UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

POSSIBLE URANIUM MINERALIZATION, BEAVER BASIN, UTAH

By

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Open-File Report 80-508

1980

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Abstract

A geochemical survey was made of ground water in the Beaver basin of west-central Utah. Wells accessible for sampling were largely limited to the southern part of the basin, and the results discussed in this report largely apply to this area. The results of raw data plots, principal-component analysis, and solution-mineral equilibria study demonstrate that the chemical environment of the Beaver basin is favorable for the occurrence of sandstone-type uranium deposits. Several areas have been identified as possible targets for exploration. The methods described in this study can be utilized to evaluate waters from wells and exploration drill holes as indicators of possible sandstone-type uranium deposits, not only in the Beaver basin, but in other alluvial basins in the western United States.

Introduction

The Beaver basin is a block-faulted depression along the eastern margin of the Basin and Range province in west-central Utah (fig. 1). The basin contains Quaternary and Tertiary lacustrine and fluviatile sediments probably a kilometer or more thick. A geochemical survey of ground water during the summer of 1979, indicated that sandstone-type uranium deposits may well exist within the sedimentary fill of Beaver basin. The basin is bounded on the east by the Tushar Mountains, which contain uranium-bearing volcanic rocks (Cunningham and Steven, 1979), and on the west by the Mineral Mountains, which contain uranium-bearing springs (Miller, McHugh, and Ficklin, 1979); both areas could have served as sources for any uranium deposited within the fill (Cunningham and Steven, 1979). The flow of most ground water and surface water within the basin is generally toward the southwest. A hydrologic outlet from the Beaver Basin of ground water is in the southwestern corner just east of Minersville Canyon (Reimer, 1979). Ground water flow along the southern margin of the basin is probably northward.

Acknowledgments

Mr. Gareth Spencer of the Soil Conservation Service in Beaver, Utah was helpful in locating wells in the Beaver basin. D. J. Preston drafted the figures. Discussions with T. A. Steven on the general geology of the area were extremely helpful.

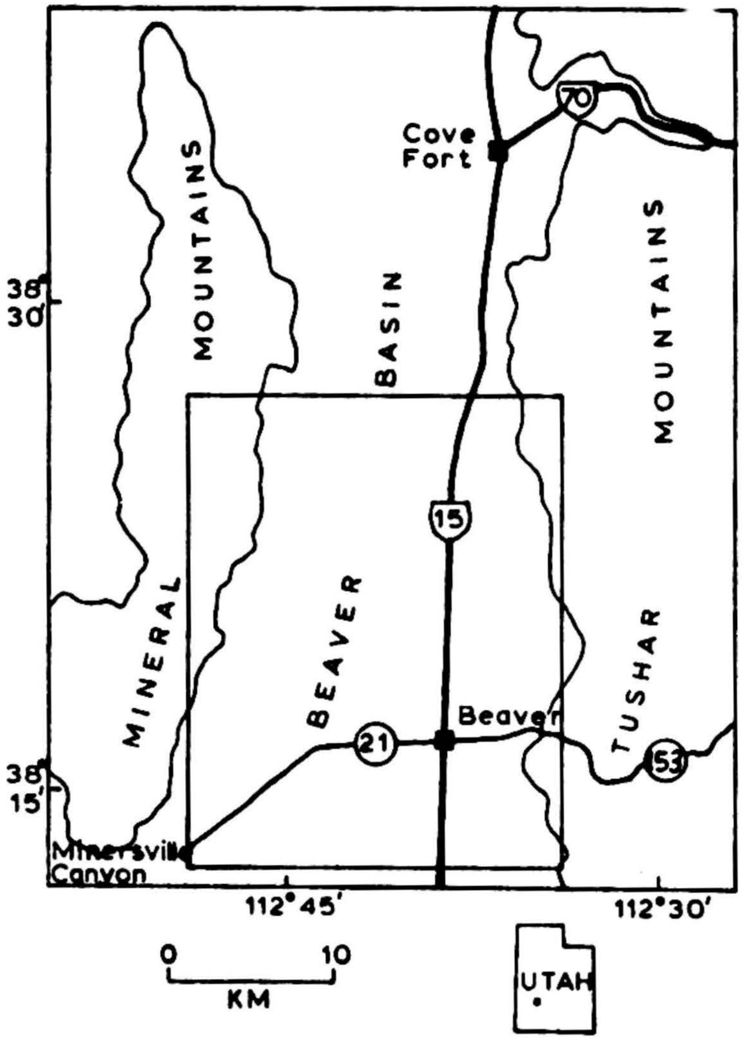

Figure 1.--Location map of Beaver basin, Utah; study area is outlined.

Collection and analytical procedures

Water samples were collected from 50 sites within the Beaver basin. Most of the sites were concentrated around the town of Beaver where irrigation wells are most abundant. Samples were collected using acid-rinsed polyethylene bottles. At each site, a 60-ml and a 30-ml sample were collected and filtered through a 0.45-µm and a 0.10 µm membrane filter respectively and acidified with reagent-grade concentrated nitric acid to pH <2. An untreated 500-ml sample was also collected. Temperature and pH were measured at each sample site. Alkalinity, specific conductance, sulfate, chloride, fluoride, and nitrate were determined using the untreated sample. Calcium, magnesium, sodium, potassium, silica, zinc, copper, molybdenum, arsenic, uranium, vanadium, selenium, and lithium were determined using the 0.45-µm filtered and acidified sample and iron, manganese, and aluminum were determined using the 0.10 µm filtered and acidified sample. The analytical techniques used for the analysis of each specie are shown in table 1. The results of the charge balance for 47 of the samples are within 5 percent, the remaining three are within 10 percent.

Table 1.--Analytical methods used for water analyses, Beaver basin, Utah

Constituent	Method	Reference
Alkalinity	Gran's plot potentiometric titration with sulfuric acid	Orion Research, Inc. (1975).
Sulfate	Ion chromatography	Dionex Corp. (1978).
Chloride	---do---	Do.
Fluoride	---do---	Do.
Nitrate	---do---	Do.
Sodium	Flame atomic absorption spectrophotometry	Perkin-Elmer Corp. (1976).
Magnesium	---do---	Do.
Potassium	---do---	Do.
Calcium	---do---	Do.
Lithium	---do---	Do.
Silica	---do---	Do.
Copper	Flameless atomic absorption spectrophotometry	Miller and Ficklin (1976).
Zinc	---do---	Do.
Molybdenum	---do---	Do.
Arsenic	---do---	Aruscavage (1977).
Vanadium	---do---	Perkin-Elmer Corp. (1977).
Selenium	---do---	Do.
Iron	---do---	Do.
Manganese	---do---	Do.
Aluminum	---do---	Do.
Uranium	Fluorometric	Ward and Bondar (1977).
Specific conductance	Conductivity bridge	Brown, Skougstad, and Fishman (1970) p. 28-29.

Geochemistry of the waters

The geochemistry of natural waters is useful both for geochemical exploration and for an understanding of the geological and geochemical processes active in an area. Background information and limitations on the use of hydrogeochemical prospecting can be found in Boyle and others (1971), Cameron (1978), and Miller (1979).

Water samples were collected from 38 wells, 7 springs, and 5 streams. A summary of the chemical analyses is shown in table 2. The geochemical survey is not representative of the entire Beaver basin, but only areas where samples were collected.

The Beaver basin contains mostly calcium-bicarbonate waters (34 samples), although 6 samples of sodium-bicarbonate and 10 samples of sodium-calcium-bicarbonate waters were also present. The water with the highest concentrations of dissolved salts as measured by specific conductance (fig. 2), was south of Beaver (BV37). BV10 (north of Beaver) and BV13 (west of Beaver) also showed high specific conductances. The distribution of specific conductance values shown in figure 2, indicates that there is no central area of high concentration of dissolved salts in water within the basin.

Table 2.--Summary of chemical analyses of 50 water samples, Beaver basin, Utah

Variable	Minimum	Maximum	Mean	Geometric mean	Standard deviation	Geometric deviation
Ca (mg/l)	9.6	120.	43.8	38.1	22.2	1.75
Mg (mg/l)	1.7	22.	8.88	7.70	4.58	1.76
Na (mg/l)	4.5	115.	25.6	19.2	22.5	2.14
K (mg/l)	1.0	12.	3.81	3.08	2.66	1.92
Li (mg/l)	<0.002	0.042	0.011	0.008	0.008	2.48
SiO_2 (mg/l)	19.	77.	39.8	36.6	16.9	1.52
Alkalinity (mg/l)	27.	360.	172.	151.	83.9	1.74
SO_4 (mg/l)	4.7	86.	27.2	22.2	18.6	1.92
Cl (mg/l)	1.9	111.	24.5	17.1	20.8	2.53
F (mg/l)	.12	1.9	.710	0.583	0.439	1.92
NO_3 (mg/l)	<0.1	49.	5.49	0.894	9.36	10.8
Fe (μg/l)	2.8	850.	72.0	25.6	160.	3.75
Mn (μg/l)	0.40	390.	31.1	4.66	80.7	6.08
Al (μg/l)	9.0	1600.	137.	68.3	267.	2.83
Zn (μg/l)	1.8	1000.	55.3	11.5	158.	4.46
Cu (μg/l)	0.70	63.	5.87	3.44	9.90	2.50
Mo (μg/l)	0.50	89.	4.25	1.88	12.6	2.61
As (μg/l)	1.0	22.	5.02	3.48	4.96	2.28
U (μg/l)	<0.2	740.	23.6	4.37	104.	5.73
Se (mg/l)	0.40	5.6	1.84	1.52	1.11	1.94
V (mg/l)	<5.0	36.	6.34	4.44	6.29	2.27
Sp. Cond. (μmhos/cm)	92.	900.	396.	354.	182.	1.65
pH	6.84	9.00	7.62	--	0.471	--

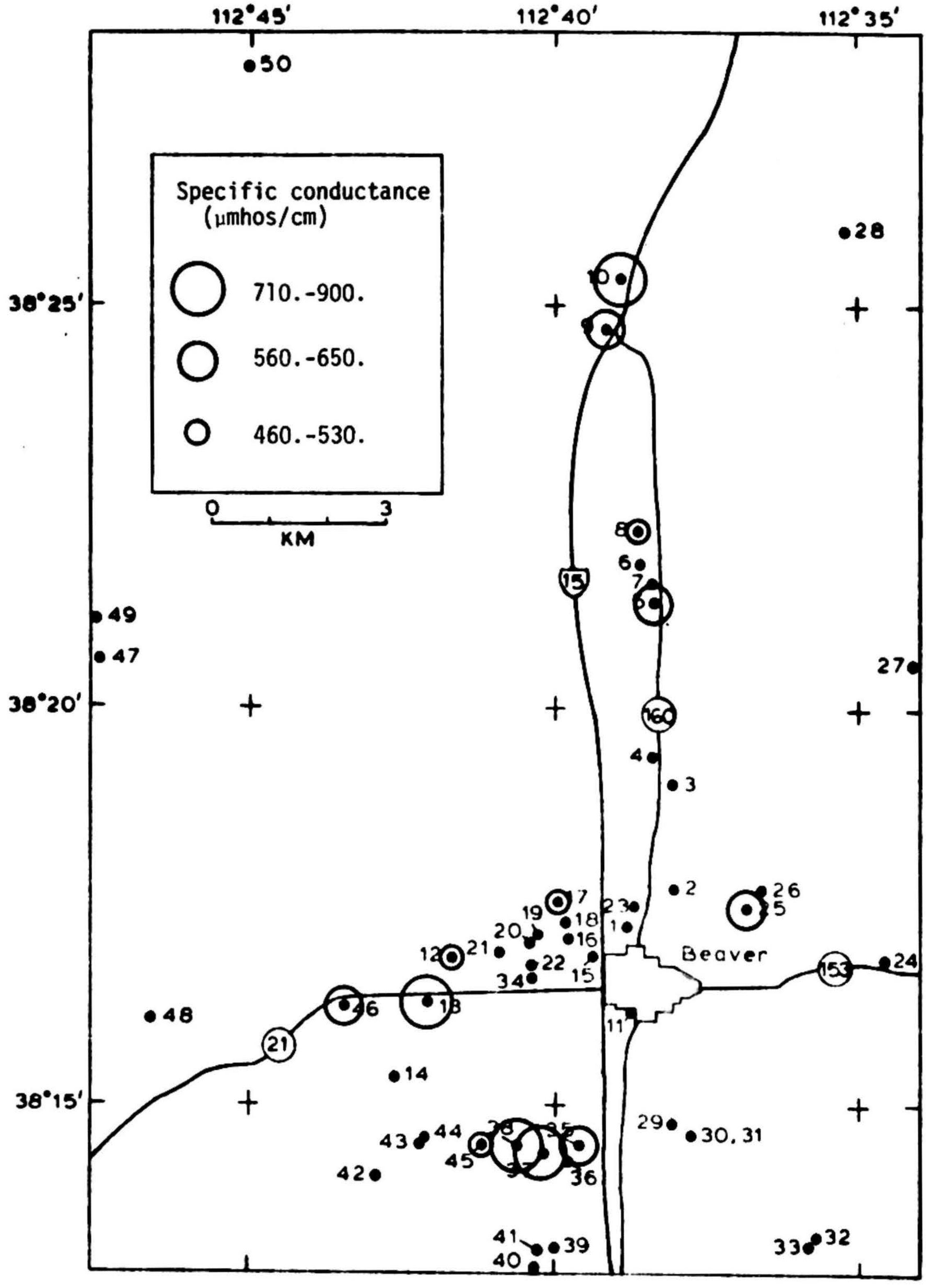

Figure 2.--Distribution of specific conductance for 50 water samples, Beaver basin, Utah. Sample numbers (prefixed BV in text) are shown for each site.

The distribution of uranium concentrations in water is shown on figure 3. The highest concentration, 740 μg/l, occurs at Mud Spring (BV 47) along the eastern flank of the Mineral Mountains and is discussed in Miller and others (1979). Additional high values occur at BV5, a well south of Manderfield with 52. μg/l; BV25, a well northeast of Beaver, with 39. μg/l; and BV17 and BV21, two wells northwest of Beaver, with 35. and 30. μg/l uranium. For sandstone-type uranium deposits, the highest concentrations of uranium in water do not necessarily correspond to the most favorable areas for the occurrence of uranium deposits, mainly because the mobility of uranium is diminished under reducing conditions that commonly are associated with such deposits.

Other elements such as Mo, As, Se, and V are sometimes used as pathfinders for sandstone-type uranium deposits. The distributions of these elements for the Beaver basin are shown in figures 4-7. The highest concentrations of molybdenum (fig. 4) are at BV47, 12, 14, 46, and 13 with 89., 16., 10., 10., and 8. μg/l respectively. All of these sites, except BV47 (Mud Spring), are about 3 km west of Beaver. The highest concentrations of arsenic (fig. 5) are west and southwest of Beaver at BV37, 13, 12, and 42 with 22., 17., 17., and 16. μg/l respectively. The highest concentrations of selenium (fig. 6) are located throughout the Beaver basin at BV10, 13, 25, and 37 with 5.6, 3.6, 3.6, and 3.5 μg/l respectively. The highest concentrations of vanadium (fig. 7) are southwest of Beaver at BV37, 45, 38, and 39 with 36., 18., 16., and 16. μg/l respectively. Correlation coefficients of the logarithm (base 10) of concentrations of ions are shown in table 3. Many pairs of significant correlations can be seen in table 3. In order to study interrelationships among species, principal-component analysis was used.

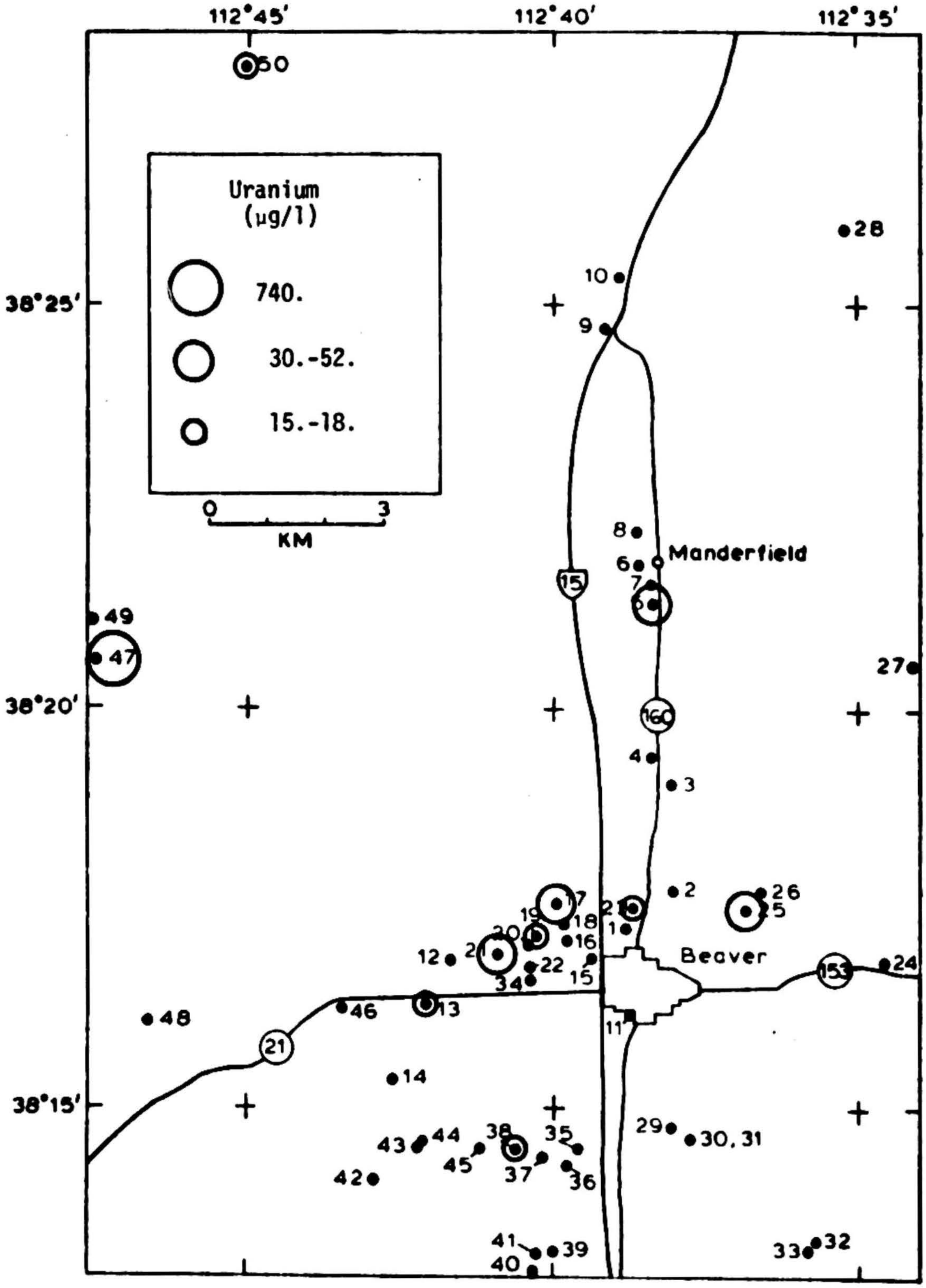

Figure 3.--Distribution for uranium for 50 water samples, Beaver basin, Utah. Sample numbers (prefixed BV in text) are shown for each site.

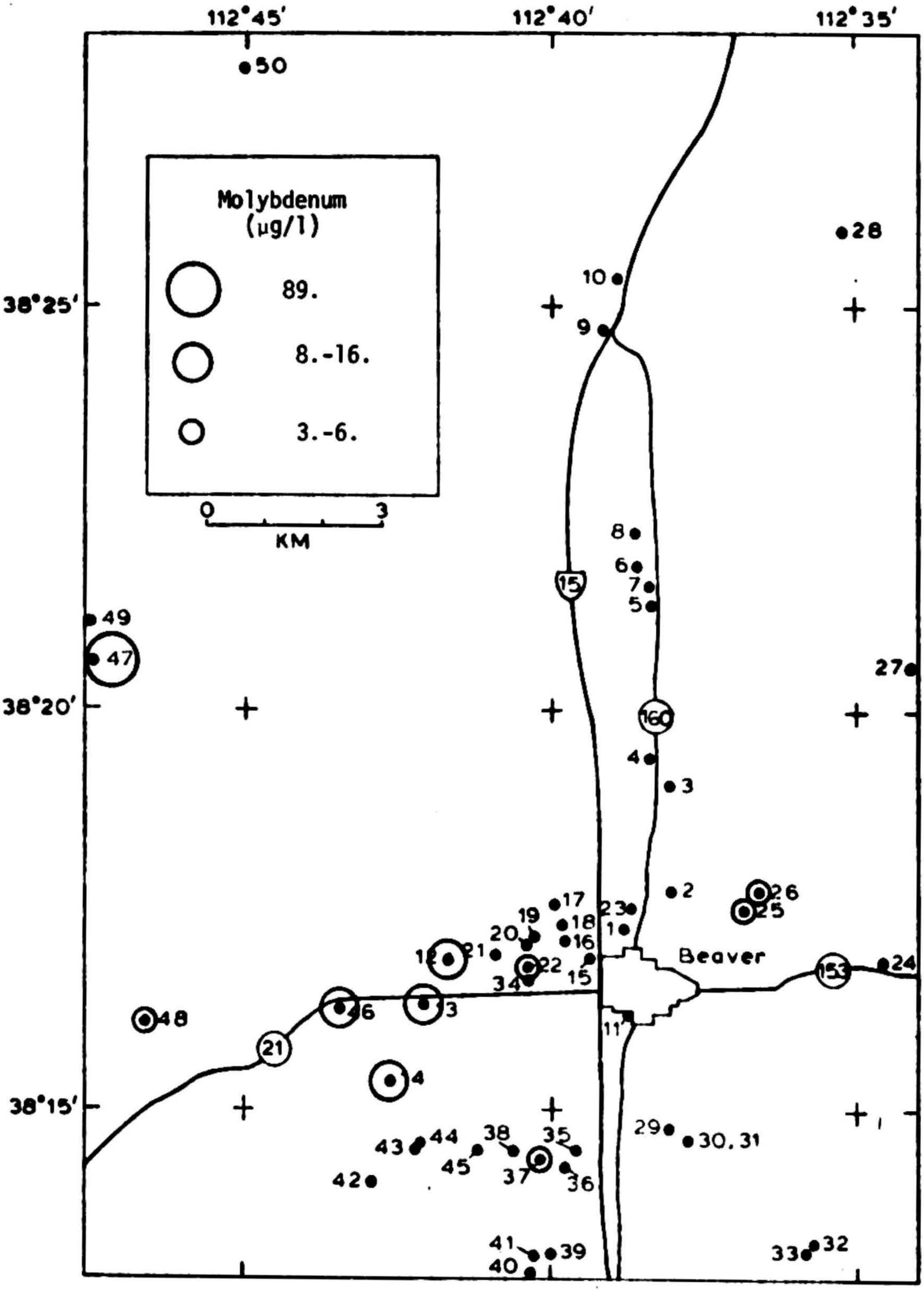

Figure 4.--Distribution of molybdenum for 50 water samples, Beaver basin, Utah. Sample numbers (prefixed BV in text) are shown for each site.

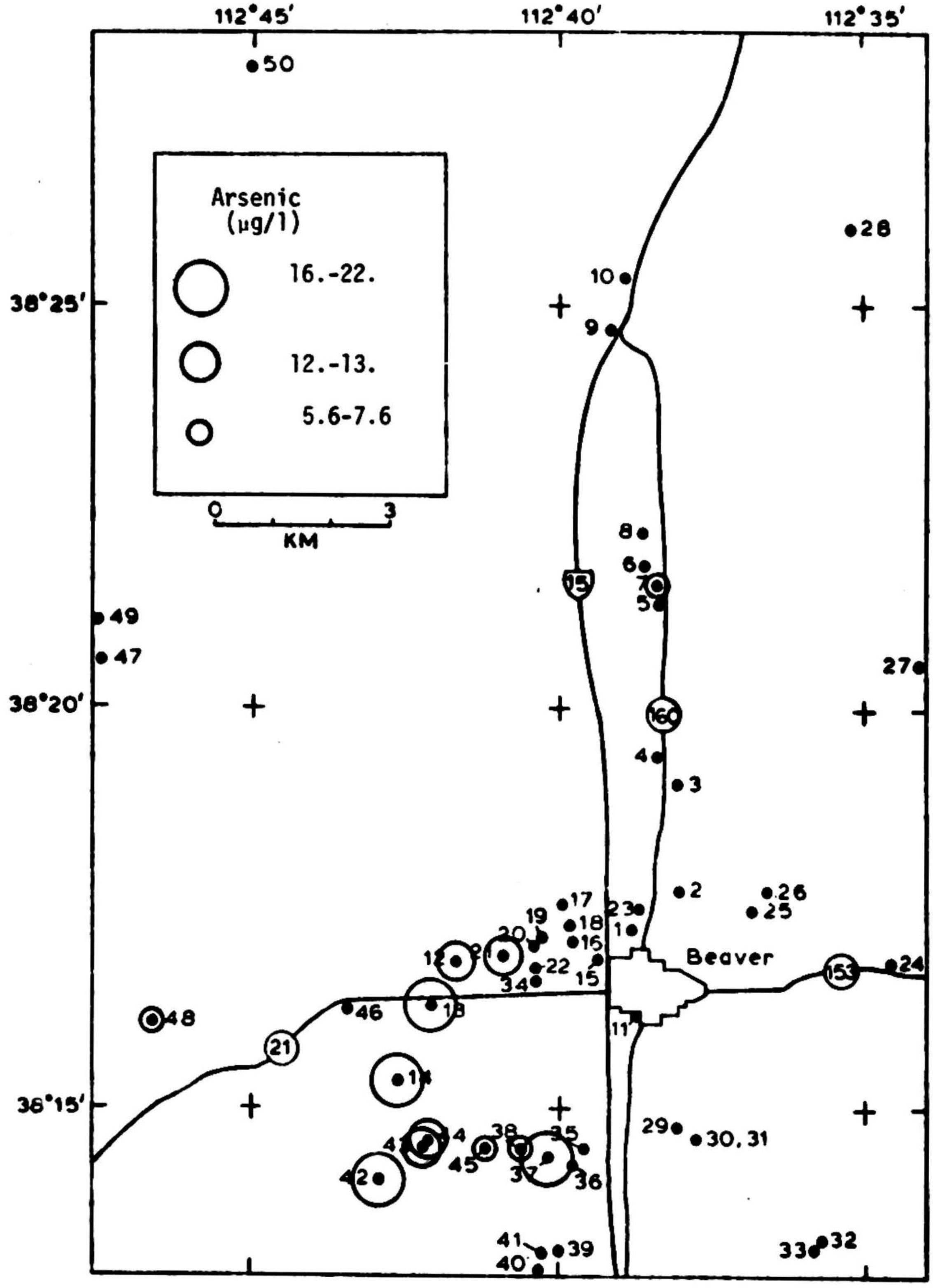

Figure 5.--Distribution of arsenic for 50 water samples, Beaver basin, Utah. Sample numbers (prefixed BV in text) are shown for each site.

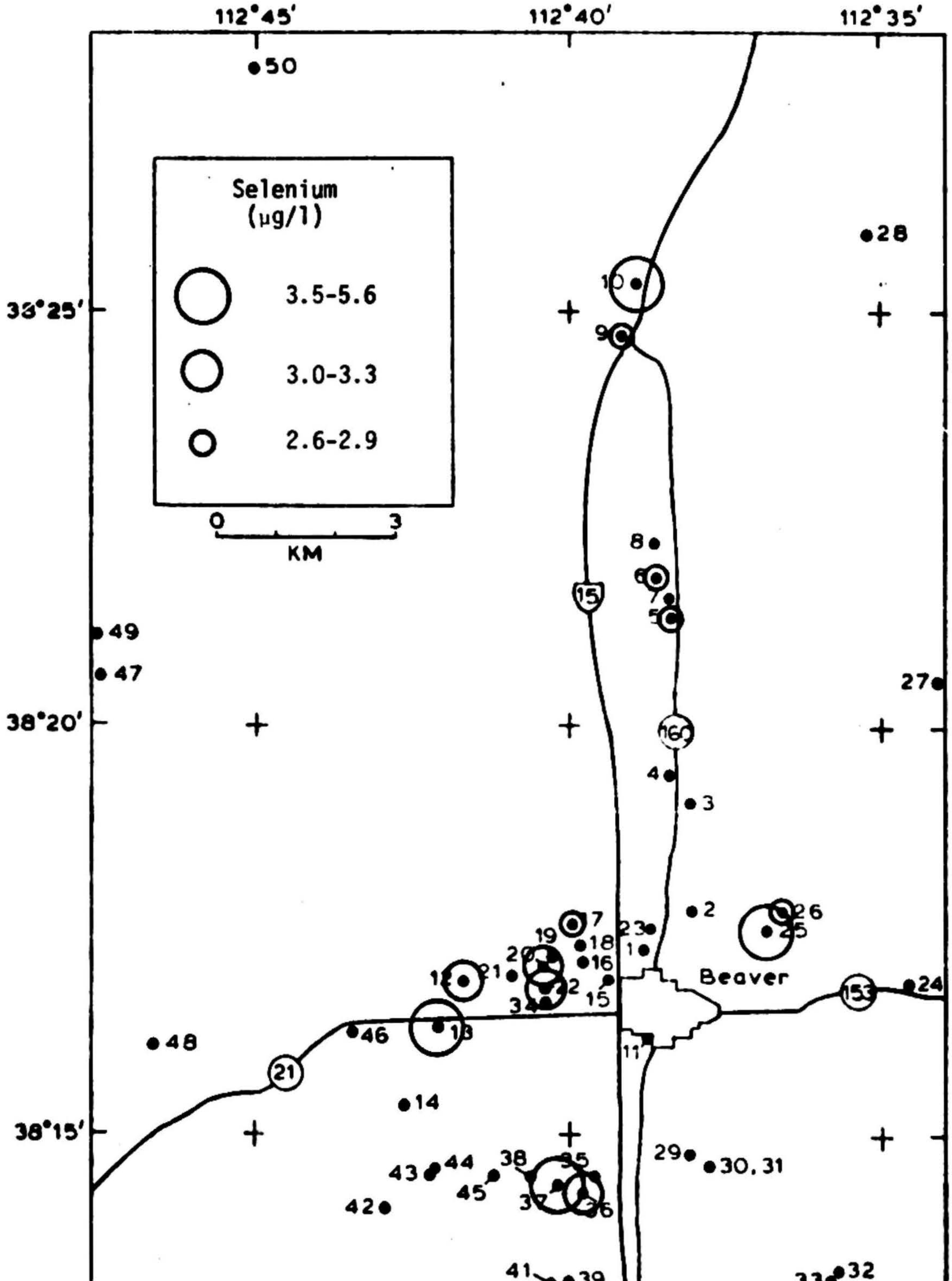

Figure 6.--Distribution of selenium for 50 water samples, Beaver basin, Utah. Sample numbers (prefixed BV in text) are shown for each site.

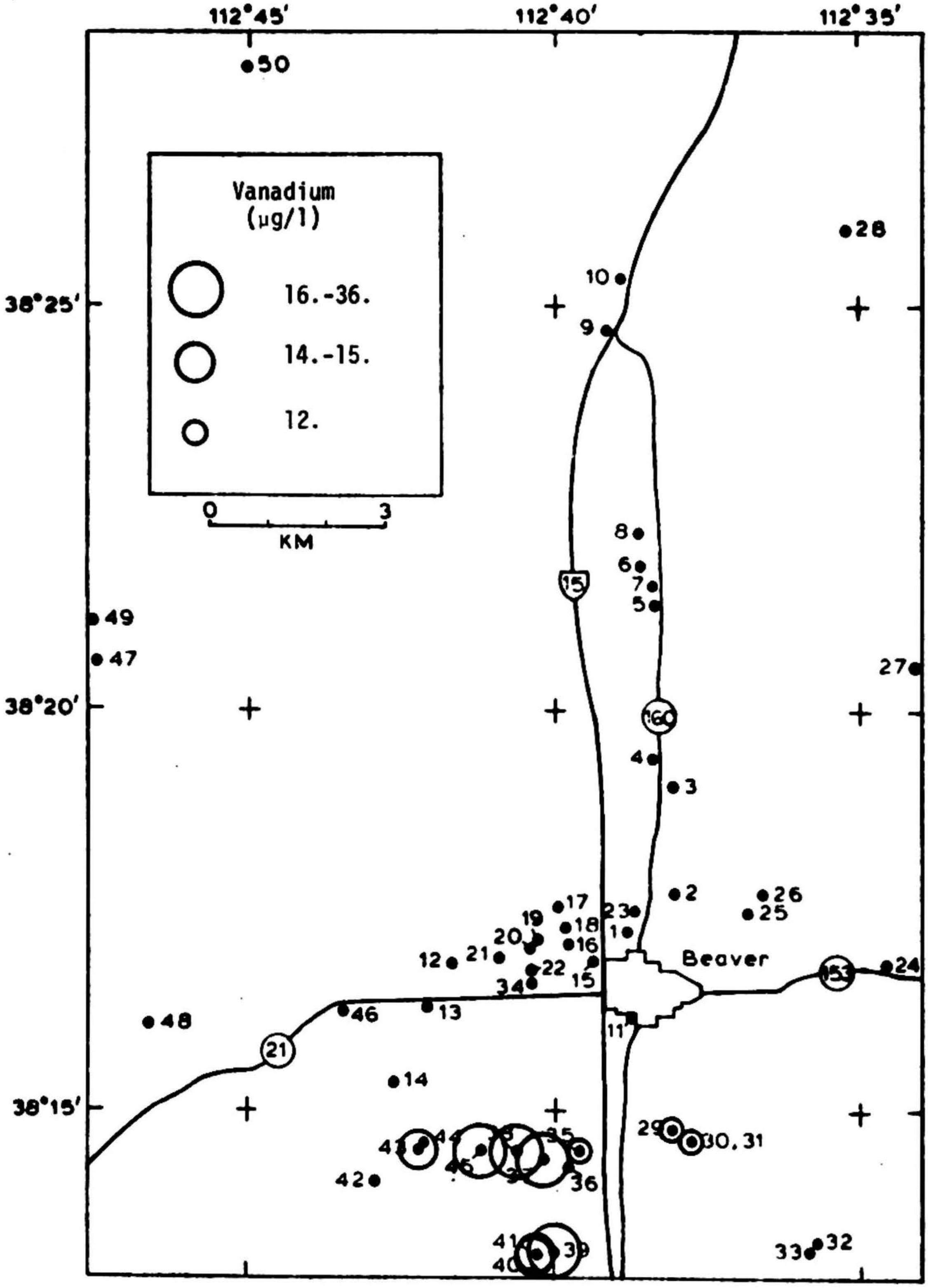

Figure 7.--Distribution of vanadium for 50 water samples, Beaver basin, Utah. Sample numbers (prefixed BV in text) are shown for each site.

Table 3.--Matrix of correlation coefficients of the log-transformed original data (number of valid pairs are shown below diagonal)

	F	Cl	SO_4	NO_3	Alk.	Zn	Cu	Mo	Mn	Fe	As	U	Al	Na	K	Ca	Mg	Li	SiO_2	Sp. Cond.	pH	Temp.	Se	V
F	1.0	.49	.60	.25	.42	.05	.37	.72	.25	.21	.16	.50	.19	.38	.09	.52	.38	.48	-.26	.53	-.21	-.20	.57	-.26
Cl	50	1.0	.64	.42	.73	.16	.50	.35	-.37	-.25	.28	.62	-.07	.66	.19	.77	.75	.70	.04	.86	-.15	-.16	.72	.19
SO_4	50	50	1.0	.32	.57	.06	.38	.53	-.12	-.17	.45	.37	.07	.71	.41	.56	.51	.59	.14	.74	.08	-.14	.65	.05
NO_3	33	33	33	1.0	.63	.43	.47	.08	-.19	.06	-.02	.44	.06	.34	.13	.62	.65	.16	-.07	.60	-.22	-.15	.61	.12
Alk.	50	50	50	33	1.0	.20	.49	.35	-.32	-.11	.34	.63	.01	.70	.38	.86	.85	.54	.16	.94	-.19	-.17	.73	.22
Zn	50	50	50	33	50	1.0	.52	-.06	-.01	.40	-.28	.26	.19	-.14	-.34	.38	.37	-.25	-.35	.22	-.37	.09	.38	-.14
Cu	50	50	50	33	50	50	1.0	.18	-.17	.16	-.24	.47	.19	.06	-.23	.76	.69	.16	-.38	.58	-.37	-.08	.75	-.28
Mo	50	50	50	33	50	50	50	1.0	.24	.14	.27	.37	-.10	.42	.15	.35	.22	.43	-.16	.42	-.04	-.09	.41	-.14
Mn	50	50	50	33	50	50	50	50	1.0	.63	-.11	-.34	.26	-.28	-.03	-.22	-.28	-.23	-.23	-.27	-.20	-.07	-.11	-.34
Fe	50	50	50	33	50	50	50	50	50	1.0	-.31	-.00	.57	-.28	-.31	-.01	-.07	-.25	-.45	-.13	-.38	.07	.07	.41
As	50	50	50	33	50	50	50	50	50	50	1.0	-.10	-.06	.68	.79	.04	.05	.64	.75	.35	.46	.01	.02	.47
U	46	46	46	31	46	46	46	46	46	46	46	1.0	.00	.33	-.24	.70	.58	.39	-.36	.62	-.44	-.16	.60	-.04
Al	50	50	50	33	50	50	50	50	50	50	50	46	1.0	-.10	.01	.05	.03	.01	-.04	.01	-.13	-.09	.09	-.15
Na	50	50	50	33	50	50	50	50	50	50	50	46	50	1.0	.68	.42	.41	.72	.46	.75	.25	-.13	.38	.37
K	50	50	50	33	50	50	50	50	50	50	50	46	50	50	1.0	.01	.11	.46	.84	.36	.42	.05	-.04	.55
Ca	50	50	50	33	50	50	50	50	50	50	50	46	50	50	50	1.0	.93	.46	-.17	.90	-.45	-.23	.92	-.03
Mg	50	50	50	33	50	50	50	50	50	50	50	46	50	50	50	50	1.0	.35	-.05	.87	-.41	-.26	.84	.15
Li	46	46	46	31	46	46	46	46	46	46	46	44	46	46	46	46	46	1.0	.36	.64	.15	-.05	.39	.23
SiO_2	50	50	50	33	50	50	50	50	50	50	50	46	50	50	50	50	50	46	1.0	.11	.42	.08	-.29	.74
Sp. Cond.	50	50	50	33	50	50	50	50	50	50	50	46	50	50	50	50	50	46	50	1.0	-.19	-.19	.83	.16
pH	50	50	50	33	50	50	50	50	50	50	50	46	50	50	50	50	50	46	50	50	1.0	.26	-.39	.15
Temp.	50	50	50	33	50	50	50	50	50	50	50	46	50	50	50	50	50	46	50	50	50	1.0	-.26	.05
Se	50	50	50	33	50	50	50	50	50	50	50	46	50	50	50	50	50	46	50	50	50	50	1.0	-.19
V	28	28	28	22	28	28	28	28	28	28	28	26	28	28	28	28	28	26	28	28	28	28	28	1.0

Principal-component analysis applied to the water data

The results of the hydrogeochemical survey consist of a set of multispecie data. To utilize this type of data better, principal-component analysis (PCA), a multivariate statistical technique, was applied to gain a better understanding of interrelations within the data. PCA is a mathematical technique that attempts to explain variations in a set of data by redistributing these variations among a number of principal components. Background information on the use of PCA applied to geological studies can be found in Davis (1973).

The technique calculates a group of end-member compositions or principal components that approximately describe the variations within the multispecie data. Each end-member composition or principal component represents a chemical control that affects water chemistry. The first principal component explains the most variation. The second principal component explains the most variation of the remaining variation, and so on. Most samples then contain different proportions of end-member compositions or principal components. Individual samples can then be described in terms of components of these end-member compositions. PCA demonstrates these principal components but does not interpret them. The interpretation of these components and the geological significance of the resulting patterns or plots are subjective and depend upon the user's knowledge of the local geological and geochemical environments.

PCA, as applied to water data from the Beaver basin, was carried out using a program written by A. T. Miesch, following procedures from Runnel (1970). The principal components (PC) interpreted as representing controls on the water chemistry are: (PC1) the effects of concentration of the dissolved salts; (PC2) the effects of hot springs; (PC3) the effects of sandstone-type uranium deposits; and (PC4) other effects. The only component that will be discussed here is principal component 3, which accounts for 10 percent of the total variation and is represented by significant loadings for manganese, molybdenum, and fluoride and less significant loadings for iron and aluminum (table 4). The loadings (table 4) are calculated mathematical values (Davis, 1973, p. 478-500) representing the most significant elements or variables that compose a principal component. The occurrence of manganese and iron as significant loadings is not unusual because species of both elements are soluble in a reducing environment that is favorable for the occurrence of sandstone-type uranium deposits. The occurrence of molybdenum as a significant loading is also not unusual because molybdenum is used as a geochemical pathfinder for sandstone-type uranium deposits. Uranium is absent from the loadings of principal component 3 (table 4) because uranium is relatively insoluble in a reducing environment.

Table 4.--Principal component-3 loadings, Beaver basin, Utah

Specie	Loading (Davis, 1973, p. 478-500)
F	0.61
Cl	-0.10
SO_4	0.29
NO_3	-0.27
Alkalinity	-0.13
Zn	-0.24
Cu	-0.15
Mo	0.63
Mn	0.72
Fe	0.49
As	0.26
U	-0.13
Al	0.35
Na	0.14
K	0.19
Ca	-0.14
Mg	-0.28
Li	0.24
SiO_2	-0.11
Sp. Cond.	-0.03
pH	0.09
Temp.	-.07
Se	0.01
V	-.37

The significant loadings are underlined with a solid line.

The distribution of scores (table 5) for principal component 3 is shown in figure 8. Scores can be thought of as representing the sites at which the waters are most affected by the chemical control represented by principal component 3. The highest principal-component scores occur at BV14, 12, and 13 with scores of 2.48, 2.40, and 2.02 respectively, and are shown as the cross-hatched area on figure 8. The distribution of elements which occur as significant loading for principal component 3 are shown for molybdenum, manganese and fluorite on figures 4, 9, and 10 respectively. The highest concentrations of manganese (listed in order of importance) occur at BV49, 24, 12, 27, and 18, with 390., 360., 190., 150., and 140. µg/l respectively. BV12 and 18 are the only sites within the cross-hatched area (fig. 8) but several less significant anomalies occur within this area. The highest concentrations of molybdenum (listed in order of importance) occur at BV47, 12, 14, 46, and 13, with 89., 16., 10., 10., and 8. µg/l respectively. All these sites occur within the cross-hatched area in figure 8. The highest concentrations of fluoride (listed in order of importance) occur at BV47, 12, 46, 13, and 6 with 1.9, 1.7, 1.6, 1.5, and 1.5 mg/l respectively. BV12, 13, and 46 occur within the cross-hatched area (fig. 8). If the interpretation that principal component 3 represents sandstone-type uranium mineralization is correct, the cross-hatched (fig. 8) area represents the most favorable area for exploration.

Table 5.--Principal component-3 scores, Beaver basin, Utah

Site number	Principal component 3	Site number	Principal component 3
BV01	-0.74	BV26	-0.55
BV02	0.20	BV27	1.20
BV03	-0.48	BV28	0.88
BV04	-0.66	BV29	-1.17
BV05	-0.56	BV30	-0.87
BV06	0.72	BV31	-1.36
BV07	-0.86	BV32	-0.99
BV08	-0.63	BV33	-0.13
BV09	-0.67	BV34	-0.03
BV10	-0.88	BV35	-1.15
BV11	-0.06	BV36	-1.27
BV12	2.40	BV37	-0.52
BV13	2.02	BV38	-1.32
BV14	2.48	BV39	-0.91
BV15	0.15	BV40	-0.79
BV16	0.86	BV41	-1.19
BV17	-0.20	BV42	0.88
BV18	1.17	BV43	0.06
BV19	-0.06	BV44	1.06
BV20	0.10	BV45	-0.79
BV21	0.93	BV46	1.67
BV22	0.45	BV47	1.25
BV23	-1.56	BV48	0.95
BV24	-0.05	BV49	0.85
BV25	-.16	BV50	0.31

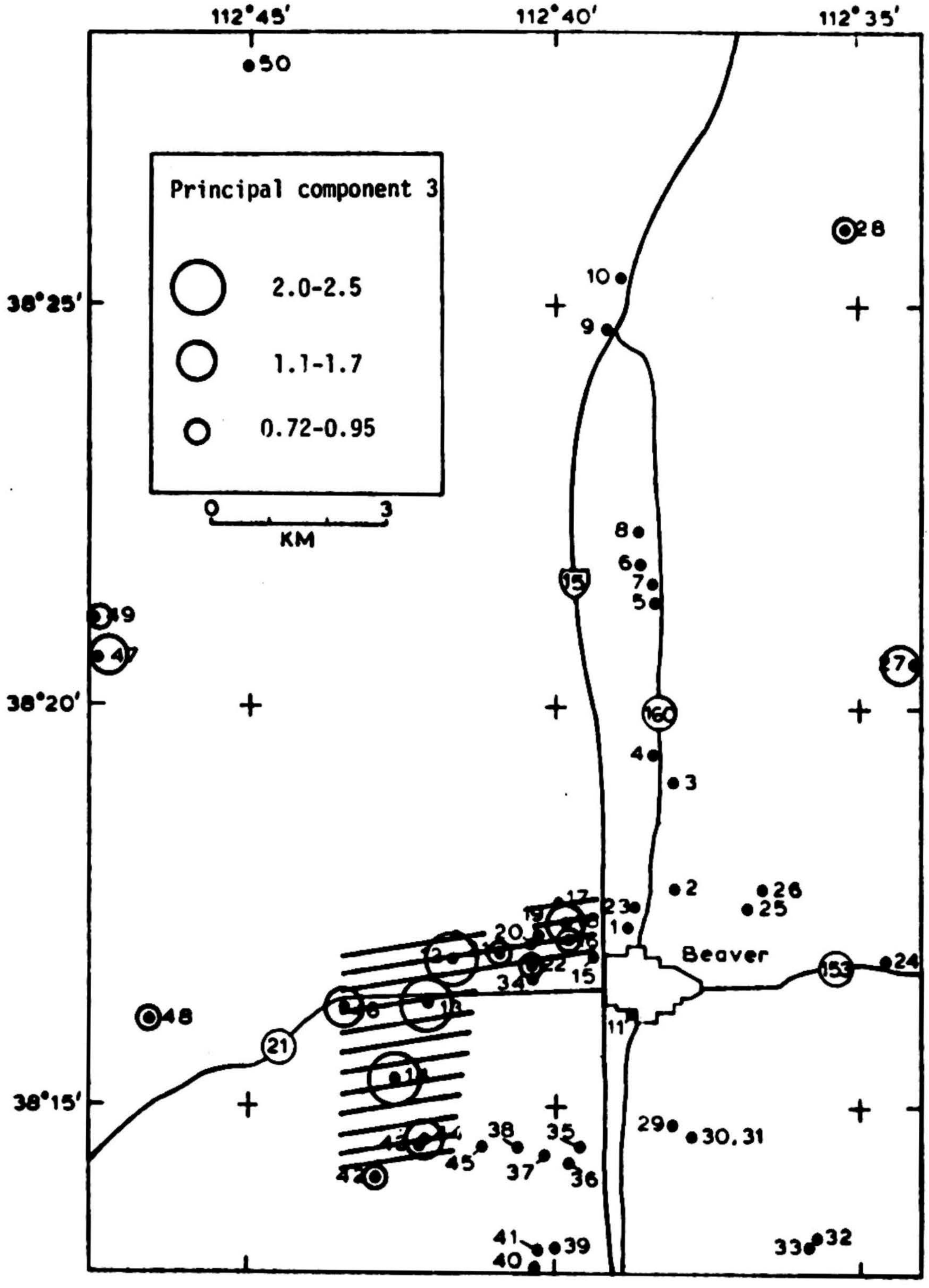

Figure 8.--Distribution of scores for principal component 3 for 50 water samples, Beaver basin, Utah. Cross-hatched area represents the most favorable area for exploration. Sample numbers (prefixed BV in text) are shown for each site.

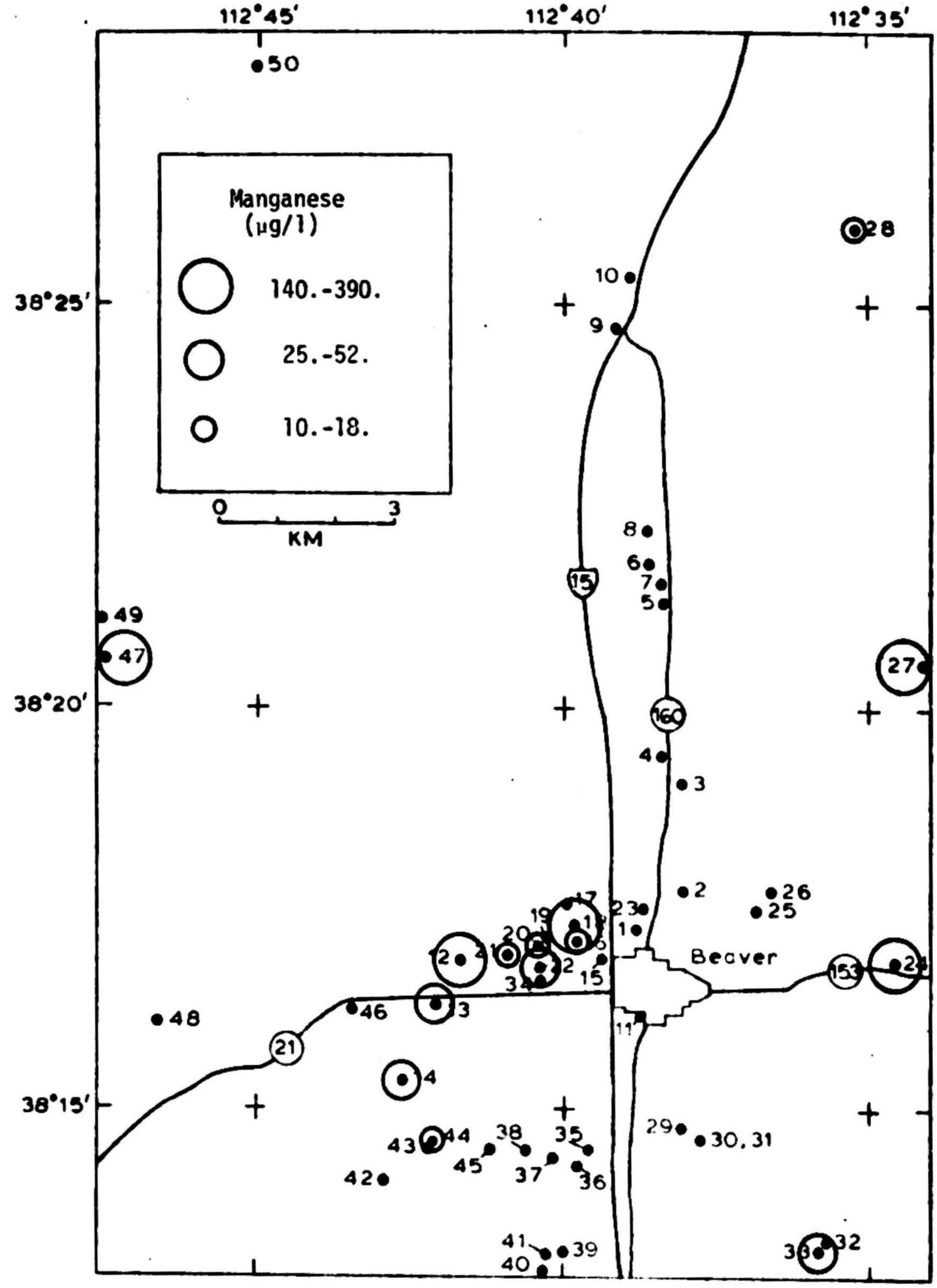

Figure 9.--Distribution of manganese for 50 water samples, Beaver basin, Utah. Sample numbers (prefixed BV in text) are shown for each site.

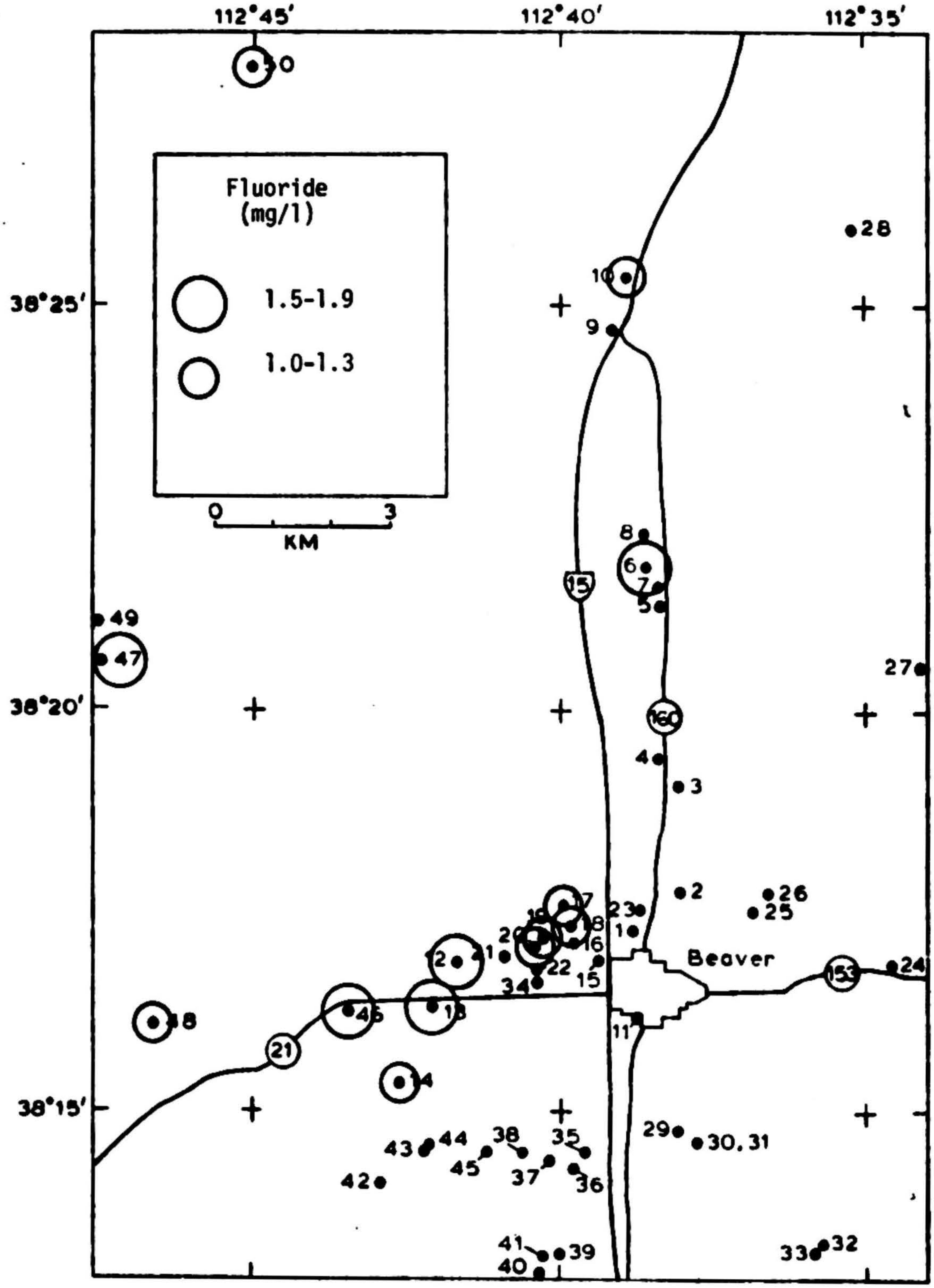

Figure 10.--Distribution of fluoride for 50 water samples, Beaver basin, Utah. Sample numbers (prefixed BV in text) are shown for each site.

Mineral-solution equilibria

Ground water geochemistry can be used to evaluate the favorability of an area for sandstone-type uranium deposits. The state of saturation of ground water can be calculated with respect to mineral phases associated with mineralization. Recent studies by Langmuir and Chatham (1980) and Runnells and others (1980) have used thermodynamic data to investigate known sandstone-type uranium deposits in Texas, Wyoming, and New Mexico.

A computer program modified from WATEQ and WATEQF, (Truesdell and Jones, 1973; Plummer and others, 1976) was used to compute the distribution of aqueous species and the state of saturation of mineral phases. Equilibrium is assumed among dissolved aqueous species. The thermodynamic data for the computer program was reviewed by D. Langmuir, K. Applin, J. Wright, and J. Chatham. The source for thermodynamic data for uranium minerals and complexes is from Langmuir (1978).

The values for Eh (table 6) were calculated by assuming equilibrium of the waters with $Fe(OH)_3$ and using the field-measured pH. The distribution of iron species was calculated using the computer program. The distribution of Eh is shown in figure 11. The ground waters from sites BV46, 44, 42, 40, 14, 12, and 41 (listed in order of importance) all have negative Eh values with -.172, -.095, -.055, -.040, -.018, -.012, and -.003 volts, respectively, indicative of a reducing environment. These are all irrigation wells west and southwest of Beaver, and are probably approximately 200 m deep. This area is considered favorable for the occurrence of sandstone-type uranium deposits because of the reducing environment.

Table 6.--Calculated Eh values and logarithms of the saturation indexes (SI) of uraninite (.25 UO_2) for 34 water samples, Beaver basin, Utah

Site number	Calculated Eh in volts	Logarithms of SI
BV01	.146	-3.33
BV02	.105	-1.88
BV03	.144	-2.87
BV05	.172	-3.38
BV06	.070	-1.48
BV08	.197	-4.32
BV09	.032	-1.86
BV12	-.012	-2.38
BV13	.115	-2.68
BV14	-.018	-1.92
BV15	.064	-0.53
BV16	.028	0.11
BV17	.137	-2.04
BV18	.088	-1.34
BV19	.208	-3.55
BV20	.182	-3.18
BV21	.087	-1.78
BV22	.125	-2.24
BV25	.103	-1.94
BV26	.082	-1.88
BV27	.107	-1.64
BV29	.126	-3.62
BV34	.152	-3.56
BV35	.077	-2.88
BV36	.161	-4.34
BV39	.006	-1.07
BV40	-.040	-0.19
BV41	-.003	-0.81
BV42	-.055	-0.61
BV44	-.095	0.26
BV45	.126	-3.26
BV46	-.172	0.02
BV47	.165	-1.41
BV48	.018	-1.13

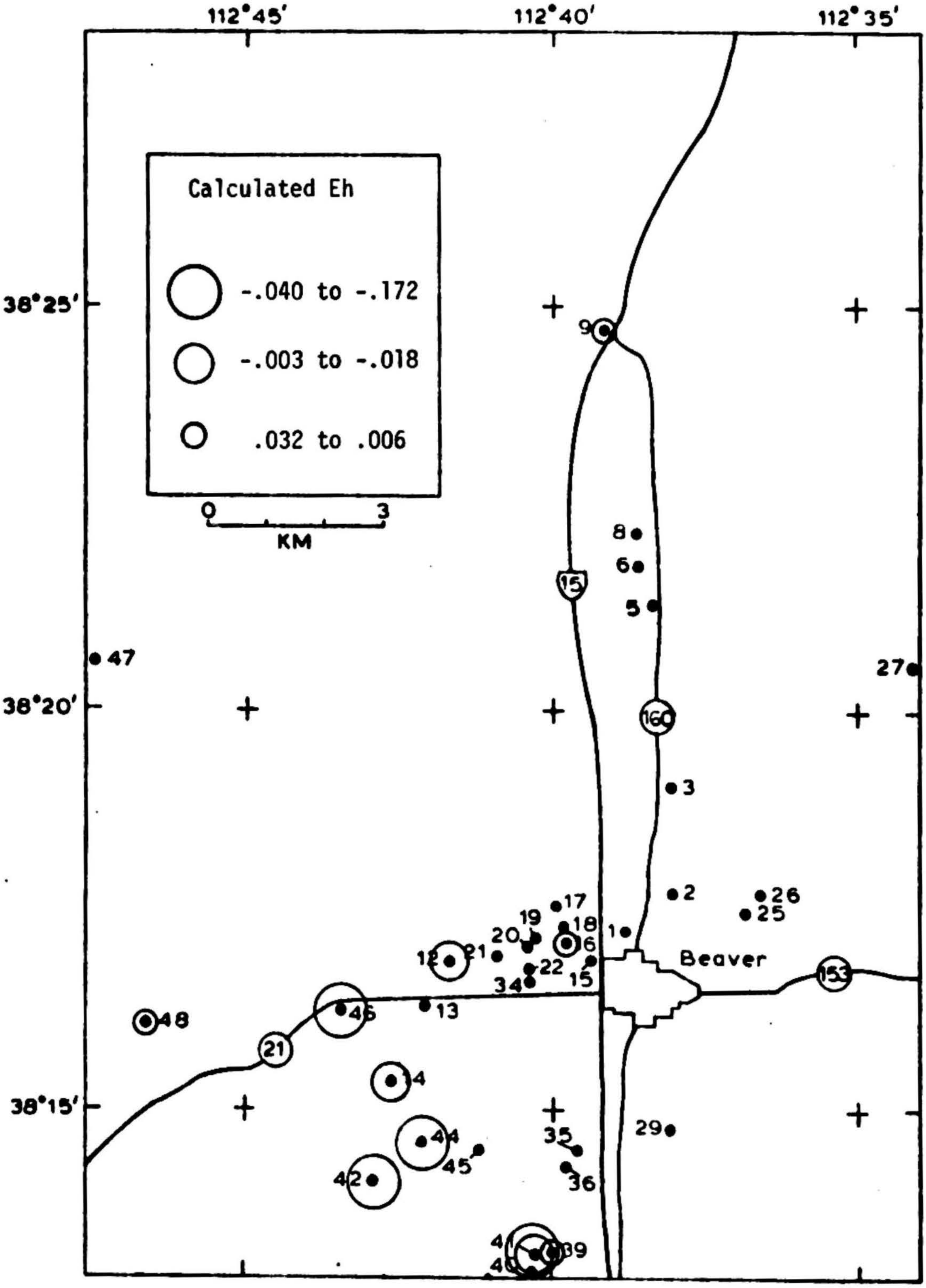

Figure 11.--Distribution of calculated Eh for 34 water samples, Beaver basin, Utah. Sample numbers (prefixed BV in text) are shown for each site.

Natural uraninites are generally partially oxidized. The solubility of pure UO_2 is less than that of the partially oxidized uraninite. The logarithm of the saturation indexes (see Runnells and others (1980) and Langmuir and Chatham (1980) for details) were calculated for partially oxidized uraninite (.25 UO_2) using the WATEQ computer program (table 6). The distribution is shown on figure 12. Positive values indicate supersaturation and negative values indicate undersaturation of ground water with respect to partially oxidized uraninite (.25 UO_2). The most anomalous sites are BV44, 16, and 46 with log-SI values of 0.26, 0.11, and 0.02 respectively. The ground water are supersaturated with respect to uraninite (.25 UO_2) at these sites.

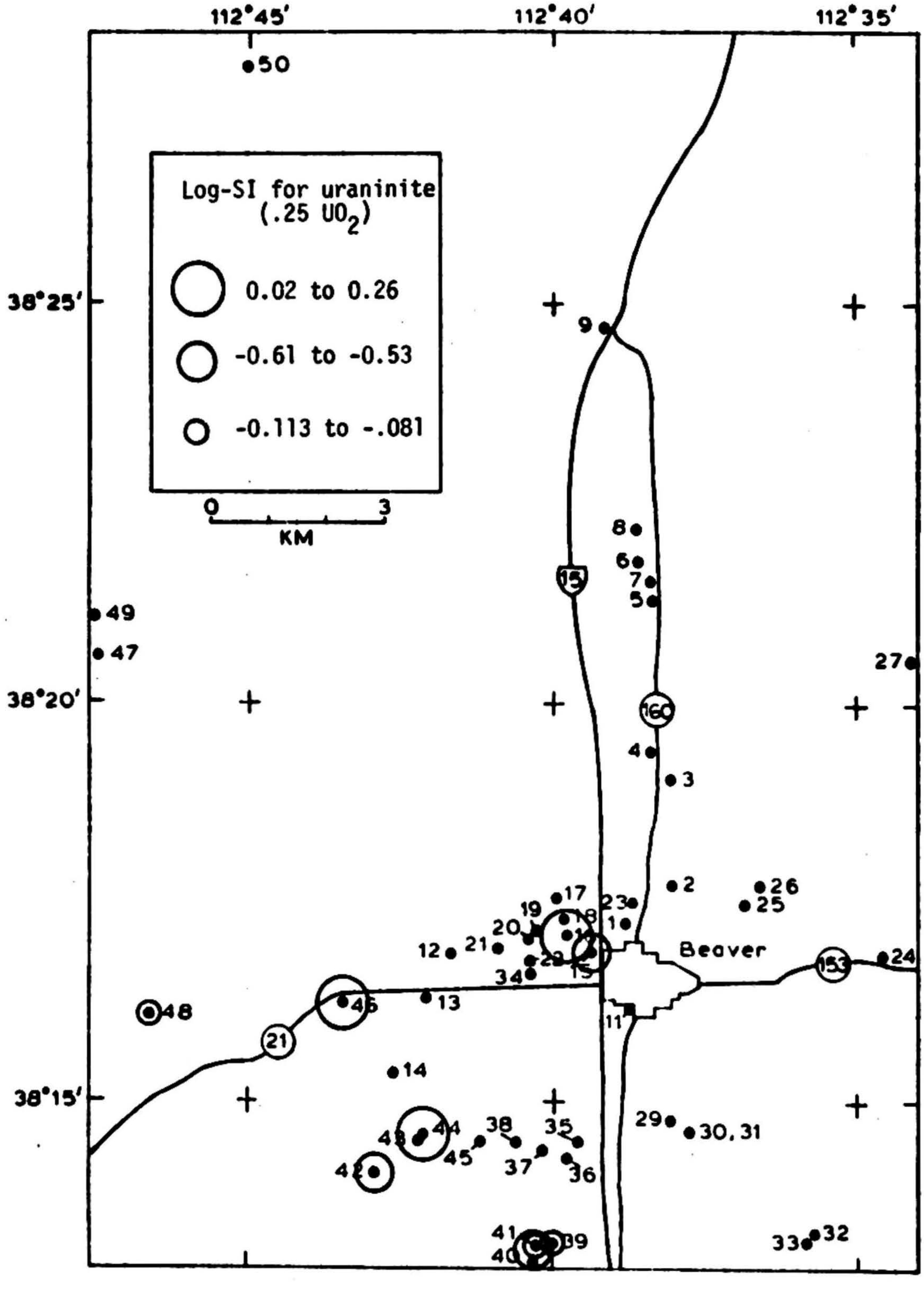

Figure 12.--Distribution of the logarithm of saturation indexes for uraninite (.25 UO_2) for 34 water samples, Beaver basin, Utah. Samples numbers (prefixed BV in text) are shown for each site.

Conclusions

The results of the principal-component analysis indicate that the area containing sites BV12, 13, 14, 18, 44, and 46 is the most favorable for sandstone-type uranium deposits. The results of the mineral-solution equilibria study indicate that the areas containing sites BV12, 14, 40, 41, 42, 44, and 46 are reducing environments that are favorable for the formation of uraninite. In addition, the ground waters at sites BV 16, 44, and 46 are supersaturated and BV15 is near saturation with respect to uraninite.

At least two geochemical systems seem to be present, probably representing different aquifers. Sample sites BV15 and 16, northwest of Beaver, probably represent the shallower aquifer, probably <100 m in depth. The ground water from BV15 and 16 is supersaturated or near saturation with respect to uraninite (.25 UO_2). BV16 is the most anomalous of the two. The area west and southwest of Beaver tests a deeper aquifer, probably 200 m or more deep. The samples indicate a reducing environment that is favorable for the formation and retention of sandstone-type uranium deposits. BV12, 14, 42, 44, and 46, are the most anomalous sites. BV44 and 46 are also supersaturated with respect to uraninite (.25 UO_2). Both of these areas are considered targets for exploration (fig. 13).

The presence of at least two aquifers complicates the interpretation. However, the results of geochemical survey demonstrate that the environment of the Beaver basin is favorable for the occurrence of sandstone-type uranium deposits, and several areas are located as potential targets for exploration. Other targets may exist in the untested parts of the basin.

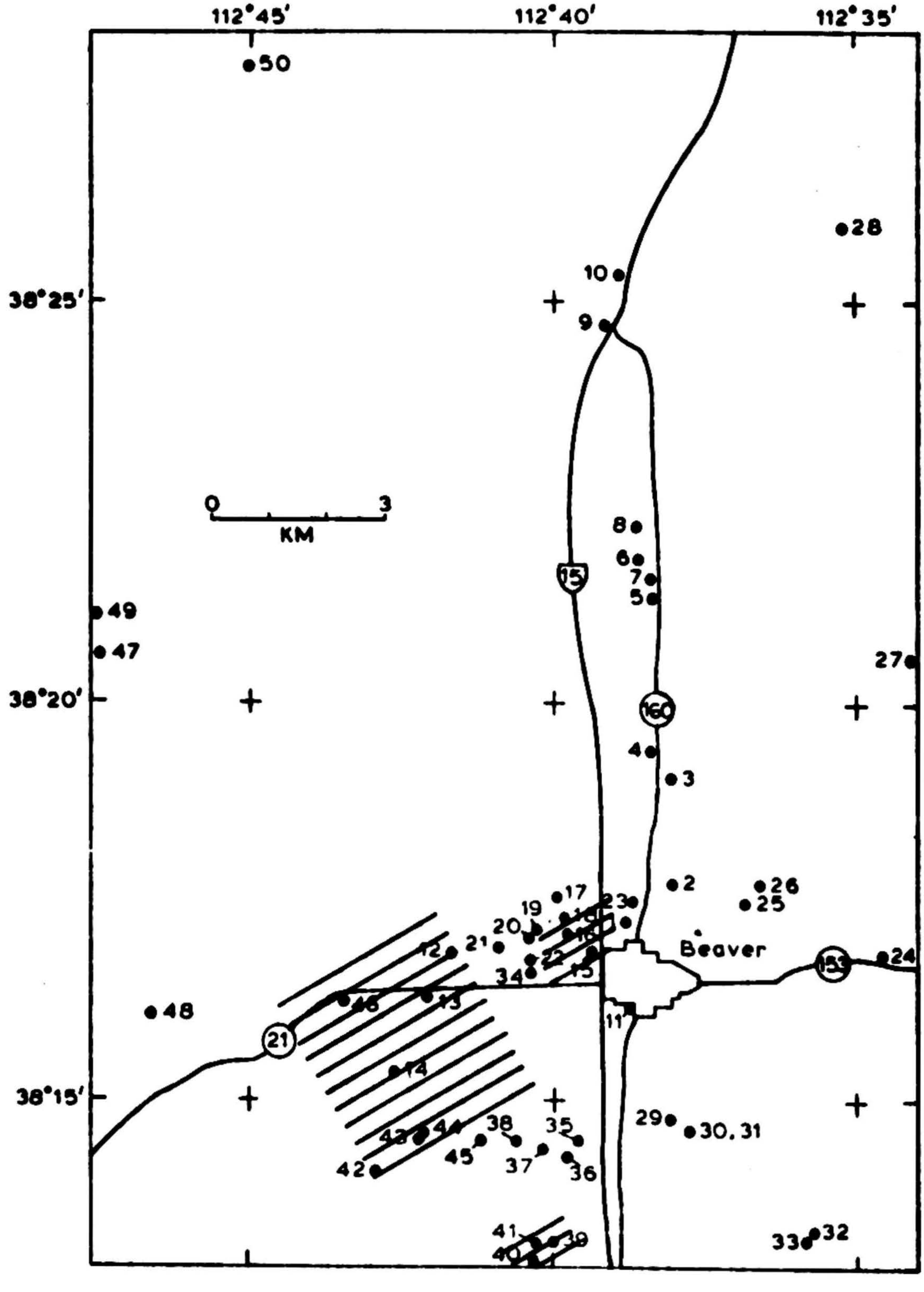

Figure 13.--Cross-hatched areas represent the most favorable areas for the occurrence of sandstone-type uranium deposits, Beaver basin, Utah. Sample numbers (prefixed BV in text) are shown for each site.

The methods described in this study can be utilized for evaluation of waters from drill holes in the Beaver basin once exploration drilling has begun and for geochemical exploration for sandstone-type uranium mineralization in other basins in adjacent parts of the Basin and Range province.

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