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A preliminary statistical analysis of some chemical and
mineralogic data from lacustrine beds in the Oligocene White
River Group in Dawes County, Nebraska

by

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This report is preliminary and has not
been reviewed for conformity with
U.S. Geological Survey editorial standards
and stratigraphic nomenclature

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INTRODUCTION

The Oligocene White River Group is a nonmarine clastic sequence consisting of the Brule Formation and the underlying Chadron Formation. The formations represent mostly fluvial and terrestrial sedimentation, but they also represent some that was lacustrine deposition. The objectives are to study an occurrence of uranium at Nodding's Ridge (Dunham, 1955), and the diagenesis and petrology of the White River in the uranium area. The purpose of this paper is to present chemical and mineralogic data from samples of a predominantly lacustrine facies in the White River Group in Dawes County, Nebraska and preliminary conclusions based on statistical analysis of these data. Forty-six samples of the White River Group were collected from three areas, Trunk Butte, Isingglass Butte and Nodding's Ridge (fig. 1). A data base was assembled from these samples. The report is divided into two parts. Part I consists of the individual statistics for each chemical element, and Part II contains correlation coefficients and factor analysis results for chemical and mineralogic data. Data for the two parts is contained in appendices I and II. Mineralogic and petrologic parts of the study are not yet complete.

METHODS

Forty-six samples (Appendix I) were analyzed chemically and mineralogically. Uranium and thorium contents were determined by the delayed-neutron method (Millard, 1976). Other chemical elements were determined by inductively-coupled plasma spectroscopy (ICP) (Crock and others, 1983) and by X-ray fluorescence (XRF). Because of the close correlation between elements determined by ICP and XRF only SiO_2 and Loss on ignition to 900°C (LOI) from the XRF data were included in the statistical analysis. Mineralogic determinations were by whole-rock X-ray diffraction (XRD). Numerical estimates were substituted for values reported as less-than values; three fourths of the lower detection limit was used. XRD peak areas were used as an estimate of mineralogical content (table 1.).

Table 1 near here

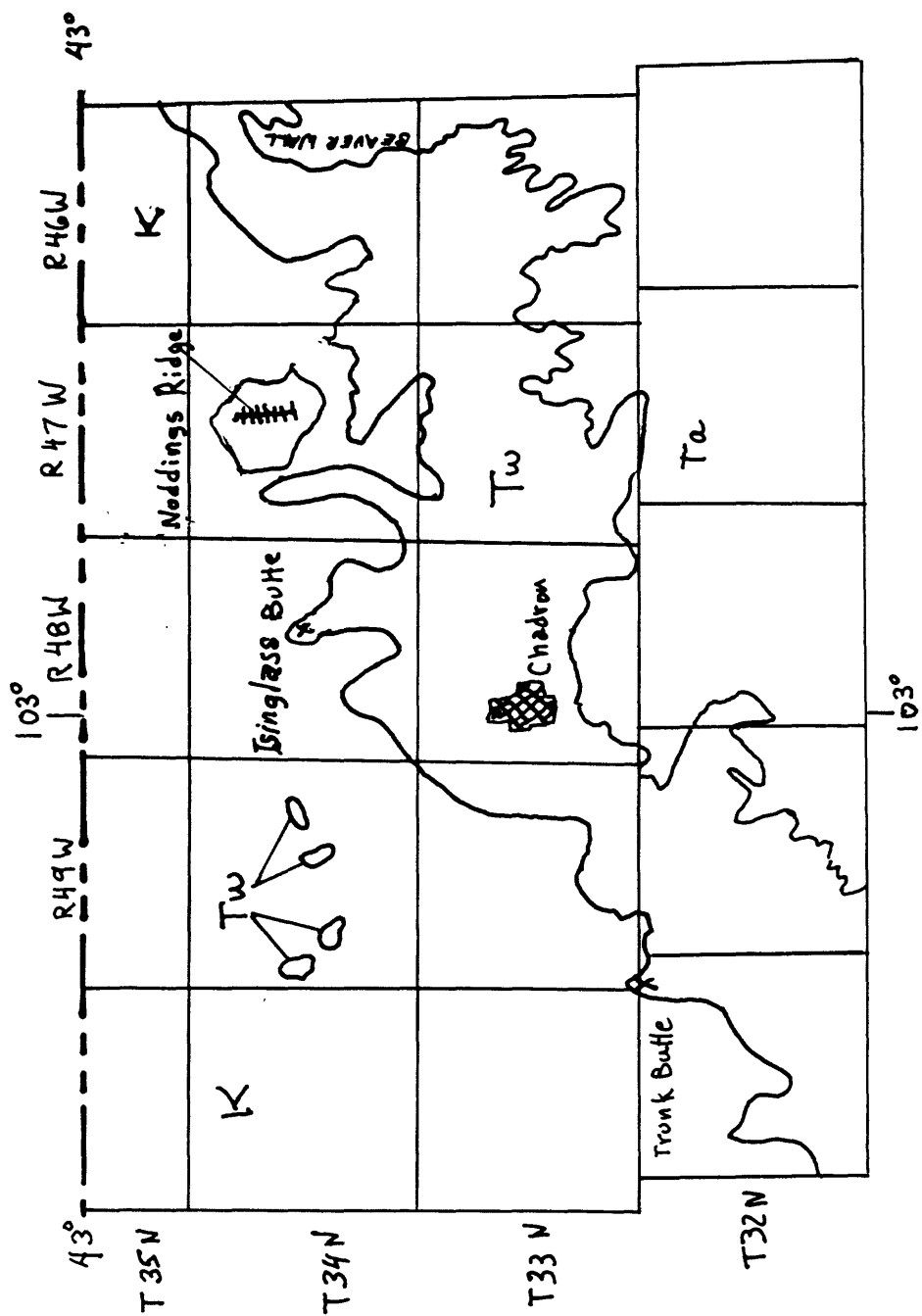


Fig. 1--Geologic map of the report area showing the Tertiary Arikaree Group (Ta), the Tertiary White River Group (Tw), and the Cretaceous (K)

Table 1. X-ray diffractogram peaks (Cu, K-alpha radiation) measured for the White River samples, data set I (Appendix 1-B)

Mineral	X-ray diffraction peak (degrees 2-theta)	Crystallographic indices
Dolomite.....	31.0	104
Calcite.....	29.4	104
Feldspar.....	26.9-27.9	002
Quartz.....	26.7	101
Opal (cristobalite).....	21.6	111
Gypsum.....	11.7	020
Illite.....	8.8	001
Montmorillonite.....	5.9	001

The statistical analyses were performed on a personal computer using a commercial program called "Number-Cruncher Statistical System" (Hintze, 1987). Individual statistics were performed on original units for both chemical and mineralogic data. Factor analysis and correlation coefficients were calculated for both original units and for log-transformed data. Only the results for the original data are presented here because for most of the chemical data the distributions for the original data better approximates normal (gaussian) distribution than does the log-transformed data. In addition, only minor differences were found between analysis of the original data and log-transformed data.

GEOLOGY

The Chadron and Brule Formations, which comprise the White River Group, consist mostly of colluvial and alluvial claystone, mudstone, and sandstone. Some gypsum and limestone resulting from lacustrine deposition are also present. The sediments were derived from a source high in volcanic content and ash beds are recognized at various intervals in the group.

The Chadron, the lower formation, unconformably overlies the Cretaceous Pierre Shale, although in some areas they are separated by an Eocene paleosol, the Interior Paleosol. The Brule, the upper formation, is overlain by the Miocene Gering Formation of the Arikaree Group.

Chadron Formation

The Chadron Formation consists mostly of light gray, green, and nearly white arkosic sandstone and mudstone. It contains prominent beds known as "purplish-white beds" (Schultz and Stout, 1955), which may represent soil horizons or altered ash beds. The top of the upper "purplish white bed" is considered to be the top of the Chadron. The mudstone above the "purplish-white beds" characteristically contains horizontal caliche veins and in the underlying bed they are vertical. This suggests that the "purplish-white beds" were a permeability barrier during calichification of the upper beds.

Brule Formation

In ascending order the Brule contains the Orella and Whitney members. An additional informal member called the Brown Siltstone was recognized above the Whitney by Swinehard and others (1985). The Orella Member consists mostly of light pink to brown mudstone but in the area of this study it contains a playa

facies characterized by gypsum and limestone. Only the Orella, together with parts of the Chadron was sampled for this study.

URANIUM

Uranium is produced at an insitu leaching pilot plant from the Chadron formation near Crawford, in western Dawes County, Nebraska, about 20 miles west of the city of Chadron (Collings and Knode, 1984). This deposit is west of the area studied in this report. Uranium enrichment as high as 0.43% was found in the playa facies of the Brule at the Noddings ridge locality sampled for this report (Dunham 1955). The Nodding's ridge uranium occurrence is considered subcommercial in size.

STATISTICAL ANALYSIS

The statistical analysis is given in two parts. Part one consists of the descriptive statistics for each chemical element or other variable for the 46 samples, part two consists of a factor analysis and correlation coefficient matrix of the chemical and mineralogic data. The appendix contains the data.

Part one

The elements involved in part one are U, Al, Ca, Fe, K, Mg, Na, Mn, P, Ti, Ba, Cu, Li, and Sr. SiO_2 and LOI were also included. Table two lists and defines the statistics presented in part 1, A one-page computer printout is given for for each variable.

Table 2.--Detailed report definitions (Hintze, 1987) for descriptive statistics for 14 elements, SiO_2 , and LOI.

Mean-Average

The mean of the non-missing values.

Lower 95% c.i. limit

The lower value of a $100(1-\alpha)\%$ confidence limit based on a t-distribution with $n-1$ degrees of freedom.

Upper 95% c.i. limit

The upper value of a $100(1-\alpha)\%$ confidence limit based on a t-distribution with $n-1$ degrees of freedom.

Adjusted sum of squares

The adjusted (corrected for the mean) sum of squares This is often referred to as $\sum(X-\text{mean})^2$.

Number of observations

The number rows of complete data (no missing values) used in calculating the statistics.

Number of missing values

The number of rows with missing values.

Sum of frequencies

The total number of observations. This depends on whether a frequency variable was specified. This is often used as n .

Sum of observations

This value depends on whether a frequency variable was specified. This is often referred to as sum of X .

Standard deviation

The sample standard deviation. Square root of the variance. This value is referred to as s .

Coefficient of variation

The standard deviation divided by the mean.

Variance

The sample variance. The adjusted sum of squares divided by $n-1$.

Standard error of the mean

The standard deviation divided by the square root of n . This is the denominator in the t-test.

T-value testing mean=value.

The t-value for testing that the sample mean is equal to the hypothesized value versus the specified alternative (as defined by the "Test Direction"). The number of degrees of freedom of this test is $n-1$. This value is calculated as the mean minus the hypothesized mean divided by the standard error of the mean.

T-test probability level

The tail probability (significance level) of the above T-test. Depends on the "Test Direction" specified.

Skewness

Measures whether the values are symmetric about the mean. Positive values indicate that the variable is skewed to the right, while negative values indicate that the variable is skewed to the left. The formula is: $n/((n-1)(n-2))\sum(x-\text{mean})^3/s^3$.

Normality Test Value

This value is a measure of departure from normality based on a biweight estimator of scale (Martinez and Iglewicz, 1981).

Kurtosis

Measures the flatness of a distribution or the heaviness of its tails. The standard is the normal distribution, the kurtosis of which is zero. All other distributions are compared to it. Distributions with short tails have negative kurtosis, whereas distributions with many extreme values have positive kurtosis.

Range

Maximum minus the minimum.

75th-25th %tile

The 75th percentile minus the 25th percentile, often referred to as the inter-quartile range.

xxx-%-tile

The xxxth percentile.

Line Plot

A line plot of the values. The numbers represent the number of rows that occur at each point on the line. The maximum and minimum are displayed on the title line.

Box plot

A box plot of the values. The left and right brackets occur at the 25th and 75th percentiles, respectively. The dashed lines end at the 10th and 90th percentiles. The "m" represents the position of the median. The "a" represents the position of the mean (average).

-----Descriptive Statistics-----

Date/Time 05-07-1988 20:33:48
 Data Base Name B:ncsswr7
 Description Imported from B:wr7.prn

Detail Report

Variable: AL	Aluminum		
Mean - Average	3.796305	No. observations	46
Lower 95% c.i.limit	2.977922	No. missing values	0
Upper 95% c.i.limit	4.614687	Sum of frequencies	46
Adj sum of squares	341.7675	Sum of observations	174.63
Standard deviation	2.755873	Std.error of mean	.4063312
Variance	7.594833	T-value for mean=0	9.342881
Coef. of variation	.7259356	T prob level	0.0000
Skewness	-4.099998E-02	Kurtosis	-1.72397
Normality Test Value	0.931	Reject if > 1.101(10%)	1.156(5%)
100-%tile (Maximum)	7.7	90-%tile	7
75-%tile	6.5	10-%tile	.37
50-%tile (Median)	4.3	Range	7.45
25-%tile	.7	75th-25th %tile	5.8
0-%tile (Minimum)	.25		

.25-----Line Plot / Box Plot-----7.7
 14213111 1 1 1 2 1 1 1 1 2 1 111 1 11112 1121 1 12
 ----[XXXXXXXXXXXXXXXXXXXXXXXXXXXXXaXXXXmXXXXXXXXXXXXXXXXXXXXX]-----

Distribution & Histogram

Variable: AL						
Bin	Lower	Upper	Count	Prcent	Total	Prcent Histogram
1	.25	.8461539	13	28.3	13	28.3 :*****
2	.8461539	1.442308	2	4.3	15	32.6 :**
3	1.442308	2.038462	2	4.3	17	37.0 :**
4	2.038462	2.634615	4	8.7	21	45.7 :****
5	2.634615	3.230769	0	0.0	21	45.7 :
6	3.230769	3.826923	2	4.3	23	50.0 :**
7	3.826923	4.423077	0	0.0	23	50.0 :
8	4.423077	5.019231	3	6.5	26	56.5 :***
9	5.019231	5.615385	3	6.5	29	63.0 :***
10	5.615385	6.211538	3	6.5	32	69.6 :***
11	6.211538	6.807693	7	15.2	39	84.8 :*****
12	6.807693	7.403846	4	8.7	43	93.5 :****
13	7.403846	8	3	6.5	46	100.0 :***

```

-----Descriptive Statistics-----
Date/Time      05-07-1988  20:40:47
Data Base Name B:ncsswr7
Description     Imported from B:wr7.prn

```

Detail Report

Variable: CA	Calcium		
Mean - Average	13.51739	No. observations	46
Lower 95% c.i.limit	10.56075	No. missing values	0
Upper 95% c.i.limit	16.47404	Sum of frequencies	46
Adj sum of squares	4460.846	Sum of observations	621.8
Standard deviation	9.956401	Std.error of mean	1.467991
Variance	99.12991	T-value for mean=0	9.208088
Coef. of variation	.7365623	T prob level	0.0000
Skewness	.6210364	Kurtosis	-.2592506
Normality Test Value	0.996.....	Reject if > 1.101(10%)	1.156(5%)
100-%tile (Maximum)	40	90-%tile	26
75-%tile	21	10-%tile	1.5
50-%tile (Median)	13	Range	39
25-%tile	4.5	75th-25th %tile	16.5
0-%tile (Minimum)	1		

```

1-----Line Plot / Box Plot-----40
15 113 112  1 31  2  3 2 1 1  1 3 1 1 1 3 2  1 1  1 1  1
-----[XXXXXXXXXXXXXXXXXmaXXXXXXXXXXXXXXXXX]-----

```

Distribution & Histogram

Variable: CA							
Bin	Lower	Upper	Count	Prcent	Total	Prcent	Histogram
1	1	4	11	23.9	11	23.9	:*****
2	4	7	4	8.7	15	32.6	:****
3	7	10	5	10.9	20	43.5	:*****
4	10	13	2	4.3	22	47.8	:**
5	13	16	6	13.0	28	60.9	:*****
6	16	19	2	4.3	30	65.2	:**
7	19	22	5	10.9	35	76.1	:*****
8	22	25	6	13.0	41	89.1	:*****
9	25	28	2	4.3	43	93.5	:**
10	28	31	0	0.0	43	93.5	:
11	31	34	1	2.2	44	95.7	:*
12	34	37	1	2.2	45	97.8	:*
13	37	40	1	2.2	46	100.0	:*

```

-----Descriptive Statistics-----
Date/Time      05-07-1988  21:00:47
Data Base Name B:ncsswr7
Description     Imported from B:wr7.prn

```

Detail Report

```

Variable: FE      Iron
Mean - Average      1.211739      No. observations      46
Lower 95% c.i.limit .9368737      No. missing values    0
Upper 95% c.i.limit 1.486605      Sum of frequencies    46
Adj sum of squares  38.55306      Sum of observations    55.74

Standard deviation   .9255996      Std.error of mean     .1364722
Variance            .8567347      T-value for mean=0    8.879017
Coef. of variation  .7638605      T prob level          0.0000
Skewness            .5060494      Kurtosis              -.8527509
Normality Test Value 0.962.....Reject if > 1.101(10%) 1.156(5%)

100-%tile (Maximum) 3.3      90-%tile              2.6
75-%tile            1.9      10-%tile              .13
50-%tile (Median)   1.2      Range                 3.2
25-%tile            .32      75th-25th %tile       1.58
0-%tile (Minimum)   .1

```

```

.1-----Line Plot / Box Plot-----3.3
331212111      121111      2 4 2      1      2 3 2      1      1 2      2 1      1
----[XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX]-----

```

Distribution & Histogram

```

Variable: FE
Bin Lower      Upper      Count Prcnt Total Prcnt Histogram
1 .1      .3461539      13 28.3      13 28.3 :*****
2 .3461539 .5923077      2 4.3      15 32.6 :**
3 .5923077 .8384616      5 10.9      20 43.5 :*****
4 .8384616 1.084615      2 4.3      22 47.8 :**
5 1.084615 1.330769      6 13.0      28 60.9 :*****
6 1.330769 1.576923      2 4.3      30 65.2 :**
7 1.576923 1.823077      3 6.5      33 71.7 :***
8 1.823077 2.069231      5 10.9      38 82.6 :*****
9 2.069231 2.315385      1 2.2      39 84.8 :*
10 2.315385 2.561539      1 2.2      40 87.0 :*
11 2.561539 2.807692      4 8.7      44 95.7 :****
12 2.807692 3.053846      1 2.2      45 97.8 :*
13 3.053846 3.3      1 2.2      46 100.0 :*

```

```

-----Descriptive Statistics-----
Date/Time      05-07-1988  21:04:01
Data Base Name B:ncsswr7
Description     Imported from B:wr7.prn

```

Detail Report

```

Variable: K      Potassium
Mean - Average      1.23087      No. observations      46
Lower 95% c.i.limit .9748218    No. missing values    0
Upper 95% c.i.limit 1.486917    Sum of frequencies    46
Adj sum of squares  33.45496      Sum of observations    56.62

Standard deviation  .8622318      Std.error of mean     .1271291
Variance           .7434437      T-value for mean=0    9.682041
Coef. of variation .7005062      T prob level          0.0000
Skewness           1.998075E-02    Kurtosis              -1.589675
Normality Test Value 0.943 ..... Reject if > 1.101(10%) 1.156(5%)

100-%tile (Maximum) 2.7          90-%tile              2.2
75-%tile            2            10-%tile              .15
50-%tile (Median)   1.3          Range                  2.63
25-%tile            .32          75th-25th %tile       1.68
0-%tile (Minimum)   .07

```

```

.07-----Line Plot / Box Plot-----2.7
12212121 1 21 1 2 1 1 1 1 1 1 2 3 2 4 2 4 2 2
-----[XXXXXXXXXXXXXXXXXXXXXXXXXaXmXXXXXXXXXXXXXXXXXXXXX]-----

```

Distribution & Histogram

```

Variable: K
Bin Lower      Upper      Count Prent Total Prent Histogram
1 .07          .2723077    11 23.9 11 23.9 :*****
2 .2723077    .4746154     5 10.9 16 34.8 :*****
3 .4746154    .6769231     2  4.3 18 39.1 :**
4 .6769231    .8792308     1  2.2 19 41.3 :*
5 .8792308    1.081539     2  4.3 21 45.7 :**
6 1.081539    1.283846     2  4.3 23 50.0 :**
7 1.283846    1.486154     1  2.2 24 52.2 :*
8 1.486154    1.688462     1  2.2 25 54.3 :*
9 1.688462    1.890769     5 10.9 30 65.2 :*****
10 1.890769    2.093077     6 13.0 36 78.3 :*****
11 2.093077    2.295385     6 13.0 42 91.3 :*****
12 2.295385    2.497692     2  4.3 44 95.7 :**
13 2.497692    2.7          2  4.3 46 100.0 :**

```

```

-----Descriptive Statistics-----
Date/Time      05-07-1988  21:07:23
Data Base Name B:ncsswr7
Description     Imported from B:wr7.prn

```

Detail Report

```

Variable: MG      Magnesium
Mean - Average    1.165435      No. observations      46
Lower 95% c.i.limit .6934392    No. missing values    0
Upper 95% c.i.limit 1.63743    Sum of frequencies    46
Adj sum of squares 113.6827     Sum of observations    53.61

Standard deviation 1.589429      Std.error of mean     .2343485
Variance          2.526283      T-value for mean=0    4.973085
Coef. of variation 1.363807     T prob level          0.0000
Skewness          3.686083      Kurtosis              14.77269
Normality Test Value 0.866 ..... Reject if > 1.101(10%) 1.156(5%)

100-%tile (Maximum) 9          90-%tile              1.5
75-%tile             1.2       10-%tile              .21
50-%tile (Median)    .815      Range                 8.91
25-%tile             .41       75th-25th %tile       .7900001
0-%tile (Minimum)    .09

```

```

.09-----Line Plot / Box Plot-----9
3335334342333 1              1      1              1
--[XXmXXa]--

```

Distribution & Histogram

```

Variable: MG
Bin Lower      Upper      Count Prct Total Prct Histogram
1 .09          .7753847    20  43.5   20  43.5 :*****
2 .7753847    1.460769   19  41.3   39  84.8 :*****
3 1.460769    2.146154    4   8.7   43  93.5 :****
4 2.146154    2.831538    0   0.0   43  93.5 :
5 2.831538    3.516923    0   0.0   43  93.5 :
6 3.516923    4.202308    0   0.0   43  93.5 :
7 4.202308    4.887693    0   0.0   43  93.5 :
8 4.887693    5.573077    1   2.2   44  95.7 :*
9 5.573077    6.258462    1   2.2   45  97.8 :*
10 6.258462   6.943847    0   0.0   45  97.8 :
11 6.943847   7.629231    0   0.0   45  97.8 :
12 7.629231   8.314615    0   0.0   45  97.8 :
13 8.314615   9.000000    1   2.2   46 100.0 :~

```

-----Descriptive Statistics-----

Date/Time 05-07-1988 21:10:38
 Data Base Name B:ncsswr7
 Description Imported from B:wr7.prn

Detail Report

Variable: NA	Sodium		
Mean - Average	.6693478	No. observations	46
Lower 95% c.i.limit	.4997273	No. missing values	0
Upper 95% c.i.limit	.8389684	Sum of frequencies	46
Adj sum of squares	14.68168	Sum of observations	30.79
Standard deviation	.5711914	Std.error of mean	8.421757E-02
Variance	.3262596	T-value for mean=0	7.947841
Coef. of variation	.8533551	T prob level	0.0000
Skewness	.304307	Kurtosis	-1.435378
Normality Test Value	0.950	Reject if >	1.101(10%) 1.156(5%)

100-%tile (Maximum)	1.7	90-%tile	1.5
75-%tile	1.2	10-%tile	.05
50-%tile (Median)	.625	Range	1.68
25-%tile	.08	75th-25th %tile	1.12
0-%tile (Minimum)	.02		

.02-----Line Plot / Box Plot-----1.7
 25321 31 12 1 1 1 1 2 1 112 3 3 2 2 2 1 2
 --[XXX]-----

Distribution & Histogram

Variable: NA							
Bin Lower	Upper	Count	Prct	Total	Prct	Histogram	
1 .02	.1492308	13	28.3	13	28.3	:*****	
2 .1492308	.2784616	7	15.2	20	43.5	:*****	
3 .2784616	.4076923	1	2.2	21	45.7	:*	
4 .4076923	.5369231	1	2.2	22	47.8	:*	
5 .5369231	.6661538	2	4.3	24	52.2	:**	
6 .6661538	.7953846	2	4.3	26	56.5	:**	
7 .7953846	.9246154	1	2.2	27	58.7	:*	
8 .9246154	1.053846	4	8.7	31	67.4	:****	
9 1.053846	1.183077	3	6.5	34	73.9	:***	
10 1.183077	1.312308	5	10.9	39	84.8	:*****	
11 1.312308	1.441538	2	4.3	41	89.1	:**	
12 1.441538	1.570769	2	4.3	43	93.5	:**	
13 1.570769	1.7	3	6.5	46	100.0	:***	

```

-----Descriptive Statistics-----
Date/Time      05-07-1988  21:13:49
Data Base Name B:ncsswr7
Description     Imported from B:wr7.prn

```

Detail Report

```

Variable: MN      Manganese
Mean - Average    1121.109      No. observations      46
Lower 95% c.i.limit 847.5352    No. missing values    0
Upper 95% c.i.limit 1394.682    Sum of frequencies    46
Adj sum of squares 3.819151E+07  Sum of observations    51571

Standard deviation 921.2493      Std.error of mean     135.8308
Variance          848700.2      T-value for mean=0    8.253716
Coef. of variation .8217306     T prob level          0.0000
Skewness          .8754246      Kurtosis              -7.079394E-02
Normality Test Value 1.023 ..... Reject if > 1.101(10%) 1.156(5%)

100-%tile (Maximum) 3300      90-%tile              2800
75-%tile            1500      10-%tile              93
50-%tile (Median)   1045      Range                  3261
25-%tile            340       75th-25th %tile       1160
0-%tile (Minimum)   39

39-----Line Plot / Box Plot-----3300
2311 23211 12 1 111 3 3 4 1 1 1 1 1 1 1 1 1 1 1
-----[XXXXXXXXXXXXXXXXXmXaXXXXXXXXXX]-----

```

Distribution & Histogram

```

Variable: MN
Bin Lower      Upper      Count Prcnt Total Prcnt Histogram
1  39          289.8462      8  17.4      8  17.4 :*****
2  289.8462    540.6923      8  17.4     16  34.8 :*****
3  540.6923    791.5385      4   8.7     20  43.5 :****
4  791.5385    1042.385      3   6.5     23  50.0 :***
5  1042.385    1293.231      6  13.0     29  63.0 :*****
6  1293.231    1544.077      6  13.0     35  76.1 :*****
7  1544.077    1794.923      1   2.2     36  78.3 :*
8  1794.923    2045.769      2   4.3     38  82.6 :**
9  2045.769    2296.616      1   2.2     39  84.8 :*
10 2296.616    2547.462      2   4.3     41  89.1 :**
11 2547.462    2798.308      0   0.0     41  89.1 :
12 2798.308    3049.154      3   6.5     44  95.7 :***
13 3049.154    3300          2   4.3     46 100.0 :**

```

-----Descriptive Statistics-----

Date/Time 05-07-1988 21:17:45
 Data Base Name B:ncsswr7
 Description Imported from B:wr7.prn

Detail Report

Variable: P	Phosphorous		
Mean - Average	.08	No. observations	46
Lower 95% c.i.limit	5.240426E-02	No. missing values	0
Upper 95% c.i.limit	.1075957	Sum of frequencies	46
Adj sum of squares	.3886	Sum of observations	3.68
Standard deviation	9.292769E-02	Std.error of mean	1.370144E-02
Variance	8.635555E-03	T-value for mean=0	5.838802
Coef. of variation	1.161596	T prob level	0.0000
Skewness	2.25415	Kurtosis	4.187182
Normality Test Value	0.809.....	Reject if > 1.101(10%)	1.156(5%)
100-%tile (Maximum)	.37	90-%tile	.26
75-%tile	.08	10-%tile	.02
50-%tile (Median)	.05	Range	.36
25-%tile	.03	75th-25th %tile	.05
0-%tile (Minimum)	.01		

.01-----Line Plot / Box Plot-----

4 4 8 4 6 3 4 6 1 1 1 1 1 2

--[XXXXmXXXXXa-----

Distribution & Histogram

Variable: P							
Bin	Lower	Upper	Count	Prcnt	Total	Prcnt	Histogram
1	.01	3.769E-02	16	34.8	16	34.8	:*****
2	3.769E-02	6.538E-02	13	28.3	29	63.0	:*****
3	6.538E-02	9.307E-02	10	21.7	39	84.8	:*****
4	9.307E-02	.1207692	1	2.2	40	87.0	:*
5	.1207692	.1484616	0	0.0	40	87.0	:
6	.1484616	.1761539	0	0.0	40	87.0	:
7	.1761539	.2038462	1	2.2	41	89.1	:*
8	.2038462	.2315385	0	0.0	41	89.1	:
9	.2315385	.2592308	0	0.0	41	89.1	:
10	.2592308	.2869231	2	4.3	43	93.5	:**
11	.2869231	.3146154	0	0.0	43	93.5	:
12	.3146154	.3423077	1	2.2	44	95.7	:*
13	.3423077	.37	2	4.3	46	100.0	:**

```

-----Descriptive Statistics-----
Date/Time      05-07-1988  21:21:01
Data Base Name B:ncsswr7
Description     Imported from B:wr7.prn

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Detail Report

```

Variable: TI      Titanium
Mean - Average    .1241304      No. observations      46
Lower 95% c.i.limit 9.352729E-02    No. missing values    0
Upper 95% c.i.limit .1547336      Sum of frequencies    46
Adj sum of squares .4779152      Sum of observations    5.71

Standard deviation .103055      Std.error of mean     1.519463E-02
Variance          1.062034E-02    T-value for mean=0    8.16936
Coef. of variation .8302156      T prob level          0.0000
Skewness          .8558183      Kurtosis              -.3904319
Normality Test Value 1.049 ..... Reject if > 1.101(10%) 1.156(5%)

100-%tile (Maximum) .36      90-%tile              .29
75-%tile            .16      10-%tile              .02
50-%tile (Median)   .1       Range                  .35
25-%tile            .03      75th-25th %tile       .13
0-%tile (Minimum)   .01

.01-----Line Plot / Box Plot-----
4 4 5 1 2 1 4 1 2 2 1 3 4 1 1 1 2 3 2 1 1
--[XXXXXXXXXXXXXXXXmXXXXaXXXXXX]-----

```

Distribution & Histogram

```

Variable: TI
Bin Lower      Upper      Count Prcnt Total Prcnt Histogram
1 .01          3.692E-02    13  28.3  13  28.3 :*****
2 3.692E-02    6.384E-02    3   6.5  16  34.8 :***
3 6.384E-02    9.076E-02    6  13.0  22  47.8 :*****
4 9.076E-02    .1176923     4   8.7  26  56.5 :****
5 .1176923     .1446154     4   8.7  30  65.2 :****
6 .1446154     .1715385     5  10.9  35  76.1 :*****
7 .1715385     .1984616     1   2.2  36  78.3 :*
8 .1984616     .2253846     1   2.2  37  80.4 :*
9 .2253846     .2523077     0   0.0  37  80.4 :
10 .2523077     .2792308     2   4.3  39  84.8 :**
11 .2792308     .3061539     3   6.5  42  91.3 :***
12 .3061539     .333077      2   4.3  44  95.7 :**
13 .333077      .36          2   4.3  46 100.0 :**

```

-----Descriptive Statistics-----

Date/Time 05-07-1988 21:24:25
 Data Base Name B:ncsswr7
 Description Imported from B:wr7.prn

Detail Report

Variable: BA	Barium		
Mean - Average	535.0653	No. observations	46
Lower 95% c.i.limit	274.3573	No. missing values	0
Upper 95% c.i.limit	795.7731	Sum of frequencies	46
Adj sum of squares	3.468382E+07	Sum of observations	24613
Standard deviation	877.9246	Std.error of mean	129.4429
Variance	770751.6	T-value for mean=0	4.1336
Coef. of variation	1.640781	T prob level	0.0002
Skewness	4.025303	Kurtosis	18.02937
Normality Test Value	0.872.....	Reject if > 1.101(10%)	1.156(5%)
100-%tile (Maximum)	5100	90-%tile	790
75-%tile	610	10-%tile	65
50-%tile (Median)	345	Range	5059
25-%tile	110	75th-25th %tile	500
0-%tile (Minimum)	41		

41-----Line Plot / Box Plot-----5100
 6842183 23123 1 1 1
 -[XXXmXXa]---

Distribution & Histogram

Variable: BA							
Bin	Lower	Upper	Count	Prcent	Total	Prcent	Histogram
1	41	430.1538	31	67.4	31	67.4	:*****
2	430.1538	819.3077	11	23.9	42	91.3	:*****
3	819.3077	1208.462	1	2.2	43	93.5	:*
4	1208.462	1597.615	0	0.0	43	93.5	:
5	1597.615	1986.769	1	2.2	44	95.7	:*
6	1986.769	2375.923	0	0.0	44	95.7	:
7	2375.923	2765.077	0	0.0	44	95.7	:
8	2765.077	3154.231	0	0.0	44	95.7	:
9	3154.231	3543.385	1	2.2	45	97.8	:*
10	3543.385	3932.538	0	0.0	45	97.8	:
11	3932.538	4321.692	0	0.0	45	97.8	:
12	4321.692	4710.846	0	0.0	45	97.8	:
13	4710.846	5100	1	2.2	46	100.0	:*

```

-----Descriptive Statistics-----
Date/Time      05-07-1988  21:28:17
Data Base Name B:ncsswr7
Description     Imported from B:wr7.prn

```

Detail Report

```

Variable: CU      Copper
Mean - Average    12.03804      No. observations      46
Lower 95% c.i.limit 8.911107    No. missing values    0
Upper 95% c.i.limit 15.16498    Sum of frequencies    46
Adj sum of squares 4989.496      Sum of observations    553.75

Standard deviation 10.52985      Std.error of mean     1.552541
Variance          110.8777      T-value for mean=0    7.753767
Coef. of variation .8747142     T prob level          0.0000
Skewness          1.957079      Kurtosis              5.755159
Normality Test Value 1.791.....Reject if > 1.101(10%) 1.156(5%)

100-%tile (Maximum) 56          90-%tile              23
75-%tile            15          10-%tile              2
50-%tile (Median)   9           Range                 56
25-%tile            5           75th-25th %tile      10
0-%tile (Minimum)   0

```

```

0-----Line Plot / Box Plot-----56
13 31 312 53 211 22 141    1 11 21    1    1    1    1
----[XXXXXmXXXaXXX]-----

```

Distribution & Histogram

```

Variable: CU
Bin Lower      Upper      Count Prcnt Total Prcnt Histogram
1  0           4.307693     11  23.9    11  23.9 :*****
2  4.307693    8.615385     11  23.9    22  47.8 :*****
3  8.615385    12.92308      6  13.0    28  60.9 :***
4  12.92308    17.23077      8  17.4    36  78.3 :****
5  17.23077    21.53846      3   6.5    39  84.8 :**
6  21.53846    25.84616      3   6.5    42  91.3 :**
7  25.84616    30.15385      2   4.3    44  95.7 :*
8  30.15385    34.46154      0   0.0    44  95.7 :
9  34.46154    38.76923      1   2.2    45  97.8 :*
10 38.76923    43.07693      0   0.0    45  97.8 :
11 43.07693    47.38462      0   0.0    45  97.8 :
12 47.38462    51.69231      0   0.0    45  97.8 :
13 51.69231    56             1   2.2    46 100.0 :*

```

-----Descriptive Statistics-----

Date/Time 05-07-1988 21:31:38
 Data Base Name B:ncsswr7
 Description Imported from B:wr7.prn

Detail Report

Variable: LI	Lithium		
Mean - Average	22.91304	No. observations	46
Lower 95% c.i.limit	18.07755	No. missing values	0
Upper 95% c.i.limit	27.74854	Sum of frequencies	46
Adj sum of squares	11931.65	Sum of observations	1054
Standard deviation	16.28336	Std.error of mean	2.400851
Variance	265.1478	T-value for mean=0	9.543719
Coef. of variation	.710659	T prob level	0.0000
Skewness	.634226	Kurtosis	-.5540698
Normality Test Value	0.984.....	Reject if > 1.101(10%)	1.156(5%)
100-%tile (Maximum)	62	90-%tile	49
75-%tile	33	10-%tile	4
50-%tile (Median)	21	Range	60
25-%tile	9	75th-25th %tile	24
0-%tile (Minimum)	2		

2-----Line Plot / Box Plot-----62
 11 412 2 21 2 12 111 231 111 212 1 1 1 1 11 1 1 1
 -----[XXXXXXXXXXXXXXXXmXaXXXXXXXXXXXXX]-----

Distribution & Histogram

Variable: LI							
Bin	Lower	Upper	Count	Prcnt	Total	Prcnt	Histogram
1	2	6.615385	9	19.6	9	19.6	:*****
2	6.615385	11.23077	5	10.9	14	30.4	:***
3	11.23077	15.84615	5	10.9	19	41.3	:***
4	15.84615	20.46154	3	6.5	22	47.8	:**
5	20.46154	25.07692	6	13.0	28	60.9	:***
6	25.07692	29.69231	3	6.5	31	67.4	:**
7	29.69231	34.30769	5	10.9	36	78.3	:***
8	34.30769	38.92308	1	2.2	37	80.4	:*
9	38.92308	43.53846	2	4.3	39	84.8	:*
10	43.53846	48.15385	2	4.3	41	89.1	:*
11	48.15385	52.76923	2	4.3	43	93.5	:*
12	52.76923	57.38461	2	4.3	45	97.8	:*
13	57.38461	62	1	2.2	46	100.0	:*

```

-----Descriptive Statistics-----
Date/Time      05-07-1988  21:47:55
Data Base Name B:ncsswr7
Description     Imported from B:wr7.prn

```

Detail Report

Variable: SR	Strontium		
Mean - Average	775.4348	No. observations	46
Lower 95% c.i.limit	413.1511	No. missing values	0
Upper 95% c.i.limit	1137.719	Sum of frequencies	46
Adj sum of squares	6.697554E+07	Sum of observations	35670
Standard deviation	1219.978	Std.error of mean	179.8759
Variance	1488345	T-value for mean=0	4.310944
Coef. of variation	1.573282	T prob level	0.0001
Skewness	3.82033	Kurtosis	16.76433
Normality Test Value	0.797.....	Reject if > 1.101(10%)	1.156(5%)
100-%tile (Maximum)	7100	90-%tile	1900
75-%tile	430	10-%tile	260
50-%tile (Median)	345	Range	6950
25-%tile	300	75th-25th %tile	130
0-%tile (Minimum)	150		

```

150-----Line Plot / Box Plot-----7100
28FA12      1  1      2  1  1                      1
-m]---a-----

```

Distribution & Histogram

Variable: SR							
Bin	Lower	Upper	Count	Prcent	Total	Prcent	Histogram
1	150	684.6154	38	82.6	38	82.6	:*****
2	684.6154	1219.231	1	2.2	39	84.8	:*
3	1219.231	1753.846	1	2.2	40	87.0	:*
4	1753.846	2288.461	3	6.5	43	93.5	:**
5	2288.461	2823.077	1	2.2	44	95.7	:*
6	2823.077	3357.692	0	0.0	44	95.7	:
7	3357.692	3892.308	0	0.0	44	95.7	:
8	3892.308	4426.923	1	2.2	45	97.8	:*
9	4426.923	4961.538	0	0.0	45	97.8	:
10	4961.538	5496.153	0	0.0	45	97.8	:
11	5496.153	6030.769	0	0.0	45	97.8	:
12	6030.769	6565.384	0	0.0	45	97.8	:
13	6565.384	7100	1	2.2	46	100.0	:*

-----Descriptive Statistics-----

Date/Time 05-07-1988 21:57:14
 Data Base Name B:ncsswr7
 Description Imported from B:wr7.prn

Detail Report

Variable: SI02	Silica		
Mean - Average	44.69022	No. observations	46
Lower 95% c.i.limit	38.50161	No. missing values	0
Upper 95% c.i.limit	50.87883	Sum of frequencies	46
Adj sum of squares	19543.6	Sum of observations	2055.75
Standard deviation	20.83992	Std.error of mean	3.072679
Variance	434.3023	T-value for mean=0	14.54438
Coef. of variation	.4663195	T prob level	0.0000
Skewness	-.4699332	Kurtosis	-.6072512
Normality Test Value	0.987	Reject if >	1.101(10%) 1.156(5%)

100-%tile (Maximum)	90.1	90-%tile	64.1
75-%tile	61.9	10-%tile	13.4
50-%tile (Median)	49.7	Range	87.22
25-%tile	29.3	75th-25th %tile	32.6
0-%tile (Minimum)	2.88		

2.88-----Line Plot / Box Plot-----90.1
 11 11 11 211 121 1 1 2 1 211 1 13112 14412 1 1
 -----[XXXXXXXXXXXXaXXXXmXXXXXXXXXX]-----

Distribution & Histogram

Variable: SI02						
Bin	Lower	Upper	Count	Prcent	Total	Prcent Histogram
1	2.88	9.589232	4	8.7	4	8.7 : **
2	9.589232	16.29846	2	4.3	6	13.0 : *
3	16.29846	23.00769	4	8.7	10	21.7 : **
4	23.00769	29.71692	2	4.3	12	26.1 : *
5	29.71692	36.42616	3	6.5	15	32.6 : **
6	36.42616	43.13539	3	6.5	18	39.1 : **
7	43.13539	49.84462	5	10.9	23	50.0 : ***
8	49.84462	56.55385	6	13.0	29	63.0 : ***
9	56.55385	63.26308	10	21.7	39	84.8 : *****
10	63.26308	69.97231	6	13.0	45	97.8 : ***
11	69.97231	76.68153	0	0.0	45	97.8 :
12	76.68153	83.39077	0	0.0	45	97.8 :
13	83.39077	90.1	1	2.2	46	100.0 : *

-----Descriptive Statistics-----

Date/Time 05-07-1988 22:00:22
 Data Base Name B:ncsswr7
 Description Imported from B:wr7.prn

Detail Report

Variable: LOI Loss on Ignition

Mean - Average	18.6437	No. observations	46
Lower 95% c.i.limit	16.00817	No. missing values	0
Upper 95% c.i.limit	21.27923	Sum of frequencies	46
Adj sum of squares	3544.497	Sum of observations	857.61
Standard deviation	8.875054	Std.error of mean	1.308555
Variance	78.76659	T-value for mean=0	14.24754
Coef. of variation	.4760352	T prob level	0.0000
Skewness	.8855067	Kurtosis	.3497251
Normality Test Value	1.090.....	Reject if >	1.101(10%) 1.156(5%)

100-%tile (Maximum)	41.6	90-%tile	29.1
75-%tile	23.7	10-%tile	9.54
50-%tile (Median)	17.2	Range	37.64
25-%tile	11.3	75th-25th %tile	12.4
0-%tile (Minimum)	3.96		

3.96-----Line Plot / Box Plot-----41.6

1 1 1121241 1 1 13 2 12111111 21 1 1 2 1 3 1 1 1 1

---[XXXXXXXXXXmXXaXXXXXXXXXX]-----

Distribution & Histogram

Variable: LOI

Bin	Lower	Upper	Count	Prcnt	Total	Prcnt	Histogram
1	3.96	6.855385	2	4.3	2	4.3	.*
2	6.855385	9.750769	3	6.5	5	10.9	.**
3	9.750769	12.64615	9	19.6	14	30.4	*****
4	12.64615	15.54154	6	13.0	20	43.5	***
5	15.54154	18.43692	7	15.2	27	58.7	*****
6	18.43692	21.33231	6	13.0	33	71.7	***
7	21.33231	24.22769	2	4.3	35	76.1	.*
8	24.22769	27.12308	3	6.5	38	82.6	.**
9	27.12308	30.01846	4	8.7	42	91.3	.**
10	30.01846	32.91385	0	0.0	42	91.3	:
11	32.91385	35.80923	1	2.2	43	93.5	.*
12	35.80923	38.70461	1	2.2	44	95.7	.*
13	38.70461	41.6	2	4.3	46	100.0	.*

Part two, correlation and factor analysis

The correlation coefficient matrix is given in table 3, and the four-factor model for factor analysis is given in table 4. The correlation coefficient matrix and the factor analysis were done on the original units rather than on log-transformed data because more of the original unit distributions are normal than are the transformed distributions as indicated by the normality test values as listed in the previous section. The interpretations presented in this section are based on the primary factor scores for each variable ignoring the fact that secondary factors are also important in explaining the distributions.

Factor one. Factor one consists of a positive group and a negative group. The variables with negative factor loadings in order of decreasing factor score are Al, Fe, K, Ti, Na, Li, Montmorillonite, feldspar, illite, and Cu. The association of these elements and minerals are believed to be controlled by their distribution in the source sediment. Ca, LOI, Calcite, Opal and U are positive elements in factor one. The association of these variables with factor one, but opposite in sign to the other variables, suggests that they are related to the detrital minerals as alteration products or that they were diluted by the detrital variables during deposition. In particular the opal which probably originated as diatom frustules was diluted by the deposition of detrital material. It should be mentioned, however, that the very low communality for uranium (0.27) indicates that only a small proportion of the uranium is thus explained is accounted for by this analysis.

Factor two. Factor two contains only Gypsum and Strontium as positive elements and phosphorous as a negative element. It is likely that the strontium remained in solution until the gypsum was deposited and the gypsum is related to the most concentrated phase of the playa lake. The phosphorous is generally related to biologic activity which is high in the most evaporative stage of the lake. The high negative association of phosphorous in factor two probably resulted from dilution by the rapidly deposited evaporitic minerals. .

Factor three. Factor three contains only Mn as a positive element. Negatively associated with the Mn is SiO_2 and quartz. The SiO_2 probably resulted from the solution of volcanic shards and was later precipitated mostly as quartz but partly as opal.

Factor four. Factor four contains only Mg and dolomite. It represents introduced material during a stage of intermediate evaporite composition.

In summary factor one represents detrital materials and their alteration products, factors 2, 3, and 4 represent introduced materials or alteration products from detrital materials such as volcanic shards that are not represented in the analysis. Factors 2 and 4 apparently represent playa lake facies.

Table 4.--Varimax matrix for four-factor model for original units (minimum eigenvalue = 2)

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Communality
U	.49	.01	-.15	-.04	.27
Al	-.95	-.22	.03	.08	.96
Ca	.82	.14	.49	.03	.94
Fe	-.93	-.17	-.07	-.04	.89
K	-.9	-.19	.09	.07	.86
Mg	-.04	-.12	.19	-.92	.89
Na	-.84	-.25	.07	.13	.79
Mn	.46	-.52	.56	-.16	.82
P	-.01	-.55	-.52	-.06	.31
Ti	-.88	-.09	-.05	-.02	.78
Ba	-.22	-.18	.29	.22	.21
Cu	-.52	-.42	-.24	-.26	.57
Li	-.83	-.18	-.02	-.11	.73
Sr	.28	.72	-.27	-.18	.7
SiO2	-.56	-.4	-.6	.31	.93
LOI	.68	-.1	.65	-.22	.94
Dolo.	.24	.32	.13	-.86	.91
Calc.	.54	-.45	.4	.53	.94
Feld.	-.63	.07	-.07	.06	.41
Quar.	.16	.07	-.81	.11	.7
Opal	.5	-.47	-.47	.15	.71
Gyp.	.24	.85	-.09	-.27	.86
Ill.	-.56	.13	-.12	.01	.35
MonT.	-.71	.03	.11	.16	.54

Figure 3.--Correlation coefficient matrix based on original values.

Correlation valid: at 90% confidence level if > 0.25,
 at 95% confidence level if > 0.29,
 at 99% confidence level if > 0.38.

	U	Al	Ca	Fe	K	Mg	Na	Mn	P
U	1								
Al	-.41	1							
Ca	.32	-.81	1						
Fe	-.4	.9	-.77	1					
K	-.39	.95	-.78	.81	1				
Mg	.01	0	-.01	.06	.01	1			
Na	-.36	.92	-.76	.72	.93	-.43	1		
Mn	.26	-.3	.54	-.36	-.25	.35	-.23	1	
P	0	.14	-.11	.05	.12	-.04	.2	.19	1
Ti	-.37	.84	-.71	.93	.72	.08	.66	-.34	-.05
Ba	-.13	.25	-.11	.18	.27	-.04	.17	.15	-.02
Cu	-.21	.54	-.53	.6	.47	.13	.44	-.24	.34
Li	-.4	.8	-.67	.91	.73	.14	.57	-.29	-.01
Sr	.4	-.4	.18	-.33	.73	.14	-.4	-.32	-.22
SiO2	-.18	.63	-.85	.58	.59	-.27	.62	-.37	.17
LOI	.29	-.62	.9	-.59	-.6	.32	-.58	.75	-.04
Dolo.	.08	-.37	.24	-.3	-.31	.79	-.36	.16	-.17
Calc.	.23	-.36	.62	-.44	-.34	-.35	-.28	.64	.11
Feld.	-.27	.51	-.49	.56	.47	0	.49	-.32	.01
Quar.	.25	-.19	-.26	-.09	-.25	-.16	-.26	-.3	-.26
Opal	.13	-.4	.15	-.35	-.45	-.21	-.37	.11	.24
Gyp.	.06	-.44	.26	-.37	-.39	.04	-.45	-.4	-.26
Ill.	-.21	.43	-.4	.59	.33	.03	.25	-.32	-.13
Mont.	-.29	.7	-.53	.56	.62	-.11	.64	-.31	.08

	Ti	Ba	Cu	Li	Sr	SiO2	LOI	Dolo.	Calc.
P									
Ti	1								
Ba	.19	1							
Cu	.46	.11	1						
Li	.84	.31	.61	1					
Sr	-.3	-.19	-.27	-.29	1				
SiO2	.52	.12	.42	.47	-.34	1			
LOI	-.56	-.02	-.37	-.47	-.02	-.82	1		
Dolo.	-.26	-.2	-.15	-.21	.35	-.57	.36	1	
Calc.	-.42	.17	-.32	-.4	-.36	-.19	.59	-.43	1
Feld.	.57	.03	.2	.41	-.18	.4	-.48	-.15	-.31
Quar.	-.06	-.08	-.04	-.08	.26	.45	-.41	-.12	-.14
Opal	-.33	-.11	0	-.29	-.17	.18	.06	-.19	.35
Gyp.	-.32	-.24	-.31	-.32	.76	-.55	.04	.54	-.47
Ill.	.62	.01	.22	.47	-.14	.29	-.38	-.15	-.31
Mont.	.52	.2	.36	.47	-.24	.36	-.45	-.21	-.28

	Feld.	Quar.	Opal	Gyp.	Ill.	Mont.
Feld.	1					
Quar.	-.03	1				
Opal	-.27	.31	1			
Gyp.	-.15	.03	-.21	1		
Ill.	.57	.12	-.19	-.08	1	
Mont.	.34	-.19	-.37	-.18	.39	1

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APPENDIX

Chemicals are given in ppm or % as indicated at the top of each column. Minerals are given as XRD peak areas in square inches. Asterisks are used where estimated values are substituted for less-than values. Data in appendix does not conform to significant-figure rules.

APPENDIX

Lab no.	Field no.	Formation	Locality	Issinglass
D-260774	F71683-3	Brule	S29-R48W-T34N	Butte
D-260775	F71683-4	Brule	"	"
D-260776	F71683-5	Brule	"	"
D-260777	F71683-6	Brule	"	"
D-260778	F71883-1	Brule	S15-R48W-T34N	"
D-260779	F71883-3	Brule	"	"
D-260780	F71883-5	Brule	"	"
D-260781	F71883-7	Brule	"	"
D-260782	F71883-9	Brule	"	"
D-260783	F71883-11	Brule	"	"
D-260784	F71983-3	Brule	S23-R48W-T34N	"
D-260785	F72183-7	Chadron	S3-R47W-T34 N	Nodding's
D-260786	F72183-8	Brule	"	Ridge
D-260787	F72183-9	Brule	"	"
D-260788	F72183-10	Brule	"	"
D-260789	F81584-4	Brule	S15-R47W-T34N	"
D-260790	F81584-5	Brule	"	"
D-260791	F81584-6	Brule	"	"
D-260792	F81584-7	Brule	"	"
D-260793	F81584-8	Brule	"	"
D-278830	F72586-1	Brule	"	"
D-278831	F72586-2	Brule	"	"
D-278832	F72586-3	Brule	"	"
D-278833	F72586-4	Brule	"	"
D-278834	F72586-5	Brule	"	"
D-278835	F72586-6	Brule	"	"
D-278836	F72686-1	Chadron	S36-R50W-T33N	Trunk Butte
D-278837	F72686-2	Chadron	"	"
D-278838	F72686-3	Brule	"	"
D-278839	F72686-4	Brule	"	"
D-278840	F72686-5	Brule	"	"
D-278843	F72886-1	Chadron	"	"
D-278844	F72886-2	Chadron	"	"
D-278845	F72886-3	Chadron	"	"
D-278855	F72886-4	Brule	"	"
D-278856	F72886-5	Brule	"	"
D-278857	F72886-6	Brule	"	"
D-278846	F72886-7	Brule	"	"
D-278847	F72886-8	Chadron	"	"
D-278848	F72886-9	Chadron	"	"
D-278849	F72986-1	Chadron	S15-R47W-T34N	Nodding's
D-278850	F72986-2	Chadron	"	Ridge
D-278851	F72986-3	Brule	"	"
D-278852	F72986-12	Brule	S10-R47W-T34N	"
D-278853	F72986-13	Chadron	"	"
D-278854	F72986-14	Chadron	"	"

APPENDIX

Field no.	Lithology
F71683-3	Limestone, gray, siliceous
F71683-4	Limestone, gray, pure
F71683-5	clay, pink, pelletal
F71683-6	Sandstone, lt. yellow to gray
F71883-1	Gypsum, lt. brown to gray
F71883-3	Gypsum, lt. yellow to brown
F71883-5	Clay, pink to lt. gray
F71883-7	Gypsum, lt. brown, crystalline
F71883-9	Gypsum, gray, crystalline
F71883-11	Gypsum, gray, crumbly, clayey
F71983-3	Mudstone, gray, noncalcareous
F72183-7	Dolomite, gray, hard (PWL)
F72183-8	Gypsum, gray, hard, clayey
F72183-9	Mudstone, lt. yellow brown
F72183-10	Gypsum, lt. brown, thin-bedded
F81584-4	Siltstone, lt. gray, laminated
F81584-5	Sandstone, lt. brown, fine
F81584-6	Mudstone, lt. yellow-brown
F81584-7	Limestone, lt. brown
F81584-8	Limestone, lt. brown-gray
F72586-1	Mudstone, white, pelletal
F72586-2	Limestone, white, sandy
F72586-3	Mudstone, white, pelletal
F72586-4	Limestone, white to lt. gray
F72586-5	Limestone, white, Mn on fract.
F72586-6	Limestone, white, ashy
F72686-1	Mudstone, buff, pelletal
F72686-2	Mudstone, buff, pelletal
F72686-3	Mudstone, buff, thin-bedded
F72686-4	Limestone, lt. brown, siliceous
F72686-5	Limestone, lt. brown, laminated
F72886-1	Mudstone, white, (PWL)
F72886-2	Mudstone, white, (PWL)
F72886-3	Mudstone, white, (PWL)
F72886-4	Mudstone, brown, pelletal
F72886-5	Mudstone, lt. gray (blue ash)
F72886-6	Mudstone, brown, massive
F72886-7	Mudstone, lt. gray, (PWL)
F72886-8	Mudstone, lt. gray, calcareous
F72886-9	Mudstone, lt. gray, calichified
F72986-1	Mudstone, white, pelletal (PWL)
F72986-2	Mudstone, white, pelletal (PWL)
F72986-3	Mudstone, white, crumbly
F72986-12	Mudstone, gray, pelletal (PWL)
F72986-13	Chalcedony, replaced limestone
F72986-14	Mudstone, white, (PWL)

APPENDIX

Field no.	Uranium (ppm)	Aluminum (%)	Calcium (%)	Iron (%)	Potassium (%)	Magnesium (%)	Sodium (%)
F71683-3	32.20	.33	15.00	.10	.15	.13	.05
F71683-4	22.20	2.10	26.00	.73	.61	.69	.23
F71683-5	15.00	2.60	24.00	.74	.46	.89	.16
F71683-6	46.50	.59	34.00	.21	.20	.39	.08
F71883-1	5.75	1.40	18.00	.66	.67	5.10	.16
F71883-3	4.12	.65	21.00	.33	.45	1.50	.05
F71883-5	19.30	.45	23.00	.18	.25	9.00	.11
F71883-7	6.66	.90	20.00	.41	.39	.41	.07
F71883-9	.94	.60	23.00	.26	.32	.21	.03
F71883-11	4.61	1.60	19.00	.80	.89	.55	.08
F71983-3	5.53	7.30	1.40	2.60	1.90	1.80	.96
F72183-7	7.50	3.50	13.00	1.40	1.40	5.90	.60
F72183-8	8.79	.70	23.00	.29	.27	.19	.06
F72183-9	3.53	4.80	11.00	1.30	1.20	1.20	.65
F72183-10	41.20	.31	13.00	.12	.12	.09	.02
F81584-4	5.06	6.80	3.20	2.80	1.90	1.50	.95
F81584-5	4.25	5.30	4.50	2.00	1.80	.67	1.20
F81584-6	5.86	7.00	1.50	3.30	2.20	1.50	.77
F81584-7	11.20	1.80	19.00	.89	.68	.67	.21
F81584-8	9.63	.30	24.00	.13	.10	.29	.05
F72586-1	2.60	3.80	22.00	1.30	1.10	.89	.50
F72586-2	10.00	2.40	19.00	1.20	.94	.82	.23
F72586-3	6.28	5.50	13.00	1.20	2.00	1.20	.77
F72586-4	8.30	.37	27.00	.15	.15	.35	.05
F72586-5	2.93	.25	40.00	.13	.07	.38	.05
F72586-6	9.13	5.00	14.00	.39	2.70	.42	1.30
F72686-1	3.93	6.60	5.40	2.20	2.10	.95	1.40
F72686-2	7.03	5.60	8.50	1.30	2.00	.60	1.50
F72686-3	7.09	2.10	14.00	.72	.45	.48	.36
F72686-4	15.80	.79	16.00	.32	.27	.26	.16
F72686-5	5.92	.58	33.00	.22	.22	.36	.17
F72886-1	4.22	6.00	11.00	1.80	1.70	.98	1.00
F72886-2	6.19	6.60	3.70	1.60	2.20	.81	1.50
F72886-3	7.32	6.70	3.60	2.00	2.30	.87	1.60
F72886-4	2.43	6.50	8.40	2.50	1.80	1.30	1.00
F72886-5	4.11	7.60	5.60	1.80	1.70	1.10	1.70
F72886-6	3.19	6.90	1.30	2.90	2.20	1.20	1.10
F72886-7	5.24	6.90	1.70	1.90	2.00	.99	1.40
F72886-8	8.09	6.40	3.30	1.90	2.00	.99	1.30
F72886-9	4.56	7.70	1.00	2.80	2.30	1.30	1.20
F72986-1	3.45	7.70	1.30	2.60	2.20	1.30	1.10
F72986-2	6.02	5.70	8.50	1.30	2.10	.79	1.20
F72986-3	3.71	6.20	7.30	1.90	1.80	1.10	1.10
F72986-12	7.70	6.30	5.10	1.40	2.70	.60	1.70
F72986-13	15.10	.41	2.40	.12	.16	.09	.06
F72986-14	6.44	5.00	9.10	.84	1.50	.80	.85
Average	9.29	2.73	9.85	.92	.85	1.57	.56
Std. Dev.	9.27	3.80	13.52	1.21	1.23	1.17	.67

APPENDIX

Field no.	Manganese (ppm)	Phosph. (%)	Titanium (%)	Barium (ppm)	Copper (ppm)	Lithium (ppm)	Strontium (ppm)
F71683-3	2100.00	.06	.01	55.00	2.00	2.00	160.00
F71683-4	2900.00	.34	.08	410.00	8.00	12.00	550.00
F71683-5	2000.00	.04	.08	110.00	9.00	12.00	420.00
F71683-6	2800.00	.03	.03	95.00	4.00	4.00	410.00
F71883-1	1200.00	.04	.07	140.00	13.00	19.00	1500.00
F71883-3	330.00	.03	.03	67.00	4.00	7.00	2200.00
F71883-5	3000.00	.08	.02	82.00	15.00	9.00	1200.00
F71883-7	63.00	.01	.04	65.00	5.00	14.00	4100.00
F71883-9	39.00	.05	.03	59.00	2.00	7.00	1900.00
F71883-11	120.00	.03	.08	76.00	7.00	21.00	2600.00
F71983-3	150.00	.08	.31	630.00	19.00	47.00	310.00
F72183-7	3300.00	.05	.15	350.00	7.00	32.00	430.00
F72183-8	45.00	.01	.03	54.00	4.00	5.00	1900.00
F72183-9	93.00	.05	.18	210.00	7.00	22.00	620.00
F72183-10	71.00	.01	.01	41.00	.75	3.00	7100.00
F81584-4	420.00	.07	.29	610.00	21.00	49.00	410.00
F81584-5	630.00	.08	.27	790.00	11.00	22.00	350.00
F81584-6	340.00	.04	.36	560.00	22.00	45.00	340.00
F81584-7	1300.00	.05	.10	220.00	3.00	23.00	390.00
F81584-8	940.00	.04	.01	130.00	1.00	4.00	340.00
F72586-1	3200.00	.11	.13	3300.00	15.00	28.00	420.00
F72586-2	1300.00	.05	.11	360.00	12.00	31.00	400.00
F72586-3	1300.00	.06	.12	5100.00	12.00	43.00	340.00
F72586-4	1400.00	.05	.02	170.00	13.00	6.00	290.00
F72586-5	2300.00	.03	.01	130.00	.75	4.00	340.00
F72586-6	1900.00	.02	.06	750.00	6.00	10.00	150.00
F72686-1	690.00	.03	.27	790.00	15.00	29.00	390.00
F72686-2	1100.00	.26	.09	370.00	6.00	17.00	280.00
F72686-3	1300.00	.37	.06	140.00	27.00	18.00	280.00
F72686-4	1200.00	.03	.03	1900.00	7.00	9.00	320.00
F72686-5	2300.00	.03	.02	79.00	2.00	6.00	400.00
F72886-1	1100.00	.08	.15	460.00	16.00	39.00	380.00
F72886-2	590.00	.02	.15	380.00	35.00	27.00	260.00
F72886-3	630.00	.07	.13	340.00	8.00	33.00	280.00
F72886-4	990.00	.06	.20	430.00	20.00	53.00	340.00
F72886-5	920.00	.08	.34	830.00	7.00	15.00	350.00
F72886-6	270.00	.08	.29	750.00	30.00	50.00	570.00
F72886-7	360.00	.02	.16	340.00	15.00	31.00	280.00
F72886-8	450.00	.37	.11	350.00	56.00	33.00	300.00
F72886-9	310.00	.01	.29	660.00	23.00	54.00	340.00
F72986-1	340.00	.02	.31	590.00	22.00	62.00	340.00
F72986-2	1500.00	.07	.10	650.00	9.00	22.00	280.00
F72986-3	1200.00	.07	.15	330.00	14.00	35.00	320.00
F72986-12	1100.00	.19	.13	360.00	8.00	21.00	260.00
F72986-13	380.00	.03	.02	110.00	10.00	4.00	210.00
F72986-14	1600.00	.28	.08	190.00	1.00	15.00	320.00
Average	911.18	.09	.10	868.33	10.40	16.11	1206.64
Std. Dev.	1121.11	.08	.12	535.07	12.05	22.91	775.43

APPENDIX

Field no.	SiO ₂ (%)	Al ₂ O ₃ (%)	Fe ₂ O ₃ (%)	MgO (%)	CaO (%)	Na ₂ O (%)	K ₂ O (%)
F71683-3	63.50	.73	.08	.26	19.10	.11	.15
F71683-4	28.10	3.87	.95	1.15	35.10	.35	.68
F71683-5	30.60	4.80	.95	1.42	32.70	.25	.51
F71683-6	13.70	1.09	.21	.69	46.90	.11	.21
F71883-1	21.10	2.50	.85	8.14	24.00	.22	.72
F71883-3	13.40	1.14	.39	2.31	28.50	.11	.51
F71883-5	3.67	.78	.19	16.10	30.60	.20	.26
F71883-7	18.90	1.65	.50	.65	25.60	.11	.44
F71883-9	7.54	.98	.28	.40	30.50	.11	.33
F71883-11	19.70	2.68	.96	.82	25.10	.15	.94
F71983-3	64.10	14.30	3.64	3.00	1.83	1.36	2.36
F72183-7	30.00	6.22	1.86	10.30	17.90	.78	1.54
F72183-8	8.56	1.16	.31	.35	29.60	.11	.28
F72183-9	40.20	8.80	1.73	1.94	14.00	.89	1.46
F72183-10	47.60	.64	.13	.18	16.90	.11	.13
F81584-4	61.60	13.00	3.84	2.46	4.27	1.32	2.36
F81584-5	68.30	10.30	2.73	1.10	5.93	1.66	2.24
F81584-6	62.60	13.70	4.65	2.55	2.01	1.14	2.77
F81584-7	46.70	3.25	1.14	1.08	24.90	.29	.74
F81584-8	42.40	.63	.12	.51	31.20	.11	.10
F72586-1	29.30	6.35	1.74	1.39	30.10	.62	1.21
F72586-2	42.50	4.14	1.63	1.30	25.20	.35	1.02
F72586-3	44.00	9.32	1.67	1.94	17.40	.91	2.20
F72586-4	33.10	.74	.13	.59	36.30	.11	.15
F72586-5	2.88	.47	.10	.67	54.20	.11	.08
F72586-6	46.70	8.59	.49	.70	19.40	1.49	3.07
F72686-1	58.80	11.60	3.16	1.57	7.26	1.64	2.49
F72686-2	56.20	9.86	1.84	1.00	11.50	1.77	2.35
F72686-3	55.50	3.66	.93	.77	18.20	.40	.48
F72686-4	58.70	1.55	.36	.43	20.30	.11	.28
F72686-5	19.00	1.03	.22	.61	43.90	.21	.20
F72886-1	48.20	10.30	2.59	1.57	15.20	1.13	1.96
F72886-2	63.00	11.90	2.28	1.32	4.97	1.92	2.69
F72886-3	62.20	11.90	2.74	1.42	4.86	1.94	2.80
F72886-4	51.20	11.20	3.58	2.00	11.20	1.23	2.06
F72886-5	53.90	13.60	2.57	1.81	7.59	2.18	1.96
F72886-6	65.10	12.30	4.08	1.93	1.74	1.38	2.62
F72886-7	65.50	12.40	2.68	1.65	2.18	1.77	2.42
F72886-8	61.90	11.80	2.86	1.64	4.48	1.37	2.56
F72886-9	62.80	13.80	3.86	2.11	1.34	1.50	2.77
F72986-1	63.70	13.80	3.66	2.21	1.64	1.37	2.61
F72986-2	55.50	9.79	1.72	1.27	11.20	1.39	2.41
F72986-3	55.40	10.90	2.59	1.75	9.70	1.28	2.03
F72986-12	60.90	11.20	1.98	.98	6.81	2.10	3.28
F72986-13	90.10	1.50	.09	.02	3.10	.11	.16
F72986-14	57.40	8.60	1.13	1.28	12.00	.95	1.72
Average	20.61	4.92	1.32	2.76	13.24	.68	1.04
Std. Dev.	44.69	6.84	1.66	1.94	18.01	.84	1.44

APPENDIX

Field no.	TiO2 (%)	P2O5 (%)	MnO (%)	LOI (%)
F71683-3	.01	.13	.26	15.80
F71683-4	.12	.74	.37	29.10
F71683-5	.11	.11	.25	29.00
F71683-6	.01	.07	.34	37.20
F71883-1	.09	.10	.14	26.50
F71883-3	.02	.07	.02	21.20
F71883-5	.01	.17	.36	40.30
F71883-7	.04	.04	.01	17.90
F71883-9	.01	.11	.01	20.00
F71883-11	.10	.07	.01	17.60
F71983-3	.56	.19	.01	8.73
F72183-7	.24	.12	.44	26.80
F72183-8	.02	.04	.01	20.20
F72183-9	.30	.11	.01	13.80
F72183-10	.01	.04	.01	11.50
F81584-4	.50	.17	.05	9.93
F81584-5	.49	.21	.08	6.69
F81584-6	.63	.10	.04	9.36
F81584-7	.13	.11	.16	21.80
F81584-8	.01	.09	.10	25.10
F72586-1	.21	.23	.40	28.00
F72586-2	.18	.12	.16	23.70
F72586-3	.22	.13	.16	21.20
F72586-4	.01	.11	.16	29.10
F72586-5	.01	.07	.27	41.60
F72586-6	.09	.04	.25	19.20
F72686-1	.47	.06	.08	12.80
F72686-2	.16	.55	.14	14.60
F72686-3	.09	.74	.16	19.10
F72686-4	.03	.06	.13	17.50
F72686-5	.01	.06	.27	35.10
F72886-1	.30	.18	.14	18.40
F72886-2	.26	.04	.07	11.30
F72886-3	.23	.14	.08	11.30
F72886-4	.41	.14	.12	16.90
F72886-5	.63	.21	.12	15.20
F72886-6	.56	.19	.03	9.54
F72886-7	.27	.04	.04	10.90
F72886-8	.26	.87	.05	11.20
F72886-9	.52	.04	.03	10.70
F72986-1	.56	.04	.04	10.10
F72986-2	.19	.15	.19	15.20
F72986-3	.30	.16	.16	15.30
F72986-12	.22	.39	.14	11.30
F72986-13	.01	.05	.04	3.96
F72986-14	.12	.58	.20	15.90
Average	.19	.20	.11	8.78
Std. Dev.	.21	.18	.14	18.64

APPENDIX

Field no.	Dolo.	Calc.	Feld.	Quar.	Opal	Gyp.	Ill.	Mont.
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
F71683-3	0.00	1.05	0.00	1.10	.39	0.00	0.00	0.00
F71683-4	0.00	1.06	0.00	0.00	0.00	0.00	0.00	0.00
F71683-5	0.00	1.05	0.00	.50	.31	0.00	0.00	.19
F71683-6	0.00	1.48	0.00	.06	.15	0.00	0.00	0.00
F71883-1	1.10	0.00	.03	.34	0.00	.61	0.00	0.00
F71883-3	.51	0.00	0.00	.21	0.00	1.24	0.00	0.00
F71883-5	1.44	0.00	.03	.07	0.00	.26	0.00	0.00
F71883-7	.39	0.00	.06	.30	0.00	.89	0.00	.02
F71883-9	.35	0.00	0.00	.08	0.00	1.18	0.00	.03
F71883-11	.32	0.00	0.00	.22	0.00	1.22	0.00	.01
F71983-3	0.00	0.00	.23	.75	0.00	.02	.02	.03
F72183-7	1.17	0.00	.08	.26	0.00	.19	0.00	0.00
F72183-8	.94	0.00	.06	.10	0.00	1.06	0.00	.30
F72183-9	.20	0.00	.46	.58	0.00	.75	.05	.21
F72183-10	.26	0.00	0.00	1.46	0.00	1.01	0.00	.01
F81584-4	0.00	.16	.27	.58	0.00	0.00	.07	.38
F81584-5	0.00	.31	1.00	.23	0.00	0.00	.03	.14
F81584-6	0.00	0.00	.20	.48	0.00	0.00	.05	.25
F81584-7	0.00	1.04	.07	.32	.39	0.00	0.00	0.00
F81584-8	0.00	1.11	0.00	.73	.33	0.00	0.00	0.00
F72586-1	0.00	1.13	0.00	.22	0.00	0.00	0.00	.10
F72586-2	0.00	.96	0.00	.22	.26	0.00	0.00	0.00
F72586-3	0.00	.79	.07	.11	0.00	0.00	0.00	.23
F72586-4	0.00	1.42	0.00	.53	.23	0.00	0.00	0.00
F72586-5	0.00	1.37	0.00	0.00	0.00	0.00	0.00	0.00
F72586-6	0.00	1.00	0.00	0.00	0.00	0.00	0.00	.09
F72686-1	0.00	.30	.18	.23	0.00	0.00	.03	.07
F72686-2	0.00	.60	.40	.18	0.00	0.00	0.00	.11
F72686-3	0.00	.74	0.00	.10	1.27	0.00	0.00	0.00
F72686-4	0.00	.96	0.00	.99	.46	0.00	0.00	0.00
F72686-5	0.00	1.22	0.00	0.00	.21	0.00	0.00	0.00
F72886-1	0.00	.61	.13	.24	0.00	0.00	0.00	.25
F72886-2	0.00	.23	.16	.26	0.00	0.00	0.00	.26
F72886-3	0.00	.17	.17	.15	0.00	0.00	0.00	.14
F72886-4	0.00	.54	.33	.29	0.00	0.00	.02	.19
F72886-5	0.00	.42	.06	.05	0.00	0.00	0.00	.31
F72886-6	0.00	0.00	.20	.53	0.00	0.00	0.00	0.00
F72886-7	0.00	.05	.12	.17	0.00	0.00	0.00	.24
F72886-8	0.00	.08	.08	.21	0.00	0.00	0.00	.26
F72886-9	0.00	0.00	.26	.45	0.00	0.00	.04	.17
F72986-1	0.00	0.00	.21	.50	0.00	0.00	0.00	.25
F72986-2	0.00	.64	.07	.17	0.00	0.00	0.00	.23
F72986-3	0.00	.29	.14	.22	0.00	0.00	.02	.11
F72986-12	0.00	.51	.15	.30	0.00	0.00	0.00	.24
F72986-13	0.00	.16	0.00	1.77	.65	0.00	0.00	0.00
F72986-14	0.00	.55	.03	.08	0.00	0.00	0.00	.22
Average	.34	.48	.17	.37	.23	.39	.02	.11
Std. Dev.	.15	.48	.11	.36	.10	.18	.01	.11