Distribution of trace elements in drilling chip samples around a roll-type uranium deposit, San Juan Basin, New Mexico

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Abstract

Chip samples from rotary drilling in the vicinity of a roll-type uranium deposit in the southwestern San Juan Basin were split into a whole-washed fraction, a clay fraction, and a heavy mineral concentrate fraction. Analyses of these fractions determined that cutting samples could be used to identify geochemical halos associated with this ore deposit. In addition to showing a distribution of selenium, uranium, vanadium, and molybdenum similar to that described by Harshman (1974) in uranium roll-type deposits in Wyoming, South Dakota, and Texas, the chemical data indicate a previously unrecognized zinc anomaly in the clay fraction downdip of the uranium ore.

Introduction

This geochemical study of rotary drill chip samples across a roll-type uranium deposit had two main objectives: first, to detect any geochemical halo which might be associated with the deposit; and second, to provide insight into the relative abundance and distribution of various elements in bulk samples, clay fractions and heavy mineral concentrates.

There are several problems inherent in using samples of cuttings for geochemical studies. One is an unavoidable contamination of the sample with drilling mud, which contains variable amounts of trace elements. Another problem is that the chip samples may not be exclusively derived from the bottom of the hole but may be contaminated by a mixture of material from more shallow levels of the hole. A third problem is a time lag between the drilling of an interval and the arrival at the surface of chips from that interval, which makes accurate depth determination somewhat uncertain. Correlations of the chip sample lithology to geophysical log response can reduce this uncertainty. Clearly there are a number of advantages to using core samples instead of chip samples for geochemical studies. However, because of the considerable time and expense involved, and because core drilling is unnecessary for detection and "assaying" of uranium, core drilling comprises only a small percentage of all uranium exploration and development drill holes. If the analysis of cutting samples from rotary drilling detects a chemical anomaly associated with mineralization, the technique could be employed as a prospecting guide.

Acknowledgments

We thank UNC-Teton Exploration Drilling Company, Inc. for providing samples for this study, and U.S. Geological Survey laboratories for the chemical analysis.

Description of the deposit and sample locations

The deposit studied is located in the southwestern part of the San Juan Basin near Dalton Pass, McKinley County, New Mexico (fig. 1). The exact

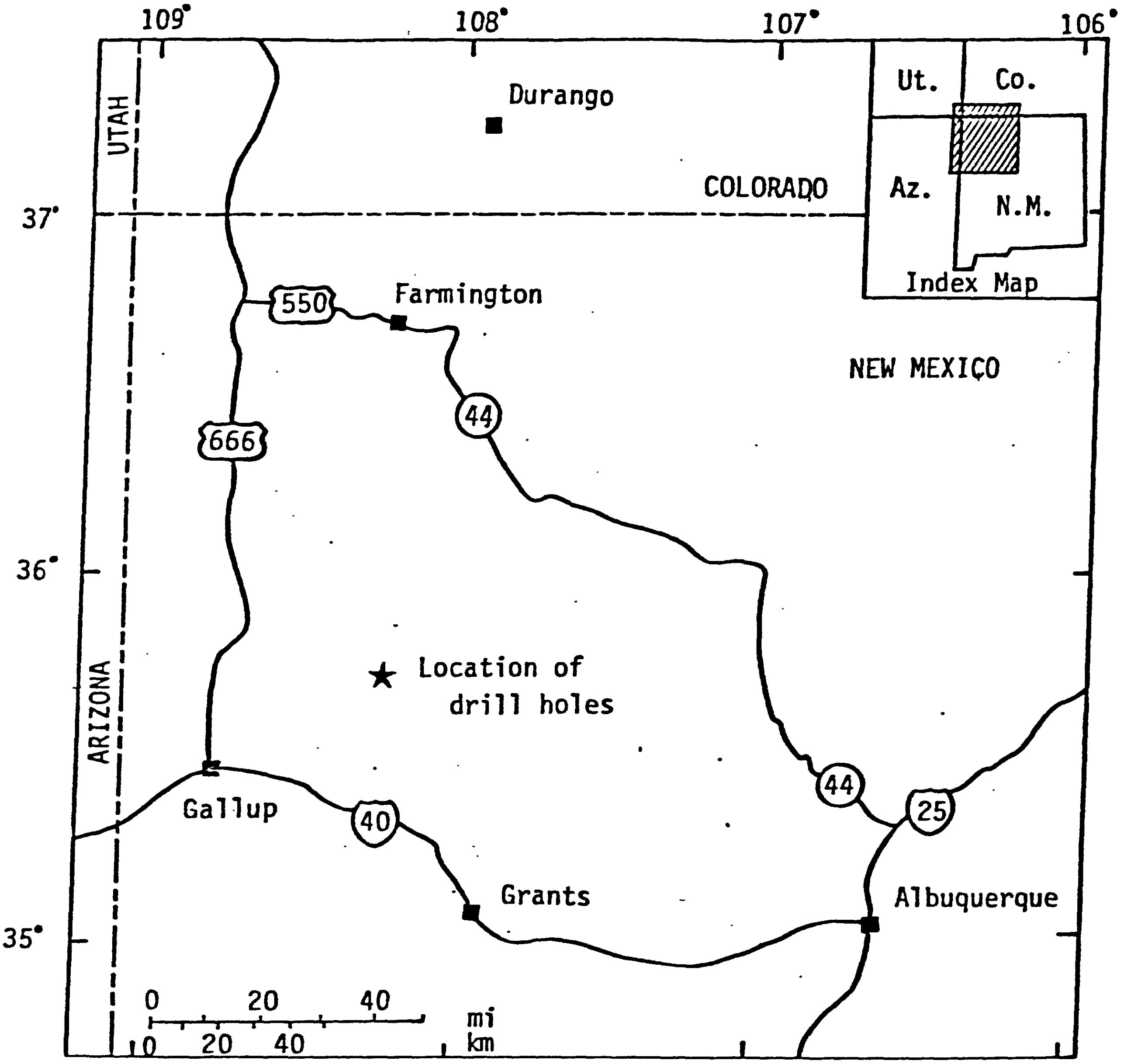

Figure 1.--Index map showing location of drill holes studied in the San Juan Basin, New Mexico.

location is not shown to preserve the confidentiality of the deposit. Uranium mineralization occurs in the Jurassic Westwater Canyon Member of the Morrison Formation. In contrast to the arcuate geometry of idealized roll-type deposits, the shape and localization of this deposit is apparently affected by many small interbedded shale layers. These relatively impermeable layers may have diverted the flow of the mineralizing solutions in such a manner as to produce several small mineralized fronts. From geophysical log data, it is not clear whether the geometry of these small fronts should be interpreted as one large but complex roll-type deposit or as several small distinct deposits which are present within the mineralized area.

Samples were obtained from 24 drill holes along a 2-mile-long line oriented in a southwest-northeast direction (fig. 2). The orientation of these holes was from barren rock 4,430 feet updip, through 1,650 feet of a mineralized, uranium-bearing zone, and through 6,130 feet of barren rock downdip of the mineralized zone. Five drill chip samples (six in hole X) were taken from each drill hole in stratigraphically equivalent intervals within the ore-bearing horizons of the Westwater Canyon Member of the Morrison Formation. Each sample represented 20 or 30 feet of rock. Geophysical logs (35) were used to correlate sample intervals within each hole and from one hole to the next (fig. 3).

Sample lithology and preparation

Most of the samples consisted of poorly cemented sandstone, disaggregated sandstone, and 5 to 10 percent shale. Individual sandstone fragments were as large as 5 mm in diameter with a dominant grain size of upper fine sand (2.5-2.0 ϕ), but with grains that range in size from clay to upper medium sand (1.5-1.0 ϕ). The color of these fragments varies from yellowish gray (5Y 7/2) (Goddard and others, 1975) to dark yellowish orange (10YR 6/6). The shale chips may have originated primarily from shale interbeds within the Westwater Canyon Member of the Morrison Formation, from the Brushy Basin Member of the Morrison Formation, or from the Mancos Shale. These chips range up to 7 mm in size and are olive gray (5Y 4/1 and 5Y 3/2) to olive black (5Y 2/1). The unconsolidated sand consists of individual frosted quartz grains of upper fine sand (2.5-2.0 ϕ). These grains are light gray (N7) to very light gray (N8). Fresh and altered pyrite grains were present in the chip samples both updip and downdip of the ore, but appeared depleted in the ore zone area relative to the updip and downdip samples. Since pyrite is known to be depleted updip from uranium roll-type deposits (Warren and Granger, 1973; Granger and Warren, 1974), the occurrence of pyrite updip may be attributed to impermeable shale layers separating pyrite grains from the oxidizing mineralizing solutions, or from contamination of the sample from uphole stratigraphic horizons.

Before obtaining the samples, they had been washed to remove most of the drilling mud. In an effort to remove as much of the drilling mud as possible, the samples were rewashed several times; the mud and wash water samples were not retained. The washed samples were split and approximately 20 grams of each washed sample was set aside for "whole rock" analysis.

After washing, the remaining drilling mud, and authigenic and detrital clays were removed from the surface of the sand grains with an ultrasonic cleaner. These clays were separated from the sand, dried, and set aside for analysis. In 5 percent of the samples, the mass of clay separated after ultrasonic treatment was too small to be analyzed.

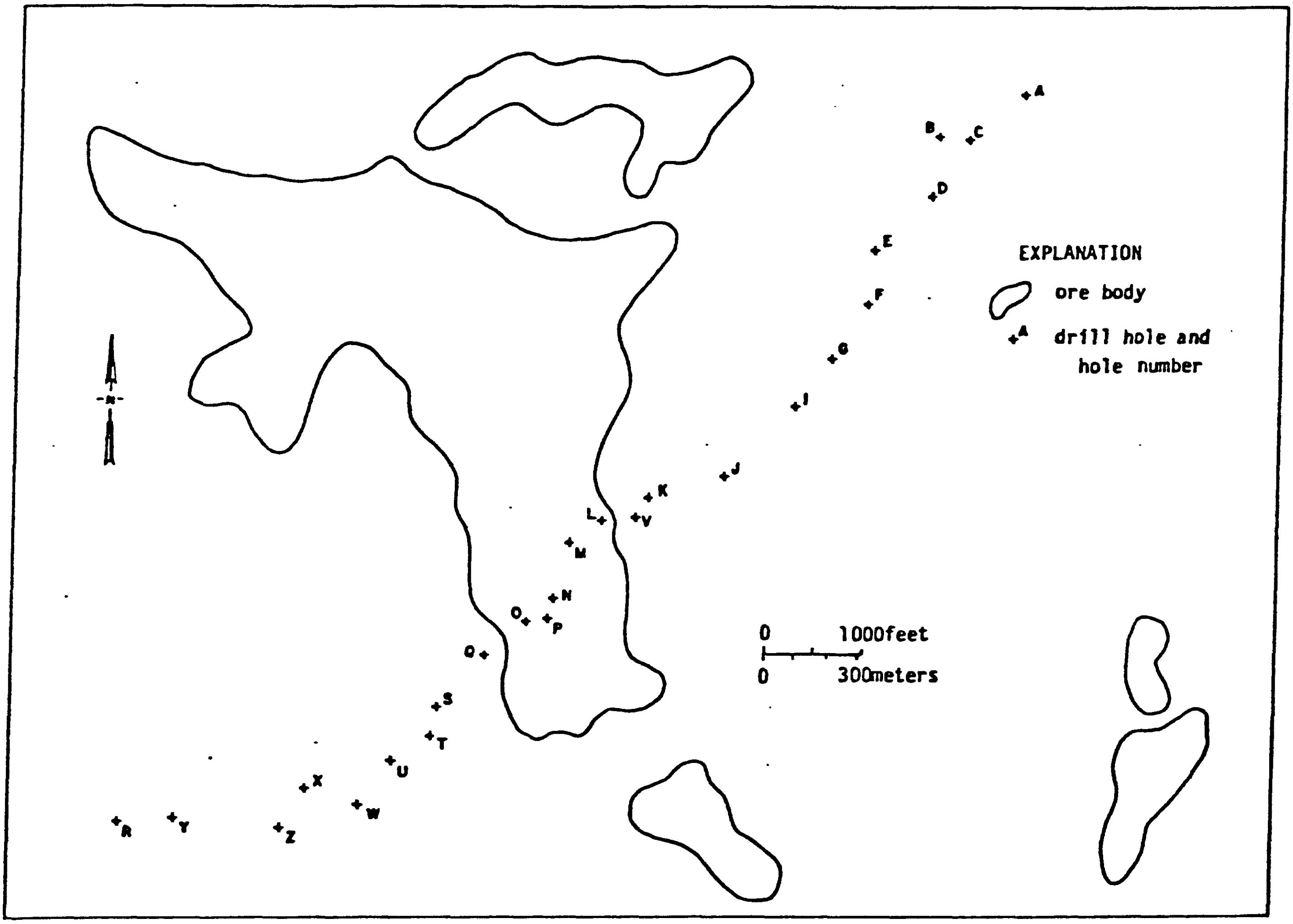

Figure 2.--Location of drill holes and planview of ore bodies. Coordinates not shown to preserve the confidentiality of the deposit.

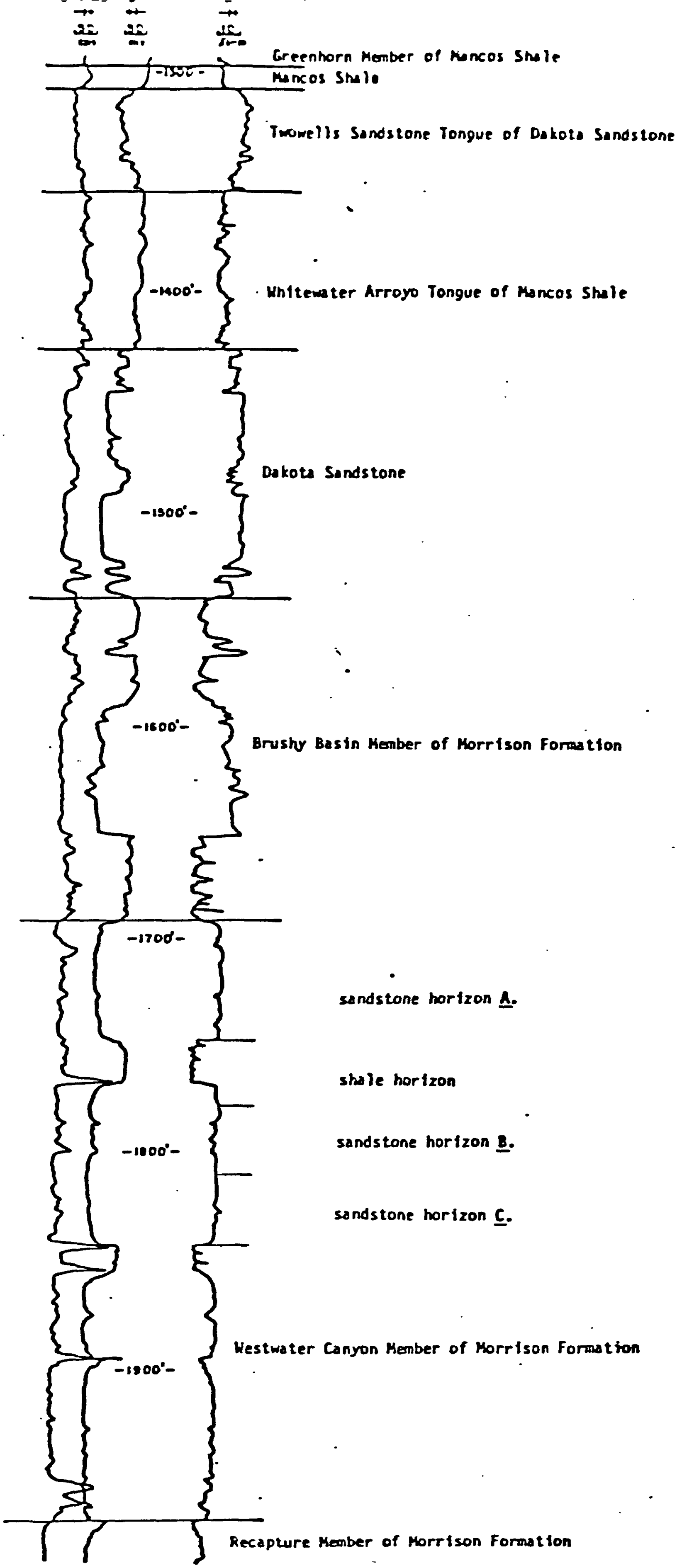

Figure 3.--Geophysical well-log showing lithologic units, with sandstone horizons A, B, C, and shale horizon used in this study.

Heavy mineral fractions were separated from the washed, ultrasonically treated samples. Many of the samples contained too little material to be analyzed, necessitating the combination of heavy mineral fractions from adjacent intervals in the same hole. After the samples were combined, each hole was represented by from 1 to 5 heavy mineral fraction samples.

Nature of the analytical data

Chemical analysis was performed on 120 whole washed samples, 114 samples of clay separated after ultrasonic cleaning, and 52 samples of heavy mineral concentrates. All analyses were made by personnel of the laboratories of the U.S. Geological Survey. The analyzed elements, lower limits of determination, and the analytical techniques used are summarized in figures 4, 5, and 6. To a large extent, the mass of available sample dictated what analyses could be performed. The heavy mineral concentrates were so small that only spectrographic analysis could be performed, whereas the mass of the whole washed samples were large enough to permit delayed neutron analysis for uranium and thorium and to permit several elements to be determined by wet chemical methods.

It should be noted that the detection limits for Ag, Au, In, Mo, Nb, Pt, Sc, W, and Zn, although analyzed by the same techniques, are different for different sample types. This is due to varying concentrations of other elements that cause interference in the analytical procedure. Most of the data were obtained from a quantitative direct current (DC) arc emission spectrographic analysis rather than the more common 6-step emission spectroscopy. In the quantitative tecnique the concentrations are reported as discrete numerical values rather than midpoints of geometric brackets. The precision of the reported values from DC arc emission for these samples is ± 10 percent.

Results from samples that contain too little of certain elements to permit accurate determinations of their abundances are presented in two categories. One category (N for "not detected") is for samples with such a low concentration of some element that there is no evidence for the presence of the element. The other category (L for "less than") is for samples in which the element is present but at a concentration too low to permit accurate determination. As an arbitrary means of estimating these values for statistical analysis of the data, a value of one-half the lower limit of determination was substituted for samples in the first category (N), and a value of three-quarters of the lower limit of determination was substituted for samples in the second category (L).

Geochemical halos

In plotting the data for interpretation the relative geographic position of each hole was projected to a straight southwest-northeast cross section transecting the uranium deposit. The vertical axis of the data plot was the depth in the holes. Each sample site was located on this cross-sectional base. The cross-sectional base was used to separately plot each element for each of the three categories (whole rock, clay, heavy mineral concentrate). The concentrations of the elements were plotted at each sample site and the results were contoured. Contour plots of the elements in the whole rock samples show enrichment of uranium, with selenium concentrated in a zone updip from the uranium occurrence, and molybdenum concentrated in a zone downdip of the uranium occurrence. Contour plots of the

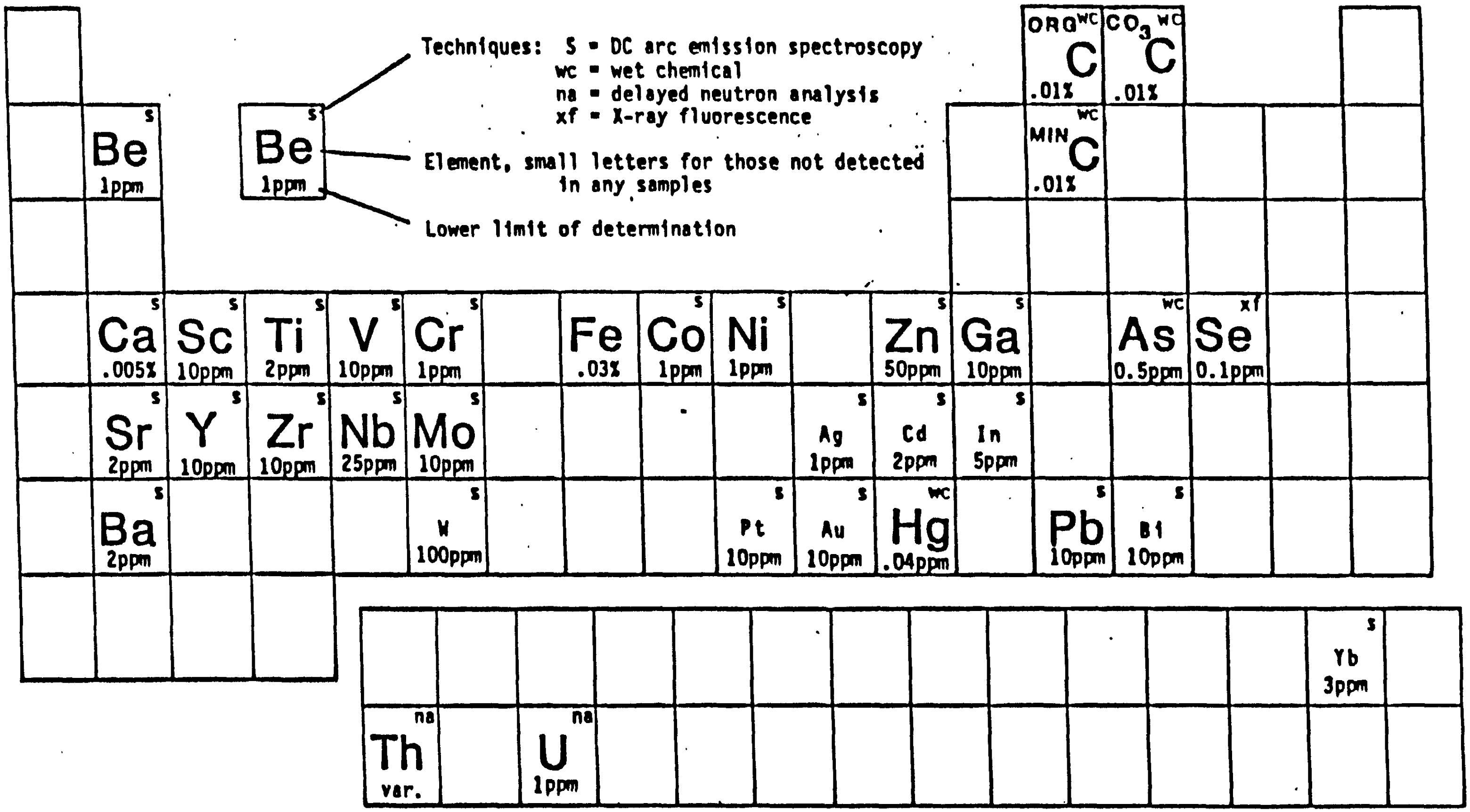

Figure 4.--Elements analyzed, techniques used, and lower limits of determination for whole rock samples.

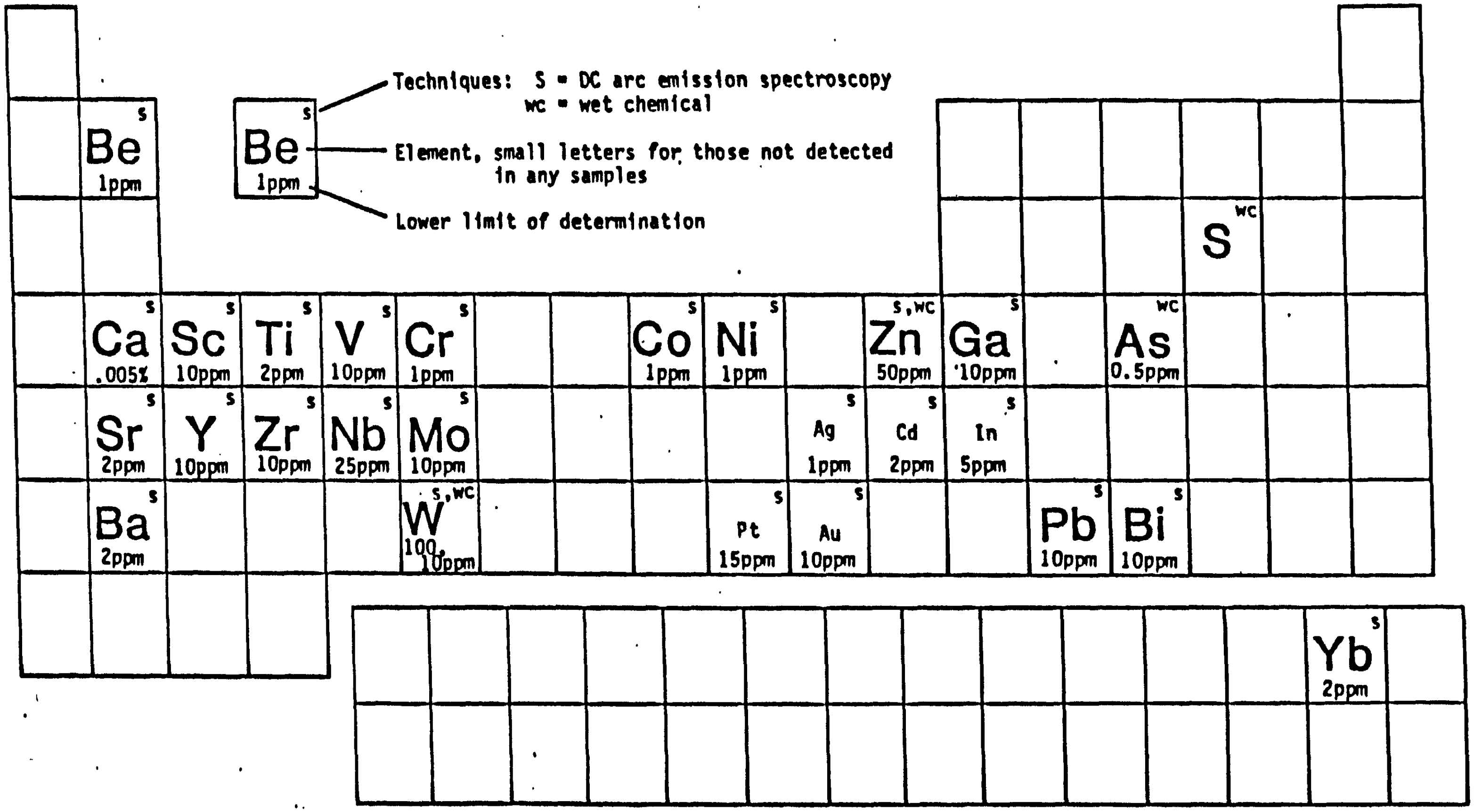

Figure 5.--Elements analyzed, techniques used, and lower limits of determination for clay samples.

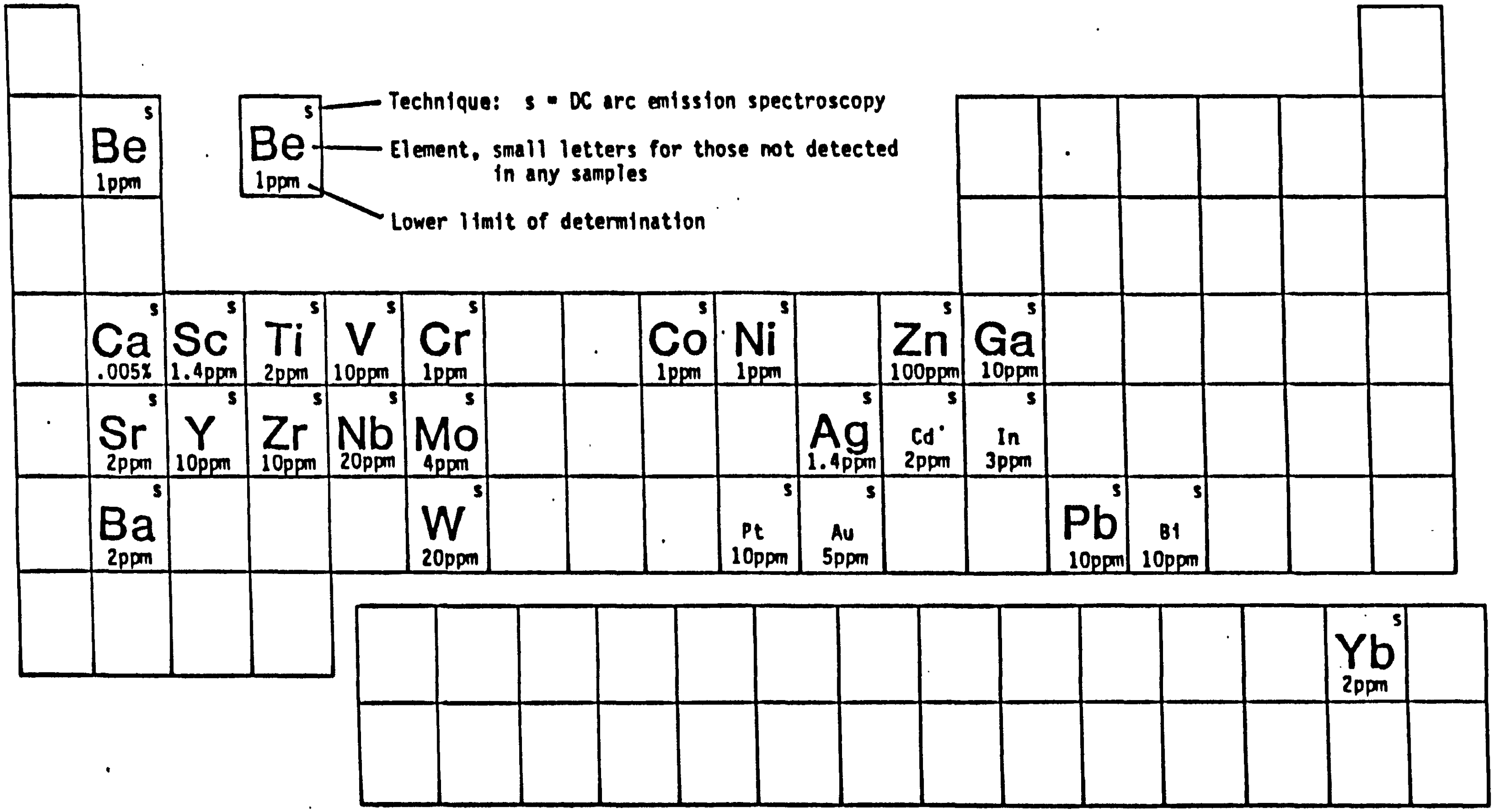

Figure 6.--Elements analyzed, techniques used, and lower limits of determination for heavy concentrate samples.

elements in the clay samples show enrichment of zinc in a zone downdip from the uranium occurrence (Figure 7).

There are some distinct disadvantages to identification of geochemical halos by contouring data by this method. The low density of drill holes across this deposit required that the data be contoured without sample points across distances as great as 1000 feet or more. This tends to obscure any subtle geochemical variations associated with the deposit, or miss them altogether. In addition, because of the small population of sample points, one anomalous sample can provide the entire geochemical anomaly for any given sample population. The character of the anomalies on these plots are in part a function of the sample density of the data, and also of the contour interval used to construct such a plot.

Another attempt to detect a geochemical halo compared the average concentration of each element in each drill hole within and on opposite sides of the deposit. Whole rock, heavy mineral concentrate, and clay fractions were compared separately. This failed to reveal any geochemical halo. Averaging the data in this manner conceals any subtle geochemical variations in the sample suite. In a third technique, we plotted the concentration of each element in a single stratigraphic horizon (defined by well-log correlations) against distance across the deposit. Three stratigraphically different sandstone horizons and a shale horizon were examined (fig. 3).

The concentrations of uranium, vanadium, selenium, molybdenum, and zinc showed anomalous distributions and concentrations when plotted versus distance in each of the four horizons (figs. 8, 9, 10, and 11). The distributions of uranium, selenium, vanadium, and molybdenum in the three sandstone horizons closely resemble the distribution of elements found across uranium roll-type deposits in Texas, Wyoming, and South Dakota (Harshman, 1974), although the distance for the distribution is many times greater in this deposit. Many roll-type ore bodies in Karnes and Live Oak Counties in Texas, the Gas Hills and Shirley Basin areas of Wyoming, and the Black Hills area in South Dakota require less than 300 feet to achieve the same elemental distribution as in this deposit. Here, the distance required to attain the distribution of the elements is as far as 6,500 feet. In addition, the concentrations of the elements in this deposit compared to others is decreased by a factor of at least 10, which could be expected because of the method of sample washing before we obtained the samples, and the additional washing and preparation prior to analysis, or due to a "dilution" by unmineralized rock over the longer distance (6,500 ft. vs. 300 ft.).

The large distance over which the various elemental anomalies are observed may be related to the timing of mineralization. Organic carbon and reduced sulfur species are the most important reducing agent in sediments and sedimentary rocks. In young sediments, organic carbon is an active reducing agent; as the sediments and the contained detrital organic matter age, reduction by organic carbon becomes a progressively slower process (Leventhal, 1980). Reduction by organic carbon will become so slow a process that an oxidizing solution front passing through the sediments will only react with a small fraction of the organic carbon. A similar decrease in the oxygen fugacity (or Eh) of an oxidizing mineralizing solution requires the reaction with a larger volume of old rock and its contained detrital organic material compared to a young rock and its contained organic material.

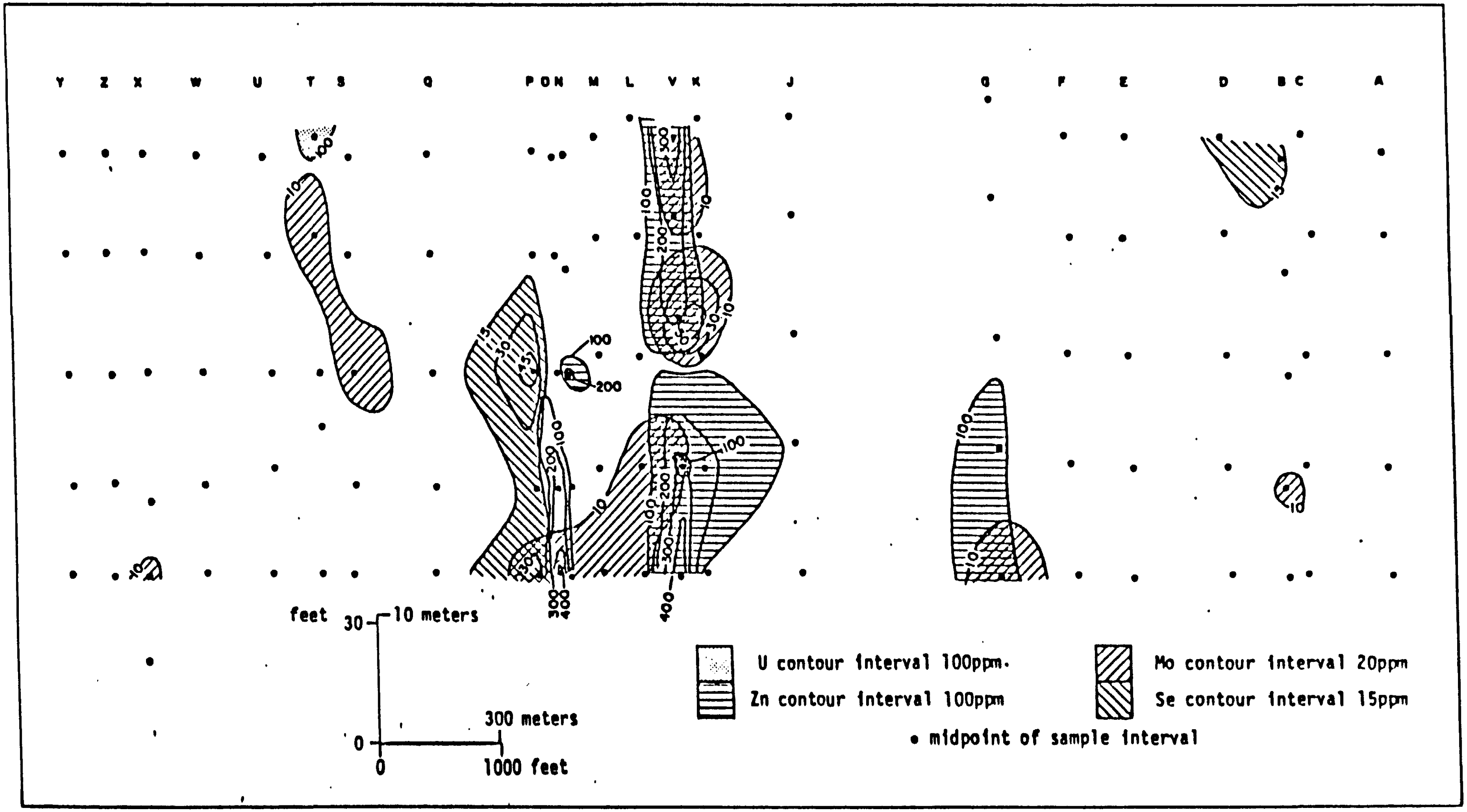

Figure 7.--Contour plot from cross-sectional base showing U, Mo, Se, and Zn concentrations across uranium deposit. Letters correspond to drill holes shown on figure 2.

The concentration of zinc in the clay fraction for each stratigraphic horizon (figs. 8, 9, 10, and 11) shows that zinc is also present in an anomalous zone occurring downdip of the uranium occurrences in the sandstone horizons. Figure 8 shows the distribution of the elements and their concentrations versus distance in sandstone horizon A (see figure 3 for location of sampling horizons). An anomalous zinc zone occurs about 3,200 feet downdip of the uranium occurrence in this horizon. The distributions of selenium and molybdenum also indicate anomalous zones of these elements. Our data show two anomalous uranium zones 2,000 feet apart in stratigraphic horizon B in fig. 9. In addition to a selenium zone coincident with one uranium occurrence, the data shows two independent sets of geochemical halos, where both zinc and molybdenum occur downdip from uranium in each set. In each pair of uranium, zinc, and molybdenum zones, the higher concentration of each element occurs downdip relative to the lower concentration of the same element, and the relative proportions in each zone pair are similar for each of the three pairs of geochemical zones. Figure 10 shows a similar anomalous zinc zone approximately 1,200 feet downdip from the uranium occurrence in sandstone horizon C, as well as the expected distribution of selenium, molybdenum, and vanadium. Figure 11 shows the elemental distribution in the shale horizon. Coincident anomalies for the elements uranium, zinc, molybdenum, and vanadium in the shale horizon may be attributed to uphole contamination, to overlap of the sample interval with the overlying sandstone horizon A or underlying sandstone horizon B, or a combination of these factors. Selenium is not present in this horizon in appreciable concentrations.

In addition to recognizing the distributions of Se, V, Mo, and Zn associated with the uranium ore zone, the concentrations of Fe^{+2}, Fe^{+3}, organic carbon and mineral carbon generally have greater concentrations downdip of the uranium ore in this deposit. Harshman (1974, p. 178) found higher concentrations of ferrous iron downdip of uranium roll-type deposits and higher concentrations of ferric iron updip from the ore zone. The high concentrations of ferric iron downdip in this deposit may be due to the total or partial oxidation of the ferrous iron minerals to ferric iron minerals in the samples prior to analysis. The low concentrations of Fe^{+3} updip may be attributed to washing out the limonite and hematite during sample preparation. Organic and mineral carbon have been observed to occur in greater concentrations in the unaltered pristine sandstone than in either the ore zone or the altered oxidized sandstone updip from the mineralized zone (Harshman, 1974, p. 177).

The use of X-ray diffraction and electron microprobe analyses to identify the phase in which zinc occurs were not possible in this study. However, authigenic sphalerite grains have been identified in drill core samples of the Westwater Canyon Member of the Morrison Formation from the Mariano Lake-Lake Valley drilling project a few miles to the northeast (R. I. Grauch, and Paula Hansley, oral commun., 1981).

Distribution of elements by samples types

Table 1 presents the geometric means of the analytical results for elements in each of the sample types. The table also provides information on the total number of samples on which the means are based and on the number of these samples that were reported as N or L values in the analytical results.

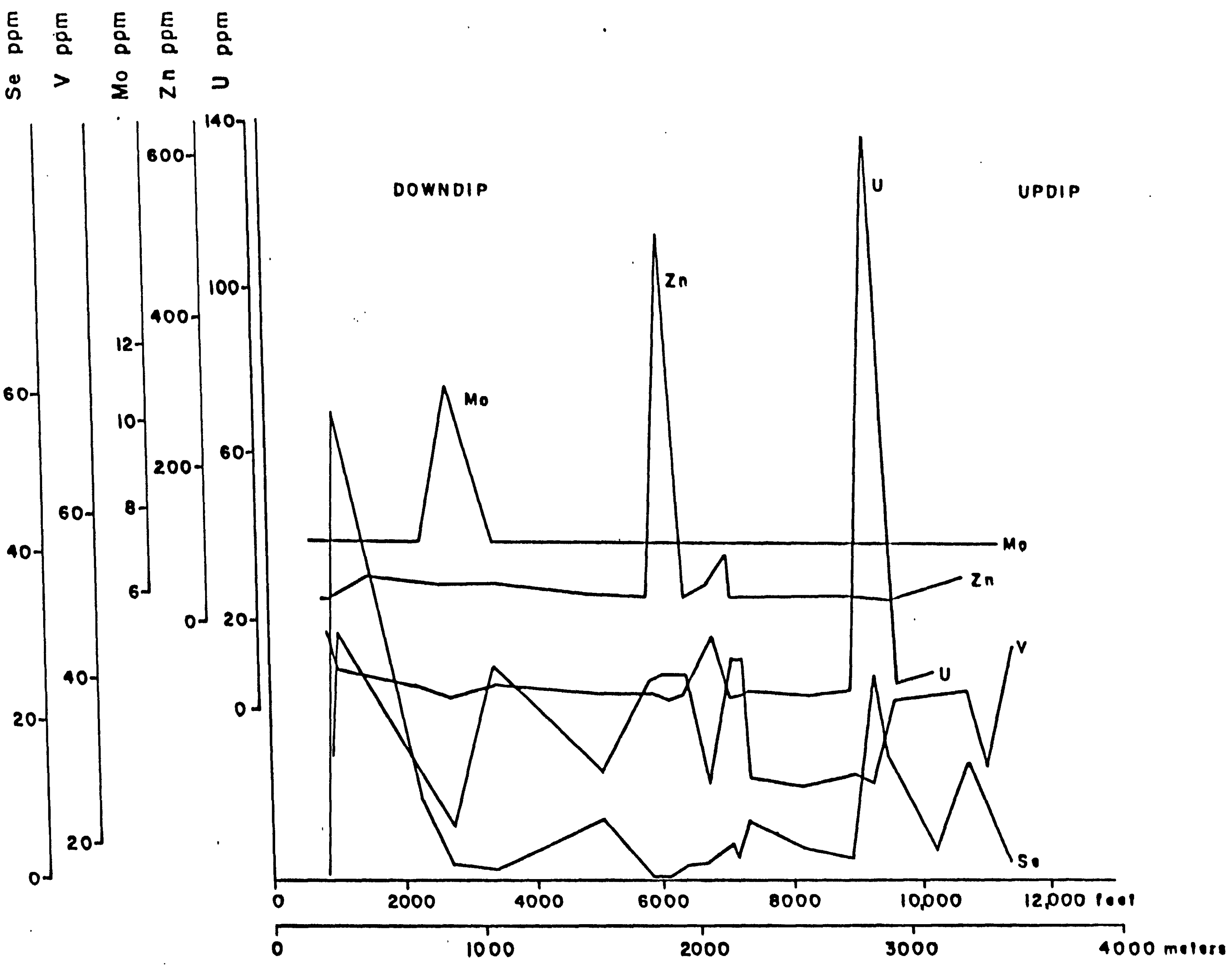

Figure 8.--Distribution and concentration of elements across uranium roll-type roll-type deposit- sandstone horizon A.

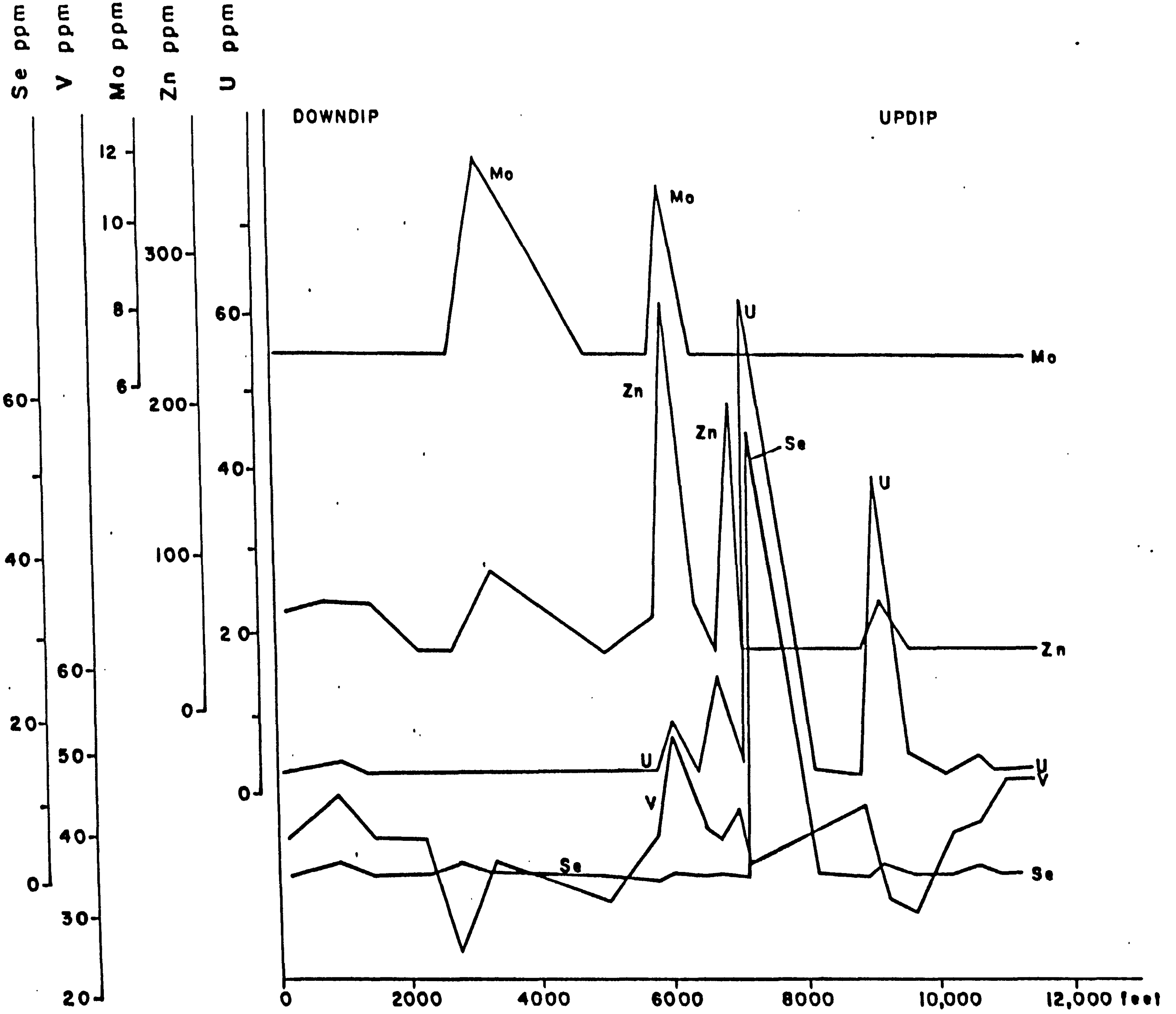

Figure 9.--Distribution and concentration of elements across uranium roll-type deposit- sandstone horizon B.

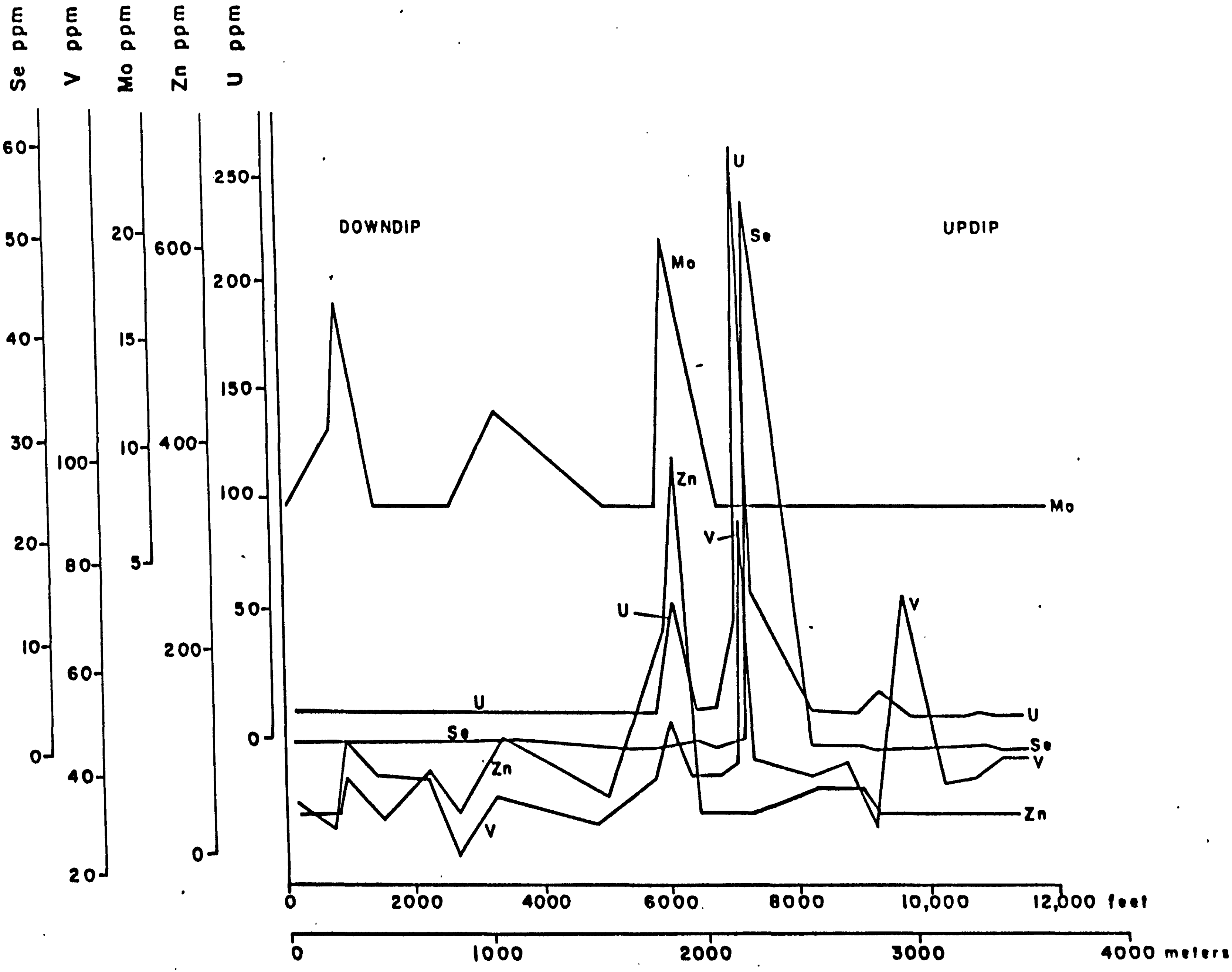

Figure 10.--Distribution and concentration of elements across uranium roll-type deposit- sandstone horizon C.

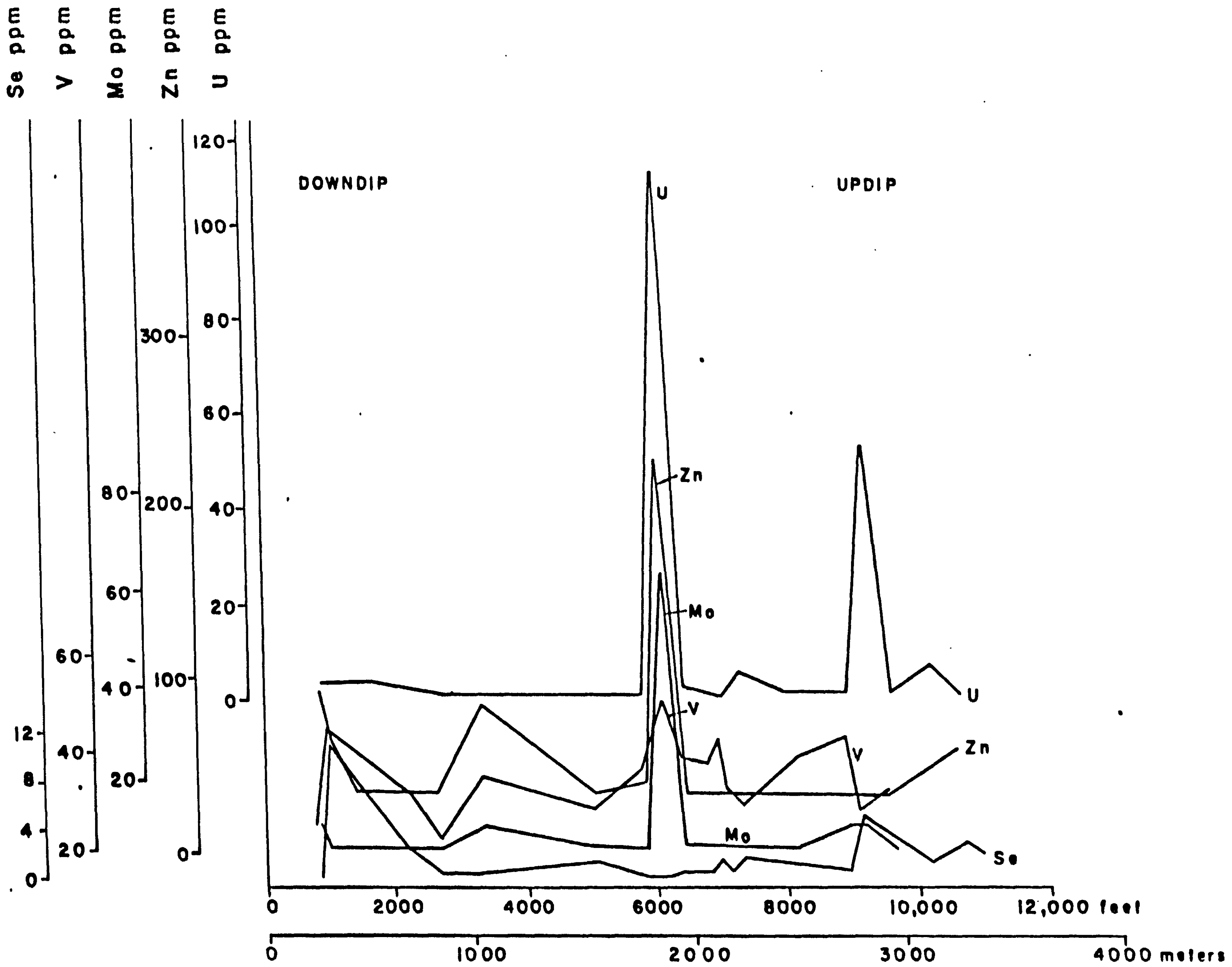

Figure 11.--Distribution and concentration of elements across uranium roll-type deposit- shale horizon.

The most reliable of the means are based on a large number of samples in which few N or L values are included. Some elements contained so many N or L values that the means for these elements in some sample types are unreliable estimates of the abundances of the elements.

In this form, these data may be used to determine the relative abundances of the elements in the 3 sample types. The low concentrations of most elements in the whole washed samples is no doubt a reflection of the dilution of the trace elements by the major abundance of SiO_2, Al_2O_3, NaO, and K_2O from quartz and feldspar in these samples.

Conclusions

In addition to recognition and confirmation of the geochemical halos as discussed by Harshman (1974), this study identified zinc as being concentrated in an anomalous geochemical zone. Zinc occurs in the clay fraction downdip of four uranium zones in three different sandstone horizons and is coincident with the uranium in a shale horizon. The distribution of zinc, in addition to uranium, vanadium, selenium, and molybdenum suggests these elements were present and mobile in the mineralizing solutions.

Zinc anomalies may not have been determinable in previous studies due to the detection limits of the analytical techniques. The relatively low determination limit for zinc (50 ppm) by quantitative emission spectroscopy compared to the lower limit of determination for zinc (300 ppm) by 6-step spectroscopy enables the zinc anomaly to stand out above background.

Comparison of the distribution of elements in this deposit to elemental distributions in uranium roll-type deposits in Texas, Wyoming, and South Dakota (Harshman, 1974) in addition to the distribution of ore in different updip-downdip positions for different stratigraphic units provides evidence suggesting this deposit may be several small distinct roll-type deposits within the mineralized area or a complex roll-type deposit rather than a tabular uranium deposit. The mineralized front does appear to be affected by the many small interbedded shale layers, but whether the deposit should be regarded as one large but complex or several small deposits remains uncertain.

According to our data, As, Bi(?), Sc, and V are most concentrated in the clay fraction. Gallium and titanium have similar abundances in the heavy concentrates and the clay fractions. Ag, Ba, Be, Ca, Co, Cr, Mo(?), Ni, Nb, Pb, Sr, W, Y, Yb, Zn, and Zr are most abundant in the heavy concentrates. The high mean concentration of Ba in the heavy fraction is probably due to the presence of barite, occurring as interstitial barite and as barite in the drilling muds.

Zinc anomalies of this type, detected by analyses of rotary drill chip samples may provide information concerning the location of uranium occurrences. Because zinc can be identified downdip from the uranium occurrences, zinc may prove useful as a uranium exploration tool.

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Table 1.--Summary of analytical results

(*) Geometric means and geometric deviations calculated from these samples are unreliable due to the large number of "N" and "L" values ("N" and "L" total 1/2 total sample number or more).

Ag ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	120	1	114
Geometric Mean	-	3.19	-
Geometric Deviation	-	1.32	-

As ppm
(by wet chemical analysis)

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	109	0	110
Number of "N" Values	11	-	4
Number of "L" Values	0	-	0
Geometric Mean	4.17	-	6.17
Geometric Deviation	1.77	-	1.33

Ba ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	0	0	0
Geometric Mean	2056.	39149	448.
Geometric Deviation	1.33	1.54	1.18

Be ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	1	0	0
Geometric Mean	1.83	3.27	2.80
Geometric Deviation	1.34	1.20	1.08

Table 1.--Continued

Bi ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	120	52	107
Geometric Mean	-	-	(*)
Geometric Deviation	-	-	(*)

Ca %

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	0	0	0
Geometric Mean	1.05	1.87	1.80
Geometric Deviation	1.77	1.51	1.22

Co ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	0	0	0
Geometric Mean	5.85	81.75	16.30
Geometric Deviation	1.63	1.76	1.22

Cr ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	0	0	0
Geometric Mean	15.6	108.4	55.3
Geometric Deviation	1.44	2.17	1.19

Ga ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	108	0	0
Geometric Mean	(*)	19.48	20.22
Geometric Deviation	(*)	1.20	1.15

Table 1.--Continued

Mo ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	117	12	98
Geometric Mean	(*)	7.72	(*)
Geometric Deviation	(*)	1.99	(*)

Ni ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	0	0	0
Geometric Mean	9.44	98.85	25.03
Geometric Deviation	1.50	1.54	1.22

Nb ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	105	13	26
Geometric Mean	(*)	50.80	31.32
Geometric Deviation	(*)	1.37	1.41

Pb ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	94	0	51
Geometric Mean	(*)	670.3	(*)
Geometric Deviation	(*)	4.74	(*)

Sc ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	119	9	0
Geometric Mean	(*)	5.55	21.88
Geometric Deviation	(*)	2.52	1.13

Table 1.--Continued

Sr ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	0	0	0
Geometric Mean	117.2	1422.	303.
Geometric Deviation	1.28	1.68	1.25

Ti %

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	0	0	0
Geometric Mean	0.087	0.362	0.368
Geometric Deviation	1.52	1.76	1.09

V ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	22	0	0
Geometric Mean	24.48	37.95	135.2
Geometric Deviation	2.10	1.30	1.31

W ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	120	9	114
Geometric Mean	-	537.6	-
Geometric Deviation	-	5.02	-

W ppm
(by wet chemical analysis)

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	0	0	114
Number of "N" Values	-	-	17
Number of "L" Values	-	-	69
Geometric Mean	-	-	(*)
Geometric Deviation	-	-	(*)

Table 1.--Continued

Y ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	1	0	0
Geometric Mean	16.60	107.5	39.62
Geometric Deviation	1.28	1.63	1.15

Yb ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	120	12	0
Geometric Mean	-	14.98	3.10
Geometric Deviation	-	1.49	1.30

Zn ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	0
Number of "L" Values	118	9	68
Geometric Mean	(*)	236.7	(*)
Geometric Deviation	(*)	5.45	(*)

Zn ppm
(by wet chemical analysis)

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	0	0	114
Number of "N" Values	-	-	17
Number of "L" Values	-	-	0
Geometric Mean	-	-	97.42
Geometric Deviation	-	-	1.49

Zr ppm

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	52	114
Number of "N" Values	0	0	1
Number of "L" Values	0	0	0
Geometric Mean	114.07	2170	273.4
Geometric Deviation	1.48	1.98	1.08

Table 1.--Continued

S %
(by wet chemical analysis)

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	0	0	114
Number of "N" Values	-	-	2
Number of "L" Values	-	-	0
Geometric Mean	-	-	0.58
Geometric Deviation	-	-	1.31

Se ppm
(by X-ray fluorescence)

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	0	0
Number of "N" Values	1	-	-
Number of "L" Values	19	-	-
Geometric Mean	0.75	-	-
Geometric Deviation	4.29	-	-

Th ppm
(by neutron activation)

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	0	0
Number of "N" Values	57	-	-
Number of "L" Values	0	-	-
Geometric Mean	5.43	-	-
Geometric Deviation	1.31	-	-

U ppm
(by neutron activiation)

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	0	0
Number of "N" Values	0	0	0
Number of "L" Values	0	-	-
Geometric Mean	4.65	-	-
Geometric Deviation	2.90	-	-

Table 1.--Continued

Hg ppm
(by wet chemical analysis)

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	0	0
Number of "N" Values	3	-	-
Number of "L" Values	0	-	-
Geometric Mean	0.083	-	-
Geometric Deviation	1.49	-	-

Total C %
(by wet chemical analysis)

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	0	0
Number of "N" Values	0	-	-
Number of "L" Values	0	-	-
Geometric Mean	0.41	-	-
Geometric Deviation	1.99	-	-

Organic C %
(by wet chemical analysis

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	0	0
Number of "N" Values	0	-	-
Number of "L" Values	0	-	-
Geometric Mean	1.99	-	-
Geometric Deviation	2.05	-	-

Mineral C %
(by difference)

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	0	0
Number of "N" Values	0	-	-
Number of "L" Values	7	-	-
Geometric Mean	0.18	-	-
Geometric Deviation	2.86	-	-

Table 1.--Continued

Total Fe as Fe_2O_3 %
(by wet chemical analysis)

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	0	0
Number of "N" Values	0	-	-
Number of "L" Values	0	-	-
Geometric Mean	1.37	-	-
Geometric Deviation	1.69	-	-

FeO %
(by wet chemical analysis)

SAMPLE TYPE	Whole	Heavy	Clay
Total Number of Analyses	120	0	0
Number of "N" Values	1	-	-
Number of "L" Values	0	-	-
Geometric Mean	0.68	-	-
Geometric Deviation	1.86	-	-