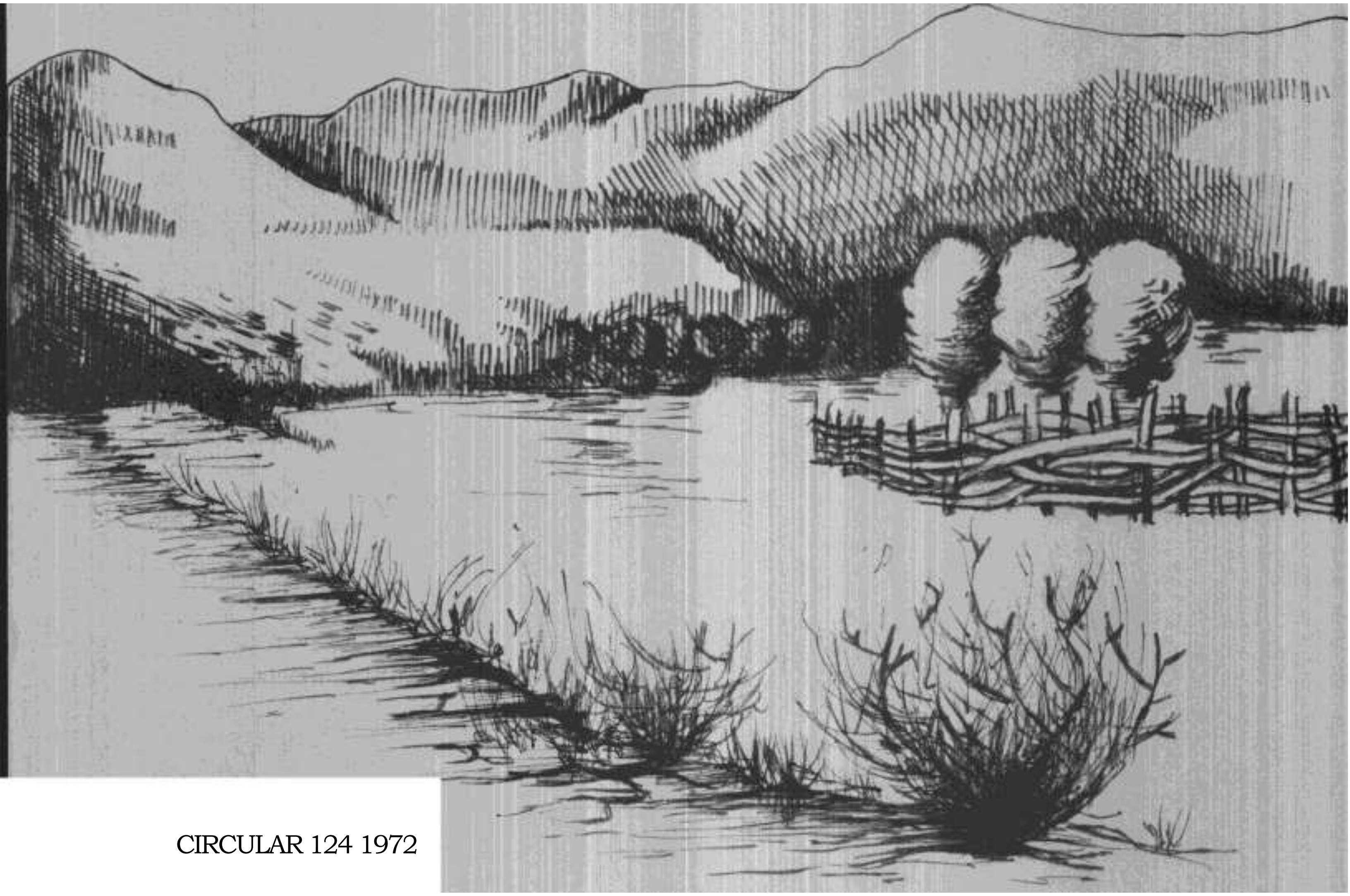
Ground waterCharacteristics in a Recharge Area Magdalena Mountains Socorro County New Mexico



CIRCULAR 124 1972

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New Mexico State Bureau of Mines and Mineral Resources

Circular 124

GROUND-WATER CHARACTERISTICS IN A RECHARGE AREA, MAGDALENA MOUNTAINS, SOCORRO COUNTY, NEW MEXICO

by

W. K. Summers, Geraldine E. Schwab,
and L. A. Brandvold

Socorro
1972

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ABSTRACT

The Magdalena Mountains are a horst block in the Basin and Range Province. Silicic Tertiary volcanics overlie sedimentary rocks of Mississippian, Pennsylvanian and Permian ages and metamorphic rocks of Precambrian age. Although many arroyos drain the mountains, none contains a permanent stream.

Springs occur at local permeability barriers in the canyons and arroyos, and may be intermittent. Temperatures of discharging ground water, after discounting variations created by ambient air temperatures and solar radiation, increase with diminishing altitude at a rate of 0.46°C/100 feet (0.8°F/100 ft.).

Field pH ranged from 6.4 to 7.8, with one sample collected from a stock tank having a pH of 8.7. Laboratory pH ranged from 7.2 to 8.8. Calcium, bicarbonate, and total dissolved solids concentrations diminished with time in several samples. Over a period of about 100 days the bicarbonate concentration in each of nine samples diminished more than 100 ppm.

Analyses were made for fluoride, nitrate, lithium, rubidium, strontium, barium, chromium, copper, zinc, iron, and manganese. Except for fluoride and strontium, most concentrations were near or below the limit of detectability.

The distribution of sample locations and the low solubility of metallic ions somewhat limit the efficacy of trace element analysis to delineate areas for subsequent metals exploration. However, one anomalous copper value occurred in a sample taken from a spring near a known copper deposit, and anomalous zinc values suggest a new area to prospect. Lithium concentration varied with lithology. Concentrations of the other trace elements were not particularly significant.

INTRODUCTION

The chemical character of ground water depends upon where the water is in the ground-water flow system and on the chemical composition of the rocks through which the water has passed. Relatively few studies of ground-water chemistry have been made in regions where the recharge area could be delineated with precision or in areas where silicic igneous rock predominates.

Mineral explorationists in New Mexico have indicated that chemical analyses of ground-water samples have become a geochemical prospecting tool. Yet very little information is available about trace element distribution in ground water in New Mexico.

This circular reports the procedures and results of a project initiated (1) to learn more about the general chemistry of ground water in a mountainous recharge area and (2) to determine whether trace element concentrations in the ground water would correlate with known ore deposits, or would suggest other areas to prospect.

The Magdalena Mountains in south central New Mexico (fig. 1) cover an area of approximately 250 square miles and range in altitude from about 6,000 feet to 10,783 feet. Annual precipitation on the mountains ranges from 13.4 inches at 7,000 feet to 17.7 inches at 10,630 feet (Langmuir Laboratory). Precipitation for July, August, and September ranges from 8.8 inches at 6,720 feet to 11.9 inches at 10,630 feet (M. H. Wilkening, personal communication, 1971).

Figure 1 – Map of New Mexico showing the location of the Magdalena Mountains.

Vegetation is sparse below 6,500 feet and above 10,000 feet, but from about 7,000 to about 9,000 feet juniper, piñon, and ponderosa pine are plentiful.

Topography and Drainage

The Magdalena Mountains rise about 3,500 feet above the surrounding plains over distances as short as six miles (fig. 2). Locally slopes exceed 2,000 feet per mile. The well-defined range crest is more than 20 miles long and trends roughly north-south. Twenty-six drainage basins carry runoff precipitation and snow melt from the mountain.

The two largest canyons draining the mountain area are as much as one quarter mile wide, are more than nine miles long, and drain the broad southern end of the range. Canyons and drainageways reach almost to the divides. In their lower reaches, canyons are incised only a few hundred feet. None of the drainageways contain perennial streams, and most canyons open onto alluvial fans that slope 200 to 400 feet per mile toward the plains.

Geologic Setting

The Magdalena Mountains are a horst block in the Basin and Range Province. Consequently, the area has undergone extensive faulting, uplift, and erosion. A low fault scarp in the alluvium along the northeastern flank demonstrates the continuing activity in the area.

Metasedimentary rocks, metavolcanic rocks, and granites of Precambrian age crop out over an area of about 20 square miles in the northeast quadrant of the range (fig. 2). Mississippian and Pennsylvanian limestones and Permian sandstones, draped unconformably over the Precambrian rocks, crop out over an area of about five square miles. The rest of the rocks are andesitic flows and latitic to rhyolitic welded tuffs of the Datil Group of middle to late Tertiary age (fig. 2). The deposits of Quaternary age include talus, thin alluvium on the canyon bottoms, and relatively thick alluvium in marginal fans.

Mineralization occurs mainly in the Paleozoic limestones and Tertiary volcanic rocks, or in veins and dikes cutting these units. L. A. File (1965) reports that zinc, lead, copper, gold, silver, manganese, tungsten, barium, and vanadium have been mined in the area. Although more than 40 mines have been developed in the mountains to extract manganese, copper, lead, silver or zinc, only one mine was active in 1969 (Hays, 1970), and it closed during 1970.

Fig. 3 is a water-table map based on water levels in wells, springs, and reported water levels in mines. Although based upon more than 60 control points, this map only approximates the actual surface. The water-table slope ranges from about 150 to more than 500 feet per mile, re-

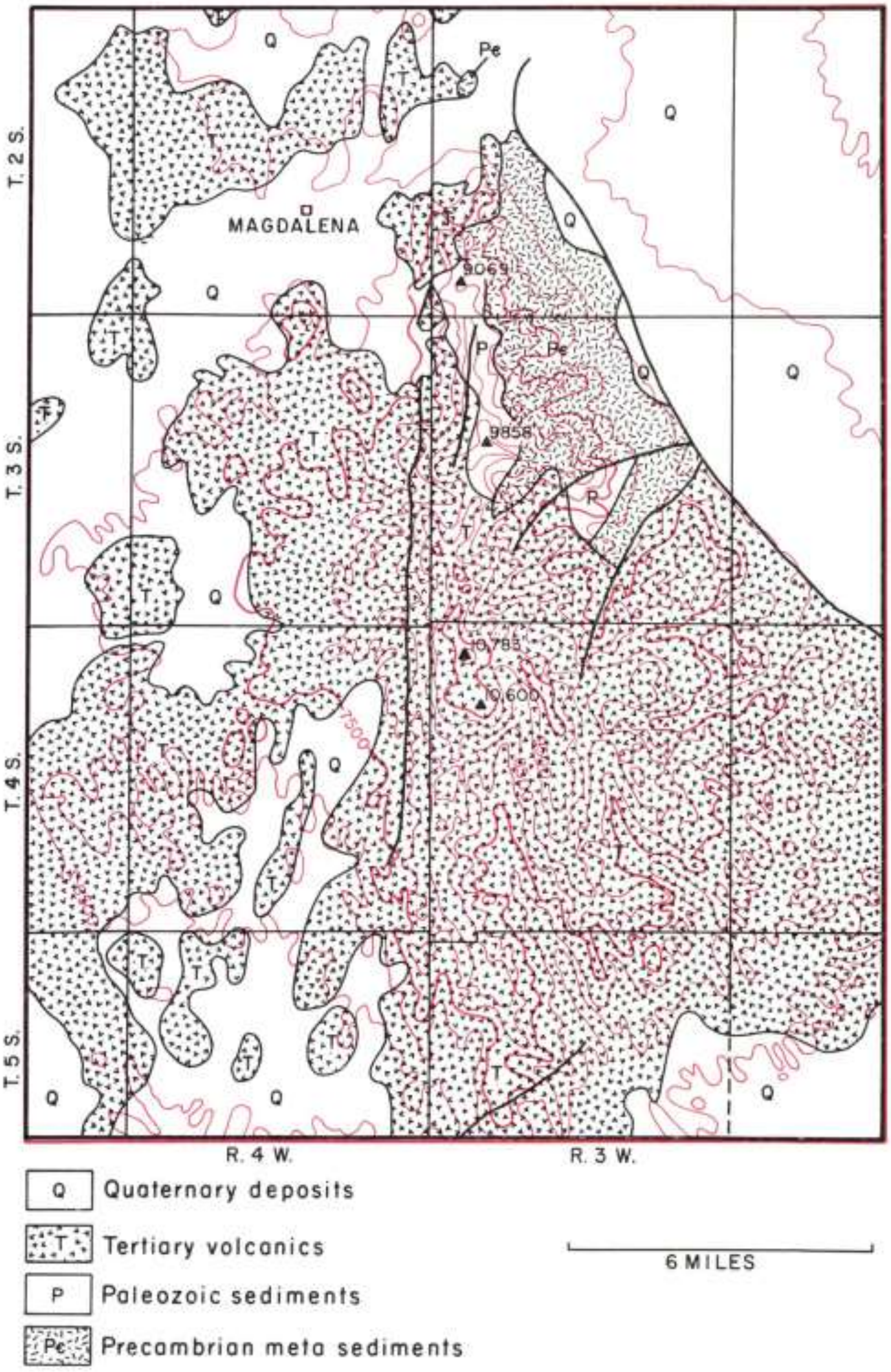

Figure 2 — Generalized geologic and topographic map of the Magdalena Mountains, New Mexico.

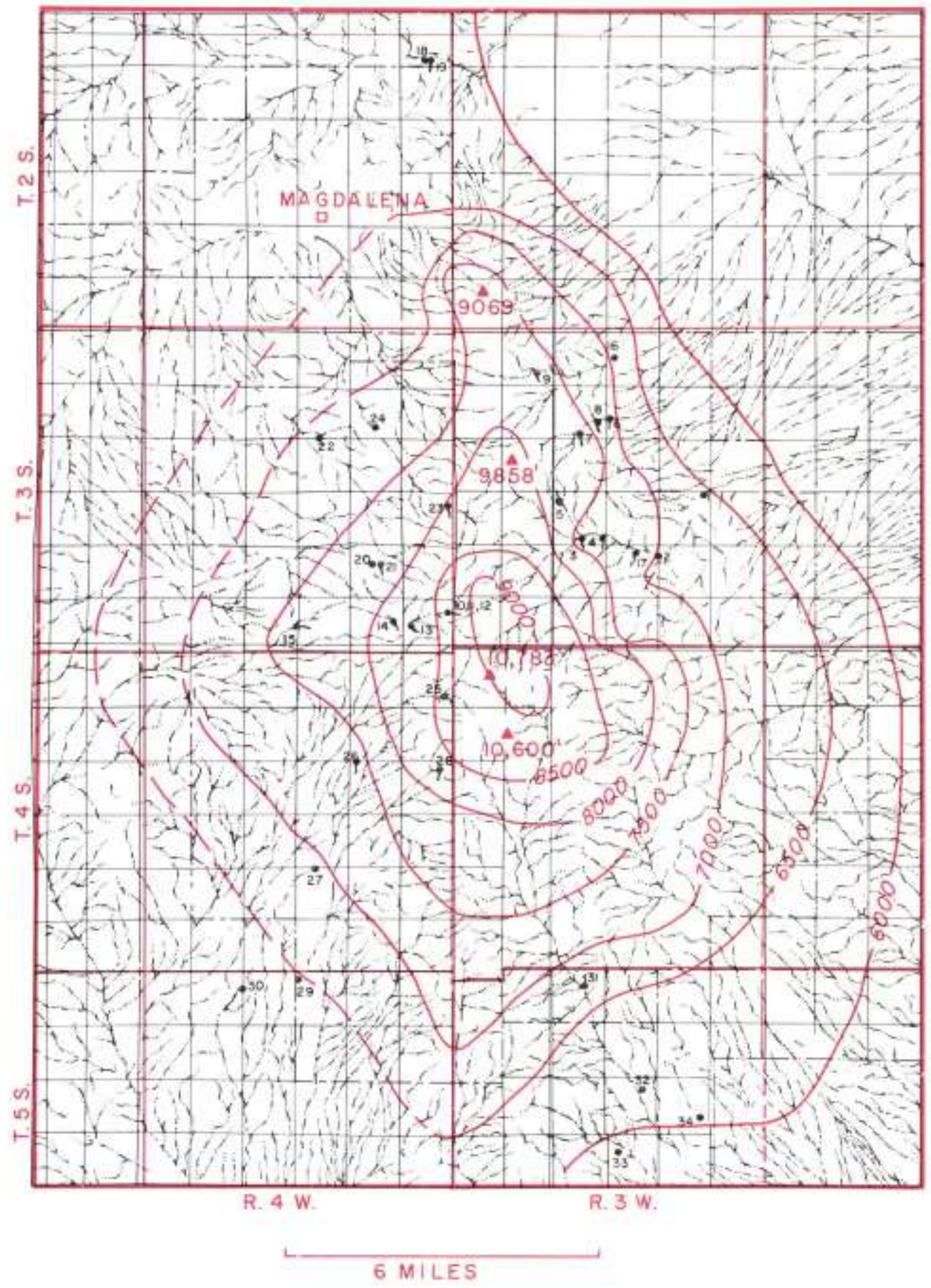

Figure 3 -- Water-table map of the Magdalena Mountains, New Mexico.

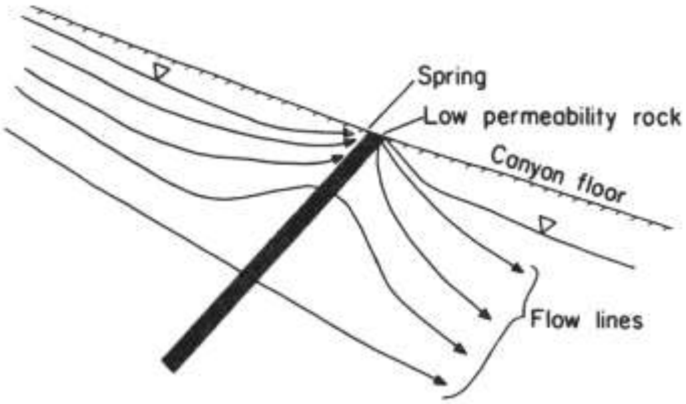

Figure 4 – Diagrammatic cross section of ground-water flow at a typical spring in the Magdalena Mountains, New Mexico.

flecting the relatively low permeability of the rocks and indicating the strong vertical component of the hydraulic gradient.

Fig. 4 shows diagrammatically a cross section through a typical spring in the Magdalena mountains. Some springs at lower altitude flow only during spring and early summer. Most of the springs at higher altitudes flow perennially. Although perched ground water may occur locally, most of the rocks are sufficiently fractured not to retain a perched water body. Yields of wells and springs are all less than 50 gpm (gallons per minute) and few yields of more than 20 gpm have been measured or reported. Lasky (1932, p. 38, 42, 50, 51-53) reported that many mines had ground-water drainage problems.

PROCEDURES

Field

Of the many wells and springs shown on topographic quadrangle maps, we visited 34 and recorded the data in tables 1 and 2. Chemical analyses for all those locations are listed in table 6. At wells, we measured the depth to water, using the chalked tape method, before turning on the pump or windmill. As table 1 indicates every well could not be measured, nor could all pumps and windmills be turned on. The yields of wells were estimated, or taken from owners' records. Spring flows were gauged with a modified Par-shall flume, or were estimated where the flume was not practical.

We obtained water samples from 9 wells and 21 springs. At each, two samples were collected: One in a gallon polyethylene container and one in a pint bottle. The pint sample was acidified in the laboratory. Samples were filtered whenever possible.

For both wells and springs, specific conduction, pH, and temperatures were measured at the site, in the discharging water wherever possible. The carbonate-bicarbonate alkalinity was also determined by titration using a portable pH meter. The field procedure was exactly the same as that used in the laboratory.

Chemical Analyses

In the laboratory, conductivity, dissolved solids, alkalinity, chloride and gravimetric sulfate were run by standard procedures (American Public Health Association, 1960). Calcium was titrated by the method of Yalman and others (1959). Nitrate was determined by the cadmium-reduction method (American Public Health Association, 1960). Sodium, potassium, magnesium, and zinc were determined by atomic absorption using standard procedures. Fluoride was analyzed using the fluoride ion selective electrode. Iron was determined on an acidified sample by the 2, 4, 6-tripyridyl-S-triazine color method of Collins and Diehl (1960, p. 27-41).

A small portion (500 milliliters) of the original sample was evaporated to a volume of less than 45 milliliters; 5 milliliters of concentrated HCl was added and the volume brought back to 50 milliliters. The following elements were then determined on this concentrated aliquot by atomic absorption using standard conditions and an expanded scale: barium, lithium, rubidium, strontium, copper, molybdenum, chromium, and manganese. This method of trace element analysis was chosen for its simplicity and speed, rather than detection limits.

Before analyzing for strontium, to avoid interferences from Na^+ and K^+, 100 ppm (parts per million) of Na^+ and K^+ were added both to the strontium standards and to each sample. A 5 percent La_2O solution in 25 percent (v/v) HCl was also added to each strontium standard and to the sample to give a final concentration of 1 percent La_2O. Addition of La_2O protects the strontium determination from interferences from SiO2, $A1_203$ and phosphorus. For manganese analysis, 50 ppm Ca^{++} were added to the standards and samples to avoid interference from SiO_2; and for barium analysis, 100 ppm of Na^+ were added to the standards and samples to protect from interference by Na^+.

RESULTS OF CHEMICAL ANALYSES

Efforts to balance the equivalent (or combining) weight of anions with that of cations, and to balance the sum of the individual ion weights with the measured total dissolved solids (residue on evaporation at 180°C), failed. Subsequent repeated measurements of carbonate-bicarbonate, calcium, silica, and total dissolved solids showed that bicarbonate, calcium, and total-dissolved-solids concentrations in stored samples diminished with time. Fig. 5 shows the concentration of calcium, bicarbonate, and total dissolved solids with time in the sample from spring No. 4. In each of nine samples the bicarbonate concentration diminished more than 100 ppm from that measured in the field; in eleven samples the concentration diminished 25 to 100 ppm; changes of less than 25 ppm occurred in the remaining ten samples (fig. 6).

For those samples in which the bicarbonate, calcium and dissolved solids concentration diminished with time, a calculated balance between anions and cations was achieved, only if calcium, bicarbonate, and dissolved solids were determined on the same day. However, this was not the original ion balance, which could only have been determined if calcium and total dissolved solids along with bicarbonate concentrations could have been measured in the field. As a consequence, we estimated the initial calcium concentration using the following relationships:

$$Ca^{++} = SO^{=}_4 + Cl^{-} + HCO^{-}_3 - Na^{+} - K^{+} -$$

Table 3 (Appendix) summarizes the results of the chemical analyses, compares the observed calcium concentration with the estimated, and gives the reliability of the technique used. No water from the Magdalena Mountains contains as much as 500 ppm total dissolved solids. Calcium and bicarbonate are the dominant ions in most samples. Silica constitutes as much as 30 percent of the total in samples with dissolved solids concentrations of 150 ppm or less.

DISCUSSION

To explain the observed water chemistries, we considered several possible factors: water temperature, pH, lithology, maximum flow-line length, and discharge rate and mode. We also considered trace element concentrations and the relation of zinc, copper, and manganese concentrations in the water to the occurrence of mineral deposits.

Ground-Water Temperatures

The temperature of ground water that discharges from the Magdalena Mountains (table 1 and 2 in Appendix, plus a few other measurements) is a function of the temperature relations within the ground-water reservoir. However, before these temperatures of discharging water can be used to interpret subsurface thermal conditions, two external effects must be assessed. One is the effect of incident solar radiation; the other is the effect of ambient air temperature.

Solar radiation causes a natural daily or seasonal variation in the near-surface ground water. The effect varies with (a) the depth of the water table below the land surface, (b) the range of temperatures experienced at the land surface, (c) thermal conductivity and specific heat of the soil, (d) the temperature of recharge water, and (e) the direction and speed of ground-water movement. Where ground water moves with sufficient speed, these effects are minimized.

Ambient air temperature affects the temperature of discharging water in those places where the discharge is relatively slow, or where the discharge occurs over a broad area, or where the discharge is directly into a pond or tank. As fig. 7 shows, the temperature of discharging ground water has a wider range at lower discharge rate than at the higher rates.

In fig. 8 we have used only those temperatures that we believe to be essentially free of external effects. Fig. 8, the relation of discharging-ground-water temperatures to altitude, shows that the temperature of discharging ground water increases with diminishing altitude at a rate of 0.46° C/100 feet. Although the observed temperatures ranged from 9° to 25°C, aquifer temperatures probably range from about 7° to 20°C.

No relation could be discerned between chemical concentration and water temperatures.

pH

The field pH of water in 20 springs ranged from 6.4 to 7.4. Bird Spring (19) discharged into a large steel tank. Its field pH was 8.7. The field pH of water from the nine wells ranged from 6.4 to 7.5. The laboratory pH of the water samples observed 1 to 6 days later ranged from 7.2 to 8.5. The laboratory pH of the Bird Spring sample was 8.8.

At some springs the pH varied markedly over short distances. The minimum pH consistently occurred at the most upstream discharge point. These observations suggest that carbon dioxide came out of solution as the water discharged with the concomitant increase in pH. Thus, the lowest values of pH measured in the field probably approximate the pH in the ground-water reservoir.

Where the ground-water reservoir is made up largely of Tertiary volcanic rocks, the minimum pH seems to be in the range of 6.6 to 6.9.

Efforts to relate the pH (both the field and the laboratory values) and the pH difference (both the observed and

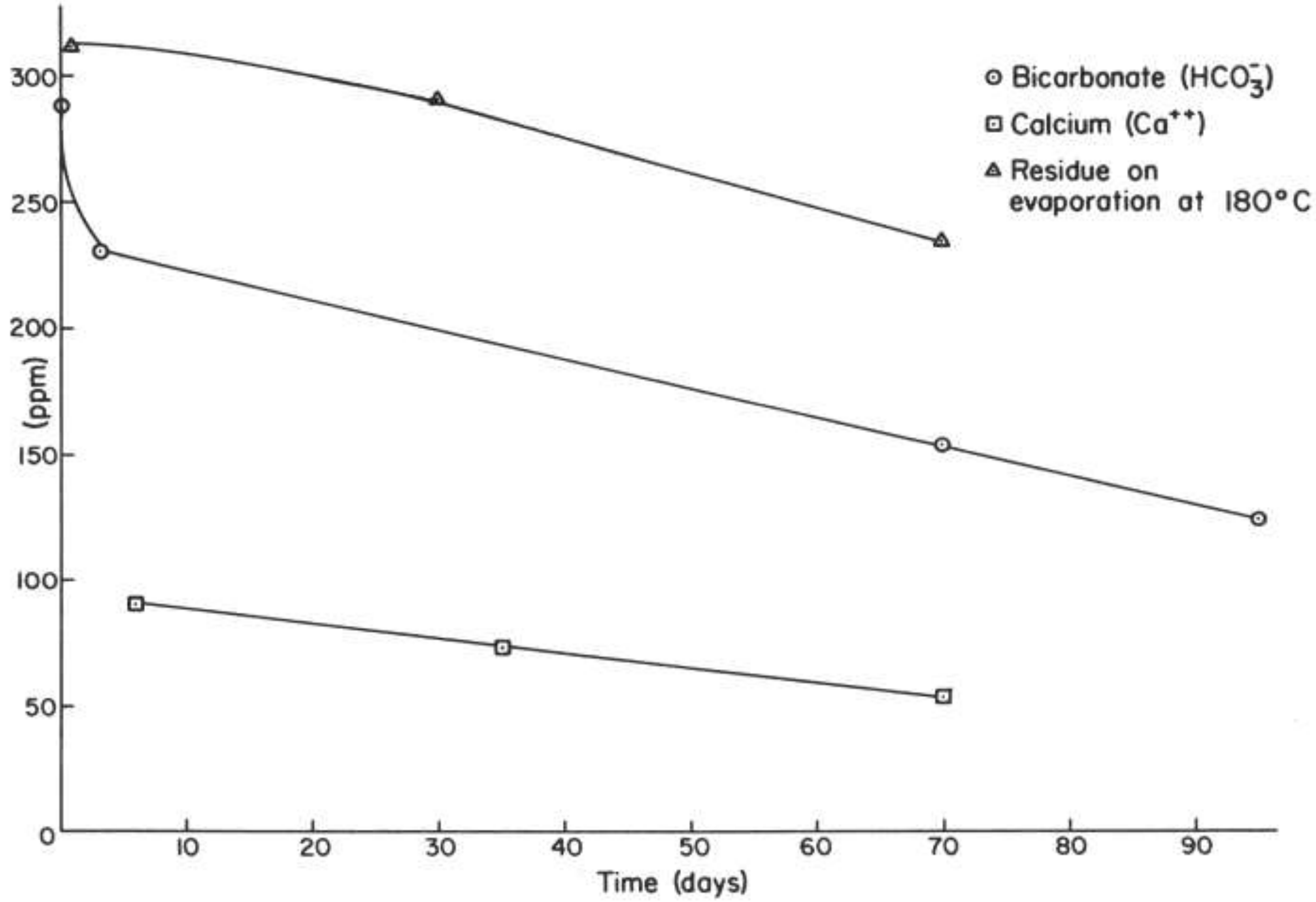

Figure 5 — Concentration of bicarbonate, calcium, and residue on evaporation at 180˚C for sample from spring no. 4 Magdalena Mountains, New Mexico.

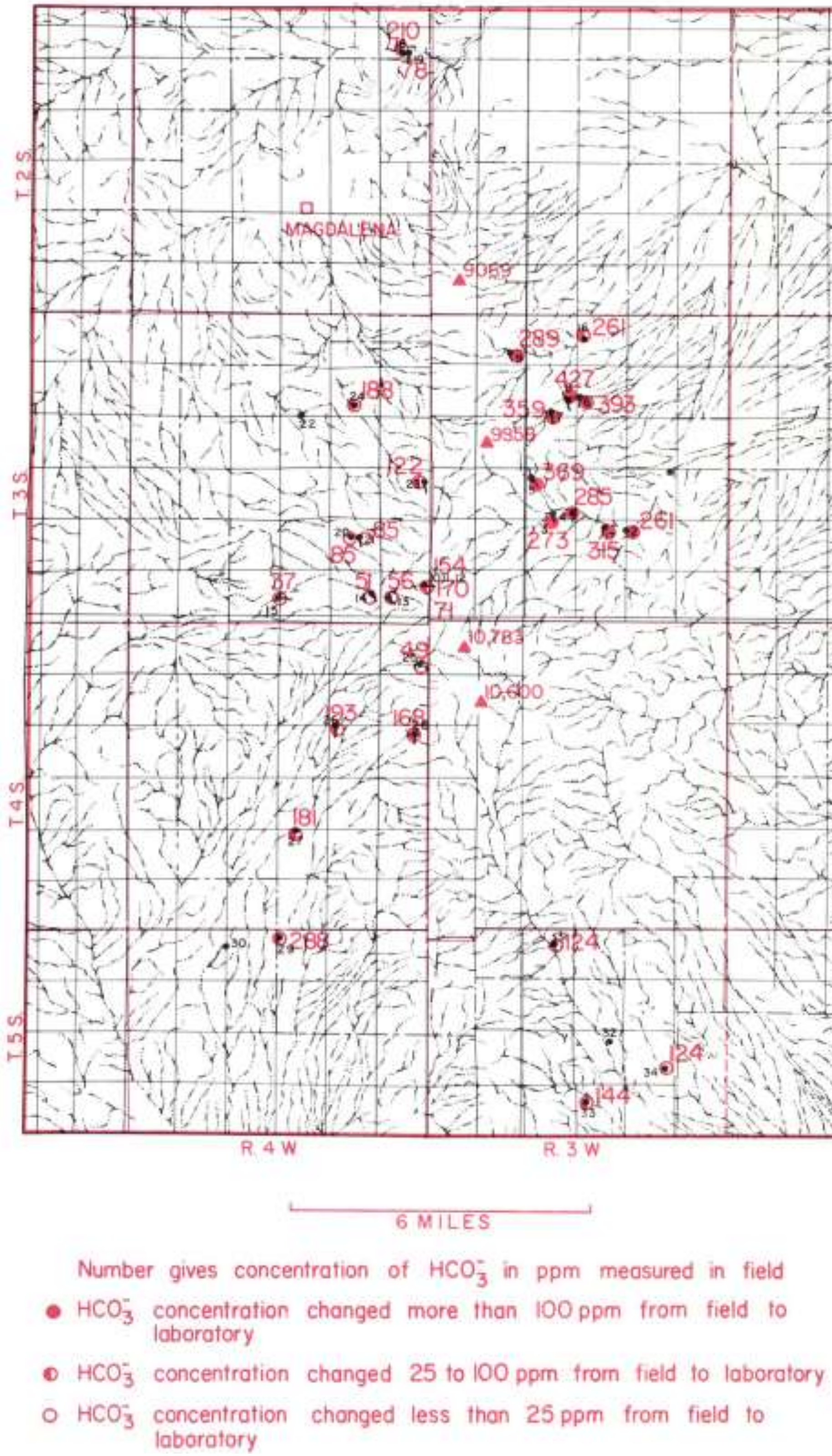

Figure 6 — Map of the Magdalena Mountains, New Mexico, showing distribution of bicarbonate ion concentration in ground water.

that calculated by substracting 6.7 from the observed laboratory value) to the observed chemistry revealed no consistent relationship.

Lithology

We sampled water from five lithologic units: Unit 1 consists of Paleozoic and Precambrian sedimentary and metasedimentary rocks. Unit 2 consists of the older Tertiary volcanic rocks in the northern extension of the mountains. The geology of this area is complex. The rocks are dominantly rhyolitic ash-flow tuffs interbedded with lesser masses of andesitic and latitic tuffs. Monzonite intrusions cut these beds. Epidote, calcite, and chlorite are common alteration minerals. Unit 3 consists of older Tertiary volcanic rocks east of the major north-south fault in the central area. These rocks consist mostly of rhyolitic welded tuffs with interbedded andesite flows. Unit 4 consists of the younger Tertiary volcanic rocks west of the fault in the central area. These rocks consist mostly of rhyolitic flows and tuffs. Unit 5 consists of the Tertiary volcanic rocks in the southeastern sector. The character of the rocks in this area is not fully understood.

We deliberately avoided sampling the alluvium.

Table 4 (Appendix) gives the arithmetic mean concentration for eight major chemical constituents and the total dissolved solids for water samples from each of these five lithologic units. Water samples from the Paleozoic-Precambrian rocks have significantly higher concentrations of calcium, bicarbonate, and total dissolved solids. They also are the samples in which the greatest change occurred between field and laboratory. Sulfates are modestly higher than those of the waters from the rocks in the northern extension.

Water from the younger volcanic rocks has a significantly higher silica concentration; potassium concentrations are also higher. The similarity of the waters from the younger volcanic and those from the volcanic rocks of the southeastern sector suggests that the rocks have similar composition. A standard trilinear plot (fig. 9) of the data for each water sample shows clearly that composition proportions of the waters from the Paleozoic-Precambrian rocks are similar to, but distinct from, those from Tertiary rocks.

By establishing the domain of each sample group as shown in fig. 10, patterns become evident. The domain of samples from the Paleozoic-Precambrian rocks is generally distinct from the domains of those from Tertiary volcanics. The domain of samples from the southeastern sector falls within the domain of the younger volcanics. Thus, even though we lack data on specific lithology in the mountains, we can attribute much of the observed difference in water chemistry to the lithological difference in the rocks from which the water samples were obtained.

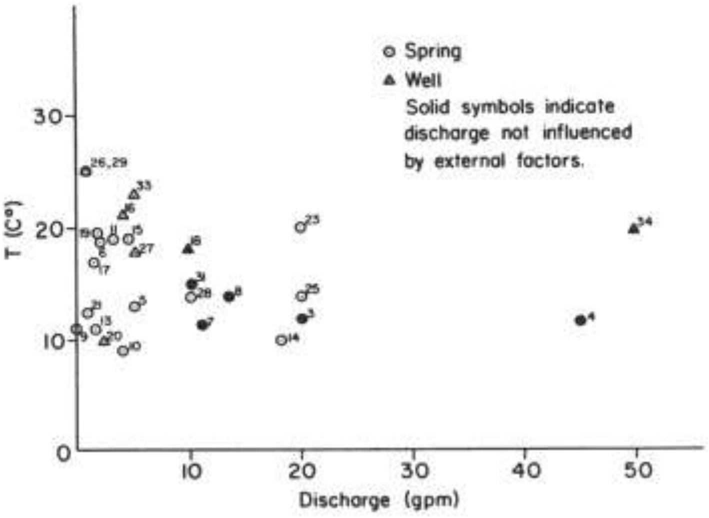

Figure 7 – Relation of temperature of discharging ground water to discharge rate.

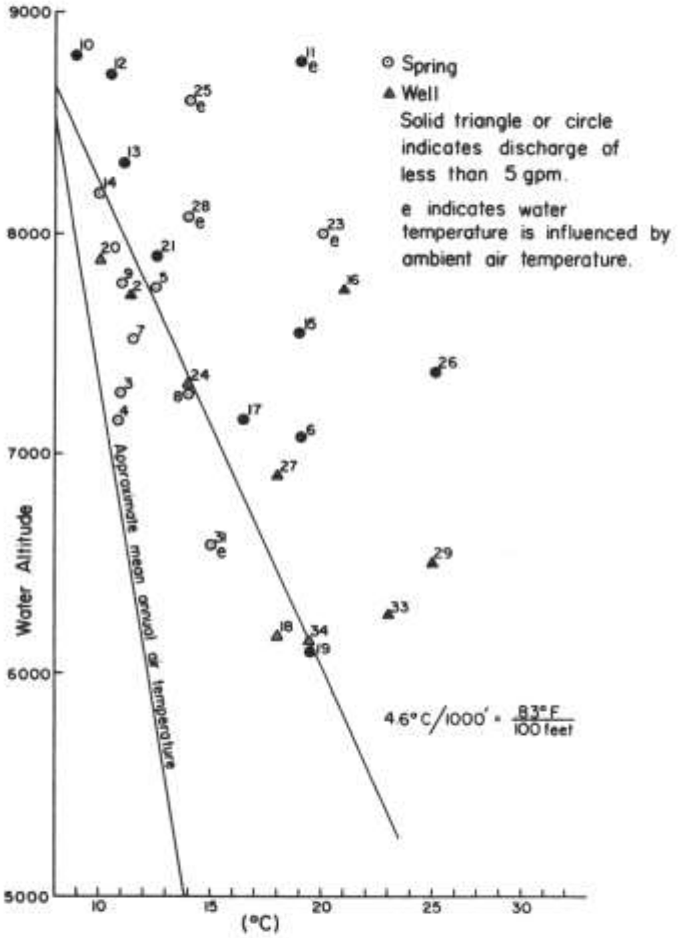

Figure 8 – Relation of the temperature of discharging ground water to land surface altitude.

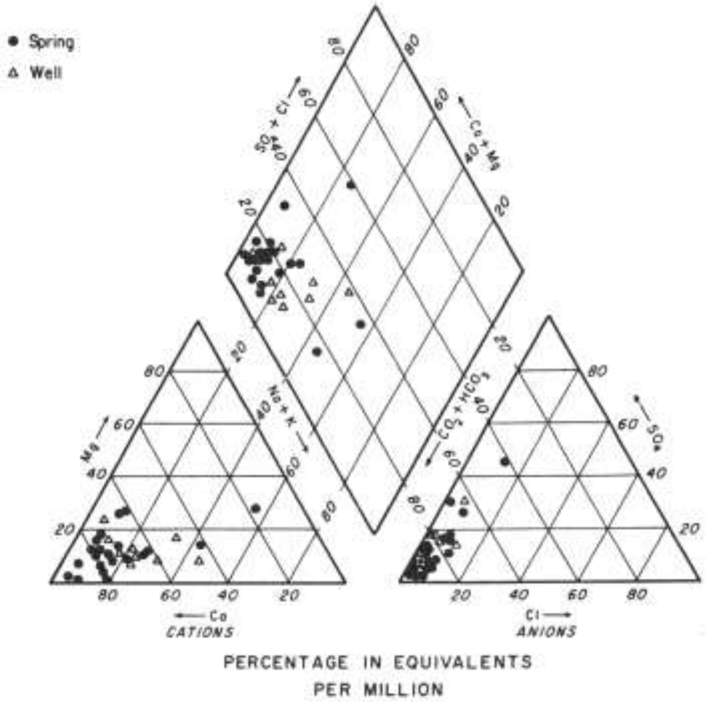

Figure 9 – Trilinear diagram of ground-water samples from the Magdalena Mountains, New Mexico.

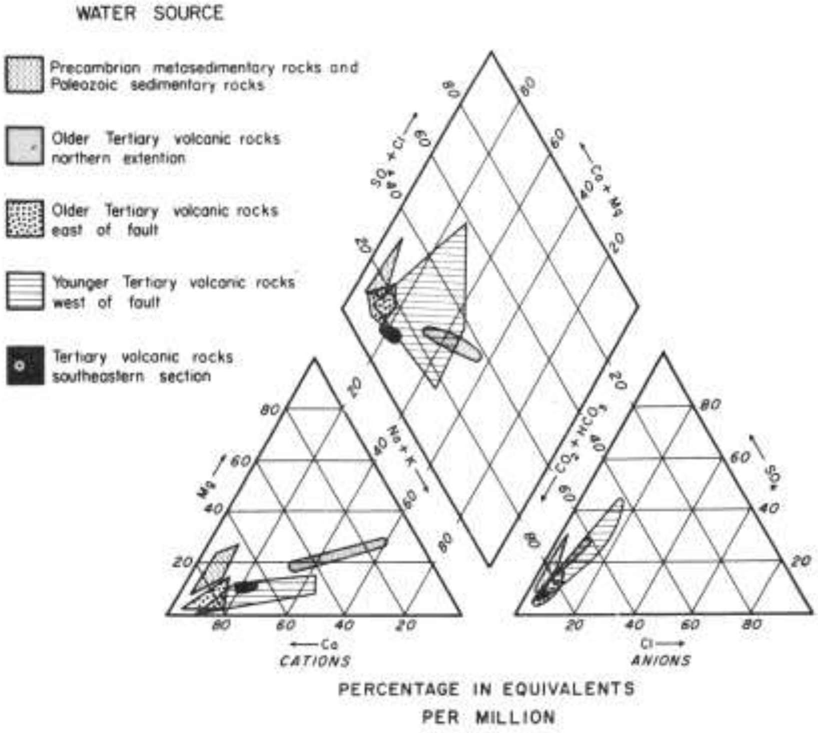

Figure 10 — Trilinear diagram of ground-water samples from the Magdalena Mountains, New Mexico, distinguished by lithologic units.

Flow-line Length

Relating compositional characteristics of ground water to the distance (or the time) that water has moved through the ground-water reservoir is difficult under the most favorable conditions. For the Magdalena Mountains the following procedure was used: We established the highest elevation of the water-table map (fig. 3) and from that point drew a line to each sample source along the shortest path that crossed the contours at right angles. This procedure probably generated the longest path that any part of the discharging water could have followed. Figures 11 and 12 illustrate diagrammatically for wells and springs the relation of this length (L) to the more probable conditions in the ground-water reservoir. As the diagram shows, the water we sampled probably followed substantially shorter paths.

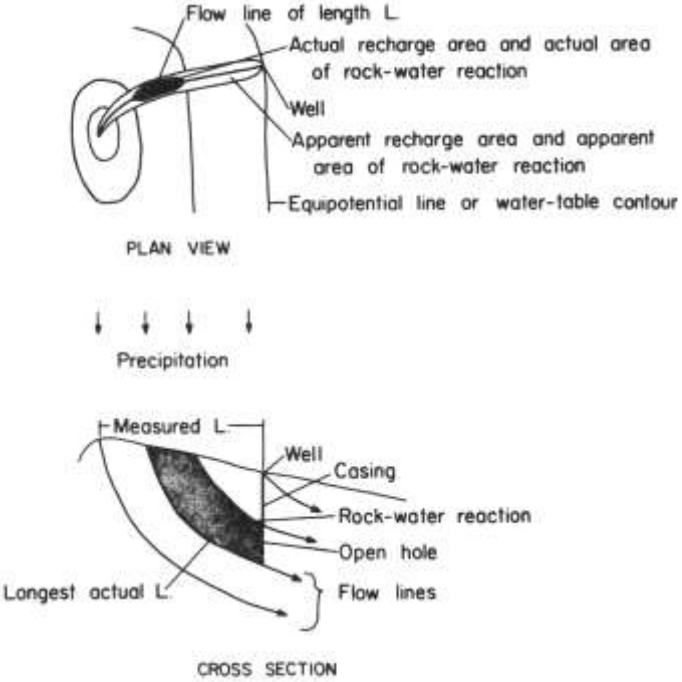

Figure 11 – Diagrammatic map and cross section through a well showing relation of recharge area and flow-line length (L) to water sample site.

Fig. 13 shows the relation between (L) and the specific conductance measured in the field. In general the specific conductance is a function of the total dissolved solids and increases with increasing values of L. The points which do not fit the general relationship can be interpreted as being specific conductance values for flow systems with much shorter flow distances than were measured by our procedure.

Rate and Mode of Discharge

Although the rate and mode of discharge influence the temperature and pH of the discharging ground water, a relation could not be recognized between discharge rate and ionic characteristics of the water. Figure 9 shows the relation of the major ions, distinguishing the discharge of wells from that of springs. Although some differences are evident among the cations, differences among the anions are minor.

Table 5 (Appendix) compares the average concentration of samples from wells in the young Tertiary volcanic rocks with those from springs. The concentration of every constituent in the water from wells is greater by a factor of about two. Much of this difference may be attributed to the location of the wells with respect to springs. The springs mark the terminus of relatively short flow lines (local flow systems); the wells are downstream from the springs and intersect more and longer flow lines (intermediate flow systems).

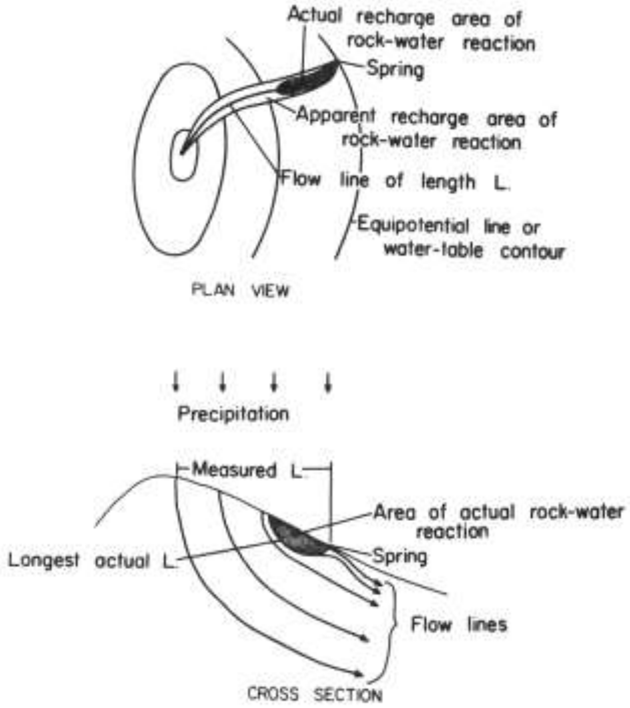

Figure 12 – Diagrammatic map and cross section through a spring showing the relation of recharge area and flow-line length to water-sample site.

Trace Elements

Twelve ions (table 3) have concentrations generally less than 1 ppm. Of these, only fluoride and strontium

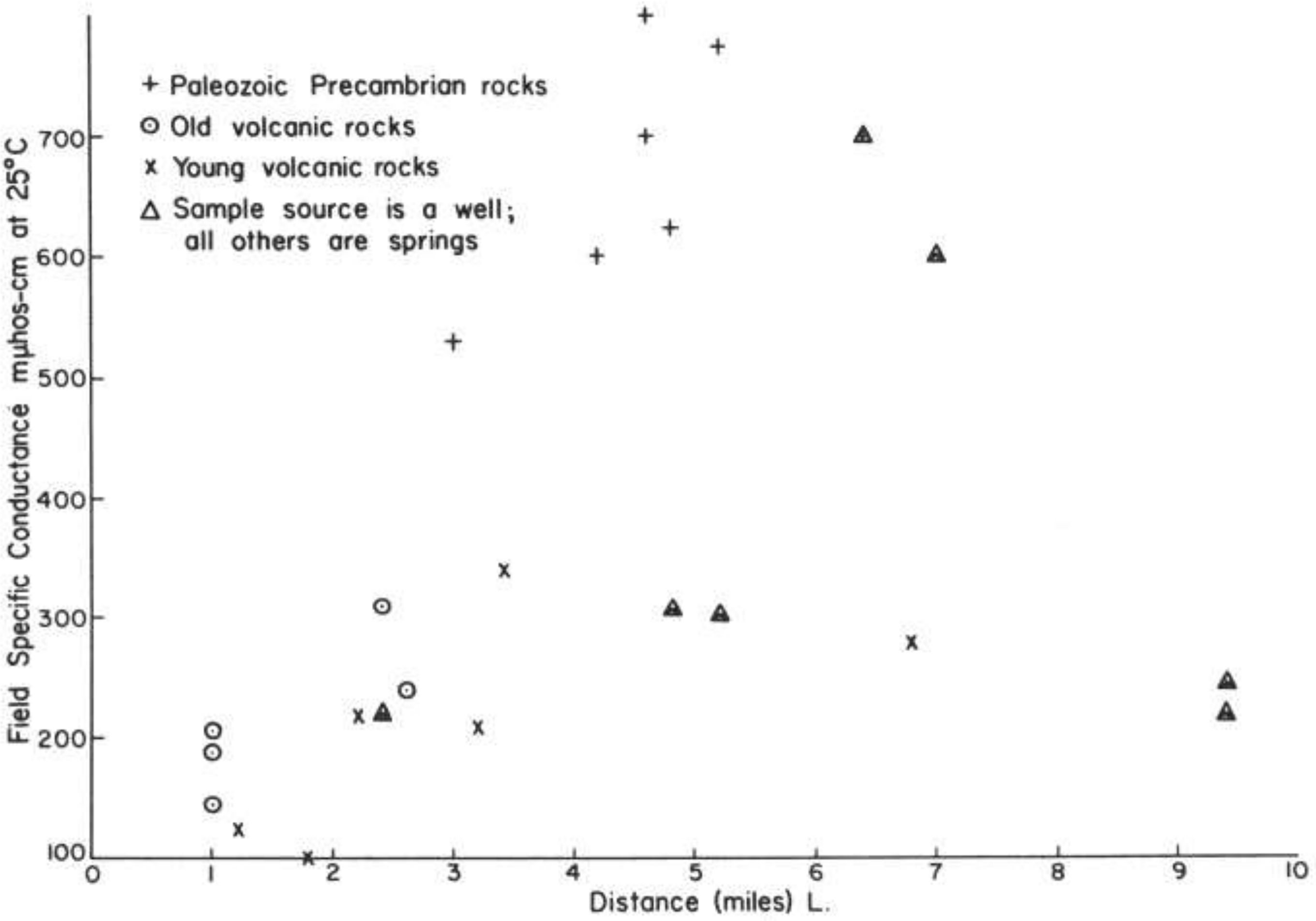

Figure 13–Relation of maximum flow-line length (L) to field specific conductance.

occurred in most samples in concentrations significantly above the limit of detectability. When the concentrations of these ions are considered in light of the variables of temperature, pH, lithology, flow-line length, and rate and mode of discharge, no significant relation can be discerned.

Lithium concentrations in the samples were low, but as the following data show, lithology plays a part in determining the observed concentrations:

Source of water sample	Li mean concentration (ppb)
sedimentary and metasedimentary rocks	2
older volcanic rocks	5
younger volcanic rocks	50

A relation could not be established with other variables.

The nitrate concentration of most samples was less than 1 ppm. In eight samples (four from wells) representing all lithologies, the concentration was 1.0 ppm, or more. Although the nitrate concentration might be from pollution, the failure of nitrate to be significant where it would be most expected (the springs that discharge slowly and are used by livestock) suggests that natural processes caused the concentrations observed.

Fig. 14 shows the location of mines in the Magdalena Mountains and the location of anomalous copper and zinc concentrations in the samples. Copper concentrations observed in all samples, except one, were at the lower limit of detectability. The exception was a sample from a spring near, and down slope, from a small copper deposit. Although several manganese deposits occur in the Magdalena Mountains, manganese concentrations in the water samples were at, or near, the lower limit of detectability.

As in the case of other low concentration ions, a relation between zinc or iron concentrations and the obvious variables could not be established. The highest zinc and iron concentrations were observed in a sample collected from a well in which anaerobic bacteria were present, and apparently feeding on a new galvanized pump column. The lesser -- but nonetheless anomalous -- zinc values of fig. 14 bear no relation to known zinc deposits. Perhaps these areas should be prospected.

The concentration of rubidium, barium, chromium and molybdenum in the water samples were at, or near, the lower limit of accuracy of our analytical procedure.

CONCLUSIONS

The source of ground water in the Magdalena Mountains is precipitation on the mountains. Our observations lead to the following conclusions relative to the characteristics of ground water in a recharge area consisting of silicic igneous rocks:

The total dissolved solid concentration is less than 500 ppm; calcium and bicarbonate are the dominant ions. In those water samples with less than 150 ppm total dissolved solids, silica is as much as 30 percent of the total.

(2) The temperature of the ground water in the reservoir increases with diminishing altitude at a rate of 0.46°C/100 feet and for the Magdalena Mountains probably ranges from 7° to 20°C.

(3) The pH of the water in the ground water reservoir is about 6.7.

(4) Lithology and flow distance have the greatest effect in the chemistry of the discharging water.

(5) The distribution of water sample sources in the Magdalena Mountains, and the solubility of metallic ions, limits, but does not preclude, the usefulness of trace element analyses for delineating areas of exploration for minerals.

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Appendix follows on page 15

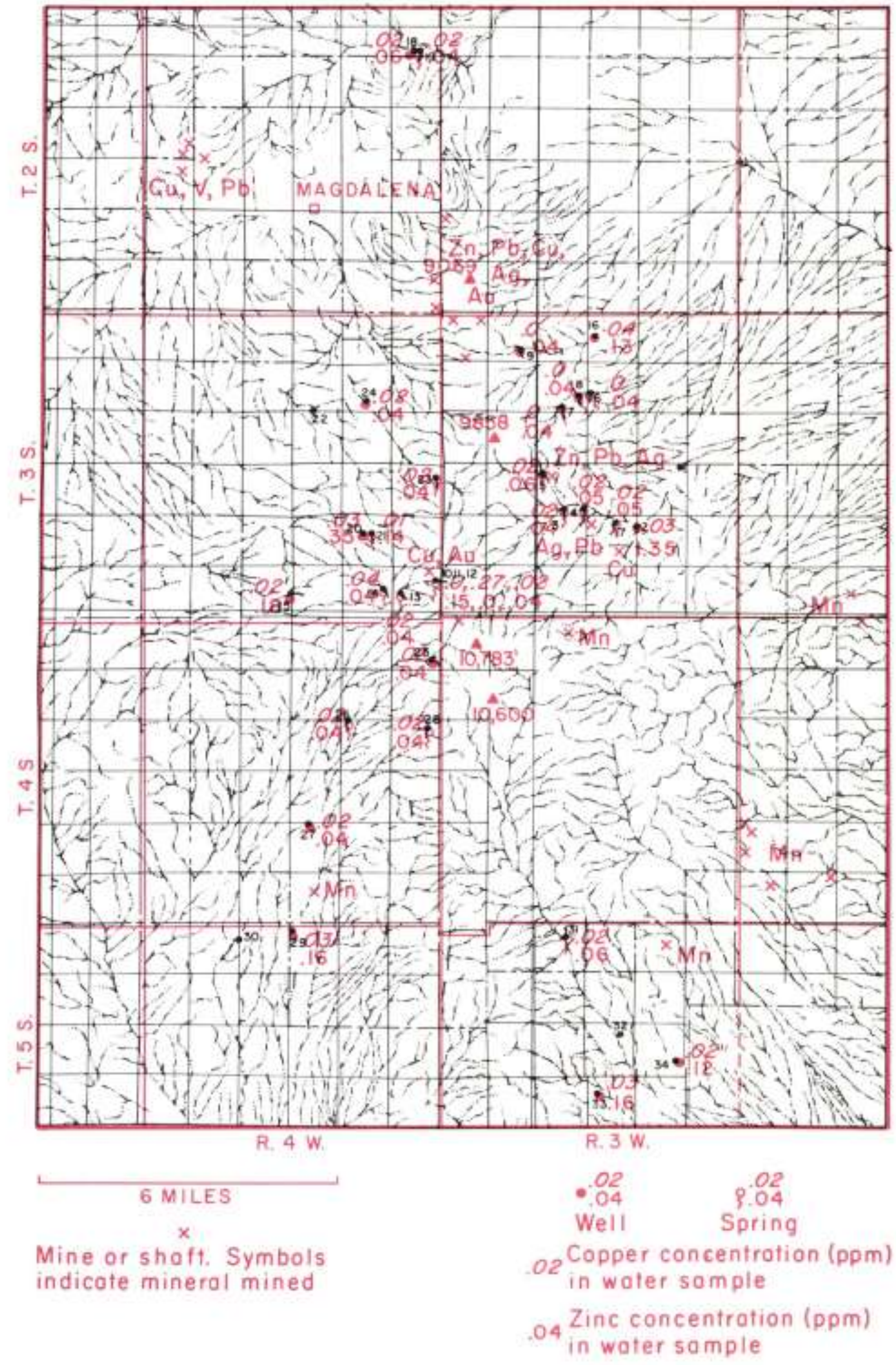

Figure 14 — Map showing the location of mines and shafts in the Magdalena Mountains, New Mexico, and the concentration of copper and zinc in groundwater samples.

APPENDIX

TABLE 1. WELLS IN THE MAGDALENA MOUNTAINS AREA, NEW MEXICO

NO.	LOCATION	ELEV. (FEET)	DATE	WATER LEVEL (FEET BELOW GROUND SURFACE)	DISCHARGE RATE (GPM)	TEMP. (°C)	DEPTH (FEET)	REMARKS
01	NWNENE 23 T03S R02W	6580	052570	43.7				WINDMILL
02	SWNWNW 26 T03S R03W	6790	052570			11.4		HAND PUMP,CHEM
16	NENWSW 03 T03S R03W	6800	060470	46.7	4 E	21.0	75	WINDMILL,CHEM
18	NWSWSE 01 T02S R04W	6120	060570	43.2	10 E	18.0		WINDMILL,CHEM
20	NESENW 26 T03S R04W	7900	060970	13.3		10.0		CHEM
22	SWSESW 10 T03S R04W	7130	061270	5.8				
24	NWNESW 11 T03S R04W	7320	061270	6.3		14.0	11	CHEM
27	NWNENW 27 T04S R04W	6900	061870	+3.0	5 E	18.0	40	WINDMILL,CHEM
29	NWSWNW 03 T05S R04W	6520	061870		1 E	25.0		CHEM
30	SWSENE 05 T05S R04W	6425	061870	9.4				
32	NESWNE 15 T05S R03W	6250	061970	139.2				
33	NESWNW 22 T05S R03W	6272	061970		5 E	23.0		WINDMILL,CHEM
34	SWNESS 14 T05S R03W	6135	061970		50	19.5	80	CHEM

E = ESTIMATE, CHEM = CHEMICAL ANALYSIS OF WATER GIVEN IN TABLE 3

TABLE 2. SPRINGS IN THE MAGDALENA MOUNTAINS AREA, NEW MEXICO

NO.	LOCATION	ELEV. (FEET)	DATE	OWNER OR NAME	DISCHARGE RATE (GPM)	TEMP. (°C)
03	SESESW 21 T03S R03W	7280	052570		20.2	10.9
04	NESESE 21 T03S R03W	7160	052570		44.9	10.8
05	NESWNW 21 T03S R03W	7740	052670		5 E	12.5
06	NWNWSW 10 T03S R03W	7080	052870		2.0	19.0
07	NWSESW 09 T03S R03W	7520	052870		11.2	11.5
08	NEWWSE 09 T03S R03W	7280	052870		13.5	14.0
09	SWNWSE 05 T03S R03W	7780				11.0
10	NESENE 36 T03S R04W	8800	053170	FRANK MAHER	4	9.0
11	NWESNS 36 T03S R04W	8780	053170	FRANK MAHER	3.2	19.0
12	SENENE 36 T03S R04W	8720	053170	FRANK MAHER	3.2	10.5
13	SESWNW 36 T03S R04W	8285	053170		1.5	11.0
14	SWSENS 35 T03S R04W	8165	053170		18.0	10.0
15	NWNESE 33 T03S R04W	7550	053173	TEXAS SPRING	4.5	19.0
17	NENWNE 27 T03S R03W	7160	060470		1.4	16.5
19	NESWSE 01 T02S R04W	6120	060570	BIRD SPRING	2 E	19.5
21	NWSENE 26 T03S R04W	7900	060970		1 E	12.5
23	NWSENE 24 T03S R04W	8000	061270	MAGDALENA MUNICIPAL WATERSHED	20 E	20.0
25	NESWSW 01 T04S R04W	8600	061670	MULESHOE RANCH	20 E	14.0
26	NWNWNW 14 T04S R04W	7370	061670	BUTTERCUP SPRING	1 E	25.0
28	SENWNE 13 T04S R04W	8080	062870	HARDY SPRING	10 E	14.0
31	NWSWNE 04 T05S R03W	6590	061970	SAWMILL SPRING	10 E	15.0

E = ESTIMATE

Table 3. Order statistics of concentration (ppm) of selected constituents in ground water from the Magdalena Mountains, New Mexico

	Number of samples in which concentration is equal to or less than value given.					
Constituent	1	8	15	22	30	Reliability
SiO_2	8.0	17.	21.	31.	57.	
Fe	0	.04	.07	.19	7.4	± .1
Mn	0	.01	.02	.04	.06	± .04
est.	9.8	32	44	69	150	
Ca obs.	14	27	45	58	120	
Mg	.1	2.5	5.0	9.8	18.	± .2
Na	2.3	7.0	12.	15.0	44.	± .2
K	.6	1.1	1.3	1.8	6.8	± .1
HCO_3	37	110	170	280	430	
SO_4	2.7	7.0	14.	36.	130.	
Cl	3	4	5	7	26	±1.
F	0.0	.02	.14	.28		± .03
Li	0.00	0.001	0.005	0.01	0.089	± .002
Rb	0.00	0.011	0.02	0.03	0.048	±0.02
Sr	0.06	0.12	0.24	0.28	0.54	±0.03
Ba	0.00	0.00	0.00	0.00	0.57	±0.5
Cr	0.00	0.00	0.01	0.02	0.04	±0.02
Cu	.01	0.02	0.02	0.02	0.27	±0.02
Zn	0.00	0.04	0.04	0.12	1.4	±0.02
NO_3	0.0	0.0	.10	.96	14.	
TDS	60	150	220	260	480	±5.
Sp Cond	90	190	260	460	720	
Lab pH	7.2	7.7	8.0	8.3		
Field pH	6.4	6.7	7.0	7.2	8.7	

TABLE 6

CHEMICAL ANALYSES OF GROUND WATER, MAGDALENA MOUNTAINS, SOCORRO COUNTY, NEW MEXICO

(CONCENTRATIONS IN PARTS PER MILLION EXCEPT SPECIFIC CONDUCTANCE (MICROMHOS/CM AT 25 DEGREES C) AND PH)

WELL OR SPRING	2	3	4	5	6	7	8	9	10	11	12
SAMPLE DATE	5-25-70	5-25-70	5-25-70	5-26-70	5-28-70	5-28-70	5-28-70	5-28-70	5-31-70	5-31-70	5-31-70
SIO2	23.	.	22.	17.	21.	17.	18.	16.	16.	.	16.
CA CALCULATED	67.	66.	69.	150.	110.	100.	123.	98.	58.	32.	23.
MG	15.	18.	18.	14.	16.	13.	16.	5.	.88	.9	.1
NA	5.5	13.	12.	13.	18.	11.	15.	5.8	7.3	7.	5.1
K	.8	1.8	1.5	1.2	1.3	1.1	1.1	1.	1.	.9	1.1
HCO3 - FIELD	260.	280.	280.	370.	400.	360.	430.	230.	150.	110.	71.
HCO3 - LAB	210.	230.	.	260.	340.	330.	330.	210.	84.	96.	56.
CO3 - FIELD	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CO3 - LAB	.00	.0	.0	.0	.0	0.	0.	0.	0.	0.	0.
SO4	19.	36.	30.	130.	53.	28.	44.	31.	7.8	2.7	6.4
CL	5.	5.	6.	10.	8.	9.	8.	7.	5.	4.	4.
TDS RESIDUE	250.	310.	290.	420.	260.	220.	230.	240.	120.	130.	100.
SP. COND - FIELD	.	.	.	.	620.	600.	700.	780.	200.	170.	140.
SP. COND - LAB	240.	420.	350.	680.	700.	700.	720.	460.	170.	180.	130.
PH - FIELD	7.1	6.7	6.9	7.1	7.2	7.3	6.9	7.2	7.2	7.1	7.2
PH - LAB	7.6	7.6	7.6	7.8	8.1	8.3	7.9	8.	7.9	8.	7.9
LI	.001	.002	.002	.002	.001	.003	.00	.00	.004	.005	.00
RB	.0	.013	.033	.026	.044	.048	.04	.007	.023	.01	.025
SR	.24	.32	.28	.35	.25	.20	.26	.15	.12	.16	.38
BA	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
CR	.01	.00	.00	.02	.01	.00	.01	.00	.00	.00	.02
MO	.1	.1	.1	.1	.1	.00	.1	.02	.01	.2	.00
MN	.06	.02	.01	.02	.01	.00	.02	.00	.02	.02	.00
FE	7.9	.0	.18	.19	.68	.00	.57	.09	.52	.13	.05
CU	.03	.02	.02	.02	.01	.01	.01	.01	.01	.27	.02
ZN	1.4	.04	.05	.06	.04	.04	.04	.04	.15	.00	.04
F	.	.	.14	.12	.08	2.	.0	.2	.0	.00	.0
NO3	.04	.03	.07	7.5	.0	.0	.0	4.6	1.6	.1	.1

WELL OR SPRING	13	14	15	16	17	18	19	20	21	23	24
SAMPLE DATE	5-31-70	5-31-70	5-31-70	6- 4-70	6-4-70	6-5-70	6-5-70	6-9-70	6-9-70	6-12-70	6-12-70
SIO2	20.	17.	30.	15.	17.	42.	8.	57.	47.	15.	46.
CA CALCULATED	47.	16.	19.	82.	100.	44.	9.8	20.	14.	34.	50.
MG	1.4	1.4	1.8	7.5	10.	9.5	9.8	2.6	3.	2.6	5.1
NA	4.9	5.	7.5	17.	14.	33.	36.	19.	14.	4.7	12.
K	1.3	1.5	1.9	1.	1.8	1.7	1.2	6.8	5.	.6	1.5
HCO3 - FIELD	56.	51.	37.	260.	320.	210.	78.	85.	85.	120.	190.
HCO3 - LAB	44.	40.	36.	20 .	190.	170.	180.	74.	76.	98.	160.
CO3 - FIELD	0.	0.	0.	0.	0.	0.	17.	0.	0.	0.	0.
CO3 - LAB	0.	0.	0.	0.	0.	4.	10.	0.	0.	0.	0.
SO4	6.8	9.7	33.	46.	56.	36.	37.	32.	5.2	2.9	14.
CL	5.	4.	7.	9.	6.	10.	10.	6.	5.	3.	5.
TDS RESIDUE	95.	100.	130.	360.	390.	310.	230.	220.	160.	150.	220.
SP. COND - FIELD	120.	100.	210.	700.	530.	320.	200.	220.	220.	240.	300.
SP. COND - LAB	120.	120.	150.	510.	580.	480.	360.	260.	190.	230.	320.
PH - FIELD	6.9	7.0	6.6	7.1	6.9	7.4	8.7	6.4	6.4	6.7	6.7
PH - LAB	7.7	7.7	7.7	.	.	8.4	8.8	8.1	8.0	7.9	7.7
LI	.00	.00	.003	.00	.007	.015	.017	.04	.01	.005	.01
RB	.021	.015	.013	.015	.011	.013	.01	.04	.04	.03	.04
SR	.07	.06	.07	.15	.4	.38	.30	.11	.09	.26	.26
BA	.00	.00	.00	.00	.00	.00	.10	.00	.25	.00	.00
CR	.01	.0	.04	.00	.00	.03	.04	.01	.00	.02	.02
MO	.0	.0	.0	.0	.0	.1	.1	.0	.1	.1	.0
MN	.00	.00	.00	.01	.02	.01	.01	.04	.04	.04	.04
FE	.05	.0	.22	.07	.0	.07	.0	.32	.40	.06	.07
CU	.02	.04	.02	.04	.02	.02	.02	.03	.01	.02	.02
ZN	.04	.04	.18	.13	.05	.06	.04	.35	.14	.04	.04
F	.0	.0	1.9	.28	.02	.7	.7	.14	.12	.05	.15
NO3	.0	.0	.0	14.	.10	12.	.96	.43	.48	.04	.09

WELL OR SPRING	25	26	27	28	29	31	33	34
SAMPLE DATE	6-16-70	6-16-70	6-18-70	6-18-70	6-18-70	6-19-70	6-19-70	6-19-70
SIO2	15.	23.	38.	18.	35.	20.	38.	36.
CA CALCULATED	16.	63.	44.	43.	76.	33.	34.	32.
MG	.8	6.8	5.1	5.	7.7	2.6	3.7	2.6
NA	2.3	15.	14.	10.	44.	7.2	14.	11.
K	1.1	4.2	2.5	1.1	3.3	1.3	3.4	2.2
HCO3 - FIELD	44.	190.	180.	170.	290.	120.	140.	120.
HCO3 - LAB	38.	160.	150.	130.	240.	100.	100.	100.
CO3 - FIELD	0.	0.	0.	0.	0.	0.	0.	0.
CO3 - LAB	0.	0.	2.	2.	2.	2.	4.	0.
SO4	8.2	7.0	7.2	9.7	46.	3.9	9.1	10.
CL	3.	8.	6.	3.	26.	4.	5.	4.
TDS RESIDUE	60.	220.	220.	180.	410.	160.	190.	160.
SP. COND - FIELD	80.	300.	300.	310.	600.	230.	240.	220.
SP. COND - LAB	90.	320.	300.	260.	600.	220.	240.	210.
PH - FIEOL	6.6	7.4	7.3	7.0	7.5	6.6	6.7	6.6
PH- LAB	7.2	8.3	8.3	8.4	8.3	8.4	8.5	8.3
LI	.006	.008	.008	.009	.025	.013	.018	.029
RB	.04	.03	.01	.02	.02	.00	.03	.00
SR	.06	.46	.39	.26	1.5	.23	.24	.21
BA	.57	.00	.00	.00	.00	.15	.00	.00
CR	.02	.02	.01	.02	.01	.02	.02	.03
MO	.1	.1	.1	.2	.2	.2	.2	.2
MN	.04	.06	.04	.04	.04	.02	.02	.02
FE	.06	.18	.10	.02	.06	.04	.28	.01
CU	.02	.02	.02	.01	.03	.02	.03	.02
ZN	.04	.04	.04	.04	.16	.06	.16	.12
F	.06	.1	.10	.02	.15	.28	.20	1.0
NO3	.04	.00	1.2	.46	.52	.00	1.0	1.3