sand
1208	47.55	25.14	23.80	94.67	trace	sand
1209	47.85	-----	-----	-----	-----	-----
1210	48.16	-----	-----	-----	-----	-----
1211	48.46	-----	-----	-----	-----	-----
1212	48.77	-----	-----	-----	-----	-----
1213	49.07	62.65	5.99	9.56	trace	clay
1214	49.38	28.75	9.63	33.50	trace	sand
1215	49.68	-----	7.25	-----	none	clay
1216	49.99	-----	-----	-----	-----	-----
1217	50.29	-----	-----	-----	-----	-----
1218	50.60	60.67	14.46	23.83	trace	sand
1219	50.90	34.00	2.07	6.12	trace	clay
1220	51.21	42.93	1.81	4.22	trace	clay
1221	51.51	-----	-----	-----	-----	-----
1222	51.82	-----	-----	-----	-----	-----
1223	52.12	-----	-----	-----	-----	-----
1224	52.43	-----	-----	-----	-----	-----
1225	52.73	-----	-----	-----	-----	-----
1226	53.04	-----	-----	-----	-----	-----
1227	53.34	-----	-----	-----	-----	-----
1228	53.64	-----	-----	-----	-----	-----
1229	53.95	-----	-----	-----	-----	-----
1230	54.25	-----	-----	-----	-----	-----
1231	54.56	10.34	9.03	87.33	trace	sand
1232	54.86	31.17	15.97	51.24	trace	sand
1233	55.17	21.76	5.84	26.84	trace	sand
1234	55.47	26.42	8.44	31.95	trace	sand
1235	55.78	40.15	4.96	12.35	trace	sand

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1236	56.08	57.06	4.14	7.26	trace	clay
1237	56.39	24.77	5.93	23.94	trace	sand
1238	56.69	33.66	2.66	7.90	trace	clay
1239	57.00	37.21	4.16	11.18	rare	sand
1240	57.30	30.08	1.88	6.25	trace	clay
1241	57.61	33.15	1.98	5.97	trace	clay
1242	57.91	41.18	1.29	3.13	trace	clay
1243	58.22	37.83	1.63	4.31	trace	clay
1244	58.52	32.75	1.33	4.06	trace	clay
1245	58.83	34.40	1.51	4.39	trace	clay
1246	59.13	-----	-----	-----	-----	-----
1247	59.44	-----	-----	-----	-----	-----
1248	59.74	25.95	1.54	5.93	trace	clay
1249	60.05	42.61	8.83	20.72	trace	sand
1250	60.35	22.18	1.29	5.82	trace	clay
1251	60.66	52.91	3.51	6.63	trace	clay
1252	60.96	-----	-----	-----	-----	-----
1253	61.26	27.38	2.35	8.58	trace	clay
1254	61.57	42.90	24.66	57.48	rare	sand
1255	61.87	23.33	6.16	26.40	trace	sand
1256	62.18	27.08	2.93	10.82	trace	sand
1257	62.48	-----	-----	-----	-----	-----
1258	62.79	-----	-----	-----	-----	-----
1259	63.09	-----	-----	-----	-----	-----
1260	63.40	-----	-----	-----	-----	-----
1261	63.70	-----	-----	-----	-----	-----
1262	64.01	-----	-----	-----	-----	-----
1263	64.31	32.66	4.34	13.29	trace	sand
1264	64.62	48.53	14.12	29.10	trace	sand
1265	64.92	36.83	14.11	38.23	rare	sand
1266	65.23	-----	-----	-----	-----	-----
1267	65.53	-----	-----	-----	-----	-----
1268	65.84	44.77	1.55	3.46	trace	clay
1269	66.14	30.48	0.98	3.22	trace	clay
1270	66.45	30.91	1.56	5.05	trace	clay
1271	66.75	-----	-----	-----	-----	-----
1272	67.06	-----	-----	-----	-----	-----
1273	67.36	-----	-----	-----	-----	-----
1274	67.67	-----	-----	-----	-----	-----
1275	67.97	-----	-----	-----	-----	-----
1276	68.28	-----	-----	-----	-----	-----
1277	68.58	-----	-----	-----	-----	-----
1278	68.88	-----	-----	-----	-----	-----
1279	69.19	23.88	13.43	56.24	trace	sand
1280	69.49	23.83	22.31	93.62	none	sand
1281	69.80	45.39	29.25	64.44	rare?	sand

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1282	70.10	-----	-----	-----	-----	-----
1283	70.41	51.48	22.54	43.78	trace	sand
1284	70.71	56.18	25.36	45.14	trace	sand
1285	71.02	46.48	8.92	19.19	trace	sand
1286	71.32	42.59	20.43	47.97	trace	sand
1287	71.63	47.54	15.28	32.14	trace	sand
1288	71.93	52.39	8.32	15.88	trace	sand
1289	72.24	-----	-----	-----	-----	-----
1290	72.54	-----	-----	-----	-----	-----
1291	72.85	-----	-----	-----	-----	-----
1292	73.15	-----	-----	-----	-----	-----
1293	73.46	-----	-----	-----	-----	-----
1294	73.76	-----	-----	-----	-----	-----
1295	74.07	-----	-----	-----	-----	-----
1296	74.37	-----	-----	-----	-----	-----
1297	74.68	63.62	9.27	14.57	trace	sand
1298	74.98	-----	-----	-----	-----	-----
1299	75.29	60.92	7.81	12.82	trace	sand
1300	75.59	25.95	5.24	20.19	trace	sand
1301	75.90	25.77	15.22	59.06	trace	sand
1302	76.20	49.82	17.38	34.89	trace	sand
1303	76.50	51.55	3.50	6.79	rare	clay
1304	76.81	65.44	3.29	5.03	trace	clay
1305	77.11	33.41	0.45	1.34	trace	clay
1306	77.42	30.75	1.85	6.02	trace	clay
1307	77.72	44.93	3.72	8.28	trace	clay
1308	78.03	44.59	2.07	4.64	trace	clay
1309	78.33	41.19	4.80	11.65	trace	sand
1310	78.64	34.55	2.70	7.81	trace	clay
1311	78.94	48.04	3.80	7.91	none	clay
1312	79.25	-----	-----	-----	-----	-----
1313	79.55	-----	-----	-----	-----	-----
1314	79.86	-----	-----	-----	-----	-----
1315	80.16	38.13	5.15	13.51	trace	sand
1316	80.47	26.66	4.99	18.72	trace	sand
1317	80.77	37.68	3.66	9.71	trace	clay
1318	81.08	47.56	4.53	9.52	trace	sand
1319	81.38	26.98	1.13	4.19	trace	clay
1320	81.69	29.24	1.76	6.02	trace	clay
1321	81.99	55.23	3.08	5.58	trace	clay
1322	82.30	53.60	6.71	12.52	trace	sand
1323	82.60	65.35	8.48	12.98	none	sand
1324	82.91	-----	-----	-----	-----	-----
1325	83.21	-----	-----	-----	-----	-----
1326	83.52	-----	-----	-----	-----	-----
1327	83.82	53.51	8.31	15.53	none	sand

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1328	84.12	60.23	6.43	10.68	none	sand
1329	84.43	52.38	2.11	4.03	trace	clay
1330	84.73	60.35	5.31	8.80	trace	clay
1331	85.04	51.83	2.90	5.59	trace	clay
1332	85.34	62.86	8.30	13.20	trace	sand
1333	85.65	-----	-----	-----	-----	-----
1334	85.95	-----	-----	-----	-----	-----
1335	86.26	-----	-----	-----	-----	-----
1336	86.56	-----	-----	-----	-----	-----
1337	86.87	-----	-----	-----	-----	-----
1338	87.17	-----	-----	-----	-----	-----
1339	87.48	-----	-----	-----	-----	-----
1340	87.78	-----	-----	-----	-----	-----
1341	88.09	-----	-----	-----	-----	-----
1342	88.39	-----	-----	-----	-----	-----
1343	88.70	-----	-----	-----	-----	-----
1344	89.00	93.78	2.37	2.53	trace	clay
1345	89.31	64.85	2.39	3.69	none	clay
1346	89.61	58.92	2.63	4.46	trace	clay
1347	89.92	56.95	3.50	6.15	trace	clay
1348	90.22	39.77	1.58	3.97	trace	clay
1349	90.53	29.41	1.14	3.88	none	clay
1350	90.83	91.15	2.55	2.80	none	clay
1351	91.14	46.46	1.46	3.14	none	clay
1352	91.44	61.40	2.29	3.73	none	clay
1353	91.74	53.80	3.98	7.40	none	clay
1354	91.05	48.87	12.30	25.17	none	sand
1355	92.35	48.37	-----	-----	none	sand
1356	92.66	57.18	10.68	18.68	none	sand
1357	92.96	76.43	2.93	3.83	trace	clay
1358	93.27	42.94	4.33	10.08	none	sand
1359	93.57	-----	-----	-----	-----	-----
1360	93.88	-----	-----	-----	-----	-----
1361	94.18	55.40	7.09	12.80	none	sand
1362	94.49	42.81	4.98	11.63	trace	sand
1363	94.79	39.13	5.91	15.10	trace	sand
1364	95.10	36.04	8.63	23.94	trace	sand
1365	95.40	51.94	2.64	5.08	trace	clay
1366	95.71	48.81	2.96	6.06	trace	clay
1367	96.01	57.99	13.52	23.31	trace	sand
1368	96.32	13.12	2.18	16.62	none	sand
1369	96.62	42.27	6.78	16.03	none	sand
1370	96.93	37.85	2.47	6.52	trace	clay
1371	97.23	25.13	3.13	12.46	trace	sand
1372	97.54	51.90	5.79	11.16	trace	sand
1373	97.84	35.43	3.05	8.61	trace	clay

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1374	98.15	29.26	2.52	8.61	trace	clay
1375	98.45	51.16	5.62	10.98	rare?	sand
1376	98.76	28.03	8.65	30.89	trace	sand
1377	99.06	32.19	5.30	16.46	trace	sand
1378	99.36	29.18	3.96	13.57	trace	sand
1379	99.67	48.60	12.38	25.47	trace	sand
1380	99.97	76.47	17.93	23.45	trace	sand
1381	100.28	26.40	2.19	8.30	trace	clay
1382	100.58	32.86	2.66	8.09	trace	clay
1383	100.89	28.82	3.75	13.01	trace	sand
1384	101.19	26.74	2.38	8.90	trace	clay
1385	101.50	28.73	3.46	12.04	none	sand
1386	101.80	26.50	5.44	21.52	trace	sand
1387	102.11	38.78	7.05	18.17	trace	sand
1388	102.41	35.37	6.84	19.33	trace	sand
1389	102.71	33.77	8.08	23.92	trace	sand
1390	103.02	-----	-----	-----	-----	-----
1391	103.33	-----	-----	-----	-----	-----
1392	103.63	38.14	7.30	19.14	rare	sand
1393	103.94	37.38	4.05	10.83	trace	sand
1394	104.24	28.54	3.84	13.45	trace	sand
1395	104.55	66.54	8.83	13.27	trace	sand
1396	104.85	31.35	4.29	13.68	trace	sand
1397	105.16	29.38	3.82	13.00	trace	sand
1398	105.46	26.42	3.11	11.77	trace	sand
1399	105.77	31.20	1.18	3.78	trace	clay
1400	106.07	41.93	2.07	4.93	trace	clay
1401	106.38	25.95	1.69	6.51	trace	clay
1402	106.68	38.80	3.93	10.12	trace	sand
1403	106.98	31.14	3.07	9.85	trace	clay
1404	107.29	36.11	3.86	10.69	rare?	sand
1405	107.59	18.25	2.18	11.95	rare?	sand
1406	107.90	31.11	3.42	10.99	trace	sand
1407	108.20	27.47	3.55	12.92	trace	sand
1408	108.51	29.16	8.52	29.22	trace	sand
1409	108.81	27.04	11.69	43.23	trace	sand
1410	109.12	24.64	9.50	30.55	trace	sand
1411	109.42	31.98	7.69	24.04	trace	sand
1412	109.73	36.22	7.91	21.84	none	sand
1413	110.03	33.00	6.00	18.18	none	sand
1414	110.34	44.68	4.47	10.00	trace	sand
1415	110.64	44.15	3.29	7.45	trace	clay
1416	110.95	32.29	1.84	5.69	trace	clay
1417	111.25	17.27	9.64	55.82	none	sand
1418	111.56	26.82	6.53	24.34	trace	sand
1419	111.86	24.51	15.16	61.85	trace	sand

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1420	112.17	18.72	2.73	14.58	trace	sand
1421	112.47	31.15	11.24	36.08	trace	sand
1422	112.78	-----	-----	-----	-----	-----
1423	113.08	50.35	7.74	15.37	trace	sand
1424	113.39	26.26	7.73	29.44	trace	sand
1425	113.69	25.61	2.27	8.86	trace	clay
1426	113.99	40.71	2.18	5.35	trace	clay
1427	114.30	27.54	3.09	11.22	trace	sand
1428	114.61	28.04	2.02	7.20	trace	clay
1429	114.91	31.08	1.46	4.69	trace	clay
1430	115.21	31.85	1.60	5.02	none	clay
1431	115.52	25.78	1.05	4.07	trace	clay
1432	115.82	34.22	2.02	5.90	trace	clay
1433	116.13	19.38	1.29	6.65	rare?	clay
1434	116.43	17.28	3.18	18.40	trace	sand
1435	116.74	21.11	1.30	6.15	trace	clay
1436	117.04	22.15	1.14	5.15	trace	clay
1437	117.35	23.31	1.24	5.32	trace	clay
1438	117.65	21.83	0.51	2.33	trace	clay
1439	117.96	11.95	0.08	0.67	trace	clay
1440	118.26	17.95	0.15	0.84	trace	clay
1441	118.57	27.22	0.27	0.99	trace	clay
1442	118.87	9.30	0.09	0.99	trace	clay
1443	119.18	27.81	0.24	0.97	trace	clay
1444	119.48	24.41	0.04	0.86	none	clay
1445	119.78	24.01	0.17	0.71	trace	clay
1446	120.09	20.96	0.30	1.43	rare?	clay
1447	120.40	18.02	0.17	0.94	trace	clay
1448	120.70	31.87	0.28	0.88	trace	clay
1449	121.01	27.11	0.13	0.48	trace	clay
1450	121.31	19.84	0.14	0.71	trace	clay
1451	121.62	14.97	0.16	1.07	trace	clay
1452	121.92	25.21	0.29	1.15	none	clay
1453	122.23	17.02	0.11	0.65	trace	clay
1454	122.53	19.79	0.27	1.36	trace	clay
1455	122.83	17.64	0.19	1.08	trace	clay
1456	123.14	22.84	0.28	1.23	trace	clay
1457	123.44	24.82	0.24	0.97	trace	clay
1458	123.75	24.47	0.37	1.51	trace	clay
1459	124.05	22.81	0.29	1.27	rare?	clay
1460	124.36	28.96	0.59	2.04	rare?	clay
1461	124.66	20.59	0.22	1.07	trace	clay
1462	124.97	12.79	0.31	2.42	trace	clay
1463	125.27	21.64	0.44	2.03	trace	clay
1464	125.58	28.48	0.66	2.32	trace	clay
1465	125.88	27.41	0.76	2.77	trace	clay

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1466	126.19	15.74	0.70	4.45	trace	clay
1467	126.49	26.80	1.09	4.07	trace	clay
1468	126.80	22.23	0.82	3.69	none	clay
1469	127.10	24.54	1.61	6.56	trace	clay
1470	127.41	32.81	1.61	4.91	trace	clay
1471	127.71	58.72	3.96	6.74	trace	clay
1472	128.02	25.67	0.77	3.00	none	clay
1473	128.32	37.69	0.41	1.08	none	clay
1474	128.63	26.29	0.47	1.79	trace	clay
1475	128.93	34.18	0.93	2.72	trace	clay
1476	129.24	26.90	0.59	2.19	trace	clay
1477	129.54	29.28	0.97	3.31	trace	clay
1478	129.85	39.44	1.73	4.39	trace	clay
1479	130.15	36.75	0.84	2.29	trace	clay
1480	130.45	28.67	0.62	2.16	trace	clay
1481	130.76	49.52	0.94	1.90	trace	clay
1482	131.06	23.94	0.70	2.92	trace	clay
1483	131.37	-----	-----	-----	-----	-----
1484	131.67	-----	-----	-----	-----	-----
1485	131.97	-----	-----	-----	-----	-----
1486	132.28	24.99	1.08	4.32	trace	clay
1487	132.59	29.06	4.46	15.35	trace	sand
1488	132.89	40.43	2.85	7.05	trace	clay
1489	133.20	20.38	1.30	6.38	trace	clay
1490	133.50	24.28	1.91	7.87	trace	clay
1491	133.80	30.25	2.60	8.60	trace	clay
1492	134.11	13.92	2.39	17.17	trace	sand
1493	134.42	25.61	4.05	15.81	trace	sand
1494	134.72	37.20	3.42	9.19	trace	clay
1495	135.03	33.33	3.17	9.51	trace	clay
1496	135.33	26.83	1.95	7.27	trace	clay
1497	135.64	23.12	2.63	11.38	trace	sand
1498	135.94	25.83	3.20	12.39	trace	sand
1499	136.25	33.72	5.75	17.05	trace	sand
1500	136.55	32.23	4.52	14.02	trace	sand
1501	136.86	24.86	3.57	14.36	trace	sand
1502	137.16	28.02	1.26	4.50	trace	clay
1503	137.47	25.72	0.75	2.92	trace	clay
1504	137.77	23.81	1.31	5.50	trace	clay
1505	138.07	20.47	1.01	4.93	trace	clay
1506	138.38	15.72	0.47	2.99	trace	clay
1507	138.68	19.74	0.40	2.03	trace	clay
1508	138.99	34.89	0.80	2.29	trace	clay
1509	139.29	25.97	1.03	3.97	trace	clay
1510	139.60	10.26	0.19	1.85	trace	clay
1511	139.90	32.08	0.41	1.28	trace	clay

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1512	140.21	26.22	0.44	1.68	trace	clay
1513	140.51	23.99	0.52	2.17	trace	clay
1514	140.82	33.58	0.39	1.16	trace	clay
1515	141.12	31.99	0.47	1.47	trace	clay
1516	141.43	23.77	0.54	2.27	trace	clay
1517	141.73	29.65	1.73	5.83	trace	clay
1518	142.04	38.62	0.72	1.86	trace	clay
1519	142.34	32.18	0.92	2.86	trace	clay
1520	142.65	30.10	0.69	2.29	trace	clay
1521	142.95	49.11	1.76	3.58	trace	clay
1522	143.26	26.94	0.86	3.19	trace	clay
1523	143.56	17.95	0.91	5.07	trace	clay
1524	143.87	23.60	0.65	2.75	trace	clay
1525	144.17	19.46	0.60	3.08	trace	clay
1526	144.48	18.33	0.29	1.58	trace	clay
1527	144.78	28.53	0.36	1.26	trace	clay
1528	145.09	18.76	0.40	2.13	trace	clay
1529	145.39	17.71	0.47	2.65	trace	clay
1530	145.69	24.71	0.58	2.35	trace	clay
1531	145.99	20.38	0.48	2.36	trace	clay
1532	146.30	-----	-----	-----	-----	-----
1533	146.61	-----	-----	-----	-----	-----
1534	146.91	-----	-----	-----	-----	-----
1535	147.22	-----	-----	-----	-----	-----
1536	147.52	16.88	0.45	2.66	trace	clay
1537	147.83	21.57	0.41	1.90	trace	clay
1538	148.13	19.06	0.31	1.63	trace	clay
1539	148.44	16.72	0.37	2.21	trace	clay
1540	148.74	30.31	0.41	1.35	trace	clay
1541	149.05	9.89	0.41	4.15	trace	clay
1542	149.35	35.83	1.41	3.94	trace	clay
1543	149.66	16.06	0.29	1.81	trace	clay
1544	149.96	33.84	0.82	2.42	trace	clay
1545	150.27	24.53	0.80	3.26	trace	clay
1546	150.57	16.39	0.35	2.14	trace	clay
1547	150.88	22.44	0.61	2.72	trace	clay
1548	151.18	18.22	0.40	2.20	trace	clay
1549	151.49	42.58	0.76	1.78	trace	clay
1550	151.79	35.82	0.81	2.26	trace	clay
1551	152.10	24.34	0.62	2.54	trace	clay
1552	152.40	20.32	1.06	5.22	none	clay
1553	152.71	18.37	0.63	3.43	none	clay
1554	153.01	19.54	0.45	2.30	none	clay
1555	153.31	21.86	0.56	2.56	trace	clay
1556	153.62	18.43	0.45	2.44	trace	clay
1557	153.92	15.09	0.91	6.03	trace	clay

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1558	154.23	23.44	0.68	2.90	trace	clay
1559	154.53	8.89	0.24	2.70	trace	clay
1560	154.84	42.15	1.02	2.42	trace	clay
1561	155.14	25.20	0.64	2.54	trace	clay
1562	155.44	29.74	0.86	2.89	trace	clay
1563	155.75	31.91	1.25	3.92	trace	clay
1564	156.06	18.25	1.05	5.75	trace	clay
1565	156.36	-----	-----	-----	-----	-----
1566	156.67	-----	-----	-----	-----	-----
1567	156.97	-----	-----	-----	-----	-----
1568	157.28	22.29	0.82	3.68	trace	clay
1569	157.58	24.92	1.35	5.42	trace	clay
1570	157.89	26.46	0.41	1.55	trace	clay
1571	158.19	39.01	1.29	3.31	trace	clay
1572	158.50	68.83	3.35	4.87	trace	clay
1573	158.80	34.86	1.41	4.04	trace	clay
1574	159.11	39.81	2.39	6.00	trace	clay
1575	159.41	57.09	1.65	2.89	trace	clay
1576	159.72	36.12	1.80	4.98	trace	clay
1577	160.02	61.09	1.80	2.94	trace	clay
1578	160.32	53.62	2.20	4.10	trace	clay
1579	160.63	90.79	3.58	3.94	trace	clay
1580	160.93	75.36	2.68	3.56	trace	clay
1581	161.24	68.10	2.89	4.24	trace	clay
1582	161.54	55.55	2.27	4.09	trace	clay
1583	161.85	59.18	4.03	6.81	trace	clay
1584	162.15	35.06	1.24	3.54	trace	clay
1585	162.46	61.93	5.59	9.51	trace	clay
1586	162.76	41.86	1.62	3.87	trace	clay
1587	163.07	20.94	1.27	6.06	trace	clay
1588	163.37	17.41	0.67	3.85	trace	clay
1589	163.68	30.77	1.32	4.29	trace	clay
1590	163.98	-----	-----	-----	-----	-----
1591	164.29	-----	-----	-----	-----	-----
1592	164.59	-----	-----	-----	-----	-----
1593	164.90	-----	-----	-----	-----	-----
1594	165.20	-----	-----	-----	-----	-----
1595	165.51	-----	-----	-----	-----	-----
1596	165.81	-----	-----	-----	-----	-----
1597	166.12	-----	-----	-----	-----	-----
1598	166.42	-----	-----	-----	-----	-----
1599	166.72	-----	-----	-----	-----	-----
1600	167.03	30.71	1.26	4.10	trace	clay
1601	167.34	23.99	0.63	2.63	trace	clay
1602	167.64	35.37	1.95	5.51	trace	clay
1603	167.95	28.53	1.65	5.78	trace	clay

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1604	168.25	56.58	1.80	3.18	trace	clay
1605	168.55	14.61	0.40	2.74	trace	clay
1606	168.86	28.96	0.81	2.78	trace	clay
1607	169.16	27.06	1.07	3.95	trace	clay
1608	169.47	22.80	0.82	3.60	trace	clay
1609	169.77	13.23	0.28	2.12	trace	clay
1610	170.08	29.80	0.46	1.54	trace	clay
1611	170.38	46.14	0.92	1.99	none	clay
1612	170.69	31.22	0.49	1.57	trace	clay
1613	170.99	84.91	1.90	2.24	trace	clay
1614	171.30	57.52	0.75	1.30	trace	clay
1615	171.60	-----	-----	-----	-----	-----
1616	171.91	-----	-----	-----	-----	-----
1617	172.21	26.48	0.52	1.96	trace	clay
1618	172.52	-----	-----	-----	-----	-----
1619	172.82	38.25	1.75	4.58	none	clay
1620	173.13	-----	3.82	-----	none	clay
1621	173.43	59.06	5.18	8.77	none	clay
1622	173.74	24.49	2.13	8.70	trace	clay
1623	174.04	43.68	9.75	22.32	trace	sand
1624	174.34	35.81	4.82	13.46	trace	sand
1625	174.65	39.57	1.57	3.97	trace	clay
1626	174.96	12.74	1.09	8.56	trace	clay
1627	175.26	14.65	1.65	11.26	rare?	sand
1628	175.56	19.38	2.85	14.71	trace	sand
1629	175.87	38.58	2.34	6.07	none	clay
1630	176.17	23.77	1.73	7.28	trace	clay
1631	176.48	45.38	2.22	4.89	trace	clay
1632	176.78	26.16	1.04	3.98	trace	clay
1633	177.09	19.40	0.81	4.18	none	clay
1634	177.39	46.58	7.60	16.32	trace	sand
1635	177.70	17.10	2.16	12.63	none	sand
1636	178.00	20.55	1.19	5.79	none	sand
1637	178.31	-----	3.72	-----	none	clay
1638	178.61	42.76	-----	-----	none	-----
1639	178.92	33.31	6.65	19.96	none	sand
1640	179.22	48.20	9.09	18.86	trace	sand
1641	179.53	27.77	2.68	9.65	none	clay
1642	179.83	22.17	0.58	2.62	none	clay
1643	180.14	-----	0.61	-----	trace	clay
1644	180.44	16.49	1.38	8.37	none	clay
1645	180.75	-----	-----	-----	-----	-----
1646	181.05	-----	-----	-----	-----	-----
1647	181.36	15.82	0.74	4.68	trace	clay
1648	181.66	21.59	4.03	18.67	trace	sand
1649	181.97	30.23	2.87	9.49	trace	clay

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1650	182.27	20.22	1.54	7.26	trace	clay
1651	182.58	15.37	0.97	6.31	trace	clay
1652	182.88	49.20	0.48	0.98	trace	clay
1653	183.19	28.94	0.18	0.62	trace	clay
1654	183.49	34.80	0.33	0.95	rare?	clay
1655	183.79	36.01	0.59	1.64	trace	clay
1656	184.10	-----	2.33	-----	trace	sand
1657	184.40	83.22	0.62	0.75	trace	clay
1658	184.71	48.16	0.63	1.31	none	clay
1659	185.01	62.56	1.84	2.94	trace	clay
1660	185.32	33.13	-----	-----	trace	clay
1661	185.62	-----	-----	-----	-----	-----
1662	185.93	-----	-----	-----	-----	-----
1663	186.23	-----	-----	-----	-----	-----
1664	186.54	45.45	0.58	1.27	trace	clay
1665	186.84	32.08	0.03	0.09	trace	clay
1666	187.15	32.89	0.21	0.64	rare?	clay
1667	187.45	59.14	0.68	1.15	trace	clay
1668	187.76	32.90	0.89	2.71	trace	clay
1669	188.06	35.68	1.74	5.02	trace	clay
1670	188.37	43.15	0.21	0.49	trace	clay
1671	188.67	36.67	0.19	0.52	trace	clay
1672	188.98	56.10	3.67	6.54	trace	clay
1673	189.28	43.42	0.24	0.55	trace	clay
1674	189.59	31.30	0.18	0.58	trace	clay
1675	189.89	33.61	0.05	0.15	trace	clay
1676	190.20	-----	-----	-----	-----	-----
1677	190.50	-----	-----	-----	-----	-----
1678	190.81	-----	-----	-----	-----	-----
1679	191.11	43.05	0.12	0.28	trace	clay
1680	191.41	46.84	0.12	0.26	trace	clay
1681	191.72	13.63	0.09	0.66	trace	clay
1682	192.02	35.73	0.26	0.73	trace	clay
1683	192.33	31.24	0.10	0.32	trace	clay
1684	192.63	45.62	0.08	0.18	trace	clay
1685	192.94	38.97	0.07	0.18	trace	clay
1686	193.24	35.20	0.23	0.65	trace	clay
1687	193.55	41.38	0.08	0.19	trace	clay
1688	193.85	26.08	0.07	0.27	trace	clay
1689	194.16	88.90	1.23	1.38	trace	clay
1690	194.46	45.91	0.15	0.33	none	clay
1691	194.77	59.49	0.20	0.37	trace	clay
1692	195.07	54.51	0.08	0.15	none	clay
1693	195.38	47.11	0.80	1.70	none	clay
1694	195.68	94.08	0.13	0.14	none	clay
1695	195.98	76.98	0.28	0.36	none	clay

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1696	196.29	49.36	0.11	0.22	none	clay
1697	196.60	44.75	0.25	0.56	none	clay
1698	196.90	-----	-----	-----	-----	-----
1699	197.21	61.45	0.26	0.42	none	clay
1700	197.51	27.21	0.13	0.48	none	clay
1701	197.82	49.13	0.13	0.26	none	clay
1702	198.12	38.17	0.08	0.21	none	clay
1702	198.43	46.55	0.10	0.21	none	clay
1704	198.73	21.84	0.15	0.69	none	clay
1705	199.03	38.56	1.30	3.37	trace	clay
1706	199.34	32.57	0.14	0.43	none	clay
1707	199.64	26.88	0.13	0.48	none	clay
1708	199.95	32.76	0.07	0.21	none	clay
1709	200.25	49.02	0.25	0.51	none	clay
1710	200.56	42.12	0.30	0.71	trace	clay
1711	200.86	49.49	1.90	3.84	trace	clay
1712	201.17	-----	0.99	-----	trace	clay
1713	201.47	48.07	6.61	13.75	trace	sand
1714	201.78	12.78	0.40	3.13	trace	clay
1715	202.08	34.80	0.38	1.09	trace	clay
1716	202.39	-----	0.38	-----	none	clay
1717	202.69	-----	0.48	-----	trace	clay
1718	202.99	27.70	0.99	3.57	trace	clay
1719	203.30	17.08	0.26	1.52	trace	clay
1720	203.61	35.47	0.64	1.80	trace	clay
1721	203.91	20.43	0.36	1.76	trace	clay
1722	204.22	48.55	3.51	7.00	rare?	clay
1723	204.52	44.59	6.15	13.79	rare?	sand
1724	204.83	18.74	0.60	3.20	trace	clay
1725	205.13	47.94	1.93	4.05	trace	clay
1726	205.44	-----	2.04	-----	trace	clay
1727	205.74	13.77	1.25	9.08	trace	clay
1728	206.05	50.34	1.27	2.52	trace	clay
1729	206.35	37.22	0.45	1.21	trace	clay
1730	206.65	35.35	0.62	1.75	trace	clay
1731	206.96	30.90	0.45	1.46	trace	clay
1732	207.26	-----	0.37	-----	none	clay
1733	207.57	38.00	0.56	1.47	trace	clay
1734	207.87	17.83	0.43	2.41	trace	clay
1735	208.18	25.15	0.31	1.23	trace	clay
1736	208.48	19.30	0.50	2.59	trace	clay
1737	208.79	36.15	0.49	1.36	trace	clay
1738	209.09	29.60	0.48	1.62	none	clay
1739	209.40	10.54	0.34	3.22	trace	clay
1740	209.70	12.87	0.15	1.17	trace	clay
1741	210.01	33.41	0.71	2.13	trace	clay

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1742	210.31	23.43	0.48	2.05	trace	clay
1743	210.62	22.30	0.33	1.48	none	clay
1744	210.92	18.84	0.36	1.91	none	clay
1745	211.23	22.78	0.47	2.06	trace	clay
1746	211.53	24.40	0.64	2.62	trace	clay
1747	211.84	-----	-----	-----	-----	-----
1748	212.14	14.06	0.29	2.00	none	clay
1749	212.44	44.74	1.25	2.79	trace	clay
1750	212.75	17.12	0.46	2.69	none	clay
1751	213.06	29.47	1.05	3.56	trace	clay
1752	213.36	21.18	0.44	2.08	trace	clay
1753	213.67	23.56	0.66	2.80	trace	clay
1754	213.97	17.25	0.42	2.01	trace	clay
1755	214.27	18.97	0.35	1.85	trace	clay
1756	214.58	32.45	2.00	6.16	rare?	clay
1757	214.88	41.14	0.94	2.28	rare?	clay
1758	215.19	22.09	0.44	1.99	trace	clay
1759	215.49	19.26	0.09	0.47	trace	clay
1760	215.80	41.20	-----	-----	trace	clay
1761	216.10	-----	0.34	-----	trace	clay
1762	216.41	30.43	0.45	1.48	trace	clay
1763	216.71	13.17	0.10	0.76	none	clay
1764	217.02	44.96	0.37	0.82	trace	clay
1765	217.32	20.02	0.13	0.65	none	clay
1766	217.63	-----	0.08	-----	trace	clay
1767	217.93	22.18	0.19	0.86	trace	clay
1768	218.24	14.15	0.12	0.85	none	clay
1769	218.54	33.83	0.30	0.89	none	clay
1770	218.85	29.39	0.50	1.70	trace	clay
1771	219.15	47.56	0.43	0.90	trace	clay
1772	219.46	30.27	0.29	0.95	trace	clay
1773	219.76	14.62	0.18	1.23	none	clay
1774	220.07	32.27	0.38	1.31	none	clay
1775	220.37	-----	-----	-----	-----	-----
1776	220.68	27.91	0.10	0.36	trace	clay
1777	220.98	25.00	0.21	0.84	none	clay
1778	221.29	18.44	0.10	0.54	trace	clay
1779	221.59	19.72	0.49	2.48	none	clay
1780	221.89	25.72	0.18	0.70	none	clay
1781	222.20	33.58	0.26	0.77	trace	clay
1782	222.50	38.39	3.22	8.39	trace	clay
1783	222.81	21.87	1.71	7.81	trace	clay
1784	223.11	21.43	1.04	4.85	trace	clay
1785	223.42	32.87	2.29	6.97	trace	clay
1786	223.72	18.61	1.11	5.96	trace	clay
1787	224.03	-----	0.63	-----	trace	clay

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1788	224.33	20.22	0.28	1.38	trace	clay
1789	224.64	35.23	5.66	16.07	trace	sand
1790	224.94	19.19	0.72	3.75	trace	clay
1791	225.25	15.25	1.65	10.82	trace	sand
1792	225.55	17.58	1.51	8.59	trace	clay
1793	225.86	-----	0.23	-----	none	clay
1794	226.16	35.97	3.23	8.98	trace	clay
1795	226.47	29.81	3.51	11.77	trace	sand
1796	226.77	44.92	3.91	8.70	trace	clay
1797	227.08	-----	-----	-----	-----	-----
1798	227.38	-----	-----	-----	-----	-----
1799	227.69	37.17	2.67	7.18	trace	clay
1800	227.99	21.50	1.17	5.44	trace	clay
1801	228.30	39.03	1.70	4.36	trace	clay
1802	228.60	17.25	-----	-----	-----	-----
1803	228.91	25.15	1.71	6.80	trace	clay
1804	229.21	12.37	0.89	7.19	trace	clay
1805	229.51	17.19	1.30	7.56	trace	clay
1806	229.82	-----	-----	-----	-----	-----
1807	230.12	42.77	-----	-----	trace	clay
1808	230.43	23.61	0.23	0.97	trace	clay
1809	230.73	42.27	3.55	8.40	trace	clay
1810	231.04	46.29	3.13	6.76	trace	clay
1811	231.34	36.24	1.24	3.42	trace	clay
1812	231.65	22.68	1.09	4.81	trace	clay
1813	231.95	23.23	1.35	5.81	trace	clay
1814	232.26	20.99	0.17	0.81	none	clay
1815	232.56	34.58	1.48	4.28	trace	clay
1816	232.87	20.90	1.46	6.99	trace	clay
1817	233.17	19.96	0.65	3.26	trace	clay
1818	233.48	18.02	1.12	6.22	trace	clay
1819	233.78	23.70	1.44	6.08	trace	clay
1820	234.09	27.12	2.25	8.30	trace	clay
1821	234.39	41.99	1.11	2.64	trace	clay
1822	234.70	44.15	1.13	2.66	none	clay
1823	235.00	-----	-----	-----	-----	-----
1824	235.31	23.67	0.04	0.17	none	clay
1825	235.61	21.94	0.04	0.18	none	clay
1826	235.92	35.30	-----	-----	trace	clay
1827	236.22	28.65	0.06	0.21	trace	clay
1828	236.52	36.03	0.25	0.69	none	clay
1829	236.83	28.01	0.14	0.50	trace	clay
1830	237.13	31.52	0.12	0.38	trace	clay
1831	237.44	28.00	0.05	0.18	trace	clay
1832	237.74	28.22	0.18	0.64	trace	clay
1833	238.05	27.64	0.11	0.40	none	clay

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1834	238.35	34.34	0.07	0.20	trace	clay
1835	238.66	15.76	0.05	0.32	none	clay
1836	238.96	8.77	.01	.11	trace	clay
1837	239.27	14.10	0.03	0.21	trace	clay
1838	239.57	22.89	0.05	0.22	trace	clay
1839	239.88	11.38	0.01	0.09	trace	clay
1840	240.18	13.85	0.13	0.94	trace	clay
1841	240.49	17.41	0.15	0.86	trace	clay
1842	240.79	-----	0.10	-----	trace	clay
1843	241.09	38.49	0.33	0.86	trace	clay
1844	241.40	37.80	0.06	0.16	none	clay
1845	241.71	23.32	0.03	0.13	none	clay
1846	242.01	-----	-----	-----	-----	-----
1847	242.32	-----	-----	-----	-----	-----
1848	242.62	-----	-----	-----	-----	-----
1849	242.93	-----	-----	-----	-----	-----
1850	243.23	-----	-----	-----	-----	-----
1851	243.54	-----	-----	-----	-----	-----
1852	243.84	-----	-----	-----	-----	-----
1853	244.15	-----	-----	-----	-----	-----
1854	244.45	-----	-----	-----	-----	-----
1855	244.75	10.46	0.01	0.10	none	clay
1856	245.06	36.41	0.01	0.03	none	clay
1857	245.36	31.56	0.01	0.03	none	clay
1858	245.67	-----	0.01	-----	none	clay
1859	245.97	24.56	0.02	0.08	none	clay
1860	246.28	19.01	0.01	0.05	none	clay
1861	246.58	22.73	0.01	0.04	none	clay
1862	246.89	32.39	0.01	0.03	none	clay
1863	247.19	40.34	0.01	0.02	none	clay
1864	247.50	24.70	0.01	0.04	none	clay
1865	247.80	27.47	0.22	0.80	none	clay
1866	248.11	24.43	0.10	0.41	trace	clay
1867	248.41	24.68	0.12	0.49	trace	clay
1868	248.72	33.56	0.17	0.51	none	clay
1869	249.02	37.45	0.22	0.59	trace	clay
1870	249.33	37.55	0.41	1.09	trace	clay
1871	249.63	8.49	0.05	0.59	none	clay
1872	249.94	20.69	0.34	1.64	none	clay
1873	250.24	25.98	0.03	0.12	trace	clay
1874	250.55	36.11	0.02	0.06	none	clay
1875	250.85	16.81	0.01	0.06	none	clay
1876	251.16	17.61	0.03	0.17	none	clay
1877	251.46	28.49	0.08	0.28	none	clay
1878	251.77	23.12	0.08	0.35	none	clay
1879	252.07	29.26	0.01	0.03	none	clay

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1880	252.37	29.28	0.22	0.75	none	clay
1881	252.68	42.84	0.20	0.47	none	clay
1882	252.98	14.77	0.07	0.47	none	clay
1883	253.29	33.52	0.19	0.57	none	clay
1884	253.59	31.71	0.31	0.98	none	clay
1885	253.89	21.00	0.25	1.19	none	clay
1886	254.20	-----	-----	-----	-----	-----
1887	254.51	13.47	0.10	0.74	trace	clay
1888	254.81	36.73	0.31	0.84	trace	clay
1889	255.12	31.99	0.34	1.06	trace	clay
1890	255.42	43.75	0.21	0.48	none	clay
1891	255.73	26.32	0.14	0.53	trace	clay
1892	256.03	18.86	0.27	1.43	trace	clay
1893	256.34	17.72	0.18	1.02	none	clay
1894	256.64	44.83	0.33	0.74	trace	clay
1895	256.95	61.88	0.66	1.07	none	clay
1896	257.25	44.49	0.28	0.63	none	clay
1897	257.56	28.82	0.19	0.66	none	clay
1898	257.86	22.90	0.07	0.31	trace	clay
1899	258.17	15.40	0.01	0.06	none	clay
1900	258.47	22.37	0.16	0.72	none	clay
1901	258.78	30.99	0.24	0.77	none	clay
1902	259.08	28.95	0.19	0.66	none	clay
1903	259.39	20.85	0.31	1.49	none	clay
1904	259.69	23.08	0.24	1.04	trace	clay
1905	259.99	26.17	0.40	1.53	none	clay
1906	260.30	19.15	0.50	2.61	none	clay
1907	260.60	41.40	1.98	4.78	none	clay
1908	260.91	28.35	1.52	5.36	none	clay
1909	261.21	18.19	1.53	8.41	trace	clay
1910	261.52	15.35	-----	-----	-----	-----
1911	261.82	25.00	2.46	9.84	none	clay
1912	262.13	22.96	1.08	4.70	none	clay
1913	262.43	14.39	0.36	2.50	trace	clay
1914	262.74	16.17	0.53	3.28	trace	clay
1915	263.04	21.46	0.59	2.75	trace	clay
1916	263.35	48.34	2.32	4.80	trace	clay
1917	263.65	23.82	0.87	3.65	trace	clay
1918	263.95	25.20	0.93	3.69	-----	-----
1919	264.26	19.92	1.40	7.03	trace	clay
1920	264.57	29.34	1.96	6.68	trace	clay
1921	264.87	31.86	1.17	3.67	trace	clay
1922	265.18	28.11	1.53	5.44	trace	clay
1923	265.48	22.53	1.07	4.75	trace	clay
1924	265.79	24.32	0.67	2.75	trace	clay
1925	266.09	24.25	2.79	11.51	trace	sand

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1926	266.40	24.26	0.85	3.50	trace	clay
1927	266.70	19.82	-----	-----	trace	clay
1928	267.01	10.58	-.01	0.09	trace	clay
1929	267.31	19.63	0.82	4.18	trace	clay
1930	267.61	29.06	0.68	2.34	trace	clay
1931	267.92	35.57	1.12	3.15	trace	clay
1932	268.22	35.75	0.74	2.07	trace	clay
1933	268.53	12.94	0.27	2.09	trace	clay
1934	268.83	18.80	0.42	2.23	trace	clay
1935	269.14	12.55	0.10	0.80	trace	clay
1936	269.44	33.35	0.22	0.66	trace	clay
1937	269.75	48.52	0.62	1.28	trace	clay
1938	270.05	22.39	0.24	1.07	trace	clay
1939	270.36	25.68	0.10	0.39	none	clay
1940	270.66	33.87	0.25	0.74	none	clay
1941	270.97	47.38	0.24	0.51	none	clay
1942	271.27	20.36	0.07	0.34	none	clay
1943	271.58	18.34	0.12	0.65	trace	clay
1944	271.88	26.78	0.11	0.41	none	clay
1945	272.19	-----	0.17	-----	none	clay
1946	272.49	34.51	0.54	1.56	none	clay
1947	272.80	18.18	0.41	2.26	trace	clay
1948	273.10	27.12	1.22	4.50	trace	clay
1949	273.41	32.15	1.45	4.51	trace	clay
1950	273.71	22.16	0.48	2.17	rare?	clay
1951	274.02	18.11	0.39	2.15	rare?	clay
1952	274.32	25.67	1.07	4.17	trace	clay
1953	274.63	37.07	0.74	1.99	trace	clay
1954	274.93	43.42	1.32	3.04	trace	clay
1955	275.23	29.74	0.62	2.08	trace	clay
1956	275.54	30.36	0.43	1.42	trace	clay
1957	275.84	25.52	0.47	1.84	none	clay
1958	276.15	38.38	0.65	1.69	trace	clay
1959	276.45	25.16	0.31	1.23	trace	clay
1960	276.76	24.60	0.41	1.67	trace	clay
1961	277.06	43.41	2.36	5.44	trace	clay
1962	277.37	38.97	1.36	3.49	none	clay
1963	277.67	17.19	-----	-----	trace	clay
1964	277.98	39.39	2.64	6.70	trace	clay
1965	278.28	29.23	1.00	3.42	trace	clay
1966	278.58	30.34	0.76	2.56	trace	clay
1967	278.89	52.56	2.35	4.47	trace	clay
1968	279.20	24.86	2.54	10.22	trace	sand
1969	279.50	38.23	-----	-----	rare?	clay
1970	279.81	25.61	1.15	4.49	none	clay
1971	280.11	36.67	1.26	3.44	none	clay

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38µm (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
1972	280.42	17.14	-----	-----	none	clay
1973	280.72	16.95	-----	-----	none	clay
1974	281.03	28.60	0.85	2.97	trace	clay
1975	281.33	30.86	0.90	2.92	trace	clay
1976	281.64	26.12	0.39	1.49	trace	clay
1977	281.94	39.70	1.53	3.85	trace	clay
1978	282.25	36.67	0.98	2.67	trace	clay
1979	282.55	29.18	0.77	2.64	trace	clay
1980	282.85	23.96	1.62	6.76	trace	clay
1981	283.16	44.76	-----	-----	trace	clay
1982	283.46	16.89	-----	-----	trace	clay
1983	283.77	-----	-----	-----	-----	-----
1984	284.07	19.86	0.40	2.01	trace	clay
1985	284.38	26.50	0.44	1.66	trace	clay
1986	284.68	37.46	0.74	1.98	trace	clay
1987	284.98	32.48	-----	-----	trace	clay
1988	285.29	14.98	-----	-----	trace	clay
1989	285.60	33.38	0.82	2.46	none	clay
1990	285.90	24.83	0.36	1.45	none	clay
1991	286.21	19.81	0.24	1.25	trace	clay
1992	286.51	27.74	0.60	2.16	trace	clay
1993	286.82	34.34	0.59	1.72	trace	clay
1994	287.12	24.10	0.22	0.91	trace	clay
1995	287.43	21.36	0.15	0.70	trace	clay
1996	287.73	36.65	0.51	1.39	trace	clay
1997	288.04	22.90	0.45	1.97	trace	clay
1998	288.34	37.19	0.59	1.59	trace	clay
1999	288.65	-----	-----	-----	-----	-----
2000	288.95	25.29	0.24	0.95	trace	clay
2001	289.26	-----	0.22	-----	trace	clay
2002	289.56	17.71	0.23	1.30	trace	clay
2003	289.86	25.31	0.22	0.87	trace	clay
2004	290.17	26.82	0.65	2.42	trace	clay
2005	290.47	45.26	1.65	3.65	trace	clay
2006	290.78	27.17	0.53	1.95	none	clay
2007	291.08	22.48	0.09	0.40	trace	clay
2008	291.39	25.87	0.41	1.58	none	clay
2009	291.69	49.64	1.26	2.54	trace	clay
2010	291.99	33.73	0.83	2.46	trace	clay
2011	292.30	19.37	0.33	1.70	trace	clay
2012	292.61	-----	0.32	-----	trace	clay
2013	292.91	30.94	0.67	2.17	trace	clay
2014	293.22	30.59	0.61	1.99	trace	clay
2015	293.52	36.27	0.50	1.38	trace	clay
2016	293.83	50.76	0.67	1.32	trace	clay
2017	294.13	24.95	0.41	1.64	trace	clay

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
2018	294.44	29.68	0.32	1.08	trace	clay
2019	294.74	20.09	0.93	4.63	trace	clay
2020	295.05	18.18	0.19	1.05	trace	clay
2021	295.35	18.62	0.30	1.61	trace	clay
2022	295.66	-----	0.19	-----	trace	clay
2023	295.96	16.36	0.20	1.22	trace	clay
2024	296.27	33.39	0.20	0.60	trace	clay
2025	296.57	17.68	0.09	0.51	trace	clay
2026	296.88	27.20	0.42	1.54	none	clay
2027	297.18	26.64	0.20	0.75	trace	clay
2028	297.48	23.92	0.26	1.09	trace	clay
2029	297.79	15.40	0.21	1.36	trace	clay
2030	298.09	-----	-----	-----	-----	-----
2031	298.40	15.77	0.10	0.63	trace	clay
2032	298.70	29.87	0.46	1.54	trace	clay
2033	299.01	35.30	0.55	1.56	none	clay
2034	299.31	44.95	0.72	1.60	rare	clay
2035	299.62	23.85	0.37	1.55	rare	clay
2036	299.92	15.01	0.37	2.47	common	clay
2037	300.23	22.81	1.01	4.28	abund.	clay
2038	300.53	22.94	0.46	2.01	abund.	clay
2039	300.84	21.22	0.77	3.67	abund.	clay
2040	301.14	30.07	2.97	9.88	layer	clay
2041	301.45	34.26	1.04	3.04	abund.	clay
2042	301.75	23.22	0.48	2.07	common	clay
2043	302.06	51.95	1.61	3.10	common	clay
2044	302.36	19.17	0.47	2.45	common	clay
2045	302.67	25.99	0.64	2.46	common	clay
2046	302.97	-----	-----	-----	-----	-----
2047	303.28	-----	-----	-----	-----	-----
2048	303.58	39.53	0.94	2.38	rare	clay
2049	303.89	-----	0.30	-----	trace	clay
2050	304.19	21.26	0.51	2.40	trace	clay
2051	304.50	26.23	0.79	3.01	trace	clay
2052	304.80	18.16	1.37	7.54	trace	clay
2053	305.11	-----	0.54	3.38	trace	clay
2054	305.41	28.13	0.95	4.25	trace	clay
2055	305.71	17.63	0.58	trace	clay	
2056	306.02	19.53	0.83	4.25	trace	clay
2057	306.32	30.63	1.02	3.33	trace	clay
2058	306.63	22.62	0.77	3.40	trace	clay
2059	306.93	-----	-.01	-----	trace	clay
2060	307.24	-----	0.50	-----	trace	clay
2061	307.54	35.75	1.17	3.27	trace	clay
2062	307.85	17.21	0.64	3.72	trace	clay
2063	308.15	-----	-----	-----	-----	-----

(Leaders indicate no core recovery or no data available)

Depth below sea level (feet)	Depth below sea floor (meters)	Total sample weight (grams)	Coarse fraction weight >38 μ m (grams)	Coarse fraction (percent)	Ash abund- ance	Litho- logy
2064	308.46	21.48	0.54	2.51	trace	clay
2065	308.76	42.47	1.30	3.06	trace	clay
2066	309.07	18.76	0.41	2.18	trace	clay
2067	309.37	11.66	0.24	2.06	trace	clay
2068	309.68	49.79	4.01	8.05	trace	clay
2069	309.98	20.55	1.16	5.64	trace	clay
2070	310.29	10.06	0.23	2.29	trace	clay

APPENDIX 3: ANALYTICAL RESULTS

Analytical data are X-ray counts from the energy-dispersive electron microprobe; C.E.

Meyer, analyst, 1986.

(Numbers shown are X-ray counts; weight percentages are before recalculation to 100 %)

SAMPLE E67-126A-1176

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	1108	198	25437	26082	9950	889	50	111	543
2	1156	212	26087	26767	11440	838	30	174	519
3	1180	191	25756	26009	10794	794	41	155	492
4	1010	176	25912	26266	12030	782	40	171	494
5	1069	189	25508	26346	11450	833	41	175	495
6	914	194	25829	26025	10809	935	23	144	430
7	1070	175	25310	25869	10175	748	38	148	546
8	1182	204	26785	26826	12567	987	41	136	488
9	966	205	25215	26017	11170	719	34	145	602
10	831	193	25044	26007	12584	611	55	151	529
11	1087	192	25110	26119	9955	745	38	159	475
12	1214	241	26453	25746	10916	996	55	113	485
13	1386	193	26593	27142	9915	1144	42	110	381
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Ave.	1065	197	25703	26173	11153	823	41	149	508
Wt. %	2.016	0.038	11.38	72.19	5.352	0.275	0.109	0.094	0.797

SAMPLE E67-126A-1254

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	1647	237	26866	26397	10823	1264	41	132	537
2	1542	188	26117	26469	10713	1005	42	141	383
3	1647	241	27763	25960	11107	1207	44	126	514
4	1247	219	26780	26784	11475	1264	31	122	429
5	1113	212	27453	26716	11907	1305	35	136	456
6	1223	216	26929	26790	11441	1300	38	131	477
7	1516	262	26457	26862	10242	1285	49	145	499
8	963	238	27533	25147	11622	951	56	152	571
9	1078	242	26397	25122	10747	1093	66	135	599
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Ave.	1331	228	26922	26250	11120	1186	45	136	496
Wt. %	2.506	0.076	11.92	72.53	5.335	0.454	0.128	0.071	0.773

(Numbers shown are X-ray counts; weight percentages are before recalculation to 100 %)

SAMPLE E67-126A-1265

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	1078	235	26894	25438	10686	1402	44	106	530
2	1458	217	27253	26257	11276	1121	38	142	409
3	1102	207	26967	26937	12668	961	41	118	431
4	1115	225	26501	26890	11831	1211	45	128	420
5	1354	170	25908	26224	11512	789	34	178	466
6	1205	220	26237	26209	12296	943	40	125	461
7	1162	209	26165	26373	11426	1036	35	112	428
8	1022	239	27086	26761	12666	1114	40	129	473
9	1049	216	26170	25850	11545	1039	39	147	434
10	1344	188	25852	26218	9957	772	38	162	505
11	1222	232	26053	25868	10357	1055	52	128	502
12	945	196	26137	25916	10745	1185	40	106	596
13	1151	229	26272	26256	12345	992	37	178	474
14	1094	310	27171	24913	9936	1672	62	142	622
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Ave.	1164	221	26476	26151	11375	1092	42	136	
Wt. %	2.198	0.067	11.72	72.19	5.459	0.407	0.115	0.072	0.746

SAMPLE E67-126A-1303

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	1079	182	25551	25460	9817	884	40	113	812
2	1072	198	27063	26768	12737	1150	49	122	468
3	1003	214	26281	25834	10882	1019	34	175	357
4	1329	195	26192	26550	11865	858	52	155	495
5	1135	183	25685	26276	12212	739	40	176	518
6	1450	230	27596	25679	10268	1108	38	149	503
7	1392	188	27529	26437	11297	1042	38	151	355
8	1196	206	26309	26922	12461	1171	43	117	422
9	1306	190	27009	25940	11366	970	35	127	356
10	1087	184	25732	26114	10834	1036	37	123	394
11	1054	210	25099	25638	10810	1241	32	129	608
12	1322	180	26031	26501	11299	860	36	143	502
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Ave.	1202	197	26339	26177	11321	1007	40	140	483
Wt. %	2.269	0.037	11.66	72.26	5.433	0.365	0.103	0.079	0.747

(Numbers shown are X-ray counts; weight percentages are before recalculation to 100 %)

SAMPLE E67-126A-2040 (Analysis 1)

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	1608	183	26350	25992	9442	1221	42	131	772
2	1636	184	25953	26325	10077	1327	38	126	902
3	1688	180	25945	26008	9631	1417	46	117	847
4	1594	195	26250	25969	10120	1377	58	133	957
5	1703	189	25731	26163	8947	1267	86	118	826
6	1720	174	25929	26279	9833	1346	53	113	914
7	1623	172	25988	26382	9721	1366	36	107	898
8	1719	182	26162	26138	9243	1225	31	124	733
9	1616	174	25295	26299	9989	1358	48	115	936
10	1645	200	25398	25521	9138	1343	51	136	966
11	1594	171	26065	26224	9567	1337	49	145	918
12	1632	179	25763	26093	9624	1353	54	116	895
13	1738	149	25948	26191	8908	1379	58	104	916
14	1779	191	26355	25946	9123	1525	54	134	1069
15	1803	194	26200	26312	9159	1240	38	110	793
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Ave.	1673	181	25956	27123	9502	1338	49	122	890
Wt. %	3.171	0.018	11.56	72.31	4.545	0.528	0.151	0.047	1.532

SAMPLE E67-126A-2040 (Analysis 2)

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	1919	188	28038	27088	10706	1471	35	105	993
2	2050	186	27584	27469	9984	1444	40	128	976
3	1888	200	27423	27654	10190	1480	64	127	1036
4	2069	198	27719	27903	10234	1332	37	124	796
5	1923	179	27755	27236	10104	1446	45	123	999
6	1984	170	27173	27547	10662	1425	62	147	963
7	1984	195	27197	27371	10343	1427	34	132	961
8	2046	185	27290	27825	10099	1470	51	125	935
9	1946	184	27782	27461	10134	1462	42	117	1012
10	1996	190	27047	27339	10390	1386	34	117	943
11	1921	222	27208	27588	10649	1420	38	121	1009
12	1937	187	27333	27529	10337	1426	39	102	939
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Ave.	1972	190	27462	27501	10269	1433	43	122	964
Wt. %	3.072	0.028	11.49	72.09	4.638	0.544	0.121	0.047	1.557

(Numbers shown are X-ray counts; weight percentages are before recalculation to 100 %)

SAMPLE E67-126A-2040 (Analysis 3)

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	819	187	26552	26586	9549	1303	50	101	765
2	889	173	26704	26424	9238	1290	39	127	812
3	774	193	26699	26855	8868	1415	45	123	865
4	713	180	26140	26685	9792	1313	39	115	881
5	783	186	26783	26575	10010	1443	46	119	953
6	852	178	26045	26669	9264	1343	30	107	918
7	754	190	26220	26719	9775	1391	55	106	883
8	851	168	26534	26682	9481	1360	34	119	909
9	873	197	26534	26551	9281	1496	60	120	923
10	875	206	26300	26562	9500	1230	39	114	817
11	812	166	26492	26748	8549	1365	50	136	936
12	830	205	26424	26594	9781	1366	36	120	929
13	978	188	26460	26747	9733	1300	28	112	810
14	719	169	26261	26964	9214	1356	33	143	828
15	713	200	26250	26632	9812	1390	51	138	897
16	758	186	25956	26670	9544	1346	40	135	911
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Ave.	812	186	26397	26666	9462	1357	42	121	877
Wt. %	3.143	0.023	11.61	72.72	4.501	0.533	0.120	0.046	1.487

SAMPLE USGS-T5-8-67W104 (Lava Creek 'B')

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	2055	197	27665	27649	10015	1255	36	122	785
2	1958	177	28012	27371	10262	1366	35	121	759
3	1823	163	27888	27565	10721	1414	40	115	879
4	2112	184	28025	27841	10137	1251	38	105	802
5	2030	181	27430	27632	10182	1303	36	111	794
6	2030	191	28158	28062	10645	1269	32	118	780
7	2074	192	27498	27742	10377	1294	42	120	857
8	2067	186	27659	27894	10527	1251	32	98	727
9	2049	190	27767	27411	10508	1326	34	110	833
10	2049	188	27732	27606	10703	1335	49	118	835
11	1826	182	27567	28038	10779	1340	28	123	853
12	1991	181	27867	27690	10503	1330	30	103	823
13	2231	195	27782	28151	9459	1249	27	109	665
14	2078	175	27830	27618	10339	1328	31	115	772
15	2047	183	27575	28003	10253	1275	50	143	851
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Ave.	2028	184	27764	27752	10361	1305	36	115	801
Wt. %	3.146	0.021	11.60	72.72	4.501	0.683	0.085	0.036	1.265

(Numbers shown are X-ray counts; weight percentages are before recalculation to 100 %)

SAMPLE USGS-T116-4-ORNA-1 (Lava Creek 'B')

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	880	195	26301	26770	9680	1266	47	100	766
2	965	191	26820	27168	10152	1281	35	110	741
3	909	190	26166	26697	10713	1312	51	90	853
4	795	185	26448	26500	11053	1273	40	112	779
5	826	174	26499	26810	9763	1252	35	118	752
6	766	184	26507	26969	9894	1333	35	115	906
7	720	186	26472	27020	10423	1257	34	105	717
8	1047	165	26530	26775	9954	1297	36	132	818
9	953	178	26713	26829	9951	1257	56	104	810
10	936	190	26728	26695	10363	1326	39	103	770
11	802	154	26199	26523	9719	1324	47	109	911
12	959	186	26761	26699	9548	1279	27	103	753
13	895	174	25911	26483	9940	1387	41	114	874
14	812	153	27072	26780	10762	1279	32	134	827
15	1055	191	26646	26645	9777	1294	44	124	806
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Ave.	888	180	26518	26758	10113	1294	40	112	806
Wt. %	3.428	0.016	11.66	72.97	4.815	0.502	0.110	0.030	1.493

SAMPLE T115-1 FABY-31 (Los Humeros volcanic center)

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	1064	381	32421	26361	9698	2200	80	110	907
2	1020	381	32344	26684	9682	2166	66	127	913
3	1138	373	31965	26475	9507	2154	79	118	889
4	857	383	32473	26243	9617	2195	59	123	888
5	973	352	32368	26492	9650	2105	63	113	944
6	1099	368	32694	26846	9507	2230	86	123	894
7	1118	399	32480	26262	9567	2074	64	134	915
8	958	360	32571	26519	9650	2143	65	116	929
9	998	400	32475	25984	9587	2186	87	125	930
10	1102	422	32645	26542	9518	2220	66	120	939
11	941	364	32448	26428	9804	2141	67	118	938
12	915	388	32679	26623	9489	2188	71	131	905
13	1010	359	32578	26640	9673	2341	91	132	911
14	1056	367	32541	26739	9666	2110	74	129	911
15	1044	366	32571	26467	9465	2119	78	132	985
16	925	383	31824	26730	9570	2274	80	131	909
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Ave.	1013	378	32442	26502	9603	2177	74	124	919
Wt. %	3.181	0.246	13.55	69.42	4.354	0.895	0.282	0.052	1.494

(Numbers shown are X-ray counts; weight percentages are before recalculation to 100 %)

SAMPLE T115-2 FABY 37 (Los Humeros volcanic center)

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	655	218	29243	27758	10510	1169	41	109	674
2	675	224	29161	27946	10784	1266	44	125	660
3	662	224	29267	27778	10128	1227	37	97	729
4	719	205	29281	27771	10401	1220	42	93	726
5	706	249	29718	27840	10769	1246	53	122	736
6	704	222	29384	28034	10559	1301	41	112	704
7	755	201	28610	27195	10221	1209	34	136	675
8	718	221	28907	27609	10463	1255	39	116	707
9	742	257	29505	27808	10276	1264	44	113	718
10	714	229	29407	28309	10409	1243	26	109	683
11	724	195	29270	27692	9993	1196	36	124	710
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Ave.	706	222	29250	27794	10410	1236	40	114	702
Wt. %	2.211	0.064	12.23	72.19	4.735	0.456	0.109	0.036	1.102

SAMPLE T115-3 PRIMAVERA 184

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	1466	155	27480	28298	8938	579	40	118	985
2	1438	156	27312	28262	8877	621	22	108	937
3	1505	165	27733	28162	9112	601	28	130	1024
4	1385	199	27479	28321	8978	642	39	119	1005
5	1546	148	27074	28363	9157	643	31	128	934
6	1353	187	27345	28067	9002	592	30	123	1042
7	1316	167	27380	28328	9042	569	38	113	985
8	1331	174	27657	28424	8867	666	29	115	1019
9	1503	162	27468	28731	8947	619	26	122	1001
10	1449	183	27706	28437	9078	648	38	153	931
11	1382	187	27170	28113	8770	648	28	104	974
12	1367	164	27413	28452	9022	631	20	110	953
13	1397	182	27274	28412	9060	661	25	122	1031
14	1457	152	27296	28495	9083	637	29	107	937
15	1328	169	27269	28410	9065	670	25	117	1023
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Ave.	1415	170	27403	28352	9000	630	30	119	986
Wt. %	4.412	0.004	11.44	73.81	4.086	0.169	0.057	0.044	1.616

(Numbers shown are X-ray counts; weight percentages are before recalculation to 100 %)

SAMPLE T115-4 PRIMAVERA 210 Sierra La Primavera)

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	1260	169	27069	27898	9586	484	32	112	969
2	1130	183	27181	28229	9767	635	39	128	1023
3	1261	164	27495	28037	9576	638	37	123	918
4	1205	174	27158	28293	9307	686	28	105	916
5	1266	171	27495	28522	9563	601	25	119	979
6	1244	192	27344	28327	9548	660	28	120	988
7	1178	157	27350	28379	9802	665	31	112	947
8	1381	150	27467	28374	9492	658	31	123	980
9	1234	152	27302	28071	9787	659	29	102	949
10	1218	167	27433	28335	9649	667	30	115	937
11	1322	167	27296	28388	9549	620	40	109	945
12	1314	182	27379	28283	9393	608	34	126	955
13	1299	171	27460	28076	9470	716	36	111	960
14	1165	168	27284	28327	9492	616	31	117	966
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Ave.	1248	169	27337	28253	9570	647	32	116	959
Wt. %	3.901	0.003	11.40	73.47	4.348	0.173	0.070	0.038	1.569

SAMPLE T115-5 PRIMAVERA 323 W12 (Sierra La Primavera)

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	1168	189	27389	28176	9067	631	44	110	1028
2	1336	173	27436	28643	9137	655	31	109	955
3	1222	200	27476	28256	8967	624	25	118	983
4	1308	171	27053	28103	9029	641	24	130	940
5	1145	162	27255	28221	9011	617	31	118	953
6	1324	154	27580	28275	8853	624	22	120	1040
7	1231	176	27272	28138	9093	604	32	113	981
8	1346	161	27151	28193	9201	621	34	119	992
9	1165	196	27665	28176	8973	613	25	102	975
10	1314	184	27070	28393	9212	654	45	113	1004
11	1287	177	27322	28411	9054	663	27	117	975
12	1231	172	27503	28205	9271	637	23	143	970
13	1433	195	27084	28741	9123	615	32	117	943
14	1455	178	27215	28512	9110	624	26	113	927
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Ave.	1283	178	27319	28356	9078	630	30	117	976
Wt. %	4.008	0.013	11.39	73.76	4.122	0.170	0.058	0.040	1.600

(Numbers shown are X-ray counts; weight percentages are before recalculation to 100 %)

SAMPLE T115-6 RABEK Y8 (Lake Atitlan volcanic center)

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	689	226	27607	27091	8184	1489	23	132	326
2	652	267	27315	26491	7839	1555	41	135	348
3	751	236	27202	26861	7747	1445	36	133	320
4	703	222	27439	27206	8167	1415	29	132	344
5	684	217	27182	26497	8538	1449	39	122	331
6	645	226	27523	26562	7558	1465	26	138	354
7	742	209	27271	27106	7927	1413	36	133	308
8	761	232	27682	27056	7990	1374	28	121	347
9	672	259	27573	26662	7153	1626	25	113	366
10	732	237	27806	27233	7990	1488	32	131	390
11	748	237	27303	27008	7326	1496	42	154	354
12	808	240	27784	26831	7550	1503	31	143	349
13	678	238	27037	26682	7843	1402	26	130	321
14	815	232	27798	27170	7493	1368	21	130	366
15	721	211	27147	26957	7938	1409	27	127	351
16	756	235	27188	26819	7718	1357	38	134	358
17	661	259	26957	26539	7288	1458	39	129	331
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Ave.	719	234	27401	26869	7779	1454	32	131	345

Wt. % 2.760 0.083 12.00 73.26 3.706 0.583 0.070 0.069 0.477

SAMPLE T115-7 ZALTIPAN 14 (Los Humeros volcanic center)

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	1047	186	30443	26238	10619	1613	39	104	707
2	1182	277	30552	25996	10526	1537	40	119	693
3	1015	260	30828	26334	10633	1615	56	126	794
4	1141	273	30496	26102	10504	1564	48	142	764
5	1002	279	30776	26019	10374	1544	45	126	696
6	974	248	30855	26096	10299	1540	39	143	735
7	1130	281	30692	26161	10479	1504	46	133	743
8	1116	260	30548	26130	10405	1621	47	106	722
9	1037	269	30430	25856	10282	1620	32	141	695
10	959	284	30608	25798	10539	1528	48	133	752
11	956	270	30825	26176	10483	1573	43	123	734
12	1028	298	30489	26176	10544	1558	49	129	760
13	972	240	29004	24473	9817	1479	53	135	704
14	953	257	30892	26185	10448	1535	65	103	739
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Ave.	1037	270	30529	25995	10429	1559	46	126	731

Wt. % 3.982 0.127 13.44 71.34 4.965 0.631 0.142 0.054 1.206

(Numbers shown are X-ray counts; weight percentages are before recalculation to 100 %)

SAMPLE T115-8 ZARAGOZA LH-41 (Los Humeros volcanic center)

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	1209	342	30162	24005	9284	2302	68	122	1065
2	1099	370	31012	25125	9060	2230	63	119	1040
3	1164	347	30753	24972	9565	1993	60	128	1053
4	1200	411	31351	24297	9172	2588	95	129	1311
5	1263	367	30816	24874	9828	2348	73	107	1105
6	1171	413	32067	24564	8865	3026	95	140	1300
7	1082	407	31375	25181	9174	2470	88	109	1121
8	1146	332	31087	25171	10023	2169	61	122	1108
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Ave.	1167	374	31078	24773	9372	2391	75	122	1138
Wt. %	4.526	0.056	13.80	68.39	4.444	1.034	0.289	0.047	1.976

SAMPLE T115-9 ZARAGOZA LH-42 (Los Humeros volcanic center)

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	1229	328	31413	25435	9653	2167	79	120	916
2	1457	364	31330	25192	9400	2175	68	124	1061
3	1467	319	31276	25622	9651	2073	75	117	993
4	1360	352	30860	25370	9260	2132	90	119	1030
5	1290	331	29660	23976	9124	2082	70	129	942
6	1214	313	31228	25693	9716	2122	76	120	1029
7	1288	336	30473	25335	9447	2126	77	113	954
8	1444	333	31230	25471	9570	2145	71	100	1059
9	1154	314	31174	15768	9424	2018	70	122	1059
10	1346	327	29902	24659	9201	2072	76	137	889
11	1166	365	29947	24513	9396	2096	82	118	1035
12	1414	314	31465	25629	9714	2158	85	143	1067
13	1240	352	30802	25266	9602	2112	93	114	869
14	1285	343	30552	25320	9643	2040	66	121	1071
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Ave.	1311	335	30808	25232	9486	2109	77	121	999
Wt. %	5.055	0.208	13.67	69.61	4.503	0.897	0.299	0.045	1.712

(Numbers shown are X-ray counts; weight percentages are before recalculation to 100 %)

SAMPLE T115-10 ZARAGOZA LH-48 (Los Humeros volcanic center)

Shard	Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe
1	1137	558	33837	24103	8045	3920	107	154	1547
2	1453	509	33383	24179	8422	3538	122	139	1428
3	1185	549	32492	23752	7933	3642	110	160	1466
4	1533	547	33395	24508	8422	3587	97	138	1464
5	1332	579	33128	23767	7792	3611	121	157	1548
6	1343	514	32274	23808	8151	3303	93	147	1501
7	1277	519	31888	23301	8119	3439	114	140	1447
8	1380	588	33156	23899	7917	3982	109	132	1571
9	1272	578	31926	23835	7989	3412	105	102	1501
10	1460	550	31989	23499	8069	3590	101	121	1522
11	1495	555	32448	24241	8144	3459	126	142	1402
12	1474	547	31306	22412	7316	3466	103	120	1599
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Ave.	1362	549	32685	23775	8027	3579	109	138	1500
Wt. %	5.311	0.479	14.63	66.08	3.788	1.605	0.461	0.072	2.657

APPENDIX 4: CHEMICAL DATA FOR BEST COMPUTER-DRAWN MATCHES

Results are in percent. Some sample localities for sample numbers shown as matches are contained in Appendix 5. Further information regarding these samples can be obtained from the Tephrochronology Project of the U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025.

A. Listing of 10 closest matches for sample 1176

C.No	Sample Number	Date	SiO2	Al2O3	Fe2O3	MgO	MnO	CaO	TiO2	Na2O	%20 Total,R	Sim. Co
1	1449 126-1176 t115-11	1/29/85	78.18	12.32	0.96	0.94	0.10	0.30	0.12	2.18	5.80	100.00 1.0000
2	1367 80-107-1 T104-6	8/26/85	76.82	12.65	0.88	0.03	0.06	0.28	0.12	2.96	6.20	100.00 0.9613
3	2165 WCR-83-C (LJ FE) T177-15	12/7/88	76.95	11.79	1.09	0.05	0.07	0.26	0.12	2.45	7.23	100.01 0.9377
4	1341 8E-24 T105-3	8/29/85	76.93	12.32	0.71	0.05	0.03	0.32	0.12	1.47	7.95	100.00 0.9323
5	357 SH-ASM-193, T41-4	8/7/89	78.00	12.50	0.87	0.04	0.10	0.25	0.11	4.57	3.76	100.00 0.9305
6	2358 FLV-1203-TC T196-8	4/17/90	77.74	12.72	0.72	0.05	0.07	0.33	0.12	3.22	5.03	100.00 0.9244
7	2393 M35SRP-7 T204-8	1/28/86	77.66	12.19	0.83	0.03	0.02	0.30	0.16	3.20	5.64	100.01 0.9194
8	1452 126-11303 t115-14	1/28/86	77.67	12.53	0.89	0.04	0.08	0.39	0.11	2.44	5.84	99.99 0.9179
9	1451 126-1265 t115-13	1/28/86	77.58	12.59	0.89	0.07	0.08	0.44	0.12	2.36	5.87	100.00 0.9160
10	2161 WCR-83-A (LJ FE) T177-13	12/7/88	75.83	12.80	1.22	0.05	0.10	0.30	0.10	2.24	7.38	100.02 0.9105

B. Listing of 10 closest matches for sample 1254

C.No	Sample Number	Date	SiO2	Al2O3	Fe2O3	MgO	MnO	CaO	TiO2	Na2O	%20 Total,R	Sim. Co
1	1450 126-1254 t115-12	1/28/85	77.26	12.70	0.91	0.08	0.09	0.48	0.14	2.67	5.68	100.00 1.0000
2	1344 R5-15-A1 T108-6	8/29/85	77.12	12.52	0.82	0.06	0.07	0.48	0.14	2.68	6.11	100.00 0.9770
3	1353 8E-255 T106-15	8/30/85	77.82	12.13	0.85	0.08	0.07	0.47	0.14	1.66	6.78	100.00 0.9722
4	356 LM-10	1/28/85	76.85	12.61	0.97	0.05	0.05	0.51	0.15	2.90	5.90	99.99 0.9601
5	1451 126-1255 t115-13	1/16/97	77.58	12.59	0.89	0.07	0.08	0.44	0.12	2.36	5.87	100.00 0.9478
6	1704 1986-101 t135-7	2/24/98	77.03	12.76	0.88	0.12	0.05	0.62	0.14	2.70	5.71	100.01 0.9467
7	1924 3ALP-41 T154-10	8/29/85	76.83	12.80	0.88	0.09	0.06	0.65	0.14	3.07	5.47	99.99 0.9384
8	692 R37111		77.93	11.81	1.05	0.02	0.00	0.54	0.14	2.90	5.60	100.00 0.9337
9	203 LUCK-3, T41-2		77.38	13.02	0.83	0.06	0.05	0.52	0.12	4.57	3.45	100.00 0.9332
10	1331 8E-222 T103-8		76.93	12.37	0.86	0.13	0.07	0.64	0.14	2.06	6.79	99.99 0.9330

C. Listing of 10 closest matches for sample 1265

C.No	Sample Number	Date	SiO2	Al2O3	Fe2O3	MgO	MnO	CaO	TiO2	Na2O	Σ20 Total,R	Sim. Co
1	1451 126-1265 t115-13	1/28/86	77.58	12.59	0.89	0.07	0.08	0.44	0.12	2.36	5.87	100.00 1.0000
2	1920 A87-1-3 F154-11	2/24/88	77.75	12.57	0.72	0.05	0.06	0.44	0.12	3.92	4.39	100.02 0.9610
3	1452 126-1303 t115-14	1/28/86	77.67	12.53	0.89	0.04	0.08	0.39	0.11	2.44	5.84	99.99 0.9594
4	1306 TREMCH #8 G3) BULK T100-15	7/2/85	77.07	12.78	0.71	0.06	0.03	0.45	0.12	3.70	5.04	100.01 0.9508
5	238 LUCK-3, T41-2		77.38	13.02	0.83	0.06	0.05	0.52	0.12	4.57	3.45	100.00 0.9486
6	1450 126-1254 t115-12	1/28/85	77.26	12.70	0.91	0.08	0.08	0.48	0.14	2.67	5.68	100.00 0.9478
7	1304 CF-2 SILICIC FRACT. BULK T100 7/2/85		77.27	12.67	0.75	0.05	0.07	0.45	0.11	3.59	5.05	100.02 0.9476
8	1333 SC-256 T185-15	8/30/85	77.82	12.13	0.85	0.08	0.07	0.47	0.14	1.66	6.78	100.00 0.9417
9	114 SV-76-5, T16-11		77.28	12.92	0.73	0.05	0.10	0.44	0.11	2.86	5.50	99.99 0.9415
10	1344 3c-15-A1 T106-6	8/29/85	77.12	12.52	0.82	0.06	0.07	0.43	0.14	2.68	6.11	100.00 0.9367

D. Listing of 10 closest matches for sample 1303

C.No	Sample Number	Date	SiO2	Al2O3	Fe2O3	MgO	MnO	CaO	TiO2	Na2O	Σ20 Total,R	Sim. Co
1	1452 126-1303 t115-14	1/28/86	77.67	12.53	0.89	0.04	0.08	0.39	0.11	2.44	5.84	99.99 1.0000
2	1520 JP 85 TP5-7 T120-2	4/29/86	76.33	12.86	0.78	0.06	0.07	0.40	0.11	2.78	6.61	100.00 0.9617
3	1451 126-1265 t115-13	1/28/86	77.58	12.59	0.89	0.07	0.09	0.44	0.12	2.36	5.87	100.00 0.9594
4	2203 FLV-128-TC T183-2	1/25/89	77.40	13.02	0.76	0.04	0.05	0.36	0.11	3.20	5.05	100.00 0.9472
5	1304 CF-2 SILICIC FRACT. BULK T100 7/2/85		77.27	12.67	0.75	0.05	0.07	0.45	0.11	3.59	5.05	100.02 0.9409
6	1938 AV12.1-T1 T154-12	4/30/88	77.24	12.61	0.86	0.04	0.07	0.39	0.08	3.52	5.18	99.99 0.9363
7	114 GV-76-5, T16-11		77.28	12.92	0.73	0.05	0.10	0.44	0.11	2.86	5.50	99.99 0.9343
8	2421 PK-141 T199-4	5/24/90	76.30	12.72	0.85	0.06	0.06	0.53	0.11	3.14	6.22	99.99 0.9317
9	2276 T191-6 FLV-77-HT	5/10/89	76.97	12.56	0.73	0.05	0.04	0.46	0.11	2.64	6.44	100.00 0.9313
10	2370 PK-80 T197-9	9/14/89	76.94	12.48	0.96	0.05	0.05	0.39	0.08	2.93	6.11	100.00 0.9282

E. Listing of 20 closest matches for sample 2040

S.No	Sample Number	Date	SiO2	Al2O3	Fe2O3	MgO	MnO	CaO	TiO2	Na2O	(20 Total,R Sim. Co	
1	1458 126-2040 (AVG 3)	1/28/85	76.96	12.28	1.80	0.02	0.05	0.57	0.13	3.33	4.85	99.99 1.0000
2	1447 126-2040 T116-1	1/27/85	77.08	12.30	1.75	0.02	0.05	0.56	0.13	3.33	4.77	99.99 0.9903
3	253 P5-23, T23-1		76.69	12.27	1.71	0.02	0.04	0.57	0.13	3.72	4.84	99.99 0.9891
4	236 P1CO-157(1), T47-7		76.61	12.25	1.73	0.03	0.04	0.59	0.13	3.72	4.89	99.99 0.9840
5	237 P1CO-157(2), T46-1		76.32	12.45	1.78	0.02	0.05	0.60	0.13	3.71	4.93	99.99 0.9834
6	3 D3DP-36-4-6, T47-3		76.33	12.46	1.73	0.03	0.06	0.59	0.13	3.61	5.05	99.99 0.9809
7	322 TECO-305, T17-14		76.75	12.66	1.72	0.03	0.03	0.55	0.13	2.78	5.36	100.01 0.9775
8	102 FALOR-2, T41-7		76.24	12.53	1.72	0.02	0.04	0.60	0.13	3.66	5.06	100.00 0.9752
9	609 HPA-1, T54-2	xx/xx/xx	76.68	12.26	1.72	0.02	0.04	0.57	0.12	3.59	5.00	100.00 0.9747
10	421 68W93, T5-9		76.46	12.37	1.71	0.02	0.05	0.58	0.12	3.55	5.22	100.00 0.9704
11	1255 CCA-1 T96-14	5/29/85	76.67	12.28	1.75	0.01	0.04	0.59	0.12	3.84	4.97	100.00 0.9667
12	166 JPD-31-8-825, T52-15		76.15	12.50	1.75	0.03	0.05	0.61	0.14	3.46	5.29	99.99 0.9640
13	378 TECO-1231, T47-6		76.30	12.36	1.75	0.03	0.05	0.58	0.12	3.51	4.81	100.01 0.9626
14	747 MC-8		76.97	12.33	1.64	0.02	0.03	0.58	0.12	3.41	5.01	100.01 0.9623
15	748 MC-8		76.87	12.33	1.64	0.02	0.03	0.58	0.12	3.41	5.01	100.01 0.9623
16	390 TECO-505, T17-12		76.14	12.58	1.60	0.02	0.04	0.54	0.13	3.51	5.44	100.00 0.9604
17	818 SS-62		76.30	12.33	1.62	0.03	0.05	0.52	0.13	3.51	5.51	100.00 0.9599
18	434 2V-196, T5-16		77.15	11.78	1.68	0.02	0.03	0.56	0.12	3.46	5.19	99.99 0.9591
19	1542 CAV-3 T124-13	5/5/86	77.65	12.33	1.58	0.03	0.03	0.53	0.13	4.12	3.60	100.00 0.9589
20	1543 CAV-5 T124-14	5/5/86	78.49	12.45	1.65	0.03	0.02	0.56	0.12	3.96	2.73	100.01 0.9578

APPENDIX 5: SAMPLE LOCALITIES

More information regarding samples listed here can be obtained from the Tephrochronology Project of the U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025.

- A. 2. BO-107-1. Ash-flow tuff in El Paso Hills, northern Mohave Desert, CA. Collected by Brett Cox, BWRG, USGS, Menlo Park. Equivalent to Peach Springs Tuff? Middle to upper Miocene?
3. WCR-88-C (Low iron). Ca. 2-m-thick, bluish-gray tuff, air-fall or water-laid, reworked, vitric, 5th tephra layer above base of section. At Willow Creek Reservoir, north-central Nevada. About N41°13.5' W116°31.0'. Collected by Andrei Sarna-Wojcicki, BWRG, USGS, Menlo Park. Middle-upper Miocene?
4. BE-24. Ca. 1-m-thick, white tuff in lake or fluvial sediments at Aldrich Station Section, west of Walker Lake, Nev. About N39°30' W118°40'. Locality and other data in Eastwood (1969). Stratigraphically a short distance below tuff dated 11.8 Ma.
5. SM-ASH-198. Tuff near base of marine Wildcat Group (Pullen Fm.?) along Van Deusen River, Humboldt Co., northwestern Calif. About N40°27.5' W123°55.5'. Collected by R.J. McLaughlin, BWRG, USGS, Menlo Park. Upper Miocene-lower Pliocene?
6. FLV-120B-TC. Coarse white Tuff in fan alluvium, ca. 0.3 m thick, in Trail Canyon, northwestern Fish Lake Valley, Nev. About N37°53.5', W118°17'. Collected by Janet Slate, Univ. of Colorado, Boulder. Similar to Tuff of Taylor Canyon, ca. 2.0 Ma.
7. M89SRP-7. Tuff of Blacktail of Hackett and Morgan, (1989). Collected by P.M. Miller, BWRG, USGS, Menlo Park. Ca. 6.5 Ma.
10. WCR-88-A. Ca. 3-m-thick tuff, bluish-gray. Basal layer in sequence. Location and other data as for A3, above.
- B. 2. BE-I5-A1. Massive, 15-m-thick tuff, basal in section. Locality and other data as in A4, above. Stratigraphically below layer dated 11.8 Ma.
3. BE-256. Correlative with B2, above.
4. LM-10. Tephra layer in Tertiary alluvium of north, upper Paranaagat Valley, southeastern Nev. Collected by Linda Metcalf and Jonathan O. Davis, Desert Research Institute, Reno. Upper Miocene?
6. 1986-101. Upper Chewaucan Marsh, Paisley, Ore. Impure ash in core from depth of ca. 14 m. Collected by D.P. Adams, BPAS, USGS, Menlo Park. Late Pleistocene?
7. 86LP-41. Tuff from Tertiary alluvium in Pahranaagat Valley, southeastern Nev. Near top of clastic alluvial sequence, overlies Kane Spring Tuff, 14 Ma. Collected by Angela Jayko, BWRG, USGS, Menlo Park. Upper Miocene.
8. Not recorded
9. LOCK-3. Impure, biotite-bearing white tuff, 10-12 cm thick, in upper part of Cayente Fm., medium- to fine-grained alluvium, Lockwood Valley, CA. About N34°45' W119°5'. Collected by A.M. Sarna-Wojcicki and Virgil Frizzell. Lower Pliocene?

10. BE-222. Stratigraphically close above layer dated ca. 10.8 Ma. Location and other data as in A4, above.
- C. 2. AB741.3. A Bishop-ash-like tephra in Kern River Fm, Kern Co., CA. May be equivalent to Bishop ash bed or Glass Mountain D or G ash beds (0.74 Ma, and about 0.9 and 1.0 Ma, respectively, Sarna-Wojcicki and others, 1984; also see Izett, 1981). From a depth of 741.3 feet, by a sidewall core, from Texaco LUCK #198 well, at N35°27'40" W119°0'5".
4. TRENCH #8 (B) BULK. Disseminated silicic shards in late Cenozoic alluvium, in trench cut in Crater Flat, southern NV. Collected by C.E. Meyer, James Yount, and A.M. Sarna-Wojcicki, BWRG, USGS, Menlo Park. Somewhat similar chemically to Bishop ash bed, but may be as old as middle to upper Miocene.
5. LOCK-3. Same sample as in B9, above.
7. CF-2 SILICIC FRACT. BULK. Same locality and other data as CU, above.
8. BE-256. Same sample as B3, above.
9. GV-76-6. Tuff in Upper Valley Springs Fm, tuffaceous alluvium, eastern Great Valley. Collected by J.A. Bartow, BWRG, USGS. Middle to upper Miocene.
10. BE-15-A1. Same sample as B2, above.
- D. 2. JP85TPS-7. Peach Springs Tuff, ash flow, at Flattop near Kingman, AZ. An erosional outlier in Sacramento Valley. Yucca SE 7.5 Quad. Loc. N34°47' W114°03'47". Collected by Jane Nielson, BWRG, USGS, Menlo Park. Well dated at 18.4-18.6 Ma by K-Ar, Ar-Ar.
4. FLV-128-TC. Same sample as A6, above.
5. CF-2 Silicic frac. bulk. Same sample as CT, above.
6. AV12.1-T1. White, fine-grained tuff in ca. 4-m-thick zone of tuffaceous diatomite, marine Monterey Fm., San Juan Capistrano, Orange Co., CA. Collected by Hugh Wagner. Upper Miocene.
7. GV-76-6. Same sample as C9, above.
8. PR-141. Tuff in Tertiary alluvium, Point of Rocks 7.5 Quad, southern NV. N36°33'49" W116°02'49.6". Collected by Jan Ziegler, formerly of BWRG, USGS, Menlo Park. Upper Miocene.
9. FLV-77-HT. Tuff in Horse Thief Canyon, faulted. Fish Lake Valley, east-central CA. Coll. by Marith Rehels, BCRG, USGS, Denver. Upper Miocene or lower Pliocene ?
10. PR-80. Same locality as D8, above.
- E. 3. P5-23. Lava Creek B ash bed ? Fine ash in peaty clays and silts within the lacustrine Corcoran Clay. From cores (H24 and/or H35) at a depth

- of 72 m in southern San Joaquin Valley, CA, near Wasco. Overlies the Bishop ash bed at about 84 m in the core(s). Brunhes Normal-Matuyama Reversed Polarity boundary is about 2 m below latter layer. In Davis and others (1977). Also see Sarna-Wojcicki and others (1984).
4. 5. PICO-157. Huckleberry Ridge ash bed, in marine Pico Fm., Balcom Canyon, Ventura Co., Calif. About N34°,20.2' W118°,58.2'. Moorpark 7.5 quad.
 6. DSDP-36-4-6. Huckleberry Ridge ash bed, in fine-grained marine sediments in DSDP Hole 36, at a depth of 35 m below sea water-sediment interface. Site 480 km N80°W of Cape Mendocino, Calif. Sarna-Wojcicki and others (1987).
 7. TECO-30G. Lava Creek B ash bed. Sample from near top of 3-m-thick, water-deposited ash bed in Pleistocene Lake Tecopa, southeastern Calif. Same locality as samples 37 and 38 in Sarna-Wojcicki and others (1984), table 4.
 8. 9. Two samples from Humboldt Co., near Arcata, northeastern Calif. 8 is at about N40°50', W123°53.5'. Both samples were collected by G. Carver and T. Stevens of Humboldt State Univ, Arcata. Korbel 7.5 quad. Both samples are in marine Falor Fm.
 10. Huckleberry Ridge ash bed, Meade Co., Kansas. Same locality as sample 42, in Sarna-Wojcicki and others, 1984, table 4. Also see Izett and Wilcox (1982).