U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

GEOCHEMISTRY OF SEDIMENTS FROM TULE LAKE, CALIFORNIA

by

Walter E. Dean[1]

Open-File Report 96-257

1996

[1]USGS, MS 980 Federal Center, Denver, CO 80225

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

GEOCHEMISTRY OF SEDIMENTS FROM TULE LAKE, CALIFORNIA

ABSTRACT

The sediments deposited in Tule Lake, California can be described in terms of a four-component system of clastic material, $CaCO_3$, organic matter and diatom debris. Samples of a 330-m core, representing deposition in Tule Lake during the last three million years, were analyzed for concentrations of 24 major, minor, and trace elements as well as organic carbon and carbonate carbon. Q-mode factor analysis of the geochemical data provides a geochemical zonation of the core based on four principal element associations. Association 1 is essentially a basic igneous rock association and groups those samples with relatively high concentrations of Ti, Zn, Ce, La, Al, Co, Cu, Ni, Y, Ba, Cr, Pb, and Sc. This component makes up an average of about 70% of the sediment deposited in Tule Lake, and represents the inorganic clastic fraction derived mainly from erosion of basic igneous rocks in the drainage basin, with minor additions from acidic volcanic ash derived from within and outside the drainage basin. Association 2 groups those sediments that are rich in siliceous biogenic debris and organic matter. The average organic carbon concentration in the Tule Lake sediments is 2.5%, with a maximum of 7.6%. The average concentration of biogenic SiO_2, estimated from the total SiO_2 content and SiO_2/Al_2O_3 ratio, is about 25% with a maximum of about 60%. Association 3 is based on the content of $CaCO_3$ and associated elements Mg and Sr. The maximum concentration is 42%, but the average is only 2.5%, and most of the carbonate-rich beds occur near the top of the sediment section between 50 and 130 m. Association 4 is weak, but appears to reflect variations in redox conditions within the lake as indicated by relatively high concentrations of Fe, Mn, Sc, V, and P.

INTRODUCTION

Tule Lake basin is a remnant of a much larger ancient lake system that once covered a large area of north-central California and south-central Oregon east of the Cascade Range. Most of the present lake basin has been drained for agriculture. In 1982 the U.S. Geological Survey collected a sequence of cores from Tule Lake Sump (Figure 1) near the town of Tulelake that resulted in almost continuous recovery of the upper 334 m of the estimated 550 m of lacustrine sediment in the basin (Adam and others, 1989). The base of the cored interval is within the Gauss normal-polarity paleomagnetic chron and is estimated to be about 3.0 My old (Reike and others, 1992). Samples of sediment were collected for studies of pollen, ostracodes, diatoms, tephra, paleomagnetics, and geochemistry. This report presents the results of the geochemical investigations.

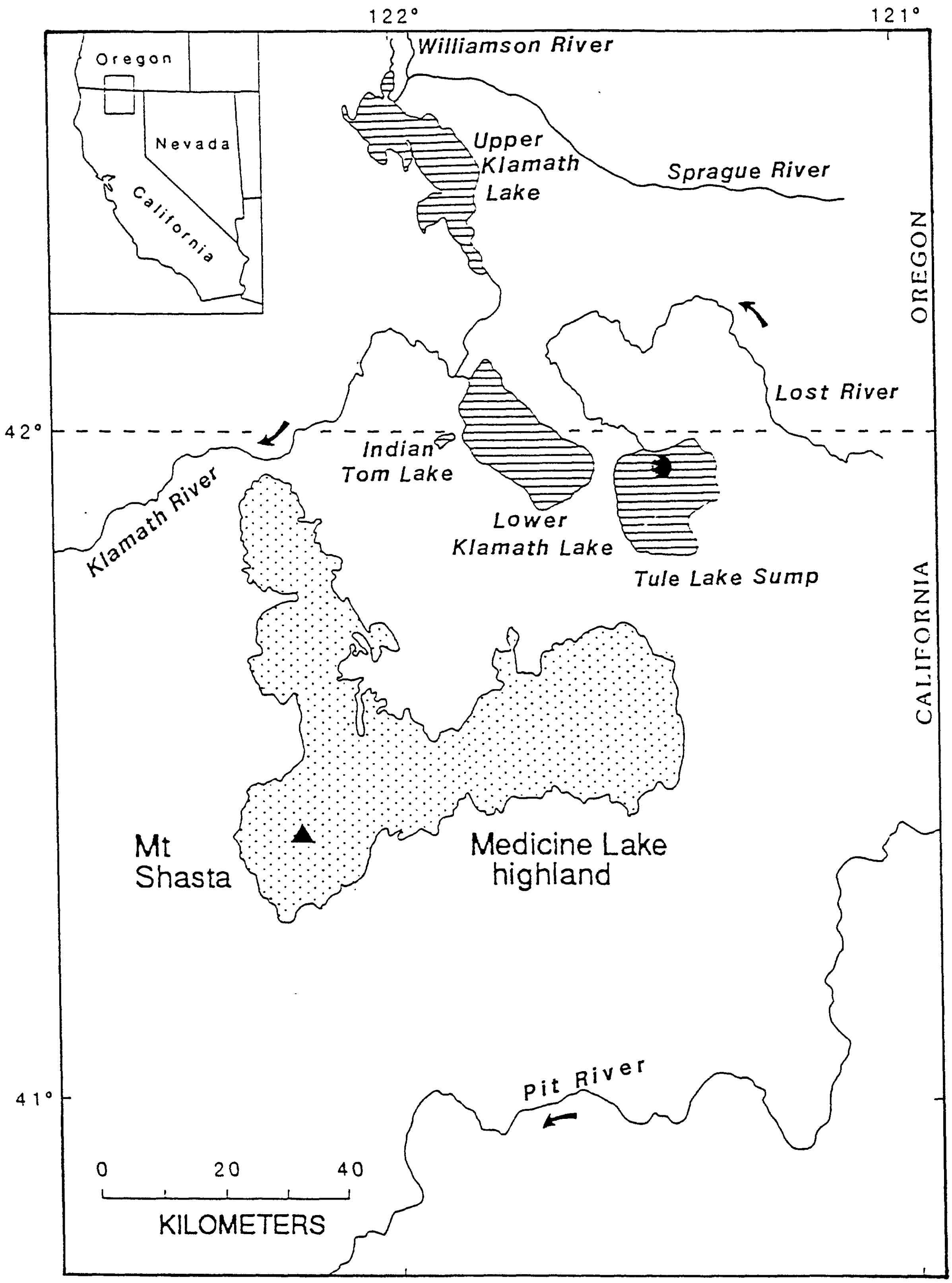


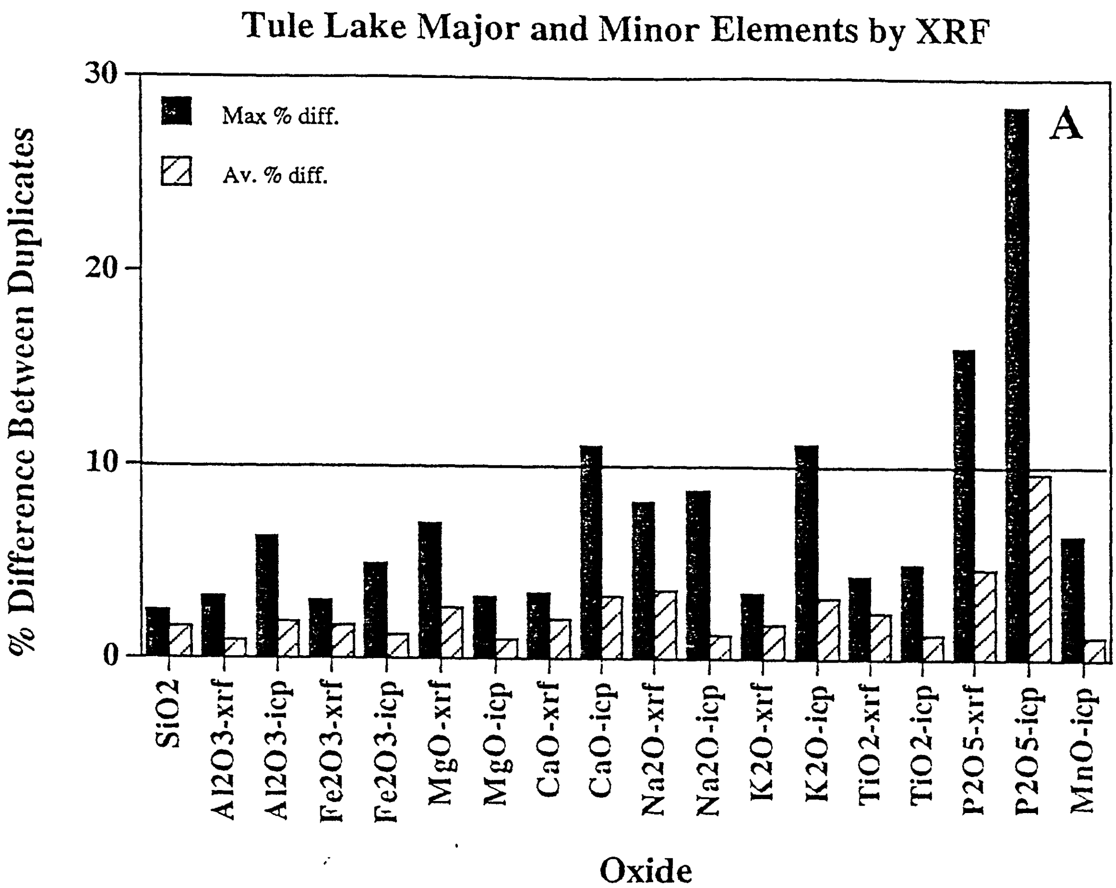
Figure 1. Map of the Tule Lake and surrounding features in northern California and adjacent southern Oregon. Horizontal ruling indicates historic lakes. Stippled area indicates parts of the Medicine Lake Highlands and Mt. Shasta with elevations greater than 1525 m (modified from Adam and others, 1989).

METHODS

A total of 133 samples from the Tule Lake core was collected for geochemical analyses. Samples were air dried and ground to pass a 100-mesh (149 µm) sieve. Twelve of the samples were chosen at random for duplicate analyses. Concentrations of total carbon and inorganic carbon were determined by coulometry (Engleman and others, 1985) in splits of the geochemistry samples. Carbonate in the untreated sample is reacted with perchloric acid to liberate CO_2, which is then titrated in a coulometer cell to measure inorganic carbon. Total carbon is measured by liberating CO_2 by combustion of an untreated sample at 1050° C in a stream of oxygen and titrating the CO_2. Values of organic carbon (OC) were determined by difference between total carbon and inorganic carbon. Replicate analyses demonstrate the coulometer technique has a precision of better than ±1% for both carbonate and total carbon.

All 145 analytical samples (133 samples plus 12 duplicates) were analyzed for 10 major and minor elements by X-ray fluorescence spectrometry (XRF; Taggart and others, 1987), and 35 major, minor, and trace elements by induction-coupled, argon-plasma emission spectrometry (ICP; Lichte and others, 1987). Twenty four elements were detected in at least some of the samples. The following 11 elements (and their lower limits of detection in parts per million given in parentheses after the element) were analyzed by ICP but not detected in any of the samples: Au (8), Be (1), Bi (10), Cd (2), Eu (2), Ho (4), Nb (4), Sn (20), Ta (40), Th (4), and U (100).

An estimate of precision of the XRF and ICP techniques was obtained by computing the percent difference between duplicate analyses. Histograms of average and maximum percent difference between duplicates are plotted in Figure 2. Scatter plots of major-element oxide by ICP versus major-element oxide by XRF are shown in Figure 3. The histograms (Figure 2) and the scatter plots (Figure 3) show that agreement between the two methods is excellent. Differences between duplicate analyses for the major-element oxides was usually considerably better than 10% for both ICP. The average differences between duplicate analyses for the minor-element oxides (TiO_2, P_2O_5, and MnO) were less than 10%, although one or two pairs of duplicates gave maximum differences greater than 10%. The lower precision for the minor elements is due in part to the fact that most concentrations of these elements are closer to the detection limits than those of the major elements. Histograms for MnO by XRF are not included in Figure 2 because about half of the samples were below the detection limit (0.02%) for that method. The XRF results for major-element oxides were used for down-core plots and multivariate statistical analyses except for MnO for which the ICP analyses were used. The average percent difference between duplicates for the trace elements (Figure 2B) is generally better than 10%, with Cr and Pb having the poorest precision.



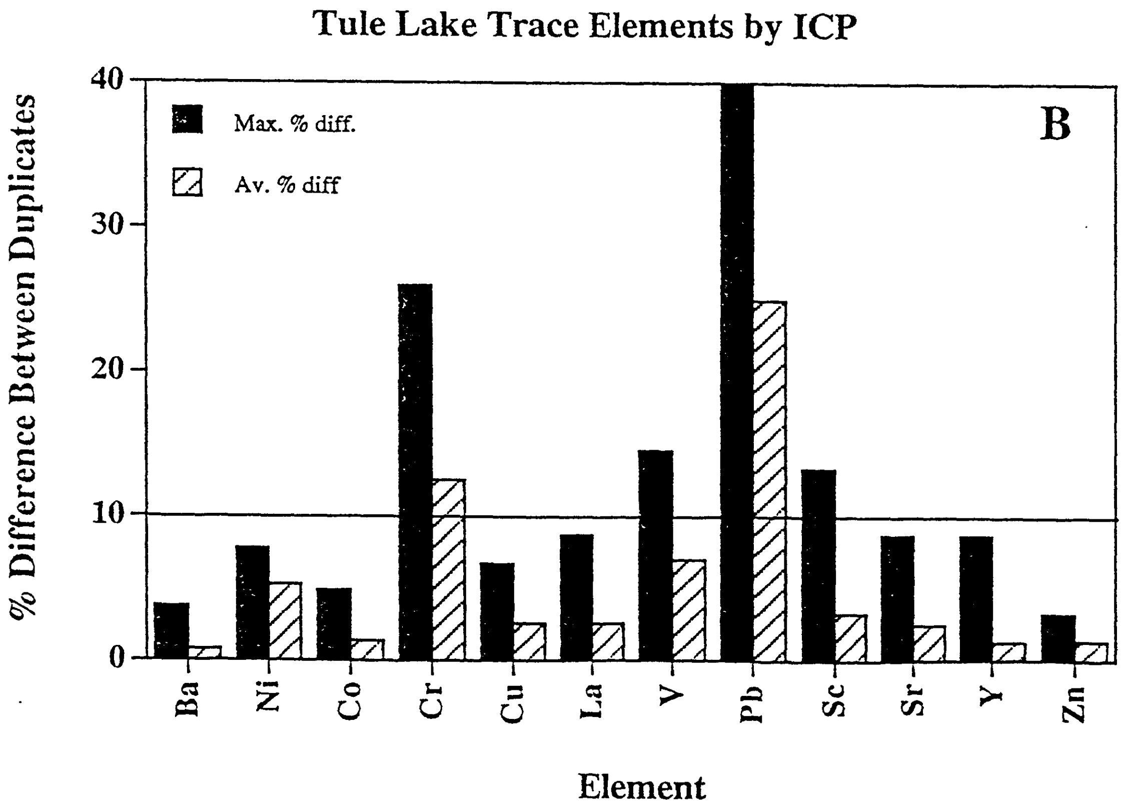


Figure 2. Histograms of maximum and average percent differences between duplicate pairs of analyses of 12 samples from the Tule Lake core for major- and minor-element oxides by XRF and ICP (A), and for trace elements by ICP (B).

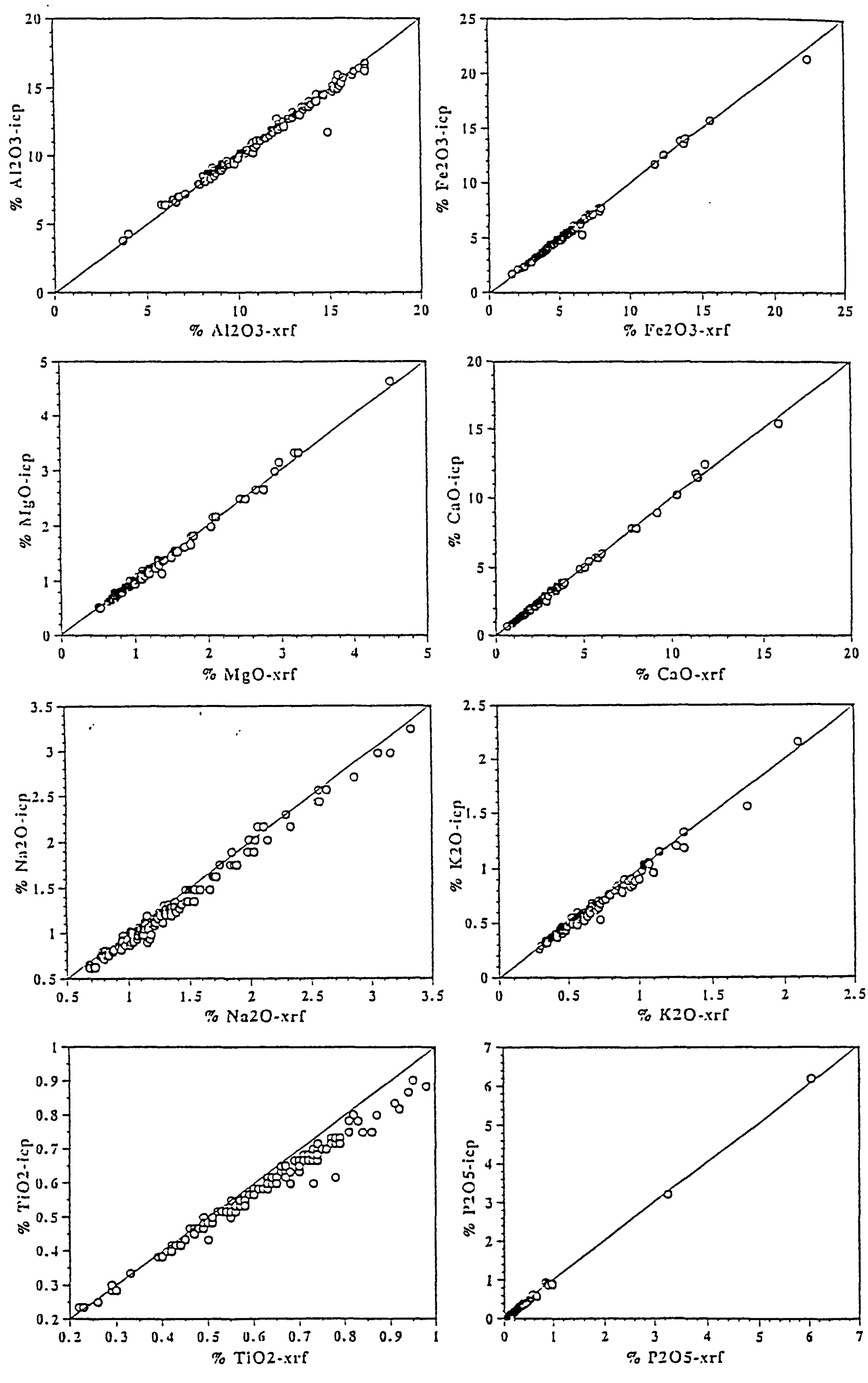


Figure 3. Scatter plots comparing concentrations of major- and minor-element oxides in samples from the Tule Lake core by ICP and by XRF.

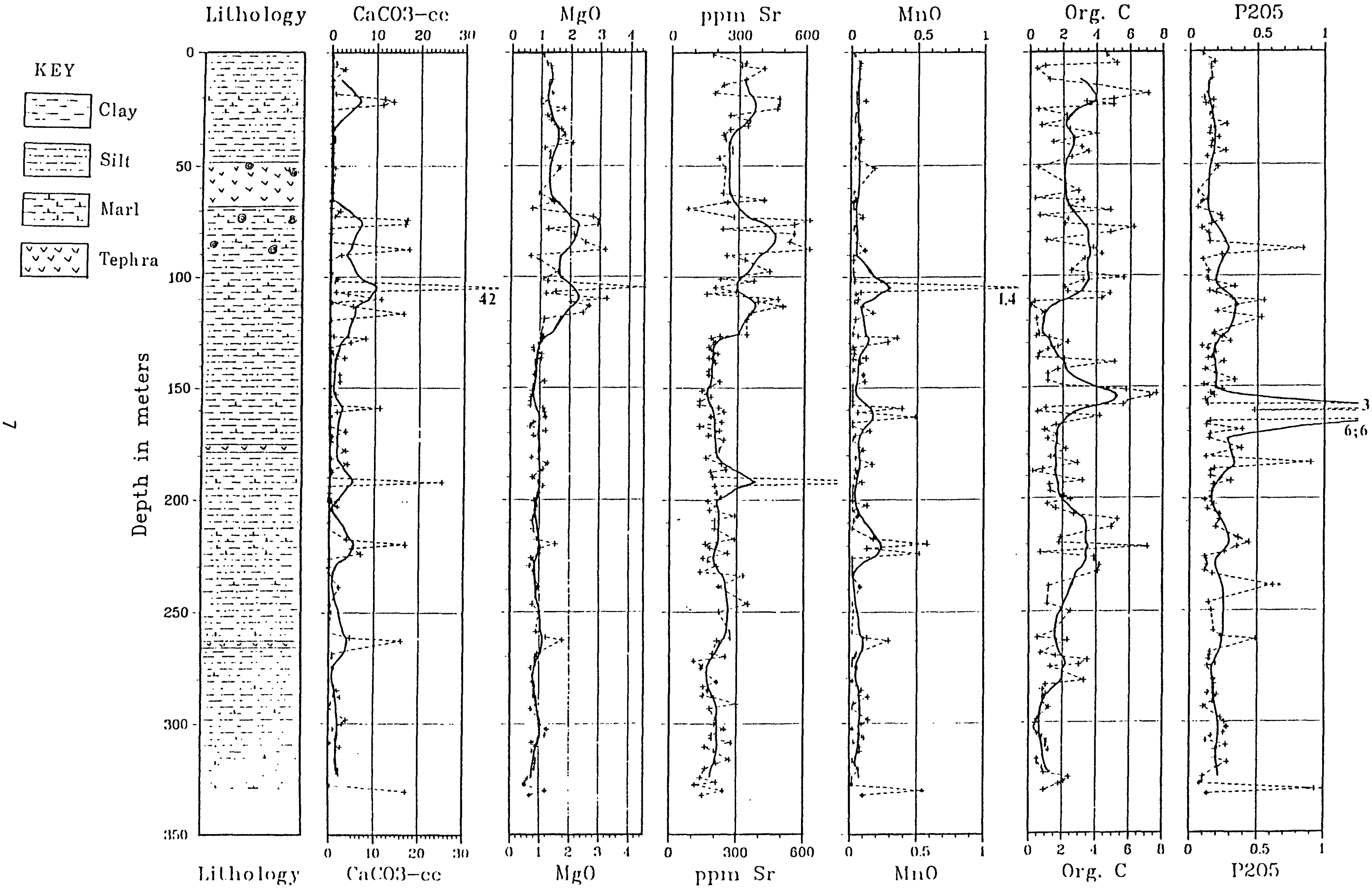
RESULTS AND INTERPRETATION

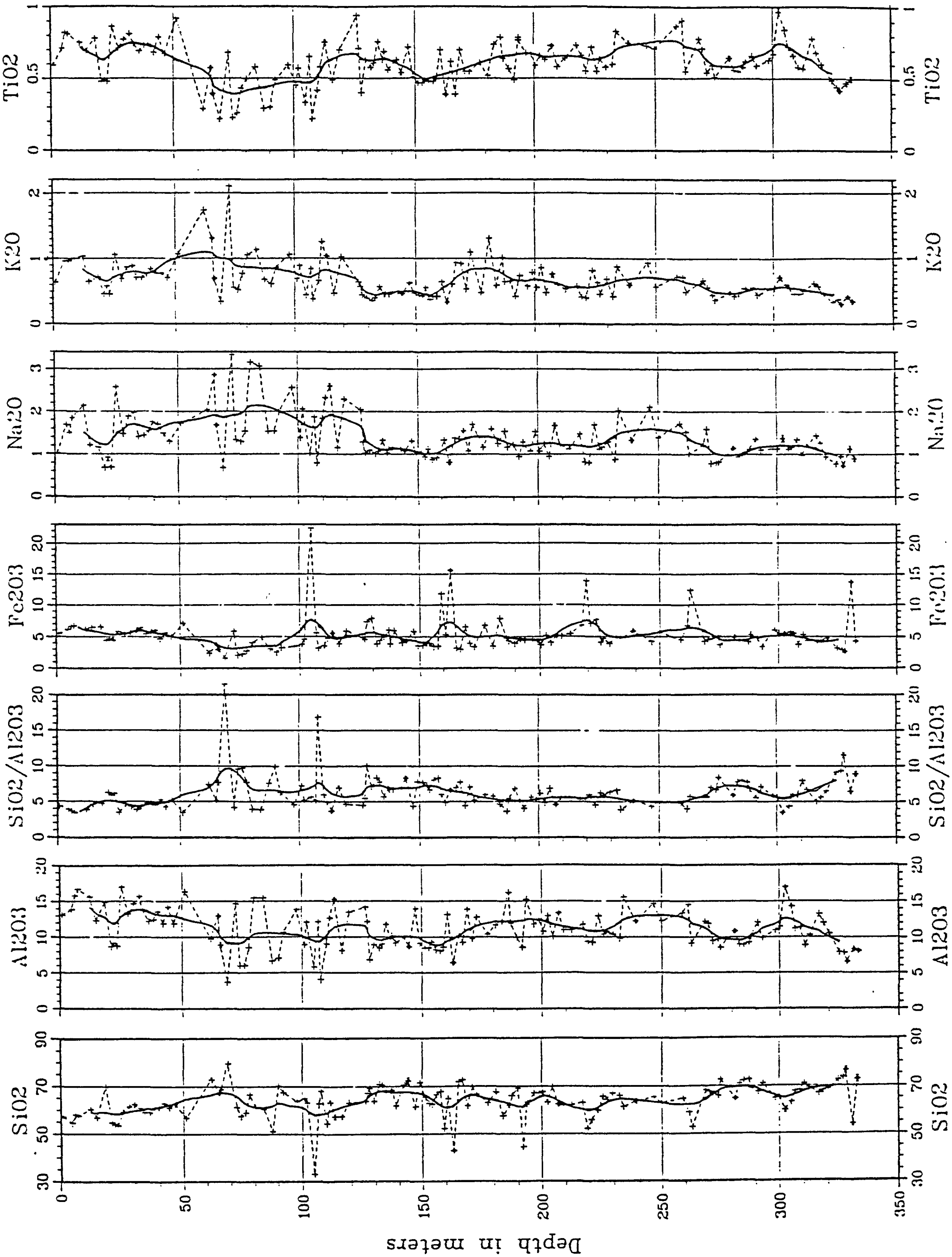
Results of analyses are presented in Appendix I, and plotted versus depth in Figure 4. Summary statistics for each oxide or element are given in Table 1.

Table 1. Minimum, maximum, mean, and standard deviation of analytical results for concentrations of major- and minor- element oxides (in percent) by XRF, for loss on ignition at 900° C (LOI-900), for concentrations of trace elements (in parts per million) by ICP, for percent $CaCO_3$ calculated from percent inorganic carbon, and for percents total carbon and organic carbon.

Oxide or Element	Minimum	Maximum	Mean	Standard Deviation
SiO_2	33.3	79.7	63.9	6.5
Al_2O_3	3.7	17	11.1	2.8
Fe_2O_3	1.5	22.4	5.2	2.6
MgO	0.5	4.5	1.2	0.61
CaO	0.62	15.9	2.74	2.33
Na_2O	0.68	3.33	1.38	0.51
K_2O	0.29	2.1	0.66	0.27
TiO_2	0.22	0.95	0.61	0.15
P_2O_5	0.25	6.05	0.28	0.59
MnO	0.008	1.24	0.086	0.14
LOI-900	0.08	24.9	11.8	3.6
Ba	63	780	313	91
Ni	11	59	34	10
Co	5	43	16	5
Cr	26	96	58	13
Cu	11	76	45	13
La	4	22	12	3
V	77	400	226	60
Pb	4	10	5	1
Sc	4	26	13	4
Sr	77	1100	251	127
Ce	8	50	28	8
Y	3	34	15	4
Zn	18	99	54	12
$CaCO_3$	0	42.2	2.6	5.8
Total C	0	7.7	2.5	1.9
Org, C	0	7.6	2.2	1.8

Figure 4. Lithologic summary and plots of concentrations of major-element oxides, $CaCO_3$, and organic carbon (in percent), and trace elements (in parts per million, ppm) versus depth in samples from Tule Lake, California. Raw data are indicated by plus symbols connected with a dashed line. Solid lines through the raw data are smoothed curves computed using 15-sample weighted moving averages.




TiO2
K2O
Na2O
Fe2O3
SiO2/Al2O3
Al2O3
SiO2
Depth in meters

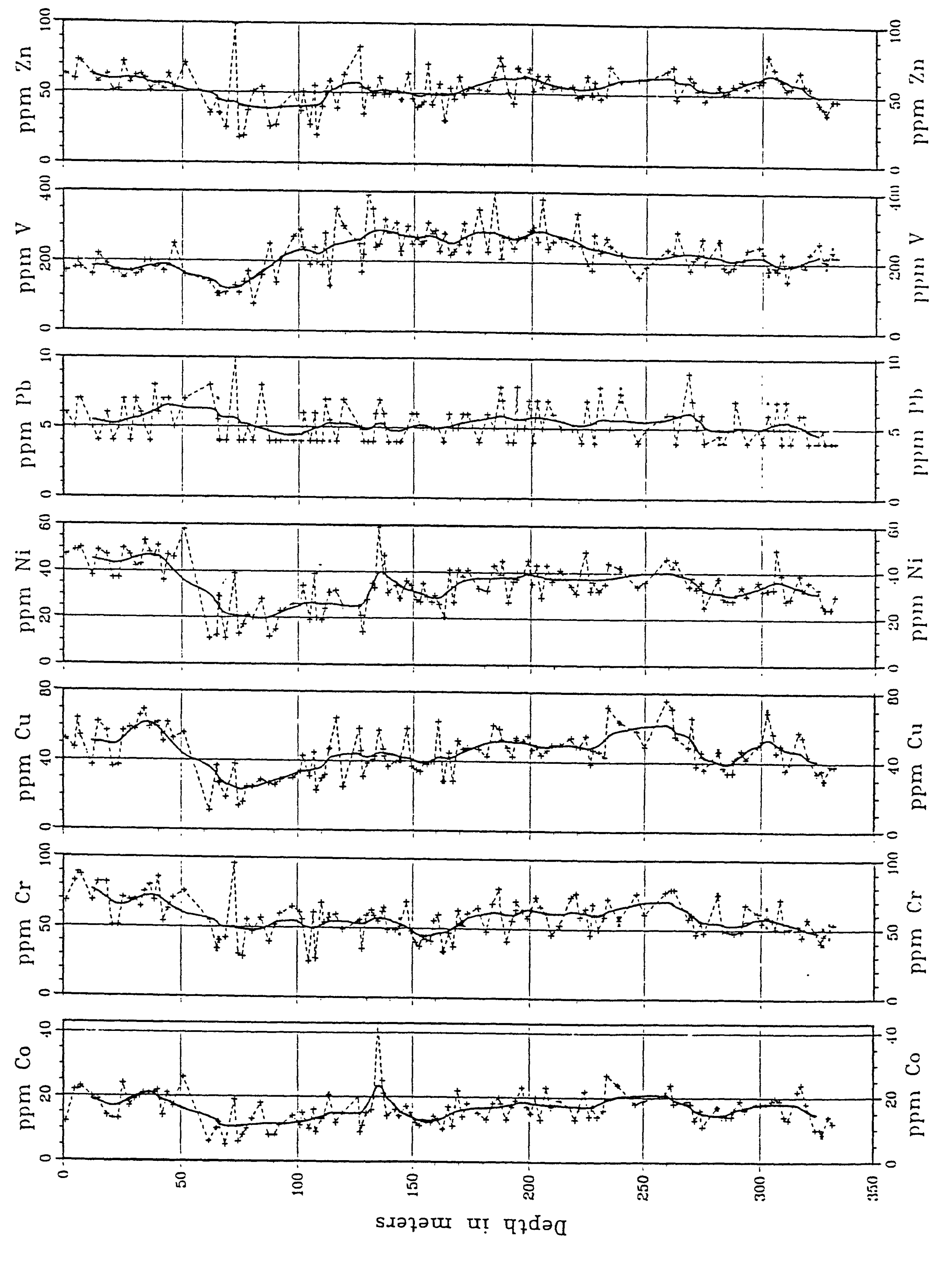
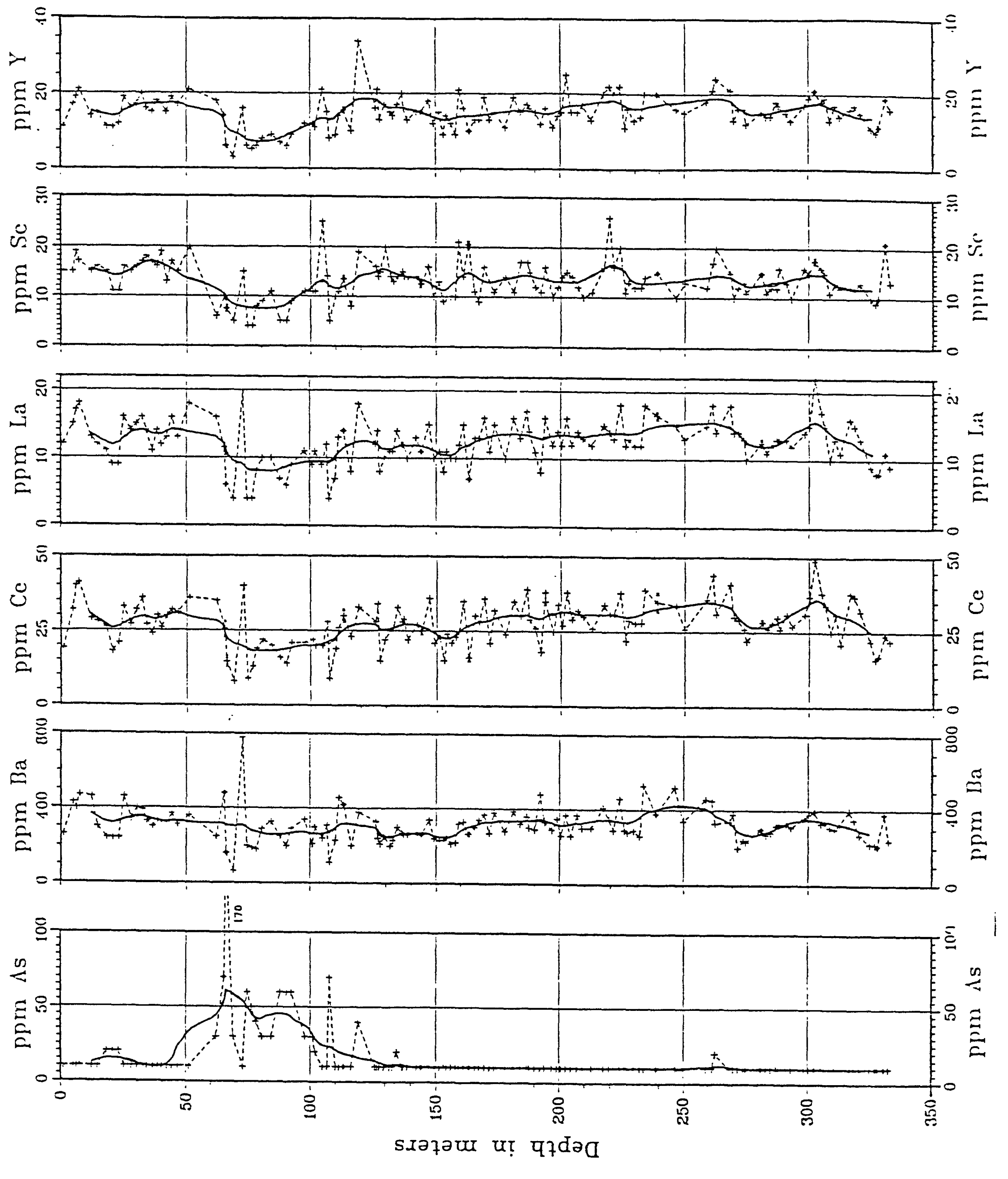

ppm Zn
ppm V
ppm Pb
ppm Ni
ppm Cu
ppm Cr
ppm Co
Depth in meters
0
50
100
150
200
250
300
350

Figure 4 (Cont.)



Based on preliminary sediment descriptions (Adam and others, 1989), the main sediment components of the Tule Lake core can be described in terms of a clastic component, $CaCO_3$, diatoms, and organic matter. Except for biogenic SiO_2 from diatom debris, estimates of these components can be obtained from the geochemical results (Figure 1). Because diatom debris is abundant in some parts of the section, the total SiO_2 values listed in Appendix I and plotted in Figure 1 are composites of nonbiogenic (clastic) SiO_2 and biogenic SiO_2 (diatom debris). In an attempt to obtain an estimate of these two different forms of SiO_2, I assumed, for reasons that will be discussed below, that the clastic fraction had average SiO_2 and Al_2O_3 contents similar to an average for Medicine Lake volcanics that cover much of the drainage basin of Tule Lake. The average SiO_2/Al_2O_3 ratio in 145 XRF analyses of this material is 3.5 (data provided by Julie Donnelly-Nolan, USGS, Menlo Park). I therefore assumed that average clastic sediment entering Tule Lake had this same average ratio, and I multiplied each value of Al_2O_3 by 3.5 to obtain an estimate of niobiogenic SiO_2. The biogenic SiO_2 content was computed by subtracting the nonbiogenic SiO_2 value from total SiO_2 for each sample.

In order to objectively examine relations among the numerous geochemical variables, and to provide a geochemical zonation of the core based on principle element associations, I ran a Q-mode factor analysis using the extended CABFAC program of Klovan and Miesch (1976). Prior to running the factor analysis, concentrations of all oxides and elements were transformed to proportions of the total range for each oxide and element. As a result of the transformation, all data were expressed on a scale of 0.0 to 1.0. After trying several different sets of reference axes in multidimensional space, I chose four orthogonal reference axes (4-factor solution) that maximize the variance of the transformed data in each dimension (varimax solution of Klovan and Miesch, 1976). The 4-factor model accounted for more then 55% of the variance in the scaled data for each variable, with an average of 70%. Basically, the 4-factor model reduced 24 measured variables (oxide and element concentrations) to four "composite" geochemical variables (factors). The intensities of the composite geochemical variables are the factor loadings. The loadings for each of the four factors for each sample are plotted versus depth in Figure 5.

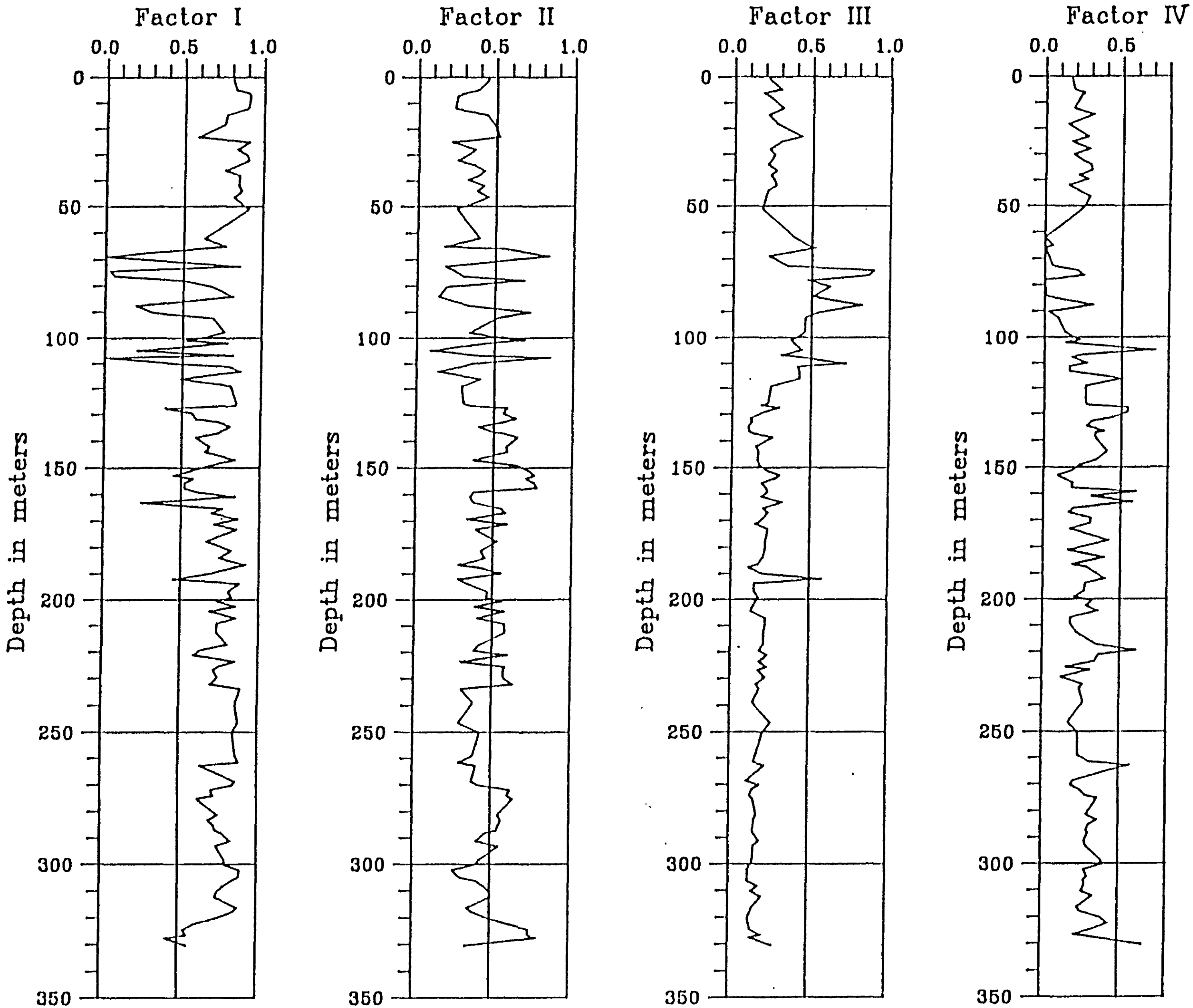


Figure 5. Plots of factor loadings from a 4-factor Q-mode factor analysis of geochemical data versus depth for samples from Tule Lake, California.

The factor loadings describe the relative importance of each of the factors for each sample, but give no indication of which of the elements had the most influence on determining each of the four factors. In order to determine which elements contributed to which factor, the factor loadings for each sample were treated as composite chemical variables with attributes of one or more actual measured variables, and correlation coefficients were computed between the loadings and the 24 measured variables. Results of the correlation analysis are given in Table 2.

Table 2. Correlation coefficients between Q-mode factor loadings and concentrations of major- and minor-element oxides, and trace elements in sediment samples from the Tule Lake core.

Oxide or Element	Factor I	Factor II	Factor III	Factor IV
SiO_2-nonbio.	0.85	-0.67	-0.23	-0.29
SiO_2-bio	-0.65	0.82	-0.01	0.06
Al_2O_3	0.85	-0.67	-0.23	-0.29
Fe_2O_3	0.00	-0.37	-0.09	0.65
MgO	-0.23	-0.60	0.67	0.07
CaO	-0.43	-0.42	0.80	0.14
Na_2O	0.38	-0.65	0.38	-0.52
K_2O	0.43	-0.58	0.23	-0.57
TiO_2	0.86	-0.48	-0.54	0.02
P_2O_5	-0.20	-0.13	0.07	0.37
MnO	-0.23	-0.30	0.07	0.64
Ba	0.65	-0.68	-0.13	-0.07
Ni	0.66	-0.23	-0.50	0.06
Co	0.67	-0.41	-0.43	0.06
Cr	0.60	-0.37	-0.30	0.02
Cu	0.68	-0.34	-0.53	0.19
La	0.83	-0.50	-0.55	-0.03
V	0.01	0.32	-0.37	0.54
Pb	0.58	-0.33	-0.25	-0.42
Sc	0.43	-0.42	-0.45	0.58
Sr	-0.06	-0.57	0.71	-0.16
Ce	0.79	-0.47	-0.55	0.02
Y	0.58	-0.42	-0.53	0.36
Zn	0.84	-0.43	-0.55	-0.06
$CaCO_3$	-0.47	-0.29	0.47	0.54
Org-C	-0.40	0.51	0.30	-0.27

The correlations between factor loadings and geochemical variables (Table 2) indicate four element associations (factors) that can be used to zone the core based on the geochemical results (Adam and others, 1989). Factor I groups samples based on concentrations of Ti, nonbiogenic Si, Al, La, Zn, Ce, Cu, Ba, Ni, Co, Y, Pb, Cr, and Sc, in order of decreasing correlation coefficients in Table 2. Figure 5 shows that sediments characterized by Factor I predominate throughout most of the recovered section in Tule Lake except in some beds in the carbonate-rich interval between 70 and 120 m.

Factor II groups biosiliceous, OC-rich samples. These samples occur in several beds within the carbonate-rich interval (70-120 m), within the organic-rich interval between 130 and 160 m, and at the bottom of the core (Figure 5). This zonation is based mainly on the concentrations of biogenic SiO_2 and organic carbon (Table 2).

Factor III sediments are those that contain the highest concentrations of $CaCO_3$ in the interval between 70 and 120 m. These carbonate-rich sediments also contain the highest concentrations of the carbonate-related elements Sr and Mg. Notice in Table 2 that the strongest variable in this carbonate association is CaO and not $CaCO_3$. The CaO values are total calcium measured by XRF and include both clastic calcium and calcium from $CaCO_3$. The $CaCO_3$ values were calculated from inorganic carbon. The fact that CaO is the strongest variable in the carbonate association suggests that analytically the CaO values provide a better estimate in the variations in $CaCO_3$ than inorganic carbon. A scatter plot of $CaCO_3$ computed from both CaO and carbonate carbon (both values listed in Appendix I) is shown in Figure 6. The values calculated from CaO are usually higher because of calcium from the clastic fraction.

Factor IV is weak, but appears to reflect variations in redox conditions within the lake. Factor IV sediments have relatively high concentrations of Fe, Mn, Sc, V, and P. $CaCO_3$ computed from carbonate carbon also contributes to this association (Table 2).

I interpret factor I sediments to represent a volcanic-ash association characterized by relatively high concentrations of Ti, nonbiogenic Si, Al, rare-earth elements, and trace transition elements. The raw geochemical data (Figure 4) and distribution of factor loadings (Figure 5) show that Tule Lake sediments are characterized by a predominant igneous rock component with varying amounts of biogenic silica (diatom debris) and organic matter, and, in a few beds, minor amounts of carbonate. The igneous rock component consists mainly of locally derived basic tephra with at least 12 acidic tephra layers that are widely distributed in the Pacific Northwest and provide the basis for regional correlations and tephrochronology of the Tule Lake core (Sarna-Wojicicki and others, 1988; Adam and others, 1989; Rieck and others, 1992).

In order to determine how much of the composition of the Tule Lake sediments can be explained in terms of the igneous rock component, a standard reference material is needed. An ideal reference would be the average composition of rocks in the drainage basin of Tule Lake. Lacking this information, I chose analyses of 145 samples of volcanic rocks from the Medicine Lake Highlands just south of Tule Lake (Figure 1) provided by Julie Donnelly-Nolan (Donnelly-Nolan and Nolan, 1986) as the basic igneous end member. The average of these analyses I will call MLV. Concentrations of major- and minor-element oxides were determined for all 145 MLV samples, but concentrations of only a few trace elements (Ba, Cu, Ni, Sr, Y, and Zn) were determined on a subset of the MLV samples. Because of the limited trace-element data for MLV, I also compared the Tule Lake ash to USGS standard basalt BCR-1 because there are more extensive trace-element data for this standard (Flanagan, 1969). For the acidic end member, I used USGS standard RGM-1, a rhyolite from Glass Mountain in the Medicine Lake Highland (Figure 1) (Tatlock and others, 1976). I chose sample 986 from a depth of 51.1 m (Appendix I) as a reference volcanic ash from the Tule Lake core. This sample probably represents a good average ash-rich sediment for the Tule Lake core because it comes from an interval in the core (50 to 65 m) that was deposited very slowly and contains several heterogeneous reworked tephra units (Adam and others, 1989; Rieck and others, 1992). A second reference analysis from the Tule Lake core is simply an average of analyses of all Tule Lake samples (Appendix I). These reference analyses are listed in Table 3.

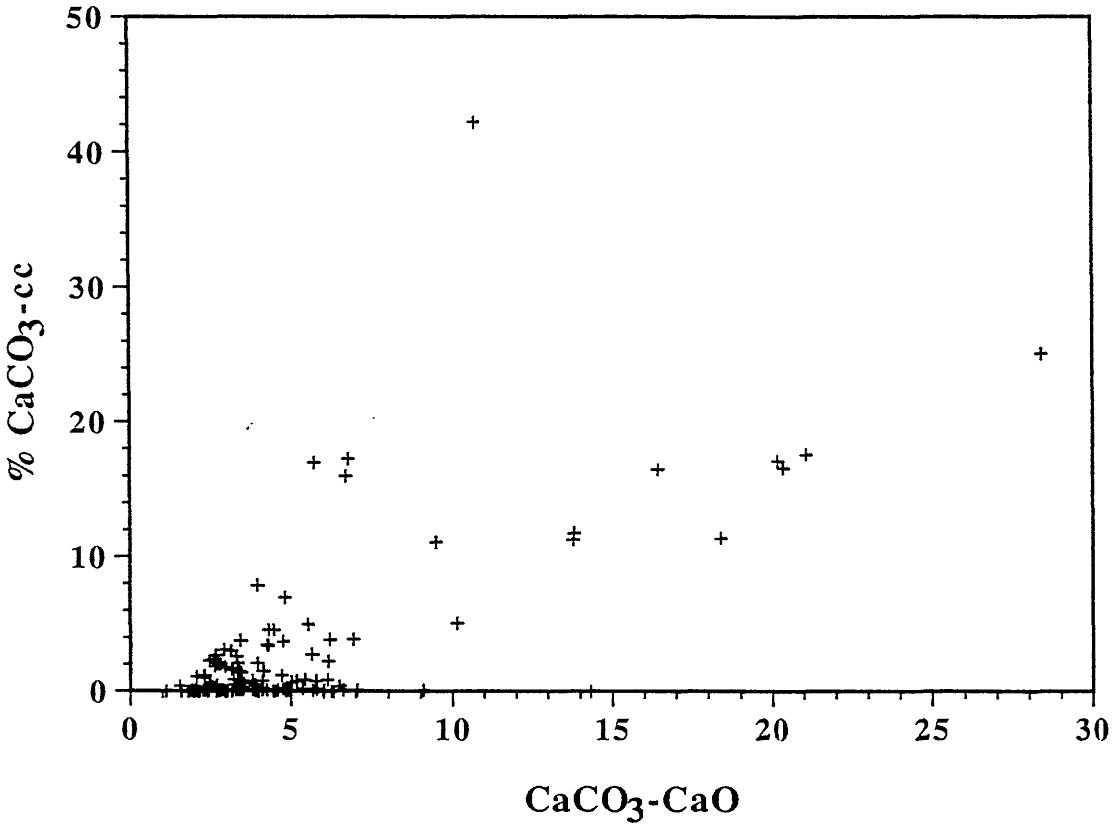


Figure 6. Scatter plot of Percent $CaCO_3$ calculated from total calcium (-Ca) and carbonate carbon (-CC) in samples of sediment from Tule Lake, California.

Table 3. concentrations of major- and minor-element oxides (in percent) and trace elements (in parts per million, ppm) in comparative standard materials. Leaders (--) indicate no analysis available.

Oxide or Element	Medicine Lake Volcanics (MLV)	Basalt (BCR-1)	Rhyolite (RGM-1)	Tule Lake 986	Average Tule Lake Sediment
SiO2	58.0	54.5	73.4	56.7	64
Al2O3	16.7	14.0	13.7	16.4	11.2
Fe2O3	7.14	13.0	1.73	7.1	5.2
MgO	4.39	3.46	0.29	1.65	1.18
CaO	6.73	6.92	1.17	2.3	2.81
Na2O	3.65	3.27	4.18	1.72	1.39
K2O	1.76	1.7	4.34	1.07	0.67
TiO2	0.88	2.2	0.26	0.92	0.61
MnO	0.12	0.18	0.05	0.18	0.09
P2O5	0.19	0.36	0.04	0.2	0.27
Ba	551	675	705	360	314
Co	--	38	--	26	16
Cr	--	18	3	76	58
Cu	79	18	10	56	46
La	--	26	--	18	12
Ni	106	16	--	58	34
Pb	--	18	21	7	5
Sc	--	33	5.5	20	13
Sr	182	330	111	240	250
V	--	400	13	160	230
Y	26	37	26.7	21	15
Zn	64	120	--	71	53
Ce	--	54	--	36	28

Figure 7 shows log-log plots of concentrations of major- and minor-elements oxides (in percent) in Tule Lake sample 986 versus those in the MLV and RGM-1 standards, and concentrations of trace elements (in parts per million) in Tule Lake sample 986 versus those in the MLV and BCR-1 standards. Figure 7A and B shows that the major- and minor-element composition of sample 986 is closer to the basic end member (MLV) than to the acidic end member (RGM-1), particularly when considering those oxides that are least likely to be affected by weathering (SiO_2, Al_2O_3, Fe_2O_3, and TiO_2). Tule Lake sample 986 is depleted in alkaline-earth- and alkali-element oxides CaO, MgO, Na_2O, and K_2O relative to MLV, and this probably reflects removal of these elements by weathering. Tule Lake ash, represented by sample 986, is depleted in most trace elements relative to BCR-1. They are distinctly enriched in Cr, Cu, and Ni relative to BCR-1 (Figure 7C), but are somewhat depleted in Cu and Ni relative to MLV (Figure 7D). Table 3 shows that average Tule Lake sediment has a composition similar to that of ash sample 986, but is enriched in SiO_2 because of inclusion of biogenic SiO_2 from diatoms. In summary, it appears that the detrital clastic material that reached the Tule Lake basin throughout the history of the lake was derived from weathered volcanic rocks from the Medicine Lake Highlands (Figure 1). In the lake, the detrital clastic material was diluted by major amounts of biogenic SiO_2 and minor amounts of carbonate and organic matter. In other words, the sediments of Tule Lake are composed mainly of weathered volcanic ash and diatoms.

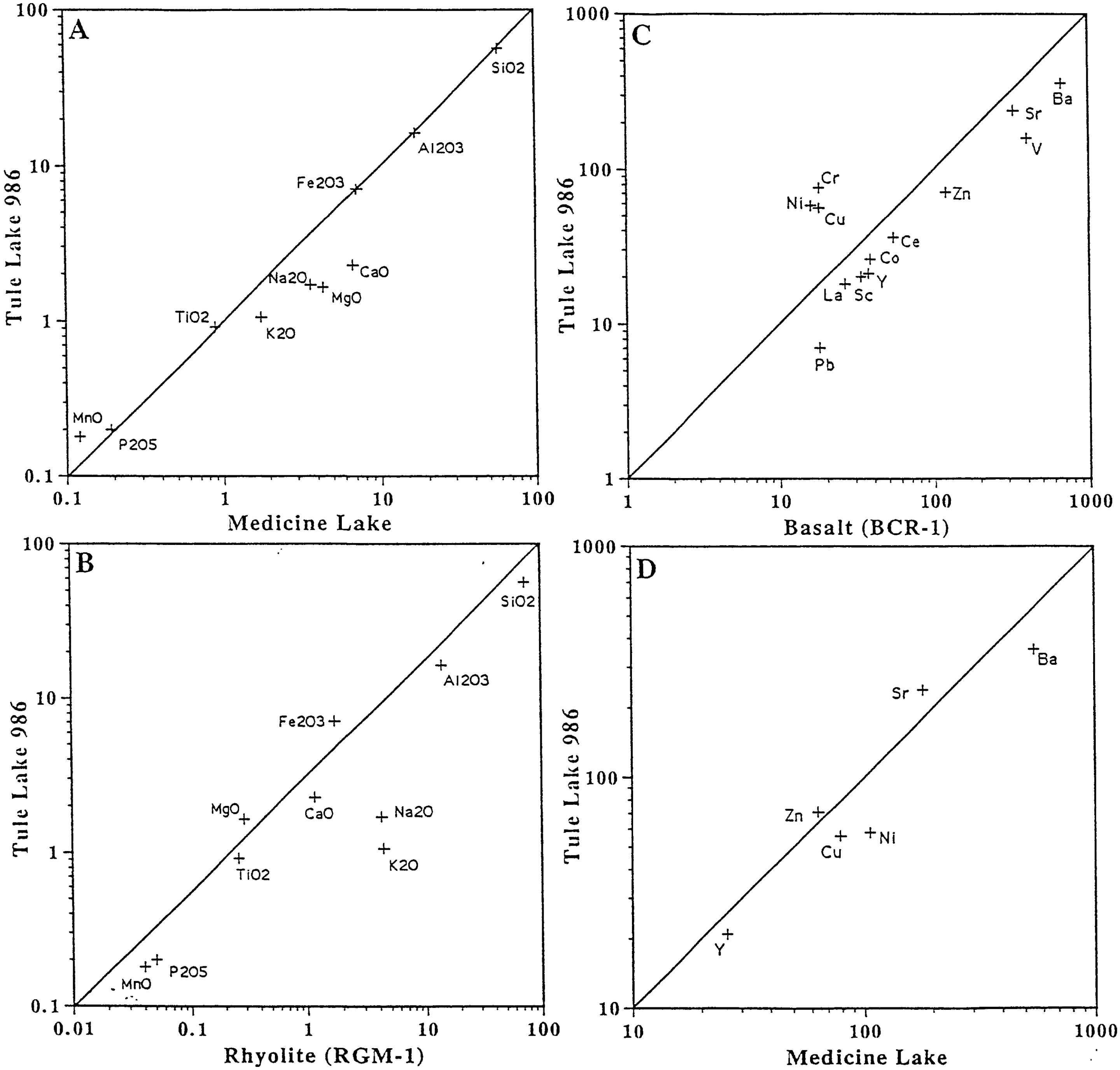


Figure 7. Log-log plots of concentrations of major- and minor-element oxides (in percent) in Tule Lake sample 986 versus those in average Medicine Lake volcanics (A) and USGS standard rhyolite RGM-1 (B); and concentrations of trace elements (in parts per million) in Tule Lake sample 986 versus those in average Medicine Lake volcanics (C) and USGS standard basalt BCR-1 (D).

As explained earlier, I used the SiO_2/Al_2O_3 ratio in the MLV standard (3.5; Table 3) and the Al_2O_3 content of each sample to compute the concentration of nonbiogenic SiO_2. Percent biogenic SiO_2 is then calculated by subtracting % nonbiogenic SiO_2 from total SiO_2. Using these calculations, average Tule Lake sediment contains 39.2% nonbiogenic SiO_2 and 24.8% biogenic SiO_2. Down-core variations of the computed estimates of these two forms of SiO_2 are shown in Figure 8 along with down-core variations in organic carbon repeated from Figure 4.

Q-mode factor II suggested that biogenic silica and organic matter were closely associated. Intuitively, this is what one might expect because most of the organic productivity in Tule Lake probably was from diatoms. However, based on all samples, the concentration of biogenic SiO_2 does not correlate very well with that of organic carbon ($r=0.20$, $n=131$). I used the moving correlation coefficient technique of Dean and Anderson (1974) to determine if there were any parts of the Tule Lake sequence where biogenic SiO_2 and organic carbon were more positively correlated than others (Figure 8). This technique computes correlation coefficients between two variables over a predetermined stratigraphic window that is moved down the section one point at a time. For the Tule Lake sequence I used a window that was 11-samples long so the coefficients plotted in Figure 8 represent correlations between samples 1-11, 2-12, 3-13, etc. Figure 8 shows the weak overall positive correlation between these two variables, but also shows that there are some intervals of much stronger positive correlation ($r>0.4$). In general, these intervals of strong positive correlation correspond to intervals of higher organic carbon content, particularly in the upper part of the sequence.

The factor analysis indicated that the sediments from Tule Lake could be described in terms of a four-component system of clastic material, carbonate, organic matter, and diatom debris. Based on the above discussion, the amounts of these components can be quantified. Assuming that the average clastic fraction has an Al_2O_3 concentration similar to that of average Medicine Lake volcanics (i.e. about 16.5; Table 3), then an average measured concentration of Al_2O_3 of 11.2% (Table 3) indicates that the average Tule Lake sediment is about 68% clastic material, derived mainly from basic igneous rocks in the drainage basin. The average concentration of organic matter would be about twice the organic carbon concentration or about 4.5%. The average concentration of $CaCO_3$ (computed from carbonate carbon) is 2.6% (Table 1), and the average computed biogenic SiO_2 content is 24.8%. These values add up to 99.9% and show that, on average, basic igneous rock debris makes up the bulk of Tule Lake sediment. The average loading for the clastic factor from the Q-mode analysis (Factor I) is 0.7, and the variations in Factor I loadings (Figure 5) can be used as a rough estimate of the proportion of the clastic fraction, ranging from as much as 0.9 (90%) to zero or near zero in lacustrine beds rich in carbonate, diatoms, and organic matter.

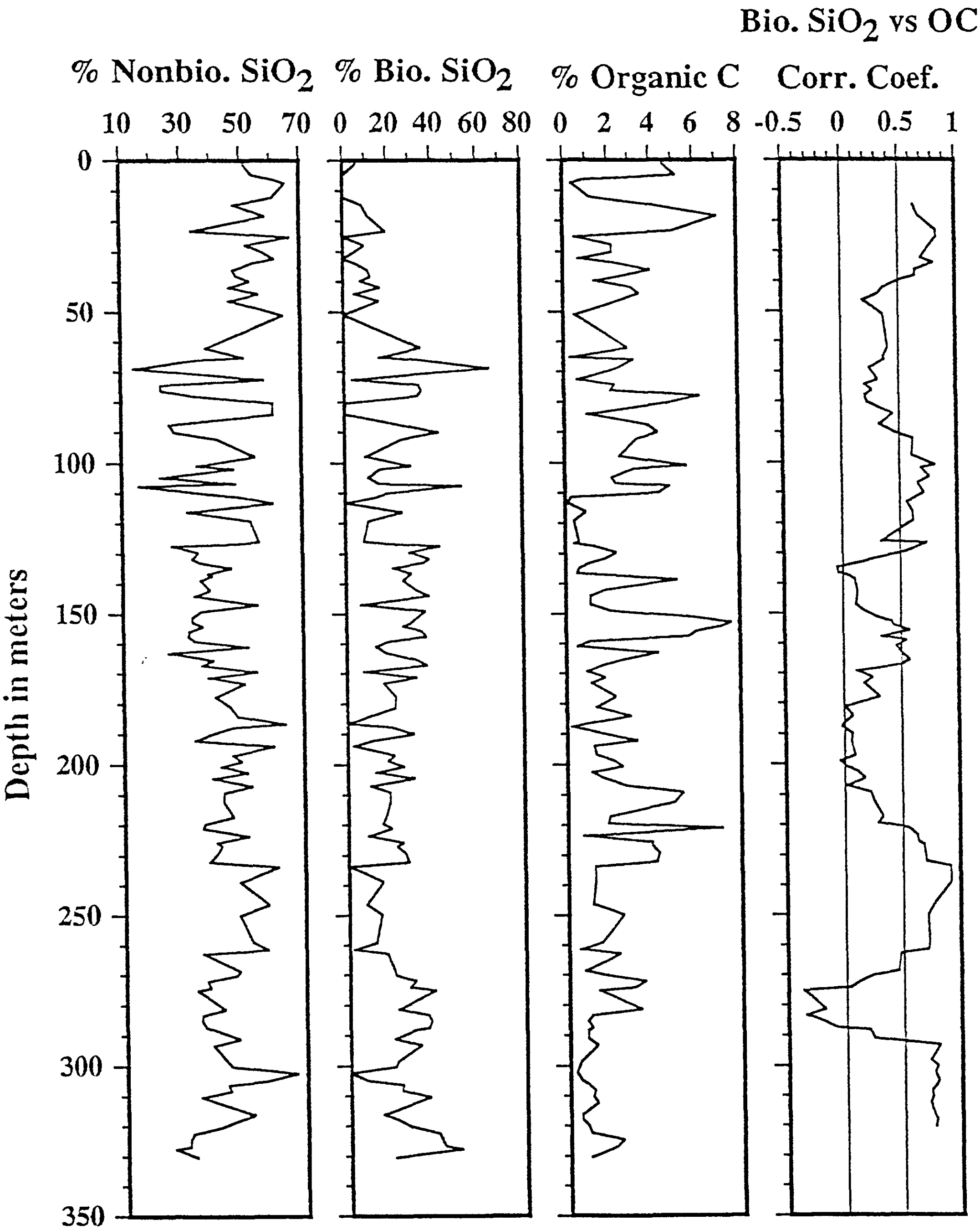


Figure 8. Plots of concentrations of nonbiogenic SiO_2,, biogenic SiO_2, and organic carbon; and moving correlation coefficients between biogenic SiO_2 and organic carbon verus depth for samples from Tule Lake, California. (See text for methods of computing nonbiogenic SiO_2, biogenic SiO_2, and moving correlation coefficients.)

REFERENCES CITED

Adam, D. P., Sarna-Wojcicki, A. M., Bradbury, J. P., Dean, W. E., Forester, R. M., and Rieck, H. J., 1989, Tule Lake, California: The last 3 million years: Palaeogeography, Palaeoclimatology, and Palaeoecology, v. 72, p. 89-103.

Dean, W. E., and Anderson, R. Y., 1974, Application of some correlation coefficient techniques to time-series analysis: Mathematical Geology, v. 6, p. 363-372.

Donnelly-Nolan, J. M., and Nolan, K. M., 1986, Catastrophic flooding and eruption of ash-flow tuff at Medicine Lake volcano, California: Geology, v. 14, p. 875-878.

Engleman, E. E., Jackson, L. L., Norton, D. R., and Fischer, A. G., 1985, Determinations of carbonate carbon in geological materials by coulometric titration: Chemical Geology, v. 53, p.125-128.

Flanagan, F, J., 1969, U.S. Geological Survey standards-II. First compilation of data for the new U.S.G.S. rocks: Geochimica et Cosmochimica Acta, v. 33, p. 81-120.

Klovan, J. E., and Miesch, A. T., 1976, Extended CABFAC and QMODEL computer programs for Q-mode factor analysis of compositional data. Computers and Geosciences, v. 1, p. 161-178.

Lichte, F. E., Golightly, D. W., and Lamothe, P. J., 1987, Inductively coupled plasma-atomic emission spectrometry, *in* Baedecker, P. A., ed., Methods for Geochemical Analysis: U. S. Geological Survey Bulletin 1770, p. B1-B10.

Rieck, H. J., Sarna-Wojcicki, A. M., Meyer, C. E., and Adam, D. P., 1992, Magnetostratigraphy and tephrochronology of an upper Pliocene to Holocene record in lake sediments at Tule Lake, northern California: Geological Society of America Bulletin, v. 104, p. 409-428.

Sarna-Wojcicki, A. M., Meyer, C. E., Adam, D. P., and Sims, J. D., 1988, Correlations and age estimastes of ash beds in late Quaternary sediments of Clear Lake, California, *in* Sims, J. D., ed., Later Quaternary climate, tectonism, and sedimentation in Clear Lake, northern California Coast Ranges: Geological Society of America Special Paper 214, p. 141-150.

Taggart, J. E., Jr., Lindsay, J. R., Scott, B. A., Vivit, D. V., Bartel, A. J., and Stewart, K. C., 1987, Analysis of geologic materials by wavelength-dispersive X-ray fluorescence spectrometry, *in* Baedecker, P. A., ed., Methods for Geochemical Analysis: U. S. Geological Survey Bulletin 1770, p. E1-E19.

Tatlock, D. B., Flanagan, F. J., Bastron, B., Berman, S., and Sutton, A. L., Jr., 1976, Rhyolite, RGM-1, from Glass Mountain, California, *in* Flanagan, F. J., ed., Descriptions and analyses of eight new USGS rock standards: U.S. Geological Survey Professional Paper 840, p. 11-14.

APPENDIX I

Chemical analyses of samples from Tule Lake, California. Analyses of major- and minor-element oxides (in percent) and trace elements (in parts per million) by induction-coupled plasma spectrometry (ICP), L.R. Layman and P. H. Briggs, analysts, are indicated by -I. All other analyses of major element oxides are by X-ray fluorescence (XRF), J. E. Taggart and K. C. Stewart, analysts.

Appendix I

Sample	Depth (m)	% SiO2-x	% Al2O3-x	% Al2O3-i	% Fe2O3-x	% Fe2O3-i	% MgO-x	% MgO-i	% CaO-x	% CaO-i	% Na2O-x	% Na2O-i	% K2O-x
947	1.26	57.2	13.1	13.0	5.49	5.43	1.07	1.04	1.86	1.96	1.02	0.89	0.64
12	5.02	54.5	13.9	13.8	6.18	6.01	1.19	1.23	3.43	3.50	1.69	1.62	0.96
16	6.29	58.0	15.8	15.7	6.63	6.58	1.31	1.39	2.73	2.94	1.50	1.48	0.97
19	7.45	57.5	16.7	16.4	6.76	6.72	1.33	1.36	3.16	3.36	1.85	1.89	1.00
28	12.22	60.3	15.6	15.3	6.17	6.01	1.37	1.36	3.18	3.22	2.14	2.02	1.04
31	14.68	56.8	12.3	12.1	6.48	6.44	1.24	1.26	2.23	2.38	1.22	1.13	0.65
39	18.34	69.9	14.9	11.7	6.60	5.29	1.37	1.14	2.90	2.52	1.15	0.89	0.72
46	20.77	54.7	8.7	8.7	4.40	4.43	0.98	0.96	7.74	7.84	0.68	0.61	0.46
973	23.21	53.5	8.7	8.9	4.39	4.43	0.98	0.98	7.72	7.84	0.69	0.61	0.45
56	25.21	59.4	17.0	16.8	5.86	5.72	1.76	1.66	3.94	3.92	2.57	2.43	1.06
63	27.98	61.5	13.3	13.0	5.59	5.58	1.20	1.16	2.21	2.24	1.47	1.35	0.69
67	30.17	62.5	14.7	14.4	5.66	5.43	1.33	1.29	2.75	2.66	1.89	1.75	0.87
70	32.31	60.9	15.7	15.3	6.00	5.72	1.50	1.49	3.00	2.94	1.98	1.89	0.89
72	33.98	59.1	13.7	13.6	6.44	6.44	1.68	1.62	2.38	2.38	1.41	1.28	0.71
79	36.21	59.1	12.2	12.3	5.45	5.58	1.80	1.82	2.57	2.66	1.44	1.32	0.71
86	38.11	61.3	12.5	12.5	5.81	5.58	1.57	1.56	2.81	2.80	1.55	1.48	0.77
87	39.74	61.1	13.6	13.4	6.07	5.86	2.07	2.16	3.37	3.36	1.75	1.75	0.84
93	41.98	63.0	11.9	11.9	4.69	4.58	1.12	1.14	2.30	2.38	1.70	1.62	0.77
97	43.94	61.1	14.3	14.5	5.66	5.72	1.32	1.31	2.31	2.38	1.49	1.35	0.78
100	46.43	62.7	11.9	11.9	4.98	5.01	1.29	1.29	1.91	1.96	1.30	1.23	0.71
986	51.1	56.7	16.4	16.2	7.13	7.01	1.65	1.61	2.30	2.38	1.72	1.62	1.07
237	62.07	73.1	9.8	9.6	2.36	2.43	0.94	1.01	1.97	2.10	2.04	2.02	1.74
254	65.22	66.9	13.0	13.2	3.68	3.72	1.38	1.38	3.70	3.92	2.86	2.70	1.31
254.1	65.22	68.1	13.0	12.8	3.78	3.72	1.39	1.38	3.82	3.78	2.86	2.70	1.31
991	66.01	68.2	9.1	9.3	2.96	3.00	1.50	1.43	2.50	2.66	1.69	1.62	0.69
991.1	66.01	69.5	8.8	8.7	2.97	2.86	1.40	1.39	2.46	2.38	1.67	1.48	0.70
1007	68.87	79.7	3.7	3.8	1.53	1.72	0.72	0.80	0.62	0.69	0.68	0.65	0.34
269	72.72	61.3	14.7	14.5	5.84	5.86	2.76	2.65	3.23	3.36	3.33	3.24	2.10
278	74.37	57.4	6.0	6.4	1.98	2.15	2.97	3.15	11.30	11.76	1.33	1.32	0.56
1030	76.35	58.9	6.0	6.4	2.25	2.29	2.91	2.98	11.40	11.48	1.29	1.31	0.52
293	78.11	66.6	8.6	8.7	2.78	2.86	1.25	1.24	1.87	1.96	1.54	1.48	0.77
301	80.46	61.4	15.5	14.9	4.03	3.86	2.11	2.16	5.08	5.04	3.16	2.97	1.06
325	84.2	60.4	15.5	15.9	4.89	4.86	2.51	2.49	4.80	4.90	3.06	2.97	1.14
335	87.66	51.2	6.7	7.0	3.07	3.15	3.18	3.32	11.80	12.46	1.53	1.48	0.69
347	90.22	70.3	7.1	7.2	2.48	2.43	0.68	0.68	3.44	3.64	1.54	1.35	0.61

Sample	Depth (m)	% SiO2-x	% Al2O3-x	% Al2O3-i	% Fe2O3-x	% Fe2O3-i	% MgO-x	% MgO-i	% CaO-x	% CaO-i	% Na2O-x	% Na2O-i	% K2O-x
354	92.36	67.5	10.7	10.8	3.24	3.29	0.98	0.98	2.71	2.80	1.99	2.02	0.87
361	97.86	63.7	13.9	14.0	3.43	3.43	1.58	1.53	3.53	3.64	2.55	2.43	1.06
366	101.02	65.1	9.0	8.9	3.77	3.86	1.10	1.19	1.91	1.96	1.38	1.35	0.69
372	102.05	63.2	12.1	12.7	4.58	4.58	1.25	1.24	3.04	3.22	2.06	2.16	0.89
377	104.95	33.3	5.8	6.4	22.40	21.45	4.50	4.64	6.01	6.02	1.01	1.01	0.44
386	106.86	62.9	12.2	12.1	5.56	5.43	1.53	1.53	2.64	2.66	1.87	1.75	0.84
389	107.7	68.1	4.0	4.3	3.18	3.29	1.20	1.19	3.87	3.78	0.79	0.80	0.38
394	110.07	54.4	9.1	9.4	3.58	3.58	3.24	3.32	10.30	10.22	1.84	1.75	0.66
400	111.35	63.4	12.7	12.7	4.72	4.72	2.04	1.99	3.64	3.64	2.33	2.16	1.26
406	113.22	56.7	15.4	15.5	5.53	5.58	2.65	2.65	5.68	5.74	2.56	2.56	1.03
406.1	113.22	57.9	15.2	15.1	5.65	5.43	2.65	2.65	5.82	5.74	2.63	2.56	1.05
410	116.18	57.4	8.1	8.5	3.89	4.00	2.44	2.49	9.20	8.96	1.15	1.19	0.47
416	119.13	63.2	13.5	13.6	5.90	5.86	1.14	1.09	3.24	3.22	2.29	2.29	1.03
439	125.97	63.9	14.2	14.0	4.84	4.72	1.06	1.03	3.50	3.50	2.04	2.02	0.64
442	126.71	67.2	12.2	12.1	4.58	4.43	1.13	1.14	1.88	1.96	1.28	1.23	0.57
444	127.59	69.2	6.8	7.0	7.33	7.15	1.02	1.04	2.23	2.24	1.03	0.97	0.44
451	129.57	64.0	9.0	9.1	7.90	7.72	1.01	1.04	2.42	2.38	1.10	1.04	0.39
456	131.76	70.9	8.5	8.3	3.82	3.86	0.78	0.81	1.22	1.30	1.01	0.86	0.35
462	132.89	70.5	9.1	8.9	4.37	4.29	0.80	0.80	1.62	1.68	1.07	1.02	0.40
466	134.61	67.5	11.8	11.7	4.97	4.86	1.07	1.06	1.99	1.96	1.33	1.25	0.57
472	136.57	67.9	9.8	9.8	6.02	5.86	1.04	1.06	1.64	1.68	1.03	0.98	0.45
473	137.14	68.4	10.2	10.2	3.82	3.72	0.88	0.88	1.57	1.54	1.13	1.08	0.46
479	138.69	61.8	9.2	9.1	5.93	5.72	0.83	0.83	1.97	1.96	1.16	1.04	0.45
488	142.14	70.6	10.0	10.0	3.99	3.86	0.90	0.90	1.31	1.33	1.12	1.04	0.49
491	143.99	71.4	8.7	8.7	4.29	4.29	0.81	0.80	1.58	1.68	1.09	1.00	0.46
491.1	143.99	73.1	8.7	8.5	4.39	4.29	0.82	0.80	1.60	1.68	1.07	1.00	0.47
496	147.04	61.5	14.0	13.8	5.86	5.86	1.17	1.16	1.88	1.96	1.31	1.23	0.63
501	149.04	71.6	9.2	9.3	3.53	3.58	0.76	0.80	1.37	1.40	1.01	1.01	0.47
506	151.19	65.5	8.5	8.3	3.63	3.72	0.74	0.71	1.18	1.22	1.04	0.90	0.44
510	152.93	62.9	8.5	8.7	3.93	4.00	0.74	0.70	1.31	1.33	0.94	0.92	0.42
514	154.13	62.4	9.3	9.3	3.94	3.86	0.71	0.71	1.51	1.54	1.13	1.12	0.56
518	155.88	66.5	8.2	8.1	3.42	3.43	0.68	0.66	1.01	1.05	0.87	0.78	0.37
524	157.71	67.8	8.1	8.1	3.48	3.43	0.68	0.68	1.08	1.09	0.92	0.84	0.42
528	159.13	52.2	8.6	8.9	11.80	11.73	1.11	1.14	5.31	5.46	1.02	1.00	0.42
534	160.93	64.8	13.2	13.0	5.29	5.15	1.16	1.14	2.32	2.38	1.34	1.27	0.65

Appendix I

Sample	Depth (m)	% SiO2-x	% Al2O3-x	% Al2O3-i	% Fe2O3-x	% Fe2O3-i	% MgO-x	% MgO-i	% CaO-x	% CaO-i	% Na2O-x	% Na2O-i	% K2O-x
538	163.1	42.9	6.4	6.8	15.60	15.73	1.18	1.23	8.02	7.84	0.79	0.75	0.34
538.1	163.1	43.0	6.5	6.8	15.60	15.73	1.21	1.23	7.97	7.84	0.84	0.75	0.33
546	165.48	71.8	10.2	10.2	3.17	3.15	0.78	0.76	1.86	1.82	1.38	1.29	0.61
554	167.13	72.6	9.3	9.3	2.93	2.86	0.66	0.66	1.15	1.18	1.36	1.29	0.94
559	169.28	61.9	13.9	13.6	6.52	6.29	1.20	1.19	2.40	2.38	1.55	1.48	0.92
563	171.33	69.9	9.8	9.8	3.88	3.86	0.78	0.81	1.43	1.54	1.08	0.96	0.53
568	173.23	66.6	12.8	12.7	3.33	3.29	0.98	0.98	2.14	2.24	1.70	1.62	1.10
580	177.72	63.0	10.4	10.4	6.73	6.72	1.02	1.01	2.39	2.52	1.16	1.06	0.48
587	181.17	67.7	11.7	11.5	3.44	3.43	0.73	0.76	1.36	1.40	1.59	1.48	1.31
591	184.02	57.5	12.2	12.1	7.82	7.44	1.26	1.24	3.47	3.36	1.24	1.16	0.59
598	186.69	62.0	16.3	15.9	4.69	4.58	1.10	1.08	1.98	1.96	1.54	1.48	1.02
600	187.62	66.1	11.9	11.9	4.26	4.29	1.00	0.98	1.52	1.54	1.16	1.05	0.65
603	189.97	69.1	10.0	9.8	3.87	3.86	0.74	0.73	1.69	1.68	1.23	1.15	0.66
611	192.17	44.7	8.6	9.1	4.55	4.58	0.93	0.90	15.90	15.40	0.95	0.97	0.43
617.1	193.85	63.3	15.2	14.7	4.44	4.29	1.10	1.06	1.52	1.54	1.28	1.11	0.74
617	193.87	62.4	15.3	14.9	4.35	4.29	1.10	1.04	1.50	1.54	1.21	1.08	0.74
624	196.95	67.2	11.8	11.9	4.42	4.43	0.97	0.96	1.57	1.54	1.08	1.06	0.58
629	198.97	67.0	12.5	12.1	4.23	4.15	0.90	0.88	1.79	1.82	1.53	1.35	0.79
635	200.67	67.6	10.8	10.2	3.69	3.58	0.82	0.81	1.30	1.34	1.07	0.93	0.56
637	202.56	63.5	13.0	12.8	5.19	5.29	0.93	1.01	1.66	1.82	1.25	1.23	0.87
641	204.58	69.8	10.1	10.2	4.05	4.15	0.86	0.90	1.28	1.37	0.95	0.92	0.48
647	207.06	62.7	13.4	13.0	5.15	4.86	0.83	0.80	2.49	2.52	1.71	1.62	0.76
651	209.21	62.0	11.0	10.8	5.10	5.01	0.76	0.75	1.69	1.68	1.21	1.12	0.60
657	212.56	62.1	11.0	10.8	5.44	5.29	0.80	0.78	1.57	1.54	1.12	1.06	0.53
666	217.26	63.2	11.8	11.7	6.80	6.72	0.93	0.95	2.66	2.66	1.47	1.48	0.58
672	219.43	52.2	9.4	9.6	13.90	14.01	1.54	1.56	3.21	3.36	0.81	0.77	0.41
676	221.16	55.8	9.2	9.3	7.01	7.15	1.04	1.08	3.10	3.36	0.80	0.71	0.40
682	223.64	59.8	13.0	12.8	7.74	7.72	1.01	0.95	2.70	2.80	1.70	1.62	0.82
691	225.74	65.7	10.4	10.2	4.14	4.15	0.73	0.73	1.12	1.15	1.12	0.98	0.64
697	226.85	64.3	10.8	10.6	4.74	4.86	0.80	0.81	1.21	1.32	1.17	0.93	0.46
699	229.45	67.0	10.4	10.4	3.87	3.72	0.67	0.66	1.67	1.68	1.29	1.21	0.69
707	232.2	66.1	9.8	9.4	4.85	4.86	0.82	0.81	1.10	1.13	0.88	0.81	0.42
711	233.8	61.4	15.6	15.1	4.78	4.72	0.84	0.86	2.52	2.66	2.03	1.89	0.88
718	238.86	63.3	12.3	12.1	5.89	5.86	0.99	0.95	2.22	2.10	1.35	1.19	0.59
718.1	238.86	64.3	12.2	12.1	5.94	5.72	0.96	0.95	2.15	2.24	1.31	1.20	0.61

Sample	Depth (m)	% SiO2-x	% Al2O3-x	% Al2O3-i	% Fe2O3-x	% Fe2O3-i	% MgO-x	% MgO-i	% CaO-x	% CaO-i	% Na2O-x	% Na2O-i	% K2O-x
724	246.47	65.4	14.7	14.5	4.20	4.15	0.76	0.78	2.66	2.80	2.11	2.16	0.94
729	249.88	63.0	12.3	12.1	5.70	5.58	0.98	0.95	1.82	1.82	1.39	1.23	0.57
739	259.03	64.9	13.4	13.0	4.49	4.43	0.89	0.88	2.19	2.24	1.72	1.62	0.73
749	261.61	59.0	14.6	14.5	6.81	6.86	1.22	1.23	2.50	2.66	1.52	1.48	0.72
745	262.91	52.8	9.1	9.3	12.40	12.58	1.77	1.82	3.76	3.92	1.01	1.02	0.49
756	268.77	68.3	12.2	11.9	4.23	4.15	0.93	0.91	1.40	1.40	1.22	1.11	0.62
764	270.19	67.7	11.9	11.7	4.49	4.43	0.87	0.88	2.13	2.10	1.59	1.48	0.67
768	272.02	67.0	9.5	9.4	4.67	4.58	0.84	0.85	0.89	0.91	0.78	0.73	0.56
772	274.22	65.8	9.8	9.8	5.12	5.15	0.85	0.85	1.22	1.27	0.81	0.80	0.44
774	275.22	72.6	8.6	8.5	3.72	3.72	0.72	0.75	1.16	1.20	0.82	0.75	0.36
785	281.37	64.8	10.9	10.6	5.03	4.86	0.77	0.76	1.70	1.68	1.13	1.04	0.47
785.1	281.37	64.7	10.8	11.0	4.97	4.86	0.79	0.78	1.68	1.68	1.16	1.05	0.48
790	283.32	70.9	9.0	9.1	4.31	4.43	0.86	0.85	1.29	1.34	0.94	0.81	0.42
794	285.22	72.2	9.0	8.9	4.32	4.29	0.80	0.83	1.48	1.54	0.99	0.92	0.47
800	287.37	72.6	9.3	9.3	4.13	4.00	0.80	0.78	1.29	1.32	1.07	0.98	0.55
802	288.24	68.8	10.1	10.2	5.30	5.15	0.91	0.91	1.86	1.82	1.12	1.05	0.54
807	291.17	67.5	12.1	12.1	4.72	4.58	0.95	0.93	2.18	2.24	1.35	1.28	0.56
815	293.24	71.0	9.9	9.8	3.42	3.43	0.72	0.78	1.35	1.40	1.10	0.97	0.44
823	298.36	64.8	11.0	11.1	6.02	6.15	1.03	1.04	1.93	2.10	1.13	1.08	0.53
826	300.21	65.3	11.5	11.3	5.46	5.58	0.98	1.01	1.77	1.96	1.13	1.11	0.55
833	302.4	59.2	17.0	16.4	5.44	5.43	1.24	1.24	1.81	1.96	1.31	1.28	0.71
833.1	302.4	60.4	17.0	16.2	5.54	5.29	1.29	1.23	1.85	1.82	1.42	1.27	0.72
837	304.96	63.1	14.3	14.0	5.71	5.58	1.20	1.14	1.53	1.54	1.11	0.98	0.60
841	306.33	67.7	11.2	11.1	5.43	5.29	0.98	0.98	1.59	1.68	1.16	1.04	0.54
846	308.31	68.1	11.4	11.3	3.70	3.72	0.75	0.76	2.20	2.38	1.34	1.29	0.46
859	310.33	70.9	8.9	8.9	5.27	5.01	0.88	0.90	1.50	1.54	0.97	0.86	0.46
861	312.26	69.1	10.3	10.2	4.27	4.29	0.76	0.73	1.80	1.82	1.19	1.09	0.51
876	316.3	66.8	13.3	13.0	4.10	4.00	0.90	0.88	1.94	1.96	1.43	1.31	0.62
883	317.95	68.0	12.0	11.9	4.41	4.29	0.87	0.86	1.78	1.82	1.26	1.19	0.57
886	320.33	68.6	10.5	10.4	4.73	4.72	0.85	0.86	1.46	1.54	0.94	0.88	0.45
894	322.45	71.8	8.1	8.1	4.27	4.43	0.68	0.71	1.39	1.54	0.87	0.80	0.33
912	324.55	72.4	7.9	7.9	3.15	3.15	0.63	0.63	1.04	1.09	0.77	0.74	0.33
904	326.63	73.6	7.8	7.9	2.86	2.86	0.52	0.50	1.51	1.54	0.95	0.90	0.37
906	327.7	75.6	6.6	6.6	2.62	2.72	0.50	0.53	0.87	0.94	0.72	0.62	0.29
906.1	327.7	77.5	6.6	6.6	2.70	2.72	0.53	0.51	0.90	0.91	0.73	0.62	0.30

Appendix I

Sample	Depth (m)	% SiO_2-x	% Al_2O_3-x	% Al_2O_3-i	% Fe_2O_3-x	% Fe_2O_3-i	% MgO-x	% MgO-i	% CaO-x	% CaO-i	% Na_2O-x	% Na_2O-i	% K_2O-x
920	330.48	53.4	8.4	8.7	13.60	13.87	1.23	1.23	3.80	3.92	1.18	0.98	0.41
920.1	330.48	54.5	8.3	8.7	13.80	13.59	1.18	1.21	3.76	3.78	1.07	0.98	0.42

Sample	% K2O-i	% TiO2-x	% TiO2-i	% P2O5-x	% P2O5-i	% MnO-x	% MnO-i	LOI 900C	ppm Ba	ppm Ni	ppm Co	ppm Cr	ppm Cu	ppm La	ppm Mo
947	0.62	0.59	0.57	0.09	0.09	<0.02	0.022	17.6	260	47	12	68	52	12	<2
12	0.85	0.71	0.68	0.18	0.16	0.07	0.075	17.2	430	49	22	83	47	15	<2
16	0.88	0.82	0.80	0.15	0.16	0.06	0.066	11.2	400	49	22	89	64	17	<2
19	0.90	0.81	0.78	0.15	0.16	0.06	0.068	9.4	470	50	23	87	54	18	<2
28	1.03	0.75	0.70	0.16	0.16	0.06	0.063	8.7	460	38	20	69	37	13	<2
31	0.59	0.69	0.67	0.13	0.14	0.05	0.053	16.6	300	49	19	82	62	12	<2
39	0.53	0.78	0.62	0.13	0.11	0.04	0.041	0.1	240	47	14	82	57	11	2
46	0.46	0.48	0.47	0.10	0.09	0.04	0.046	20.2	240	37	13	51	36	9	2
973	0.47	0.48	0.47	0.11	0.11	0.04	0.046	21.4	240	37	13	51	37	9	<2
56	1.06	0.86	0.75	0.17	0.14	0.05	0.054	7.1	460	50	24	71	57	16	<2
63	0.67	0.71	0.68	0.14	0.14	0.03	0.037	12.2	340	47	17	69	59	14	<2
67	0.85	0.77	0.73	0.17	0.16	0.03	0.041	9.3	400	42	19	70	58	15	<2
70	0.86	0.81	0.75	0.27	0.25	0.07	0.068	8.9	390	43	20	65	66	16	<2
72	0.71	0.74	0.70	0.15	0.16	0.07	0.068	12.8	330	53	21	75	69	14	<2
79	0.71	0.69	0.67	0.14	0.14	0.05	0.056	14.8	300	48	21	80	59	11	<2
86	0.76	0.73	0.67	0.21	0.21	0.08	0.085	12.3	330	46	21	69	61	14	2
87	0.84	0.74	0.68	0.16	0.14	0.06	0.065	9.6	330	51	22	86	62	12	<2
93	0.76	0.68	0.63	0.15	0.14	0.03	0.041	12.1	320	36	14	54	51	13	<2
97	0.77	0.79	0.73	0.26	0.25	0.06	0.065	10.7	370	47	21	63	62	16	<2
100	0.64	0.67	0.63	0.12	0.11	0.03	0.037	13.2	310	46	17	71	53	13	<2
986	1.04	0.92	0.82	0.20	0.16	0.18	0.168	10.6	360	58	26	76	56	18	<2
237	1.56	0.29	0.28	0.05	0.05	<0.02	0.023	5.8	250	11	6	55	11	16	<2
254	1.32	0.57	0.55	0.12	0.09	0.04	0.046	5.2	480	13	10	36	37	11	5
254.1	1.32	0.58	0.55	0.12	0.11	0.04	0.046	5.0	480	12	10	33	37	12	5
991	0.68	0.39	0.38	0.08	0.07	0.02	0.030	11.8	160	30	12	42	27	6	71
991.1	0.68	0.40	0.38	0.09	0.09	0.01	0.028	11.7	160	28	12	39	27	6	74
1007	0.32	0.22	0.23	0.05	0.05	<0.02	0.008	10.4	63	11	5	43	19	4	<2
269	2.16	0.68	0.60	0.22	0.21	0.09	0.093	5.0	780	39	19	96	38	20	<2
278	0.60	0.23	0.23	0.23	0.23	0.04	0.054	15.3	200	13	6	31	14	4	3
1030	0.55	0.26	0.25	0.15	0.16	0.04	0.049	14.7	190	17	8	29	16	4	2
293	0.76	0.43	0.42	0.08	0.07	<0.02	0.019	15.4	180	21	10	56	25	8	<2
301	1.04	0.50	0.48	0.13	0.11	0.04	0.052	7.4	290	20	13	47	25	10	<2
325	1.15	0.58	0.57	0.14	0.14	0.05	0.058	6.1	330	28	18	57	29	10	<2
335	0.67	0.29	0.30	0.84	0.94	0.11	0.112	17.8	250	12	8	40	27	7	4
347	0.52	0.30	0.28	0.23	0.25	<0.02	0.022	12.2	200	15	8	52	26	6	<2

Sample	% K2O-i	% TiO2-x	% TiO2-i	% P2O5-x	% P2O5-i	% MnO-x	% MnO-i	LOI 900C	ppm Ba	ppm Ni	ppm Co	ppm Cr	ppm Cu	ppm La	ppm Mo
354	0.86	0.49	0.47	0.09	0.09	<0.02	0.023	10.2	290	23	11	60	29	9	<2
361	1.04	0.59	0.57	0.13	0.11	0.02	0.034	8.7	340	26	14	65	30	11	<2
366	0.62	0.45	0.43	0.12	0.14	0.03	0.034	14.5	210	26	11	61	34	9	<2
372	0.90	0.57	0.55	0.13	0.14	0.03	0.039	11.2	300	34	15	56	43	11	<2
377	0.46	0.33	0.33	0.33	0.32	1.35	1.239	24.9	240	19	10	26	31	9	<2
386	0.84	0.65	0.62	0.14	0.14	0.08	0.083	11.1	310	39	16	61	45	12	<2
389	0.37	0.22	0.23	0.19	0.18	0.04	0.043	16.1	110	20	9	28	23	4	5
394	0.68	0.42	0.42	0.31	0.32	0.06	0.068	15.1	230	19	13	68	30	7	5
400	1.20	0.58	0.57	0.55	0.55	0.03	0.039	7.8	460	24	14	54	32	13	<2
406	1.04	0.74	0.67	0.34	0.32	0.09	0.094	8.4	420	32	21	60	47	14	<2
406.1	1.04	0.76	0.70	0.35	0.34	0.09	0.093	8.1	420	30	20	55	47	14	<2
410	0.46	0.49	0.48	0.20	0.21	0.17	0.168	14.6	200	32	12	60	65	8	<2
416	1.02	0.70	0.67	0.53	0.50	0.04	0.049	7.9	380	25	15	49	25	18	4
439	0.64	0.94	0.87	0.18	0.16	<0.02	0.026	8.2	330	25	20	55	59	12	<2
442	0.56	0.71	0.67	0.18	0.16	0.06	0.067	9.8	240	21	9	56	46	14	<2
444	0.44	0.40	0.38	0.24	0.23	0.35	0.323	10.8	210	14	11	35	31	8	<2
451	0.38	0.63	0.60	0.30	0.30	0.28	0.258	12.6	250	28	15	59	39	10	<2
456	0.32	0.58	0.57	0.09	0.09	<0.02	0.013	11.4	200	35	16	63	41	11	<2
462	0.40	0.61	0.58	0.13	0.11	0.03	0.036	10.7	230	33	20	59	43	11	<2
466	0.54	0.76	0.70	0.19	0.21	0.03	0.040	9.5	300	59	43	55	58	14	<2
472	0.44	0.63	0.58	0.16	0.14	0.12	0.121	10.3	270	40	25	62	47	12	<2
473	0.46	0.69	0.67	0.13	0.11	<0.02	0.014	11.3	260	47	21	65	43	12	<2
479	0.41	0.56	0.52	0.25	0.23	0.08	0.081	17.4	260	31	14	49	37	10	4
488	0.48	0.63	0.58	0.11	0.09	0.01	0.021	10.6	270	34	16	49	40	13	<2
491	0.41	0.53	0.52	0.19	0.21	<0.02	0.102	9.3	260	29	14	57	40	11	<2
491.1	0.46	0.55	0.50	0.19	0.18	<0.02	0.102	8.6	260	28	14	46	41	11	<2
496	0.56	0.72	0.68	0.33	0.32	0.11	0.107	11.5	340	36	17	69	59	15	<2
501	0.46	0.51	0.48	0.10	0.09	<0.02	0.013	10.8	240	34	15	48	37	10	<2
506	0.43	0.47	0.47	0.24	0.23	<0.02	0.018	16.7	230	28	12	40	35	11	<2
510	0.40	0.47	0.45	0.15	0.14	<0.02	0.013	19.8	230	27	11	37	34	8	3
514	0.54	0.49	0.47	0.18	0.16	<0.02	0.018	18.9	250	35	13	44	39	11	<2
518	0.37	0.48	0.47	0.11	0.11	<0.02	0.013	17.0	210	29	12	42	38	10	<2
524	0.41	0.48	0.47	0.13	0.11	<0.02	0.013	16.0	220	27	12	41	40	10	<2
528	0.40	0.50	0.43	3.26	3.21	0.39	0.374	13.8	320	30	14	56	40	12	<2
534	0.64	0.70	0.63	0.48	0.48	0.06	0.061	9.7	330	26	13	60	63	15	<2

Sample	% K2O-i	% TiO2-x	% TiO2-i	% P2O5-x	% P2O5-i	% MnO-x	% MnO-i	LOI 900C	ppm Ba	ppm Ni	ppm Co	ppm Cr	ppm Cu	ppm La	ppm Mo
538	0.34	0.39	0.38	6.05	6.19	0.49	0.452	18.1	260	21	10	34	28	7	<2
538.1	0.34	0.39	0.38	6.02	6.19	0.49	0.452	17.8	270	20	10	33	29	7	<2
546	0.60	0.62	0.58	0.15	0.14	<0.02	0.022	8.8	300	41	17	47	45	13	<2
554	0.91	0.39	0.38	0.12	0.09	<0.02	0.028	10.0	340	27	11	37	29	13	<2
559	0.89	0.70	0.65	0.39	0.37	0.15	0.142	10.6	370	41	22	63	52	16	<2
563	0.52	0.55	0.53	0.15	0.14	0.04	0.045	10.8	270	38	14	52	47	11	<2
568	0.96	0.55	0.53	0.14	0.14	0.01	0.025	9.2	380	41	18	61	48	15	<2
580	0.43	0.61	0.58	0.38	0.39	<0.02	0.098	12.8	280	33	15	65	47	10	<2
587	1.18	0.52	0.52	0.12	0.11	0.04	0.043	9.8	390	32	13	48	43	16	<2
591	0.58	0.74	0.68	0.90	0.87	0.17	0.155	14.2	320	43	18	68	61	13	<2
598	0.98	0.79	0.73	0.18	0.16	0.04	0.045	10.1	360	39	20	79	59	17	<2
600	0.64	0.64	0.62	0.15	0.14	0.05	0.052	11.5	300	45	18	61	53	14	<2
603	0.65	0.57	0.53	0.15	0.14	0.03	0.039	11.6	290	27	13	41	48	11	<2
611	0.44	0.49	0.48	0.30	0.30	0.09	0.096	21.6	480	36	17	56	43	8	<2
617.1	0.71	0.79	0.72	0.18	0.18	<0.02	0.017	10.8	340	37	19	64	54	16	<2
617	0.71	0.77	0.72	0.17	0.16	<0.02	0.017	11.3	330	40	19	70	53	16	<2
624	0.56	0.68	0.63	0.16	0.14	<0.02	0.015	10.2	290	40	23	63	52	12	<2
629	0.76	0.67	0.62	0.16	0.14	<0.02	0.019	10.5	350	45	17	58	55	14	<2
635	0.48	0.59	0.57	0.11	0.11	<0.02	0.018	11.7	260	35	15	64	47	12	<2
637	0.78	0.66	0.63	0.18	0.18	0.13	0.129	10.8	370	43	20	73	49	16	<2
641	0.44	0.63	0.62	0.13	0.14	<0.02	0.023	10.3	260	29	13	66	44	12	<2
647	0.72	0.73	0.68	0.22	0.21	0.06	0.065	11.3	370	43	23	61	47	14	<2
651	0.58	0.58	0.53	0.22	0.23	0.03	0.041	16.4	300	36	17	46	50	13	<2
657	0.52	0.64	0.60	0.19	0.18	<0.02	0.021	16.2	300	41	19	53	50	12	<2
666	0.58	0.73	0.70	0.36	0.34	0.18	0.168	11.0	410	34	17	73	54	15	<2
672	0.40	0.66	0.63	0.44	0.41	0.58	0.555	16.1	350	31	13	76	49	14	<2
676	0.37	0.55	0.55	0.35	0.39	0.13	0.128	20.4	290	40	17	59	49	13	<2
682	0.80	0.72	0.68	0.26	0.25	0.52	0.465	10.4	460	49	22	65	55	18	<2
691	0.61	0.55	0.52	0.11	0.11	<0.02	0.015	14.4	290	32	14	46	39	12	<2
697	0.41	0.64	0.62	0.12	0.14	<0.02	0.012	14.3	280	36	17	68	47	13	<2
699	0.66	0.58	0.55	0.13	0.11	<0.02	0.014	13.0	290	32	14	50	46	12	<2
707	0.37	0.60	0.58	0.11	0.11	<0.02	0.017	14.3	260	35	16	59	43	12	<2
711	0.78	0.83	0.78	0.17	0.16	<0.02	0.027	9.6	530	44	27	72	72	18	<2
718	0.59	0.74	0.72	0.67	0.57	0.08	0.079	10.8	380	43	24	60	64	16	<2
718.1	0.58	0.76	0.70	0.57	0.62	0.08	0.080	10.4	380	41	24	54	63	17	<2

Appendix I

Sample	% K2O-i	% TiO2-x	% TiO2-i	% P2O5-x	% P2O5-i	% MnO-x	% MnO-i	LOI 900C	ppm Ba	ppm Ni	ppm Co	ppm Cr	ppm Cu	ppm La	ppm Mo
724	0.83	0.73	0.60	0.14	0.11	<0.02	0.026	8.1	520	34	18	76	58	15	<2
729	0.56	0.71	0.67	0.16	0.16	0.03	0.035	12.3	340	36	19	61	49	13	<2
739	0.71	0.87	0.80	0.18	0.16	<0.02	0.023	9.9	460	46	21	77	76	15	<2
749	0.67	0.91	0.83	0.23	0.21	0.13	0.129	11.1	450	42	24	79	71	18	<2
745	0.47	0.55	0.55	0.49	0.46	0.29	0.284	16.0	330	45	18	79	55	14	<2
756	0.60	0.78	0.72	0.15	0.14	0.05	0.056	9.5	340	34	19	58	49	18	<2
764	0.66	0.71	0.67	0.15	0.14	0.04	0.048	9.4	380	38	18	61	66	14	<2
768	0.54	0.54	0.52	0.14	0.11	<0.02	0.022	14.3	200	33	13	47	38	14	<2
772	0.43	0.59	0.57	0.19	0.18	<0.02	0.025	14.0	240	36	16	56	46	13	<2
774	0.36	0.51	0.50	0.13	0.11	0.06	0.065	10.0	230	25	11	48	36	10	<2
785	0.47	0.65	0.60	0.18	0.16	<0.02	0.019	13.7	300	38	17	77	45	12	<2
785.1	0.47	0.64	0.62	0.17	0.16	<0.02	0.021	13.7	300	37	17	73	48	13	<2
790	0.42	0.56	0.53	0.18	0.16	0.06	0.063	10.1	270	29	14	50	37	11	<2
794	0.46	0.55	0.52	0.18	0.16	0.09	0.097	9.1	280	28	14	49	34	12	<2
800	0.54	0.58	0.55	0.13	0.11	0.07	0.075	9.1	320	28	14	48	34	13	<2
802	0.53	0.62	0.58	0.20	0.18	0.14	0.142	9.2	330	30	16	48	42	13	<2
807	0.56	0.66	0.63	0.17	0.16	0.03	0.037	9.7	330	34	19	49	47	13	<2
815	0.41	0.59	0.57	0.10	0.09	<0.02	0.009	9.6	310	30	16	68	42	12	<2
823	0.49	0.63	0.60	0.23	0.23	0.14	0.142	10.7	360	36	18	62	50	14	<2
826	0.52	0.67	0.65	0.26	0.27	0.09	0.096	10.6	380	32	18	55	53	15	<2
833	0.64	0.95	0.90	0.27	0.27	0.02	0.028	10.9	400	33	18	66	71	22	<2
833.1	0.68	0.98	0.88	0.28	0.27	0.02	0.028	10.4	390	32	18	53	67	22	<2
837	0.58	0.84	0.75	0.25	0.27	0.08	0.083	10.5	330	33	19	57	57	17	<2
841	0.53	0.72	0.67	0.16	0.16	0.11	0.106	10.0	340	50	20	51	46	15	<2
846	0.43	0.66	0.65	0.12	0.11	0.03	0.041	9.9	310	39	19	72	50	10	<2
859	0.44	0.58	0.53	0.27	0.25	0.08	0.083	9.6	300	28	14	50	36	13	<2
861	0.50	0.57	0.55	0.19	0.18	0.08	0.079	9.9	330	29	13	51	40	11	<2
876	0.60	0.78	0.73	0.19	0.18	0.02	0.034	9.5	400	39	22	53	58	16	<2
883	0.56	0.68	0.63	0.28	0.32	0.04	0.046	9.2	350	32	24	45	55	15	<2
886	0.41	0.60	0.57	0.21	0.21	0.07	0.077	10.4	270	36	18	58	44	13	<2
894	0.31	0.49	0.50	0.13	0.14	<0.02	0.103	9.8	240	30	12	54	38	9	<2
912	0.32	0.49	0.48	0.10	0.09	<0.02	0.011	11.5	220	33	10	48	34	9	<2
904	0.36	0.44	0.42	0.10	0.09	<0.02	0.023	10.8	220	26	10	41	36	8	<2
906	0.26	0.41	0.40	0.08	0.07	<0.02	0.028	10.3	210	25	9	52	31	8	<2
906.1	0.29	0.42	0.40	0.08	0.07	<0.02	0.028	9.8	210	24	8	40	29	8	<2

Sample	% K2O-i	% TiO2-x	% TiO2-i	% P2O5-x	% P2O5-i	% MnO-x	% MnO-i	LOI 900C	ppm Ba	ppm Ni	ppm Co	ppm Cr	ppm Cu	ppm La	ppm Mo
920	0.38	0.46	0.47	0.98	0.89	0.54	0.516	14.6	380	25	14	55	39	11	<2
920.1	0.42	0.48	0.47	0.89	0.92	0.55	0.516	14.7	380	24	14	45	38	11	<2

Sample	ppm V	ppm Pb	ppm Sc	ppm Sr	ppm Ce	ppm Y	ppm Zn	% CaCO3-cc	% CaCO3-Ca	% Corg
947	170	6	15	180	19	11	63	0.1	3.2	4.6
12	180	5	15	330	32	17	59	0.9	5.9	5.2
16	200	7	19	310	40	19	73	0.1	4.7	0.9
19	180	7	17	410	41	21	72	2.8	5.4	0.4
28	160	5	15	330	29	14	63	0.1	5.5	1.2
31	220	3	16	230	28	15	57	0.1	3.8	4.0
39	190	6	15	190	26	11	63	0.8	5.0	7.1
46	170	3	11	480	18	11	51	11.8	13.3	5.0
973	170	5	11	480	21	12	52	11.3	13.3	5.0
56	150	7	16	470	33	19	72	0.1	6.8	0.5
63	170	3	15	260	27	16	57	0.1	3.8	2.2
67	160	7	16	350	32	17	62	0.1	4.7	2.2
70	170	6	17	340	36	20	63	0.2	5.2	0.7
72	200	5	18	260	27	16	60	0.1	4.1	2.4
79	200	3	17	230	24	15	51	0.1	4.4	4.0
86	180	8	16	240	30	18	56	0.7	4.8	2.7
87	190	6	19	260	26	17	56	0.1	5.8	1.4
93	170	7	13	270	30	15	52	0.1	4.0	3.1
97	190	7	17	270	32	19	63	0.2	4.0	3.5
100	250	5	15	210	31	17	53	0.1	3.3	2.5
986	160	7	20	240	36	21	71	0.8	4.0	0.5
237	140	8	6	230	35	18	35	0.2	3.4	2.9
254	110	4	10	420	23	14	45	0.1	6.4	0.3
254.1	100	7	10	410	28	14	45	--	6.6	--
991	100	4	7	260	13	6	35	0.0	4.3	3.2
991.1	110	4	8	240	16	6	35	--	4.2	--
1007	110	3	5	77	8	3	25	0.0	1.1	2.4
269	130	10	15	280	40	16	99	0.8	5.6	0.6
278	110	3	4	620	9	6	18	17.1	19.5	2.3
1030	140	3	4	550	13	5	19	16.6	19.7	2.1
293	170	5	8	230	19	6	37	0.0	3.2	6.2
301	77	3	9	550	22	8	51	0.1	8.8	4.8
325	160	8	11	530	20	9	54	0.0	8.3	1.0
335	250	3	5	620	16	7	26	17.6	20.3	3.8
347	140	3	5	250	14	6	27	2.3	5.9	4.3

Sample	ppm V	ppm Pb	ppm Sc	ppm Sr	ppm Ce	ppm Y	ppm Zn	% CaCO3-cc	% CaCO3-Ca	% Corg
354	200	4	9	330	21	9	40	0.0	4.7	3.3
361	270	4	11	440	21	12	50	0.0	6.1	2.5
366	290	3	11	220	22	12	37	1.5	3.3	5.6
372	240	6	11	370	20	11	51	0.9	5.2	3.2
377	190	3	25	200	20	21	27	42.2	10.4	2.1
386	240	6	14	290	28	15	55	1.2	4.6	2.3
389	200	3	5	160	9	8	20	3.9	6.7	4.8
394	190	3	10	480	19	9	40	11.4	17.8	4.3
400	280	7	11	390	26	14	51	0.4	6.3	0.3
406	130	7	13	510	28	15	58	5.1	9.8	0.1
406.1	130	4	14	490	32	16	59	--	10.0	--
410	350	3	8	360	23	10	39	16.5	15.9	0.9
416	300	7	19	340	33	34	63	0.2	5.6	0.4
439	250	5	16	340	28	16	83	0.0	6.0	0.6
442	170	5	14	220	34	21	54	0.8	3.2	0.4
444	220	3	15	180	15	13	35	7.9	3.8	1.2
451	390	3	20	200	22	17	54	4.6	4.2	2.3
456	350	3	14	170	25	15	48	0.0	2.1	1.7
462	240	6	13	180	26	14	50	0.1	2.8	1.1
466	250	7	14	210	33	17	61	0.6	3.4	0.6
472	290	6	15	170	28	20	49	3.1	2.8	0.5
473	320	5	14	190	29	16	52	0.1	2.7	2.1
479	280	3	14	200	22	13	49	0.1	3.4	5.1
488	310	3	14	170	27	15	52	0.1	2.3	1.7
491	240	3	13	170	26	15	45	2.0	2.7	1.1
491.1	220	3	12	170	24	15	46	--	2.8	--
496	300	5	16	220	36	18	64	2.1	3.2	1.1
501	250	6	10	180	21	12	46	0.1	2.4	2.0
506	270	6	13	140	23	15	40	0.0	2.0	5.8
510	250	5	9	160	15	9	42	1.2	2.3	7.6
514	260	5	10	180	24	14	44	0.0	2.6	7.2
518	310	5	10	130	21	12	71	0.0	1.7	6.0
524	280	5	10	130	23	9	42	0.1	1.9	5.6
528	290	5	21	220	25	21	49	11.1	9.2	1.0
534	230	5	14	240	35	16	57	1.5	4.0	0.5

Sample	ppm V	ppm Pb	ppm Sc	ppm Sr	ppm Ce	ppm Y	ppm Zn	% CaCO3-cc	% CaCO3-Ca	% Corg
538	280	3	20	180	15	10	30	0.0	13.8	4.2
538.1	280	3	21	180	17	10	31	--	13.7	--
546	220	6	11	230	30	13	54	--	3.2	--
554	230	5	9	130	28	13	46	0.1	2.0	1.6
559	250	5	16	220	36	19	62	3.4	4.1	0.9
563	310	6	13	170	21	13	49	0.4	2.5	1.7
568	230	6	11	240	32	15	54	0.1	3.7	1.1
580	350	3	14	220	24	11	53	3.5	4.1	2.2
587	230	6	11	160	35	19	52	0.3	2.3	1.3
591	400	5	17	230	30	15	62	3.9	6.0	2.9
598	210	8	17	250	39	17	76	0.3	3.4	0.8
600	270	7	15	180	29	16	70	0.5	2.6	0.2
603	270	3	12	190	26	15	51	0.0	2.9	1.6
611	240	4	11	1100	18	12	43	25.1	27.4	3.2
617.1	270	8	16	200	38	16	69	0.1	2.6	1.2
617	270	5	16	200	35	16	68	--	2.6	--
624	270	5	10	210	25	11	62	0.1	2.7	1.3
629	290	7	12	230	34	14	68	0.0	3.1	2.1
635	300	4	14	170	27	15	52	0.1	2.2	2.5
637	260	7	15	210	38	25	63	1.8	2.9	1.1
641	380	5	14	180	29	15	55	0.1	2.2	1.6
647	240	7	12	290	32	15	63	0.0	4.3	2.7
651	260	6	10	200	30	17	54	0.0	2.9	5.3
657	270	5	11	200	26	13	55	0.0	2.7	4.9
666	250	5	16	290	34	20	56	3.8	4.6	1.9
672	340	5	26	160	31	22	48	17.0	5.5	1.8
676	250	3	16	180	31	20	49	5.0	5.3	7.1
682	200	7	20	260	38	22	63	7.0	4.7	0.7
691	180	5	11	150	22	11	49	0.0	1.9	3.9
697	280	3	13	170	29	16	59	0.0	2.1	3.9
699	230	8	12	210	28	13	47	0.0	2.9	4.2
707	270	5	12	140	28	14	50	0.0	1.9	4.1
711	250	5	14	330	39	20	70	0.0	4.3	1.2
718	230	8	15	220	32	20	60	2.1	3.8	1.2
718.1	220	7	15	220	38	20	60	--	3.7	--

Sample	ppm V	ppm Pb	ppm Sc	ppm Sr	ppm Ce	ppm Y	ppm Zn	% CaCO3-cc	% CaCO3-Ca	% Corg
724	160	4	10	350	34	16	61	0.2	4.6	1.1
729	190	5	13	220	26	15	61	0.5	3.1	2.5
739	240	6	12	270	36	18	67	0.0	3.8	1.5
749	230	6	17	270	44	21	70	4.6	4.3	0.5
745	290	3	20	210	31	24	47	16.0	6.5	2.3
756	180	9	15	190	41	21	63	0.7	2.4	0.7
764	210	7	10	250	30	13	60	0.8	3.7	1.6
768	220	5	12	110	29	16	53	0.0	1.5	3.5
772	270	6	13	150	26	16	54	0.0	2.1	3.0
774	200	3	11	140	22	12	46	1.1	2.0	1.3
785	260	5	15	210	28	15	56	0.0	2.9	3.3
785.1	270	3	15	210	29	15	57	--	2.9	--
790	190	3	11	150	26	14	51	1.2	2.2	1.0
794	180	5	12	170	28	14	52	1.9	2.6	0.8
800	190	5	12	150	30	18	57	1.0	2.2	1.0
802	210	7	16	200	26	17	55	2.6	3.2	0.8
807	210	5	13	300	31	15	60	0.5	3.8	0.8
815	240	4	10	180	27	13	55	0.0	2.3	1.2
823	250	5	16	210	31	17	59	3.8	3.3	0.5
826	230	3	15	200	37	19	61	3.0	3.1	0.4
833	190	5	18	250	50	21	79	0.9	3.1	0.3
833.1	170	7	17	240	48	21	77	--	3.2	--
837	190	5	16	190	38	18	69	2.1	2.6	0.5
841	180	7	15	190	34	19	63	2.0	2.7	0.8
846	230	4	11	280	25	13	60	0.4	3.8	1.1
859	150	7	13	160	31	17	54	2.7	2.6	1.0
861	200	3	12	200	21	14	56	1.7	3.1	1.2
876	200	6	12	270	38	16	67	1.4	3.3	0.5
883	190	6	12	210	37	17	58	1.6	3.1	0.5
886	230	3	13	160	32	15	56	2.4	2.5	0.8
894	220	3	13	150	22	16	47	2.3	2.4	0.9
912	260	3	10	140	22	11	44	0.0	1.8	2.4
904	210	5	9	210	16	10	41	0.0	2.6	2.1
906	220	3	10	120	17	12	37	0.4	1.5	1.8
906.1	190	3	10	110	17	11	37	--	1.6	--

Sample	ppm V	ppm Pb	ppm Sc	ppm Sr	ppm Ce	ppm Y	ppm Zn	% CaCO3-cc	% CaCO3-Ca	% Corg
920	250	3	21	240	24	19	48	17.3	6.6	0.9
920.1	220	3	21	240	24	19	46	--	6.5	--