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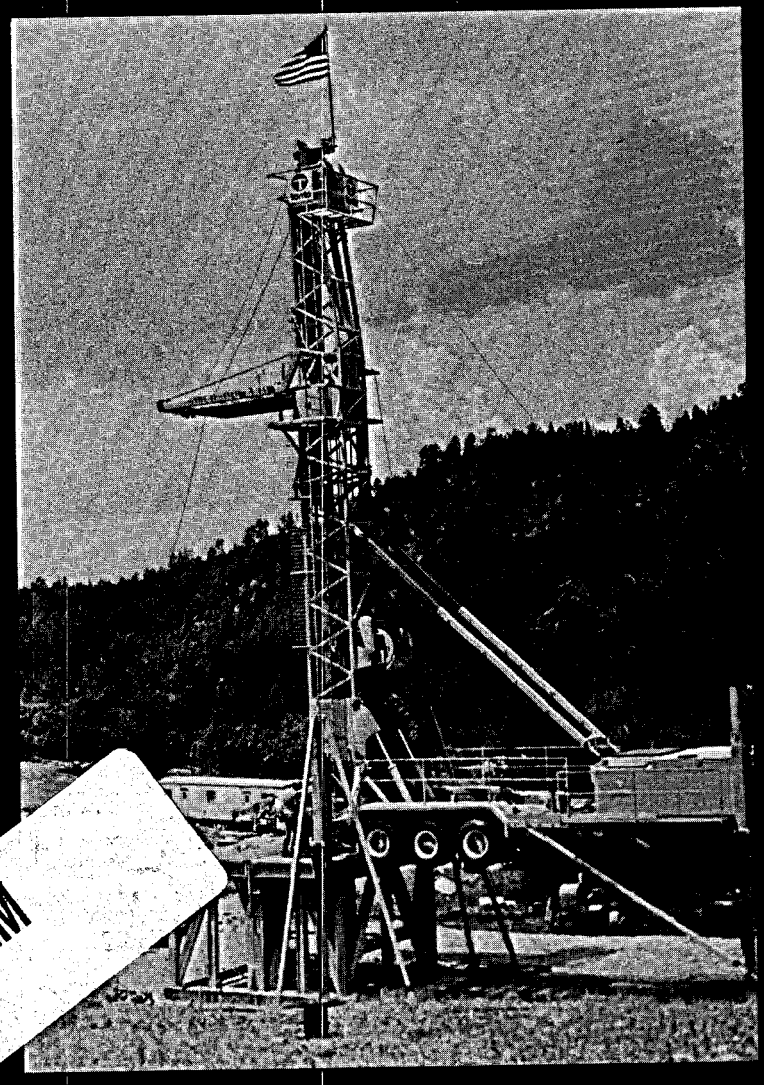
Environmental Sampling and Mud Sampling Program of CSDP Core Hole VC-2B, Valles Caldera, New Mexico



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Cover Photograph: *The Universal 5000 drill rig in operation during coring of VC-2B.*

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ENVIRONMENTAL SAMPLING AND MUD SAMPLING PROGRAM OF CSDP CORE HOLE VC-2B, VALLES CALDERA, NEW MEXICO

by

Kimberly Meeker, Fraser Goff, Jamie N. Gardner,
Patricio E. Trujillo, and Dale Counce

ABSTRACT

An environmental sampling and drilling mud sampling program was conducted during the drilling operations of Continental Scientific Drilling Program (CSDP) core hole VC-2B, Valles caldera, New Mexico. A suite of four springs and creeks in the Sulphur Springs area were monitored on a regular basis to ensure that the VC-2B drilling program was having no environmental impact on water quality. In addition, a regional survey of springs in and around the Jemez Mountains was conducted to provide background data for the environmental monitoring. A drillling mud monitoring program was conducted during the operations to help identify major fluid entries in the core hole.

The environmental data clearly demonstrate that there was no impact on the surface hot spring system and the surrounding watershed by VC-2B drilling operations. In addition, several interesting chemical and isotopic trends related to summer storms and seasonal variations were revealed by the regular collection of surface waters in the Sulphur Springs area.

Some of the water entries defined by the mud monitoring program at depths below 215 m correlate with fractured zones and permeable horizons visible in the core samples. Chloride concentration proved to be a reliable indicator of possible fluid entries in the mud returns. Chloride enrichment (119 mg/kg) in mud returns from 1676 m in the Precambrian section may be an indication of a slightly overpressured zone at this depth and provides preliminary evidence for hydrothermal fluids existing at depth in core hole VC-2B.

I. INTRODUCTION

Core hole VC-2B, the third CSDP core hole in the Valles caldera, was drilled in the Sulphur Springs area (Fig. 1) roughly 1 km northeast of core hole VC-2A. A total depth of 1762 m (5780 ft) was reached and bottom-hole temperature was approximately 295°C (565°F).

The VC-2B core hole was a collaborative effort among Los Alamos National Laboratory, Sandia National Laboratory Geoscience Research Drilling Office (GRDO), and the University of Utah Research Institute. Tonto Drilling Services of Salt Lake City, Utah, performed the coring operations by subcontract to GRDO. Nearly 100% core recovery by Tonto Drilling Services provided a continuous, undisturbed record of the Valles intracaldera ignimbrite sequence and underlying precaldera units, including the Tertiary Santa Fe Sandstone, the Abo and Yeso Formations (Permian), the Madera Limestone and Sandia Formation (Pennsylvanian), and the Precambrian basement.

A chief objective of VC-2B, among a wide range of scientific investigations, is the physical and chemical characterization of the four principal components of the active, high-temperature, Sulphur Springs hydrothermal system: (1) the deep, hot conductive zone; (2) the liquid-dominated zone; (3) the boiling transition zone; and (4) the vapor cap. This objective incorporates a complete study of fluid-rock interaction and ore mineralization within the Valles hydrothermal system. A second major objective is to provide insight into the magmatic history and eruption mechanisms involved in the development of the Valles caldera.

The purpose of this report is to provide a data base from the environmental and mud monitoring programs that were conducted throughout the drilling of VC-2B. A suite of four springs and creeks in the Sulphur Springs area was monitored on a regular basis to ensure that the VC-2B drilling program was having no environmental impact on near-surface waters. In addition, a regional survey of springs in and around the Jemez Mountains was conducted to provide background data for the environmental monitoring. Finally, a drilling mud monitoring program was conducted during the operations to help identify major fluid entries in the core hole.

II. GEOLOGIC SETTING

The geology of the Jemez Mountains and the evolution of the Valles caldera have been widely discussed in the literature since Smith et al. (1961). More recent publications include Heiken and Goff (1983), Nielson and Hulen (1984), Heiken et al. (1986), Gardner et al. (1986), Self et al. (1986), Aldrich (1986), Stix et al. (1988) and Turbeville and Self (1988). The Valles caldera

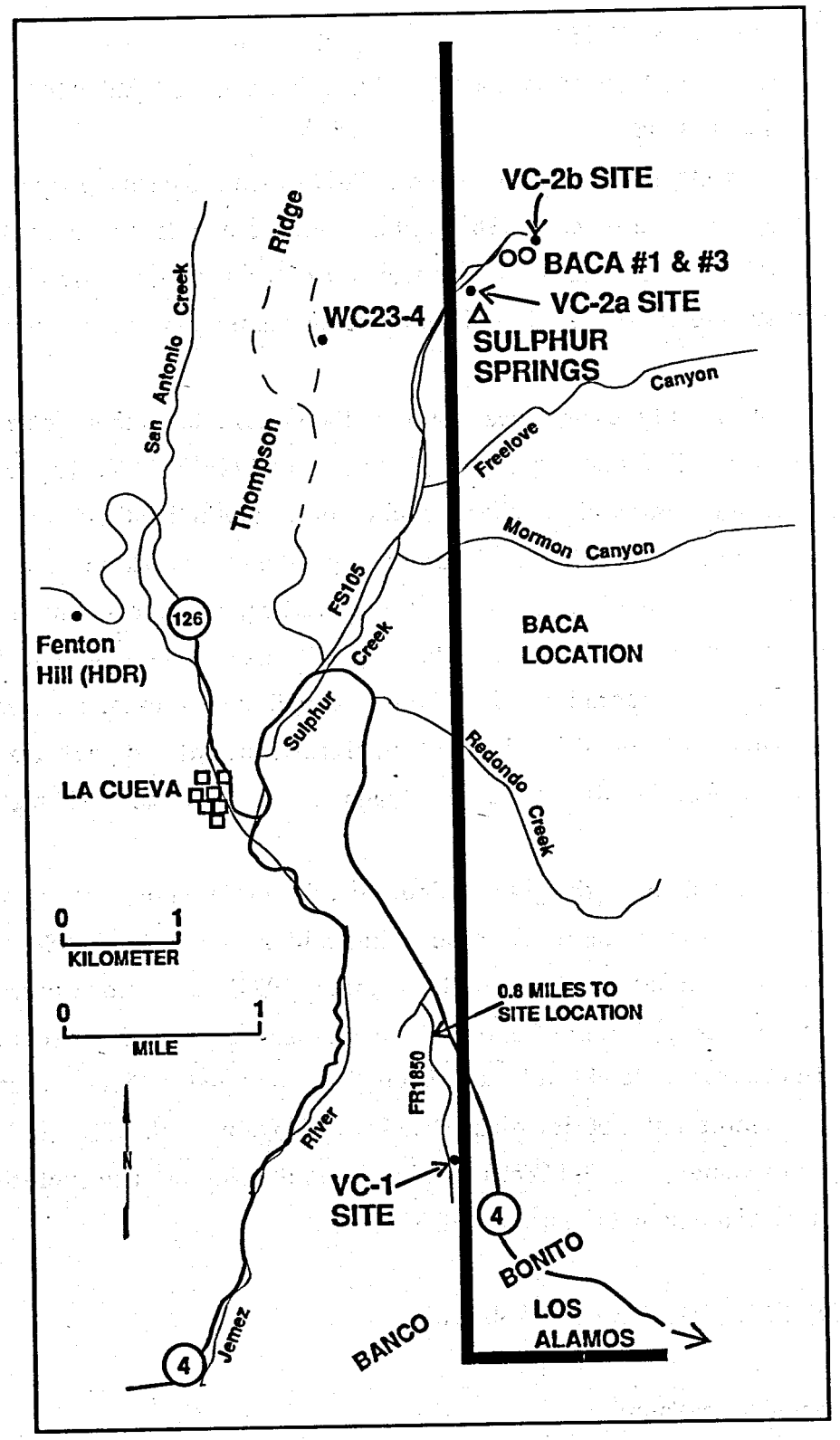

Fig. 1.
Location map of Sulphur Springs area and core holes VC-1, VC-2A, and VC-2B.

(1.12 Ma), the Toledo caldera (1.45 Ma), and the associated Bandelier Tuff are the most well known features of the Jemez Mountains volcanic field, which erupted basaltic through rhyolitic rocks between >13 and 0.13 Ma.

Evidence for hydrothermal alteration in the Valles caldera has been clearly demonstrated (Hulen and Nielson, 1986; Charles et al., 1986; Keith, 1988), and a hydrothermal outflow plume has been recognized by Goff et al. (1988) as characteristic of the active geothermal system. This outflow plume appears to be controlled by the northeast-trending Jemez fault zone within San Diego Canyon.

Several thermal water types have been found in the Valles caldera that are geochemically and isotopically distinct (Goff and Grigsby, 1982; Vuataz and Goff, 1986). Thermal meteoric waters are chemically and isotopically similar to cold groundwater in that they have low chloride and other trace element concentrations and isotopically fall on the world meteoric water line. Acid-sulfate waters form by surface mixing of cold groundwater with condensed steam from boiling at depth, and with SO_4 (from oxidation of H_2S). Isotopically, acid-sulfate waters commonly show effects of evaporation. Fluid from a deep, liquid-dominated reservoir and its derivatives are generally neutral in pH, contain significant chloride and trace element concentrations, and are isotopically enriched in oxygen-18 relative to the world meteoric water line.

At least two subsystems of the greater Valles geothermal system, Redondo Creek and Sulphur Springs, have been recognized in the Valles caldera (Goff et al., 1988). Smith and Kennedy (1985), White (1986), and Truesdell and Janik (1986) have also recognized subtle variations in fluid types within the Redondo Creek reservoir. Other geochemically and isotopically distinct hydrothermal fluids have been recognized in the Precambrian basement rocks beneath the Fenton Hill hot dry rock (HDR) site (Grigsby et al., 1984) and within the western ring fracture zone (WC 23-4 Well) (Goff et al., 1988) (Fig. 1). The evolution of these relatively saline fluids has still not been resolved.

III. SAMPLING PROCEDURES AND ANALYSIS

A. Environmental Water Sampling

A basic suite of four samples was collected from springs and creeks in the Sulphur Springs vicinity (Fig. 2) and from regional springs in the Jemez Mountains: (1) a 125-ml bottle of filtered,

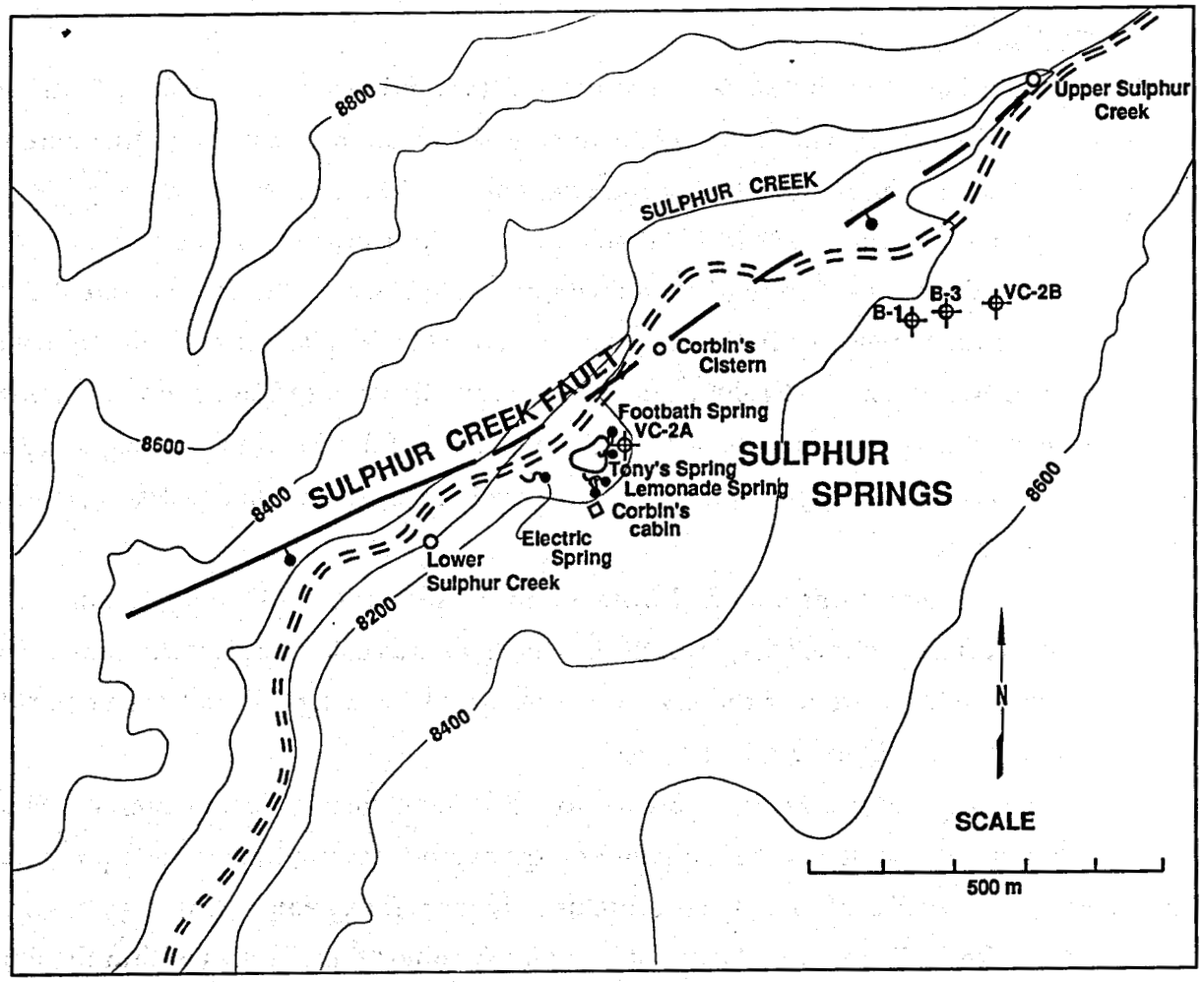

Fig. 2.
Map of environmental sampling locations within the Sulphur Springs area.

unacidified water for anions; (2) a 125-ml bottle of filtered, acidified water for cations; (3) a 500-ml glass bottle of unfiltered water for tritium analysis; and (4) a 30-ml glass bottle of unfiltered water for stable isotope analysis. Samples were filtered using a hand-operated vacuum pump and 0.45-μm filter paper. Cation samples were acidified in the field to a pH <2 with concentrated HNO_3.

Chemical analyses were performed at Los Alamos National Laboratory as described by Trujillo et al. (1987). Deuterium and oxygen-18 isotope analyses were performed by Jim Borthwick at the Stable Isotope Laboratory, Southern Methodist University, Dallas, Texas. Tritium analyses were performed by H. Gote Ostlund at the Tritium Laboratory, University of Miami, Florida.

B. Drilling Mud Sampling

Mud monitoring of core hole VC-2B began after the second casing string was cemented at about 213 m (700 ft) (Fig. 3). Goff et al. (1985) noted low formation pressures in surrounding geothermal wells to depths of 450 m (137 ft), and data from VC-2A verified that a low-pressure vapor zone extended to 240 m (787 ft) (Goff et al., 1987). Unfortunately, lost circulation in a highly faulted and fractured zone of ignimbrite between 232 and 296 m (760 and 970 ft) prevented systematic monitoring in this interval. At 325 m (1068 ft), lost circulation materials were pumped down the hole. Circulation was temporarily restored but soon lost again. Continuous mud returns were not obtained until emplacement of the third casing string to 637 m (2090 ft). Below this depth, samples were collected every 30 m and/or when penetrating faulted or heavily veined zones.

Mud make-up water was obtained from Sulphur Creek about 200 m upstream of the VC-2B site. Water from the creek and from the holding tank was continuously monitored. The average chloride concentration in these waters was 1.6 ± 0.3 mg/kg. The average chloride concentration in fresh mud mix was 4.2 ± 1 mg/kg.

Monitoring the mud geochemistry proved to be a difficult task for several reasons. First, the "liquid-dominated reservoir" of the Sulphur Springs hydrothermal system is underpressured (Dondanville, 1978; Goff et al., 1987) and contains only moderately concentrated geothermal fluids (5300 mg/kg TDS), making it difficult to identify minor fluid entries within the mud returns. Geochemical monitoring was further hindered by continuous addition of fresh mud. As the hole deepened and temperatures rose above about 225°C, the polymers in the mud broke down, causing a loss of viscosity and lubricity (Lysne and Jacobson, in press). Increasingly, the mud began to break down into two phases: a viscous phase and a watery phase. In order to alleviate the viscosity problem, several experimental mud mixes and drilling lubricants were pumped downhole. Fresh mud was continuously monitored during this period, and K, SO_4, Li, SiO_2, Mg, and HCO_3 show variable concentrations in the fresh mud mix as a function of mud type. Diesel oil, possibly used as a lubricant in the high-temperature conditions near the bottom of the hole, was noted in some mud samples, making them difficult to analyze. However, chloride remained consistently low in the mud mix, making it an excellent tracer and the most reliable indicator of relatively chloride-rich fluid entries.

Because of the difficulty of filtering the highly viscous mud, a 500-ml bottle of raw unfiltered, unacidified mud was collected for analysis. Filtering was performed in the laboratory, and chemical analysis was performed on a limited suite of ions.

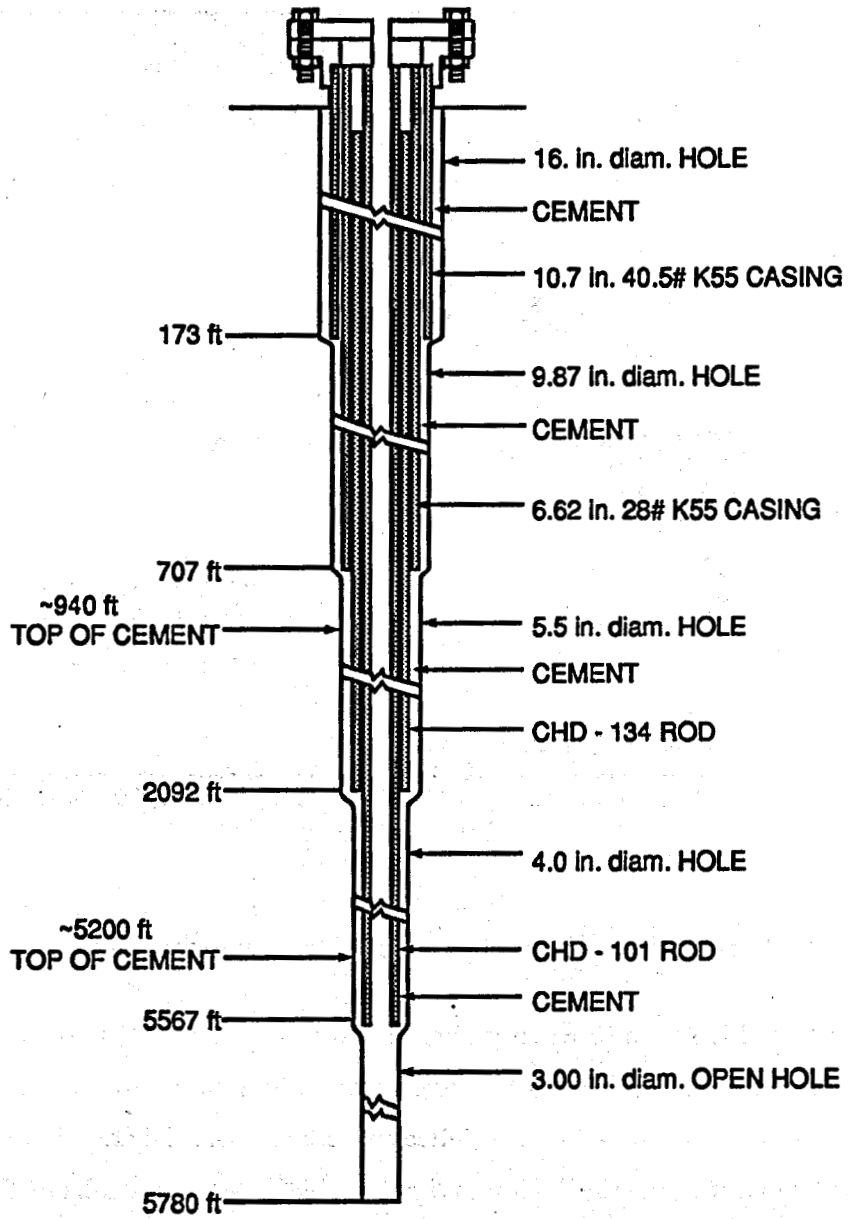

Fig. 3.
Diagram of VC-2B core hole configuration (from Lysne and Jacobson, in press).

IV. RESULTS

The results of the environmental sampling program are presented in Tables A-I - A-V in the Appendix. A regional survey of springs in the Jemez Mountains is included with the suite of samples collected from sites in the Sulphur Springs area. Figure 4, a boron vs chloride plot of regional waters, displays the trend that is repeated for most conservative elements in the survey.

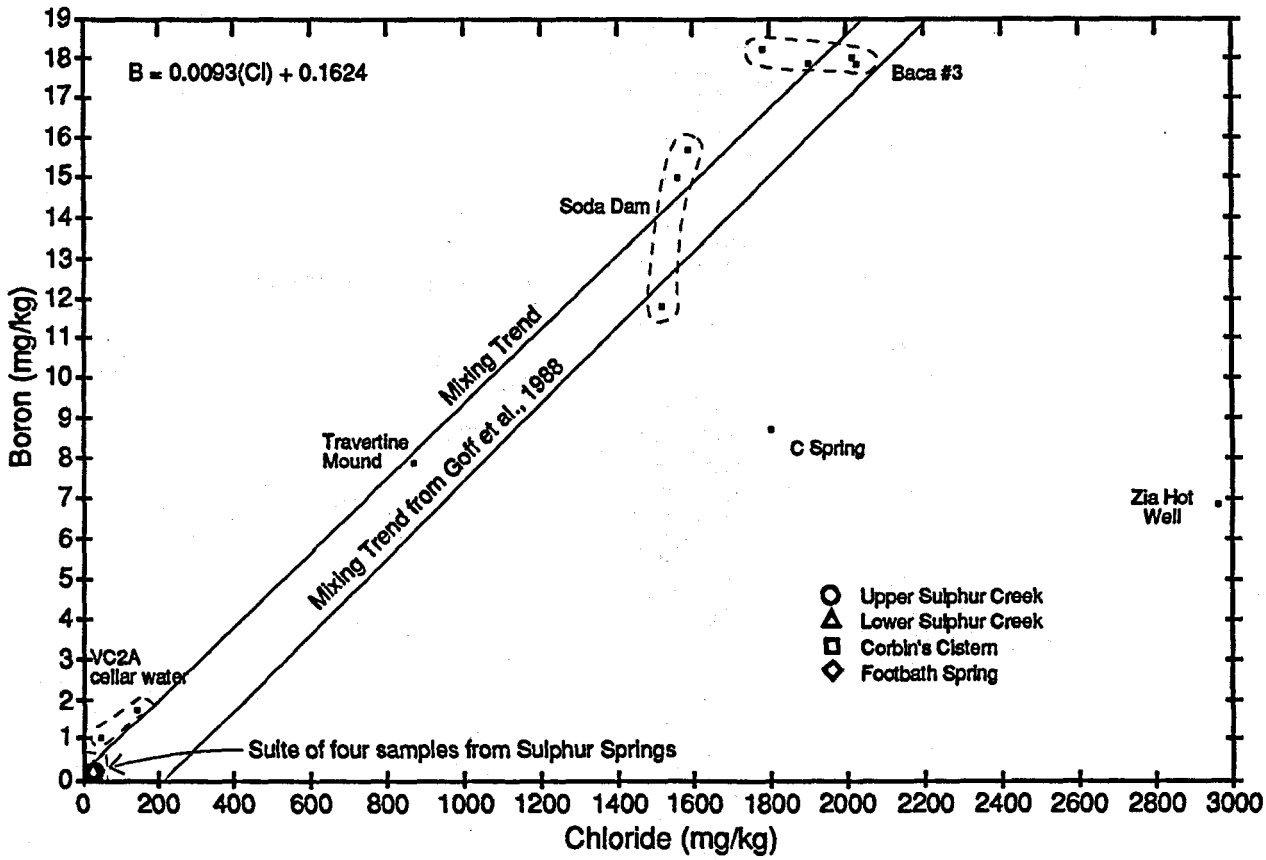

Fig. 4.
Plot of chloride vs boron in Valles caldera regional waters.

Fluids from the San Ysidro area (C Spring and Zia Hot Well) are distinctly more saline with respect to other elements. These fluids are derived from interaction with evaporite sequences in the San Juan Basin and are unrelated to the Valles caldera fluids. The chemistry of these waters has been discussed by Goff et al. (1981), Goff and Sayer (1980), Mariner et al. (1977), Trainer (1974, 1975), and Vuataz and Goff (1986). Other waters such as Soda Dam and Travertine Mound are derivative waters of the deep geothermal system of Valles caldera (Vuataz and Goff, 1986) that emerge along the trace of the Jemez fault zone and define a mixing line with the more concentrated fluids from the caldera represented by fluids from Baca #3. These fluids show the predicted positive oxygen-18 shift due to rock-water isotope exchange (Fig. 5).

Figure 6 demonstrates the relatively negative correlation between tritium and chloride contents of most thermal springs in the region. Tritium, which has a half-life of 12.43 years, is an excellent tracer for shallow groundwater flow (Vuataz and Goff, 1986). The tritium content of all chloride-rich waters is < 2 T.U., indicating that these waters are derived from deeply circulating

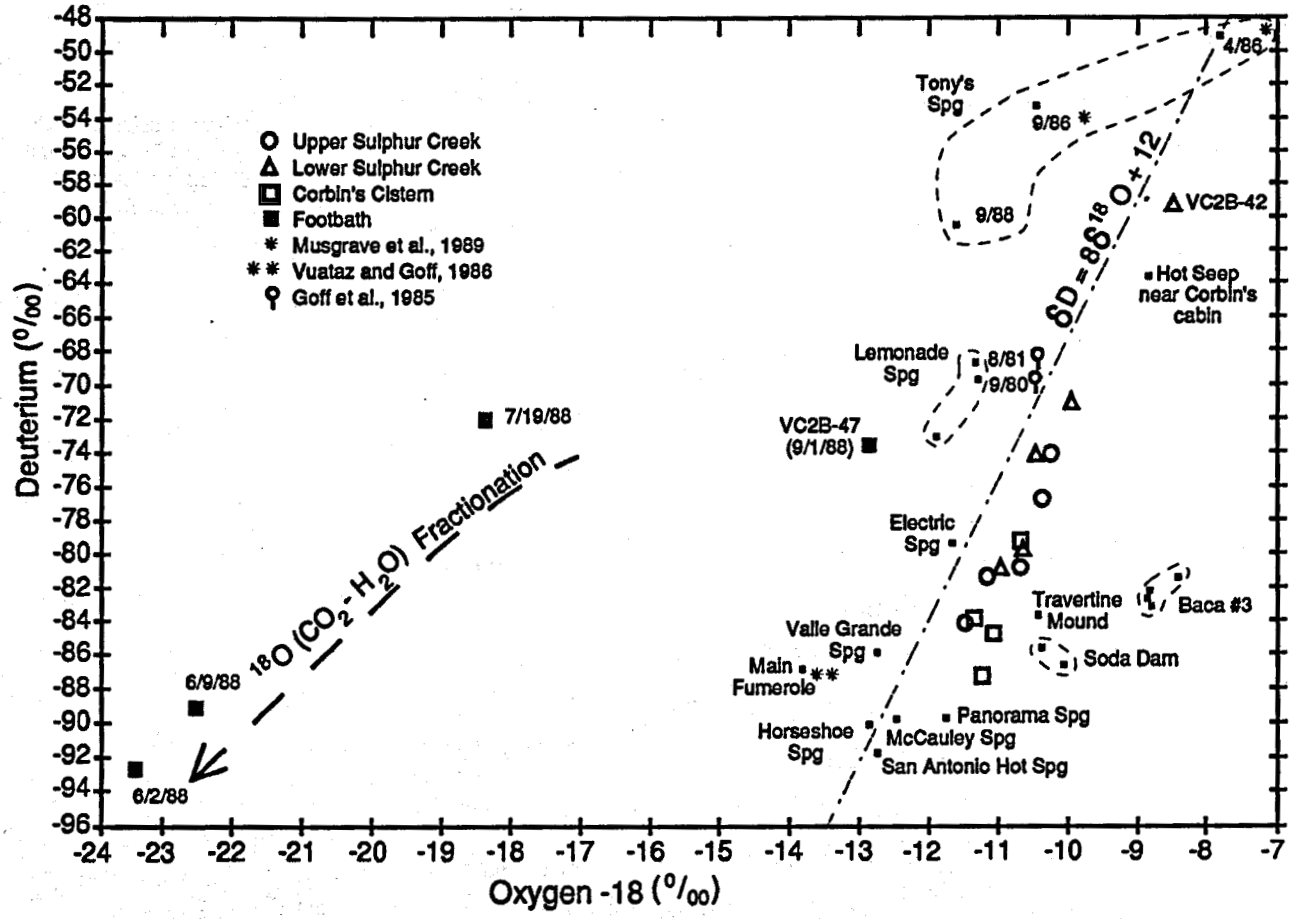

Fig. 5.
Plot of oxygen-18 vs deuterium in Valles caldera regional waters.

water >50 years old. Relatively low chloride and tritium waters (San Antonio Creek, San Antonio Hot Springs, Valle Grande Spring, Bathhouse Spring) imply a relatively old source of shallow groundwater for these springs. Footbath Spring appears to be composed of varying mixtures of condensed steam (originating from a deep source) and near-surface waters. Figure 6 portrays how Footbath becomes increasingly dilute and enriched in tritium with the onset of the summer storm season.

For environmental monitoring purposes, the suite of four creeks and springs in the Sulphur Springs area was sampled on a regular basis. Plots of boron vs chloride (Fig. 7) and lithium vs chloride (Fig. 8) demonstrate that VC-2B drilling operations had no effect on the chemistry of these waters. Table A-V shows the variation with time throughout the drilling period for major elements in the basic suite of springs and creeks. With the exception of Corbin's Cistern and Footbath Spring early in the summer, chloride concentrations of most samples remained less than 3 mg/kg.

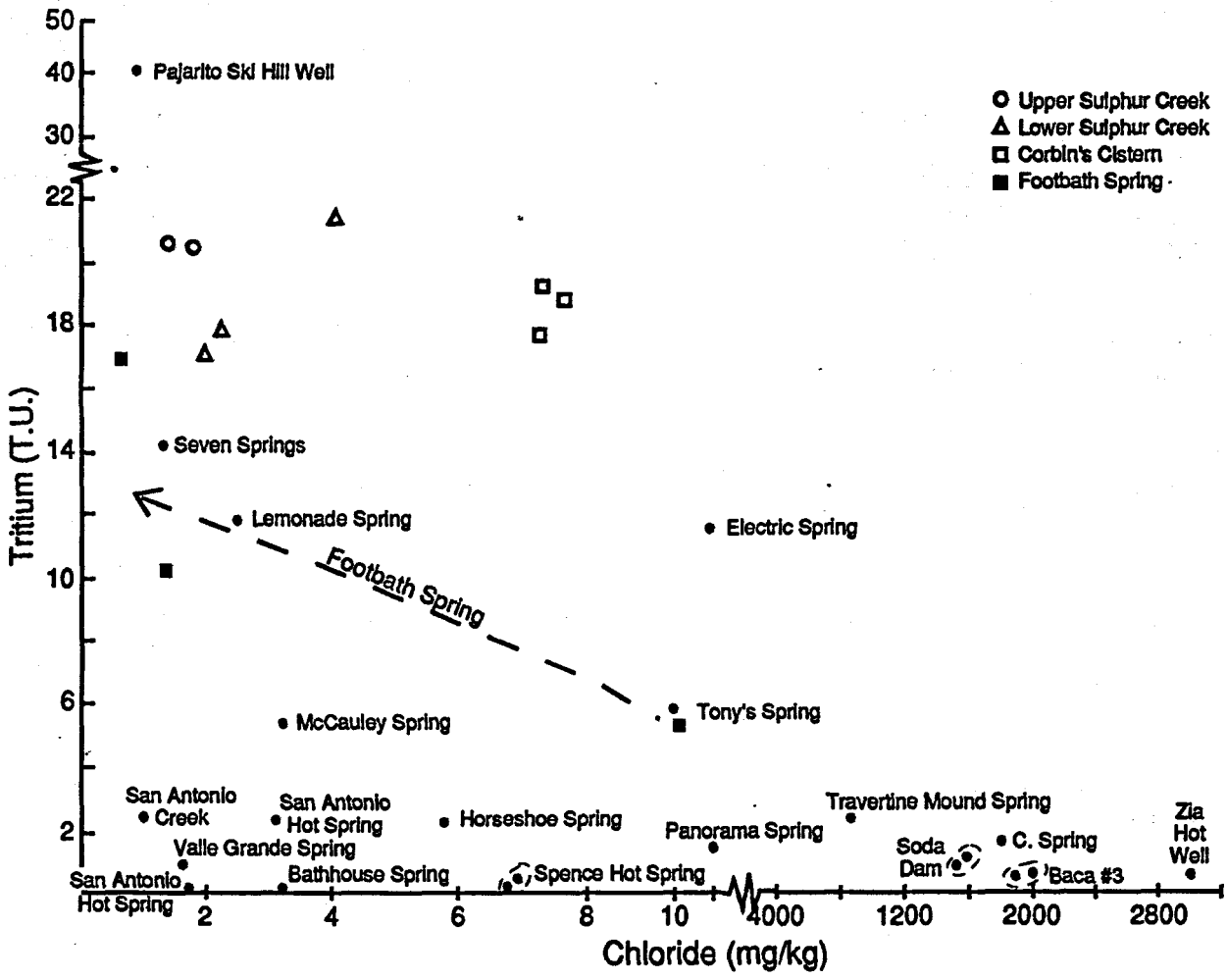

Fig. 6.
Plot of chloride vs tritium in Valles caldera regional waters.

An interesting seasonal variation is portrayed in Figs. 9 and 10. Sodium and total aluminum are plotted against time to demonstrate the effect of seasonal rainfall on surface water chemistry. Sodium is most representative of neutral pH waters, whereas aluminum is a reliable indicator for acidic waters. Footbath Spring shows a significant drop in sodium by late June; however, the most dramatic changes in chemistry for Sulphur Creek and Footbath are seen following heavy rains (days 72 and 94) in August and September. A storm around day 94 precipitated 4 inches of rain in 3 days and diluted Footbath by 70%. Corbin's Cistern water displays higher total dissolved solids in general, indicating that it may derive from a slightly deeper aquifer. As expected, Corbin's Cistern shows a delayed and less significant response to rainfall.

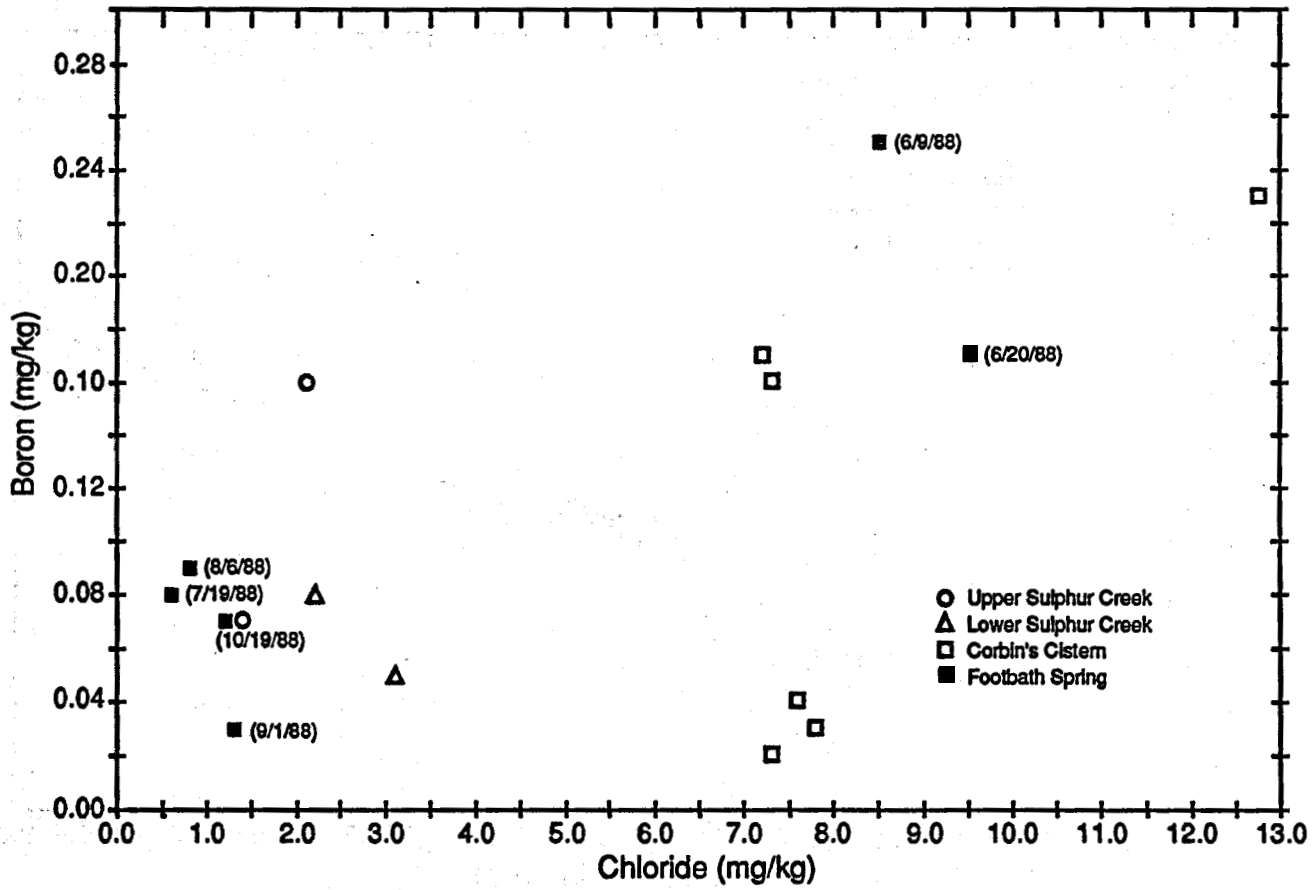

Fig. 7.
Plot of chloride vs boron in environmental water samples collected in the Sulphur Springs area.

Footbath Spring, an open, relatively cool (<30°C) mud pot, vigorously degasses CO_2 and is depleted in oxygen-18, probably because of exchange between CO_2 and H_2O (Vuataz and Goff, 1986). Footbath is most evaporated at the beginning of the summer (6/2/88) when it shows the greatest effect of CO_2 - H_2O fractionation (Fig. 5). Footbath is also the most concentrated in chloride and trace elements at this time (Figs. 6 and 7). CO_2 - H_2O fractionation appears to override the effect of Raleigh distillation by evaporation. With increasing dilution from summer storms, Footbath isotopically approaches the meteoric water line. Sample VC2B-47 at Footbath was collected immediately following a late summer storm (day 94) and may be explained by sudden dilution with meteoric water. Lower Sulphur Creek also appears to respond to the summer meteoric influx with systematic increases in deuterium values that parallel the Jemez Mountain meteoric water line. Sample VC2B-42 (Fig. 5) was collected at Lower Sulphur Creek during a storm (day 72) in which the creek flow rate exceeded 100 l/min in contrast to its normal 50-60 l/min. This sudden influx of meteoric water is reflected in the erratic enrichment of deuterium and oxygen-18 for VC2B-42 in Fig. 5.

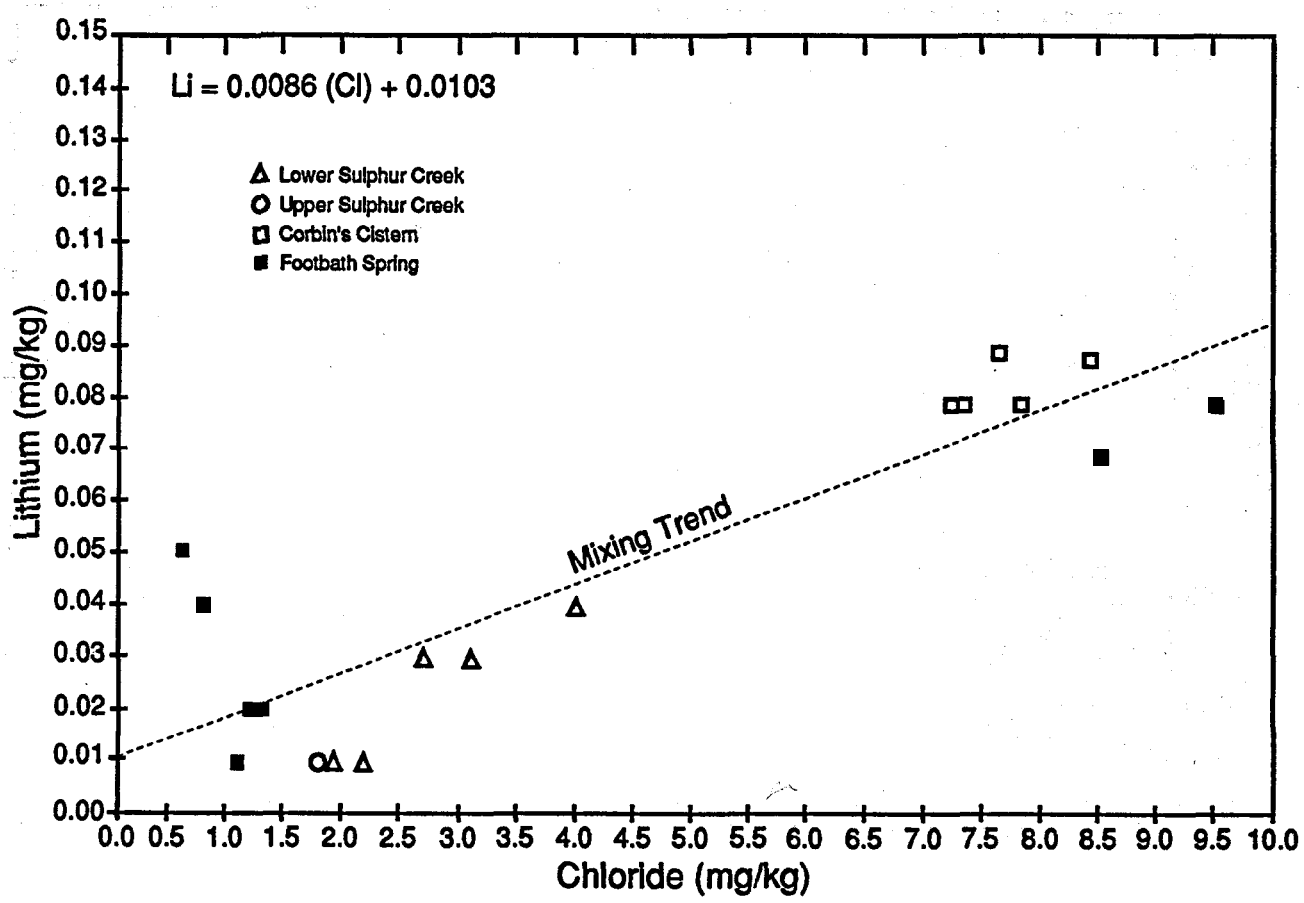

Fig. 8.
Plot of chloride vs lithium in environmental water samples collected in the Sulphur Springs area.

Clearly, some interesting chemical and isotopic trends were revealed by regular collection of waters in the Sulphur Springs area. However, for the purpose of this report, the data demonstrate that VC-2B drilling operations had no impact on the surface hot spring system and the surrounding watershed and confirm that drilling mud wastes were well contained.

Tables A-VI and A-VII present the data obtained from all VC-2B mud samples. Because of good control on background chloride, this ion is the most sensitive indicator of geothermal fluid entries. Figure 11 compares chloride concentration to the general stratigraphy of VC-2B. Possible fluid entries are indicated by small chloride enrichments in the mud returns from the base of the Lower Tuffs [640-792 m (2100-2600 ft)] and in the Abo Formation [1158-1219 m (3800-4000 ft)]. However, the most distinct increase in chloride concentration (119 mg/kg) is observed in the Precambrian section at about 1676 m (5500 ft), before the cementing of the final casing string.

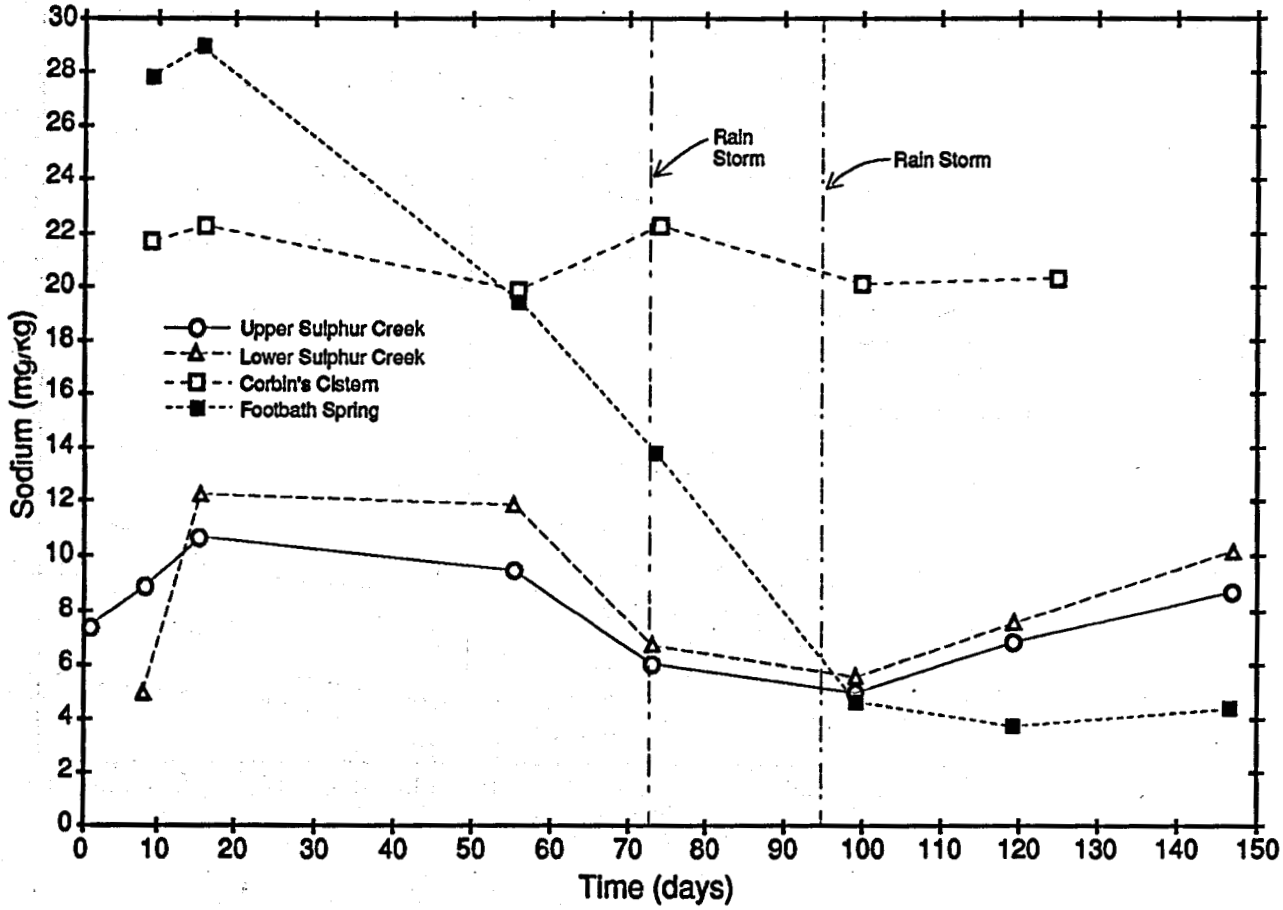

Fig. 9.
Plot of sodium vs time for environmental water samples collected in the Sulphur Springs area.

Other ions show greater variability with depth, particularly lithium (Fig. 12), which may be controlled by other factors such as the lithium concentration in the initial mud mix. Silica (Fig. 13) also shows large fluctuations with depth and may be responding to changes in temperature, lithology, and variable concentrations in the fresh mud and in the cement used for casings. However, the largest silica concentrations are found in a veined and fractured zone at the base of the Abo Formation [1310 m (4300 ft)] and near a fracture zone in the Precambrian section [1679 m (5510 ft)]. Silica enrichments may be indicative of fluid entries.

Calcium and magnesium (Fig. 14), and HCO_3 enrichments through the Yeso/Abo Formations and Madera Limestone, may result from the mud interacting with these calcite-bearing units. However, both calcium and magnesium are highly enriched along with chloride and silica in the Precambrian [around 1676 m (5500 ft)], giving further evidence for a much more concentrated fluid entry at this depth.

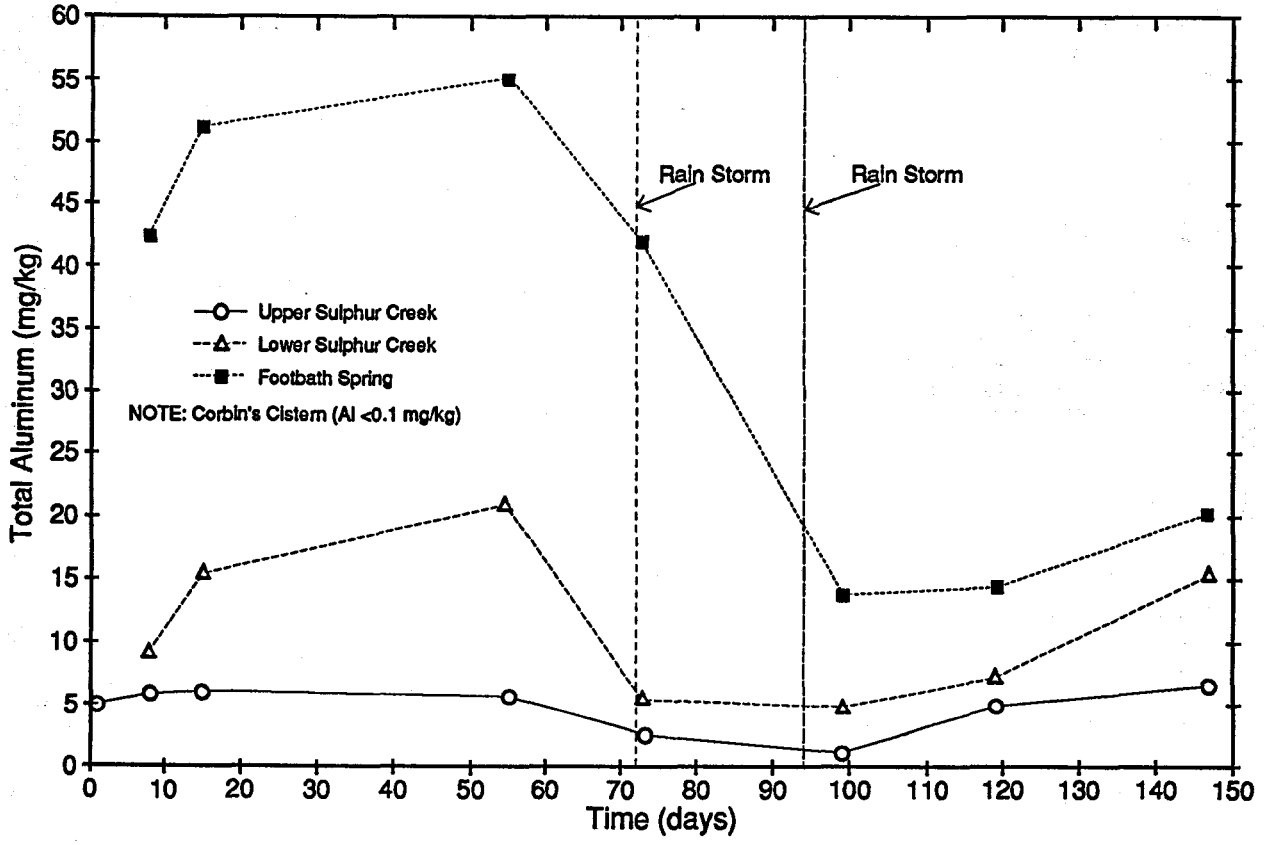

Fig. 10.
Plot of aluminum vs time for environmental water samples collected in the Sulphur Springs area.

V. CONCLUSIONS

In conclusion, the environmental monitoring program successfully assured that the VC-2B drilling program had no environmental impact on the Sulphur Springs watershed and provided interesting information on seasonal variations of the Sulphur Springs fluids.

The mud monitoring program showed that some ions, particularly chloride, were reliable indicators of fluid entries. Some of the water entries defined by the mud monitoring program correlate with fractured zones and permeable horizons in the core samples (Hulen and Gardner, 1989). Below 637 m (2090 ft) we maintained about 80% mud returns, which is unusual for drilling conditions in the Valles caldera. Water was observed bubbling up with the drilling mud at about 1706 m (5500 ft), although this could have been related to the separation problem mentioned above or to the cementing job that occurred just above this point. This limited evidence and the chloride-enriched mud returns at 1676 m (5500 ft) may be indicative of a slightly overpressured zone at depth that, to date, has only been observed in other wells completed into Precambrian rocks in the caldera region.

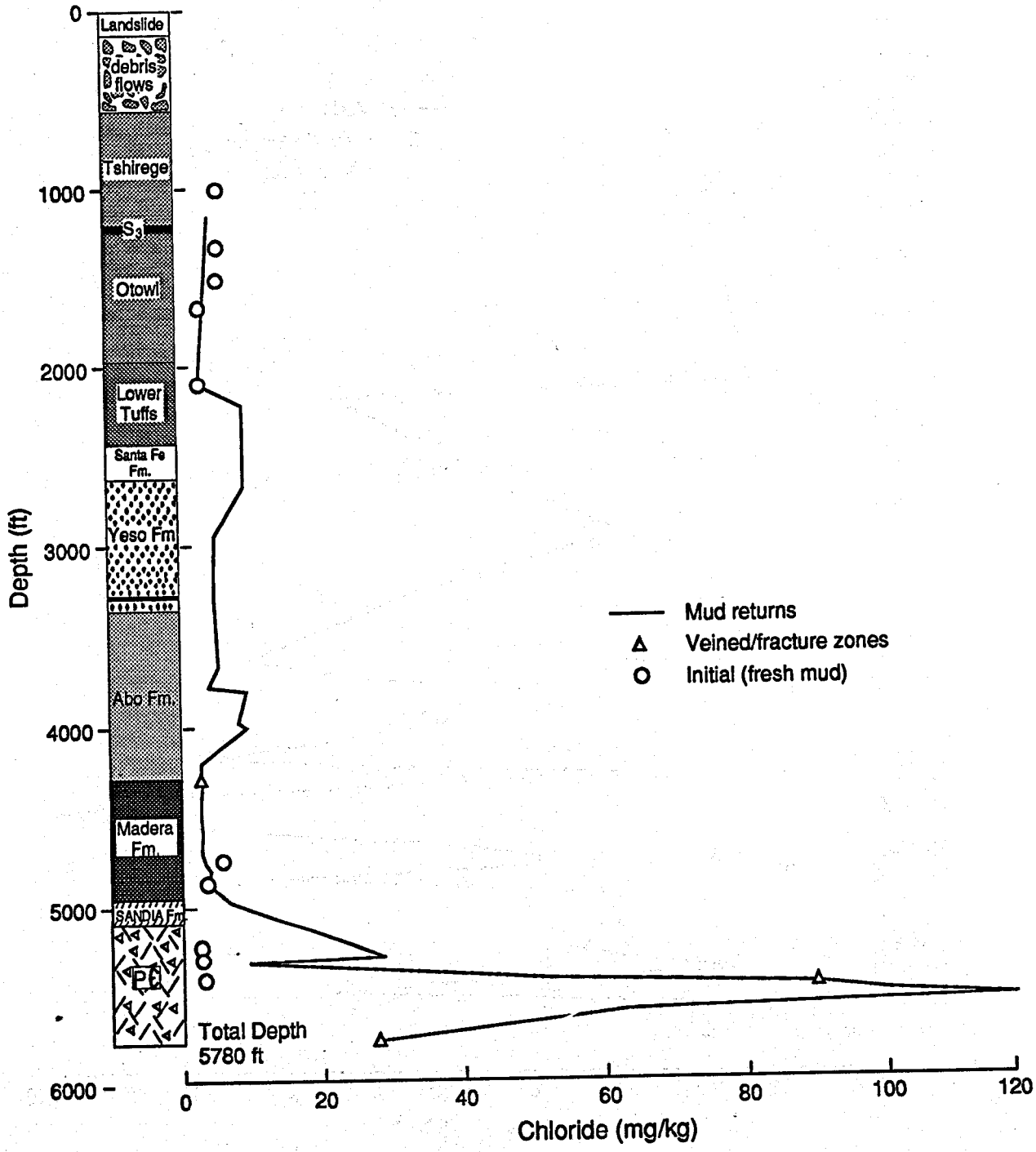

Fig. 11.
Plot of chloride concentration vs depth in drilling mud returns from core hole VC-2B. Chloride concentrations in initial mud mix are represented by triangles.

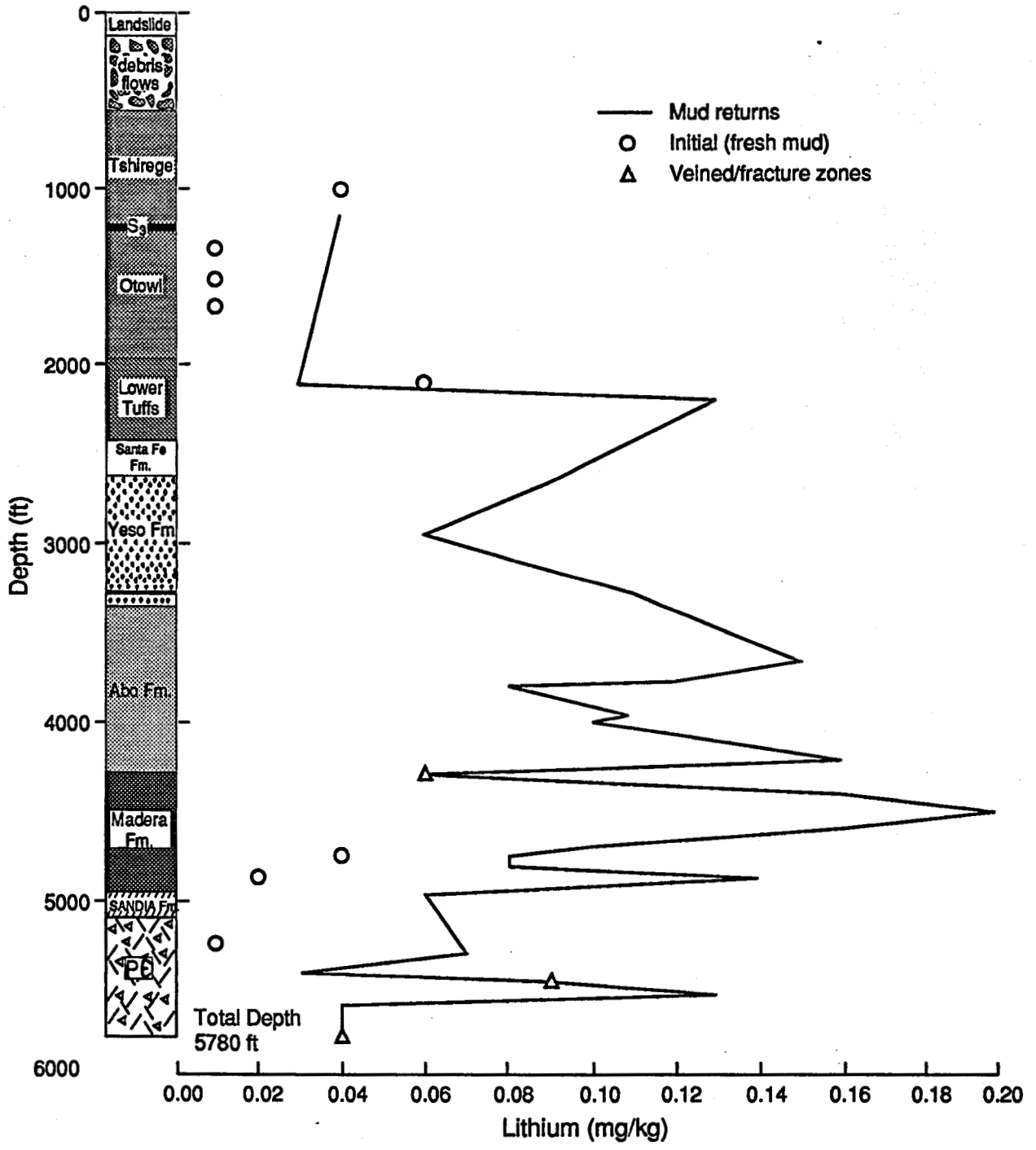

Fig. 12.
Plot of lithium concentration vs depth in drilling mud returns from core hole VC-2B. Lithium concentrations in the initial mud mix are represented by triangles.

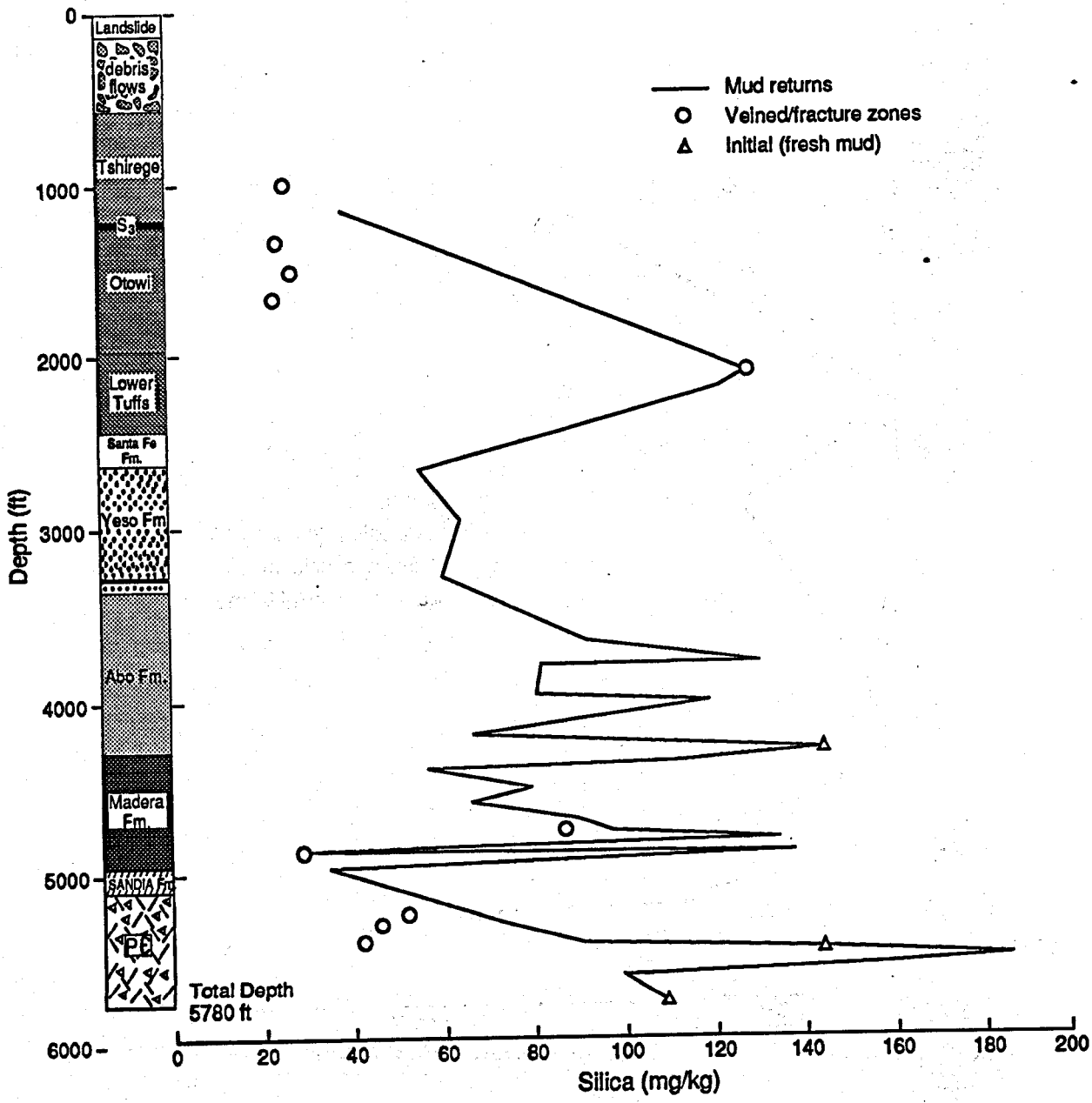

Fig. 13.
Plot of silica concentration vs depth in drilling mud returns from core hole VC-2B. Silica concentrations in the initial mud mix are represented by triangles.

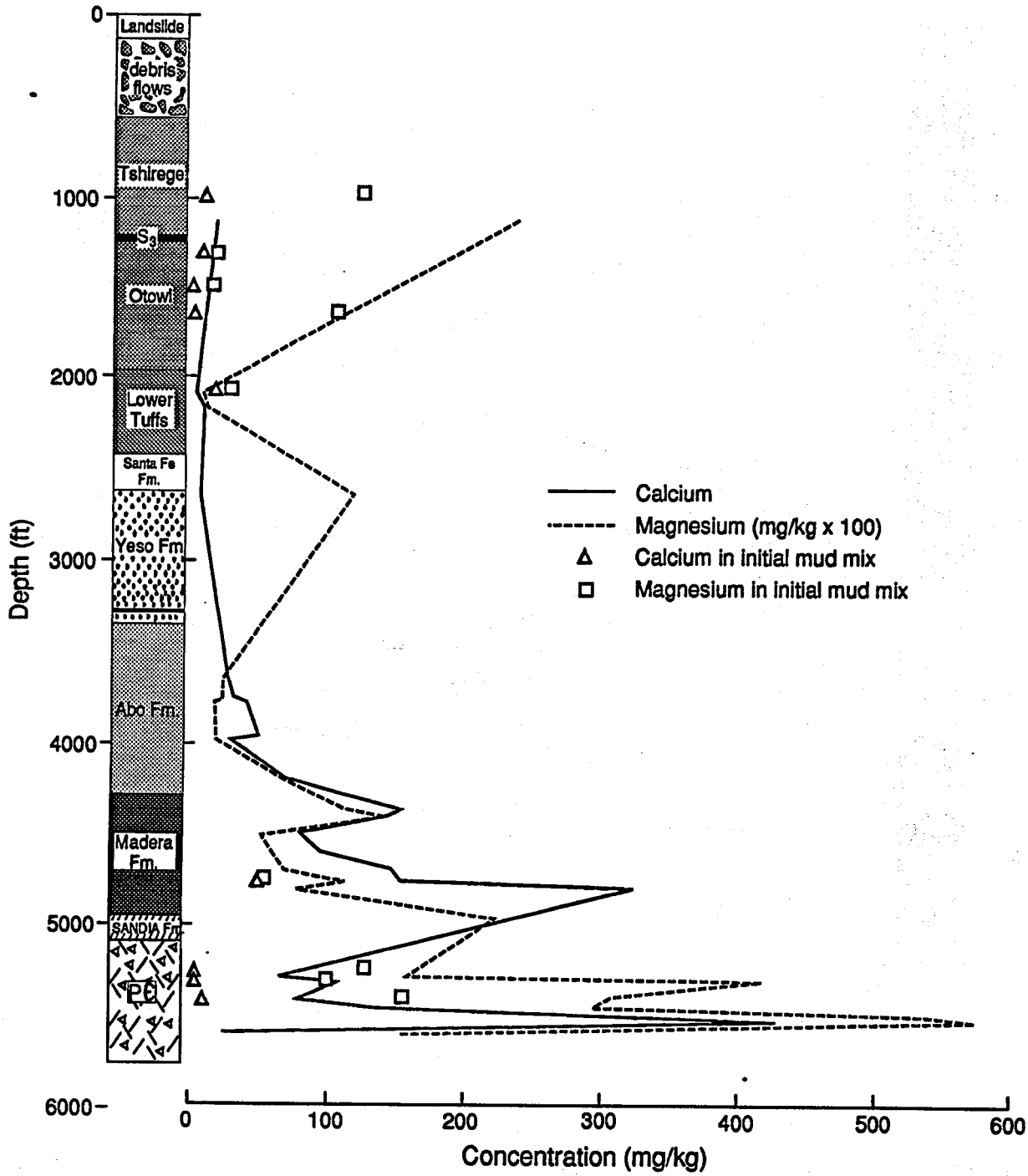

Fig. 14.
Plot of calcium and magnesium concentrations vs depth in drilling mud returns from core hole VC-2B. Calcium and magnesium concentrations in the initial mud mix are represented by triangles and squares respectively.

ACKNOWLEDGMENTS

This project and core hole VC-2B were funded by the U.S. Department of Energy, Office of Basic Energy Sciences. We thank Pete Lysne and Ron Jacobsen (Sandia National Laboratory), Jeff Hulen (University of Utah Research Institute), Larry Pisto (Tonto Drilling Company), and Larry Newman (Nova Mud Company) for assistance and advice throughout this project. Well site geologists John Musgrave, Bill Criswell, Rob Gribble, Dan Wilson, and Tim Smith facilitated the drilling mud monitoring program. We thank the Dunigan Companies, Baca Minerals, and the Baca Land and Cattle Company for the permission to conduct drilling operations on the Baca land. Finally, Marcia Jones and Barbara Hahn prepared the manuscript, and Anthony Garcia drafted the figures.

APPENDIX

TABULAR RESULTS OF THE ENVIRONMENTAL AND MUD SAMPLING PROGRAM OF CSDP CORE HOLE VC-2B

TABLE A-I

FIELD DATA, ENVIRONMENTAL MONITORING, VALLES CALDERA, NEW MEXICO

Name	Field Number	Date	Field (pH)	Temp (°C)	Conductivity (µmho/cm)
Upper Sulphur Creek	VC2B-2	26-MAY-88	3.0	10.8	--
Footbath Spring	VC2B-4	02-JUN-88	1.5	26.1	5690
Upper Sulphur Creek	VC2B-5	02-JUN-88	3.5	18.9	358
Corbin's Cistern	VC2B-6	02-JUN-88	6.5	12.8	613
Lower Sulphur Creek	VC2B-7	02-JUN-88	3.0	21.6	772
Soda Dam, Main Spring	VC2B-9	03-JUN-88	6.5	47.7	6770
Travertine Mound Spring	VC2B-10	03-JUN-88	7.0	73.3	3820
Upper Sulphur Creek	VC2B-12	09-JUN-88	3.5	17.5	373
Corbin's Cistern	VC2B-13	09-JUN-88	6.5	13.6	618
Footbath Spring	VC2B-14	09-JUN-88	2.0	31.2	7970
Lower Sulphur Creek	VC2B-15	09-JUN-88	3.0	18.8	1186
Corbin's Lake	VC2B-16	14-JUN-88	2.5	19.2	3490
Overflow pond below VC-2B	VC2B-17	14-JUN-88	6.0	20.7	517
VC-2A well cellar	VC2B-19	14-JUN-88	5.5	48.5	4210
Baca #3 bailer,1700 ft	VC2B-23	22-JUN-88	8.0	190	7290
Baca #3 *in situ* sampler, 1100 ft	VC2B-24	22-JUN-88	6.5	165	7380
Baca #3 *in situ* sampler, 1100 ft	VC2B-25	22-JUN-88	6.5	165	7250
Baca #3 *in situ* sampler, 1750 ft	VC2B-26	22-JUN-88	6.8	190	7220
Valle Grande Spring*	VC2B-27	29-JUN-88	6.0	15.8	61
Seven Springs*	VC2B-28	29-JUN-88	6.0	13.4	106
Horseshoe Spring*	VC2B-29	30-JUN-88	6.5	11.8	261
Upper Sulphur Creek	VC2B-30	19-JUL-88	3.5	13.5	404
Corbin's Cistern	VC2B-31	19-JUL-88	6.0	14.1	662
Footbath Spring	VC2B-32	19-JUL-88	1.5	29.9	13,940
Lower Sulphur Creek	VC2B-33	19-JUL-88	3.0	21.0	1655
San Antonio Pond (cement make-up water)	VC2B-34	27-JUL-88	5.7	--	471
Mud make-up tank	VC2B-35	27-JUL-88	4.5	--	414
Soda Dam, Main Spring	VC2B-36	03-AUG-88	6.2	47.0	6870
Panorama Spring*	VC2B-37	03-AUG-88	6.8	17.4	719
McCauley Spring*	VC2B-38	03-AUG-88	6.5	32.3	156
Upper Sulphur Creek	VC2B-39	06-AUG-88	3.0	13.9	312
Corbin's Cistern	VC2B-40	06-AUG-88	6.5	13.4	628
Footbath Spring	VC2B-41	06-AUG-88	1.5	25.9	11,220
Lower Sulphur Creek	VC2B-42	06-AUG-88	3.0	16.1	614
VC-2A, Cellar Water	VC2B-43	25-AUG-88	3.5	--	4070

*Location shown in Shevenell et al. (1987, Figure 2).

TABLE A-I (cont)

Name	Field Number	Date	Field (pH)	Temp (°C)	Conductivity (µmho/cm)
Steam condensate from VC-2A annulus	VC2B-44	25-AUG-88	5.0	--	29
Upper Sulphur Creek	VC2B-45	01-SEP-88	4.8	--	144
Corbin's Cistern	VC2B-46	01-SEP-88	6.0	--	586
Footbath Spring	VC2B-47	01-SEP-88	2.0	--	4600
Lower Sulphur Creek	VC2B-48	01-SEP-88	3.2	--	514
Seep in front of Corbin's cabin	VC2B-49	01-SEP-88	2.0	>70	5740
Mud make-up tank	VC2B-50	01-SEP-88	5.0	--	151
San Antonio Hot Spring	VC2B-51	04-SEP-88	6.3	32.0	99
Lower Sulphur Creek	VC2B-52	21-SEP-88	4.3	19.0	598
Footbath Spring	VC2B-53	21-SEP-88	2.0	28.0	4120
Tony's Spring	VC2B-54	21-SEP-88	1.5	<30	30,100
Lemonade Spring*	VC2B-55	21-SEP-88	1.5	>70	5410
Electric Spring*	VC2B-56	21-SEP-88	1.5	>70	10,200
Upper Sulphur Creek	VC2B-57	21-SEP-88	4.0	--	338
Corbin's Cistern	VC2B-58	21-SEP-88	6.3	--	578
Lower Sulphur Creek	VC2B-60	19-OCT-88	2.5	7.4	1100
Footbath Spring	VC2B-61	19-OCT-88	1.5	24.3	3890
Upper Sulphur Creek	VC2B-62	19-OCT-88	4.5	6.6	380
Farmington cement make-up water	VC2B-63	15-OCT-88	7.5	<20	526
Upper Spence Spring	VC2B-63A	11-NOV-88	7.0	37.5	302
"Way up" Spence Spring	VC2B-64	11-NOV-88	7.0	47.0	242
Spence Hot Spring	VC2B-65	11-NOV-88	6.5	45.2	253
Soda Dam, Main Spring	VC2B-66	11-NOV-88	7.8	48.5	6870
C Spring*	VC2B-67	11-NOV-88	6.5	16.3	9840
Zia Hot Well*	VC2B-68	11-NOV-88	7.3	56.2	16,120
Bathhouse Spring*	VC2B-69	24-JAN-89	6.8	38.0	175
San Antonio Creek	VC2B-70	24-JAN-89	6.5	1.0	175
San Antonio Hot Spring	VC2B-71	24-JAN-89	6.5	41.5	116
Pajarito Ski Hill Well	VC2B-72	03-FEB-89	--	8.8	82

* Location shown in Shevenell et al. (1987, Figure 2).

TABLE A-II

MAJOR ELEMENT ANALYSIS FOR ENVIRONMENTAL SAMPLING, VALLES CALDERA, NEW MEXICO
(values in mg/kg)

Name	Field Number	Temp (°C)	SiO_2	Ca	Mg	Sr	Na	K	Li	HCO_3	CO_3	SO_4	Cl
Upper Sulphur Creek	VC2B-2	10.8	36.0	16.1	2.63	0.13	7.4	5.5	<0.02	---	---	---	---
Footbath Spring	VC2B-4	26.1	150	49.9	6.88	0.32	27.9	20.4	0.08	0	0.0	1144	9.5
Upper Sulphur Creek	VC2B-5	18.9	52.0	18.6	2.99	0.12	8.9	6.7	<0.02	0	0.0	127	1.4
Corbin's Cistern	VC2B-6	12.8	27.0	92.1	13.6	0.40	21.7	9.2	0.08	212	0.0	153	7.2
Lower Sulphur Creek	VC2B-7	21.6	52.0	46.1	6.69	0.18	5.0	9.4	<0.02	0	0.0	230	2.2
Soda Dam, Main Spring	VC2B-9	47.7	47.0	396	24.0	1.55	964.0	182.0	12.7	1488	0.0	32.6	1540
Travertine Mound Spring	VC2B-10	73.3	91.0	135	4.82	0.59	646.0	75.0	8.0	632	0.0	38.7	862
Upper Sulphur Creek	VC2B-12	17.5	57.0	23.4	3.48	0.12	10.7	8.8	<0.02	0	0.0	143	2.1
Corbin's Cistern	VC2B-13	13.6	29.0	93.0	14.0	0.40	22.3	9.6	0.08	217	0.0	151	7.3
Footbath Spring	VC2B-14	31.2	176	53.6	8.14	0.18	29.2	24.5	0.07	0	0.0	1660	8.5
Lower Sulphur Creek	VC2B-15	18.8	56.0	69.6	10.1	0.28	12.3	13.6	0.03	0	0.0	427	3.1
Corbin's Lake	VC2B-16	19.2	53.0	185	23.0	0.50	26.1	35.5	0.14	0	0.0	1137	12.8
Dump pond below VC-2B	VC2B-17	20.7	1.0	85.3	14.8	0.38	9.7	1.5	<0.02	232	0.0	96.7	1.5
VC-2A well cellar	VC2B-19	48.5	49.0	634	51.3	1.94	274.0	154.0	1.19	58.6	0.0	2510	144
Baca #3 bailer, 1700 ft	VC2B-23	190	240	10.4	0.31	2.36	1384.0	174.0	18.8	288	103.0	70.6	2010
Baca #3 *in situ* sampler, 1100 ft	VC2B-24	165	250	61.2	0.48	2.77	1364.0	164.0	18.4	670	0.0	67.7	2020
Baca #3 *in situ* sampler, 1100 ft	VC2B-25	165	260	35.8	0.34	2.75	1370.0	168.0	18.6	594	0.0	68.9	1880
Baca #3 *in situ* sampler, 1750 ft	VC2B-26	190	255	31.6	0.26	2.40	1310.0	158.0	18.2	588	0.0	68.8	1780
Valle Grande Spring	VC2B-27	15.8	55.0	4.5	1.37	<0.01	9.1	1.4	<0.02	53.7	0.0	0.8	1.6
Seven Springs	VC2B-28	13.4	31.0	15.1	1.81	0.05	6.8	2.2	<0.02	79.3	0.0	3.5	1.3
Horseshoe Spring	VC2B-29	11.8	57.0	20.6	4.04	0.11	34.9	3.3	0.03	172	0.0	4.5	5.7
Upper Sulphur Creek	VC2B-30	13.4	52.0	22.8	3.48	0.14	9.6	8.8	0.01	0	0.0	148	1.8
Corbin's Cistern	VC2B-31	14.1	30.0	101	17.3	0.46	20.0	8.8	0.08	232	0.0	169	7.3
Footbath Spring	VC2B-32	29.9	83.0	40.2	7.80	0.11	19.6	26.8	0.05	0	0.0	2224	0.6
Lower Sulphur Creek	VC2B-33	21.0	61.0	79.5	11.3	0.28	12.0	16.4	0.04	0	0.0	565	4.0
San Antonio Pond (cement make-up water)	VC2B-34	---	65.0	22.0	5.49	0.13	84.0	4.4	0.06	315	0.0	4.6	3.8
Mud make-up tank	VC2B-35	---	56.0	24.8	3.61	0.16	11.2	10.4	0.01	0	0.0	165.0	1.0
Soda Dam, Main Spring	VC2B-36	47.0	46.0	339	23.0	1.50	1008.0	186.0	13.1	1560	0.0	34.9	1565
Panorama Spring	VC2B-37	17.4	56.0	64.6	22.2	0.51	96.0	6.0	0.11	508	0.0	18.2	13.3
McCauley Spring	VC2B-38	32.3	53.0	10.7	4.92	0.02	20.6	1.1	0.29	120	0.0	4.4	3.1
Upper Sulphur Creek	VC2B-39	13.9	33.0	14.7	2.32	0.08	6.2	6.0	<0.01	0	0.0	94	1.9
Corbin's Cistern	VC2B-40	13.4	32.0	107	17.1	0.44	22.5	10.0	0.08	251	0.0	154	7.8
Footbath Spring	VC2B-41	25.9	73.0	27.2	6.48	0.08	14.0	20.8	0.04	0	0.0	1731	0.8
Lower Sulphur Creek	VC2B-42	16.1	37.0	29.7	4.24	0.12	6.9	7.7	0.01	0	0.0	195	2.2
VC-2A, cellar water	VC2B-43	---	93.0	466	53.9	1.14	147.0	107.0	1.04	0	0.0	2883	54.8

TABLE A-II (cont)

Name	Field Number	Temp (°C)	SiO_2	Ca	Mg	Sr	Na	K	Li	HCO_3	CO_3	SO_4	Cl
Steam condensate from VC2A annulus	VC2B-44	---	<0.3	0.4	0.06	0.04	0.2	0.2	<0.01	34.2	0.0	1.8	0.5
Upper Sulphur Creek	VC2B-45	---	34.0	12.7	2.20	0.09	5.2	5.4	<0.01	0	0.0	58.1	1.9
Corbin's Cistern	VC2B-46	---	32.0	84.8	14.4	0.39	20.4	10.3	0.09	228	0.0	138.0	7.6
Footbath Spring	VC2B-47	---	35.0	12.8	2.40	0.04	4.9	9.1	0.02	0	0.0	1013	1.3
Lower Sulphur Creek	VC2B-48	---	38.0	23.0	3.75	0.12	5.8	6.9	0.01	0	0.0	160.0	1.9
Seep in front of Corbin's cabin	VC2B-49	>70	238	79.2	12.2	0.24	16.4	20.2	0.04	0	0.0	1482	1.5
Mud make-up tank	VC2B-50	---	34.0	14.6	2.29	0.09	5.1	5.4	0.01	22	0.0	59.8	1.7
San Antonio Hot Spring	VC2B-51	32.0	80.0	3.2	0.36	0.02	22.1	1.9	0.03	68.3	0.0	6.5	2.1
Lower Sulphur Creek	VC2B-52	---	51.0	30.9	5.16	0.16	7.9	8.4	<0.01	0	0.0	200.0	2.0
Footbath Spring	VC2B-53	---	33.0	11.5	2.20	0.05	4.1	12.8	0.01	0	0.0	971.0	1.1
Tony's Spring	VC2B-54	---	185	3.5	2.64	0.06	19.8	15.6	0.28	0	0.0	6232	9.4
Lemonade Spring	VC2B-55	30-4	209	168	41.4	0.04	7.7	5.6	0.07	0	0.0	1711	2.4
Electric Spring	VC2B-56	>70	190	118	23.8	0.13	13.7	50.7	0.06	0	0.0	2950	1.5
Upper Sulphur Creek	VC2B-57	---	42.0	17.6	2.97	0.12	7.2	6.7	<0.01	0	0.0	116.0	1.6
Corbin's Cistern	VC2B-58	---	28.0	85.7	14.3	0.40	20.7	8.9	0.09	240	0.0	124.0	8.4
Lower Sulphur Creek	VC2B-60	7.4	56.0	56.6	8.89	0.22	10.6	11.8	0.03	0	0.0	403.0	2.7
Footbath Spring	VC2B-61	24.3	82.0	14.3	2.98	0.07	4.8	23.6	0.02	0	0.0	1137	1.2
Upper Sulphur Creek	VC2B-62	---	50.0	22.1	3.57	0.15	9.1	8.1	<0.01	0	0.0	147.0	2.1
Farmington cement make-up water	VC2B-63	---	4.0	63.8	10.8	0.90	50.4	5.8	<0.02	142	0.0	140.0	20.3
Upper Spence Spring	VC2B-63*	37.5	62.0	8.0	1.74	0.05	58.1	2.1	0.87	173	0.0	23.5	7.4
"Way up" Spence Spring	VC2B-64	47.0	59.0	5.1	1.49	0.04	50.7	1.4	0.79	87.8	27.6	12.0	6.7
Spence Hot Spring	VC2B-65	45.2	60.0	7.0	1.67	0.04	52.0	1.6	0.81	90.2	28.8	15.1	6.9
Soda Dam, Main Spring	VC2B-66	48.5	40.0	317	22.5	1.50	1025.0	176.0	13.8	1541	0.0	33.1	1502
C Spring	VC2B-67	16.3	12.0	281	67.3	5.08	1892.0	76.0	6.38	1924	0.0	1152	1791
Zia Hot Well	VC2B-68	56.2	29.0	322	57.8	8.25	3510.0	78.0	4.76	1540	0.0	3239	2970
Bathhouse Spring	VC2B-69	38.0	103	5.0	0.55	0.04	30.8	4.7.	0.05	85.4	0.0	13.0	3.2
San Antonio Creek	VC2B-70	1.0	55.0	7.6	1.27	0.04	10.8	2.1	0.04	53.7	0.0	6.8	1.0
San Antonio Hot Spring	VC2B-71	41.5	78.0	2.9	0.35	<0.01	23.1	2.1	0.04	72	0.0	5.2	1.7
Pajarito Ski Hill Well	VC2B-72	8.8	44.0	7.8	2.97	0.06	4.5	2.4	0.01	59.8	0.0	2.2	0.8

TABLE A-II (cont)

Name	F	Br	B	TDS	Σ Cation	Σ Anion
Upper Sulphur Creek	0.14	---	0.07	---	---	---
Footbath Spring	2.20	<0.4	0.17	1520.6	19.463	24.428
Upper Sulphur Creek	0.22	<0.1	0.07	227.3	2.554	2.724
Corbin's Cistern	0.32	<0.1	0.17	537.6	6.922	6.919
Lower Sulphur Creek	0.46	<0.1	0.08	367.4	4.626	4.927
Soda Dam, Main Spring	3.44	4.6	15.20	4718.7	69.974	68.893
Travertine Mound Spring	4.79	2.6	8.00	2514.6	38.348	35.914
Upper Sulphur Creek	0.18	<0.1	0.16	257.7	2.941	3.084
Corbin's Cistern	0.32	<0.1	0.16	544.3	7.037	6.955
Footbath Spring	2.49	<0.4	0.25	2091.7	25.642	35.167
Lower Sulphur Creek	0.76	<0.2	0.05	619.7	8.554	9.090
Corbin's Lake	2.97	<0.2	0.23	1568.9	23.857	24.364
Dump pond below VC-2B	0.31	<0.1	0.10	444.4	5.982	5.905
VC-2A well cellar	0.69	0.6	1.82	4034.1	59.738	57.603
Baca #3 bailer, 1700 ft	12.20	6.0	18.10	4344.6	67.774	67.188
Baca #3 *in situ* sampler, 1100 ft	11.30	5.8	18.00	4664.3	69.292	70.188
Baca #3 *in situ* sampler, 1100 ft	11.10	5.9	18.10	4443.3	68.361	65.081
Baca #3 *in situ* sampler, 1750 ft	10.60	5.8	18.40	4255.0	65.189	62.189
Valle Grande Spring	0.28	<0.1	<0.05	129.2	0.777	0.976
Seven Springs	0.20	<0.1	<0.05	142.3	1.259	1.435
Horseshoe Spring	0.24	<0.1	<0.05	303.7	2.972	3.103
Upper Sulphur Creek	0.23	<0.1	<0.02	256.6	2.892	3.176
Corbin's Cistern	0.33	<0.1	0.02	586.3	7.584	7.572
Footbath Spring	0.60	<0.4	0.08	2583.2	38.700	46.637
Lower Sulphur Creek	0.75	<0.1	<0.02	791.3	11.361	12.013
San Antonio Pond (cement make-up water)	0.95	<0.1	0.16	507.9	5.438	5.424
Mud make-up tank	0.23	<0.1	<0.02	283.1	3.187	3.514
Soda Dam, Main Spring	3.64	4.2	15.90	4806.5	69.108	70.837
Panorama Spring	0.92	0.3	0.25	787.6	9.409	9.149
McCauley Spring	0.79	<0.1	0.05	219.3	1.917	2.197
Upper Sulphur Creek	<0.05	<0.1	<0.02	163.8	1.778	2.032
Corbin's Cistern	0.14	<0.1	0.03	602.5	8.014	7.578
Footbath	0.81	<0.4	0.09	2034.0	28.628	36.348
Lower Sulphur Creek	<0.05	<0.1	<0.02	296.5	3.338	4.159
VC-2A, cellar water	1.76	4.5	1.08	4273.5	66.399	62.010
Steam condensate from VC-2A annulus	<0.05	<0.1	<0.02	60.0	1.252	0.613
Upper Sulphur Creek	0.10	<0.1	<0.02	122.3	1.342	1.282

TABLE A-II (cont)

Name	F	Br	B	TDS	Σ Cation	Σ Anion
Corbin's Cistern	0.32	<0.1	0.04	536.9	6.606	6.865
Footbath Spring	0.92	<0.3	0.03	1161.0	14.168	21.336
Lower Sulphur Creek	0.55	<0.1	<0.02	250.1	3.518	3.444
Seep in front of Corbin's cabin	0.62	<0.1	<0.02	1928.7	20.622	31.140
Mud make-up tank	0.11	<0.1	<0.02	147.5	1.449	1.675
San Antonio Hot Spring	0.67	<0.1	<0.02	187.4	1.226	1.378
Lower Sulphur Creek	0.54	<0.1	<0.02	319.0	4.438	4.286
Footbath Spring	0.65	<0.3	<0.02	1145.0	13.365	20.433
Tony's Spring	0.81	<0.4	0.21	6654.4	44.081	130.314
Lemonade Spring	2.69	<0.3	0.03	2241.8	31.103	36.060
Electric Spring	4.62	<0.3	<0.02	3563.5	41.542	62.013
Upper Sulphur Creek	0.14	<0.1	<0.02	201.5	2.282	2.488
Corbin's Cistern	0.28	<0.1	<0.02	532.0	6.618	6.791
Lower Sulphur Creek	0.74	<0.1	<0.02	576.3	7.843	8.576
Footbath Spring	0.85	<0.3	0.07	1462.2	18.697	23.923
Upper Sulphur Creek	0.19	<0.1	<0.02	252.0	2.887	3.157
Farmington cement make-up water	0.63	<0.1	<0.02	439.7	6.449	5.873
Upper Spence Spring	0.78	<0.1	<0.1	337.4	3.260	3.578
"Way up" Spence Spring	0.66	<0.1	<0.1	253.6	2.740	2.824
Spence Hot Spring	0.70	<0.1	<0.1	265.2	2.941	2.976
Soda Dam, Main Spring	3.09	4.7	12.00	4698.1	687.562	68.544
C Spring	2.89	5.1	8.90	7229.3	104.306	105.763
Zia Hot Well	2.44	4.9	6.90	11775.9	174.402	174.873
Bathhouse Spring	1.31	<0.1	<0.05	248.4	1.769	1.848
San Antonio Creek	1.30	<0.1	<0.05	140.2	1.037	1.126
San Antonio Hot Spring	0.77	<0.1	<0.05	187.7	1.264	1.396
Pajarito Ski Hill Well	0.18	<0.1	<0.05	126.5	0.907	1.086

TABLE A-III

TRACE ELEMENT ANALYSIS FOR ENVIRONMENTAL SAMPLING, VALLES CALDERA, NEW MEXICO
(values in mg/kg)

Name	Field Number	Ag	Al	As	Ba	Cd	Co	Cr	Cs	Cu	Fe
Upper Sulphur Creek	VC2B-2	<0.001	4.9	<0.05	0.05	<0.002	<0.002	<0.002	<0.005	0.008	2.60
Footbath Spring	VC2B-4	<0.001	42.4	<0.05	0.01	0.005	0.040	0.040	0.008	0.014	60.6
Upper Sulphur Creek	VC2B-5	<0.001	5.9	<0.05	0.05	<0.002	<0.002	<0.002	<0.005	<0.002	2.60
Corbin's Cistern	VC2B-6	<0.001	<0.1	<0.05	0.05	<0.002	<0.002	<0.002	<0.005	<0.002	<0.01
Lower Sulphur Creek	VC2B-7	<0.001	9.2	<0.05	0.04	<0.002	0.003	<0.002	<0.005	<0.002	4.69
Soda Dam, Main Spring	VC2B-9	<0.001	<0.1	1.58	0.44	<0.002	<0.002	<0.002	1.440	<0.002	0.08
Travertine Mound Spring	VC2B-10	<0.001	<0.1	0.65	0.22	<0.002	<0.002	<0.002	0.870	<0.002	0.08
Upper Sulphur Creek	VC2B-12	<0.001	6.0	<0.05	0.04	<0.002	<0.002	<0.002	<0.005	<0.002	1.94
Corbin's Cistern	VC2B-13	<0.001	<0.1	<0.05	0.04	<0.002	<0.002	<0.002	<0.005	<0.002	0.02
Footbath Spring	VC2B-14	<0.001	51.2	<0.05	0.01	0.045	0.046	0.130	0.007	0.310	72.9
Lower Sulphur Creek	VC2B-15	<0.001	15.6	<0.05	0.04	<0.002	0.006	0.009	<0.005	<0.002	9.36
Corbin's Lake	VC2B-16	<0.001	45.1	<0.05	0.01	<0.002	0.022	0.022	0.013	0.018	45.10
Dump pond below VC-2B	VC2B-17	<0.001	<0.1	<0.05	0.04	<0.002	<0.002	0.003	<0.005	0.006	0.24
VC-2A well cellar	VC2B-19	<0.001	<0.1	<0.05	0.15	<0.002	<0.002	0.003	0.120	<0.002	122.
Baca #3 bailer, 1700 ft	VC2B-23	<0.001	<0.1	1.16	0.10	<0.002	<0.002	<0.002	1.610	<0.002	0.27
Baca #3 *in situ* sampler, 1100 ft	VC2B-24	<0.001	<0.1	1.30	0.08	<0.002	<0.002	<0.002	2.080	<0.002	2.88
Baca #3 *in situ* sampler, 1100 ft	VC2B-25	<0.001	<0.1	1.30	0.09	<0.002	<0.002	<0.002	2.000	<0.002	1.56
Baca #3 *in situ* sampler, 1750 ft	VC2B-26	<0.001	<0.1	1.23	0.08	<0.002	<0.002	<0.002	2.080	<0.002	1.34
Valle Grande Spring	VC2B-27	<0.001	<0.1	<0.05	<0.01	<0.002	<0.002	<0.002	0.006	0.004	0.02
Seven Springs	VC2B-28	<0.001	<0.1	<0.05	0.01	<0.002	<0.002	<0.002	<0.005	0.002	0.06
Horseshoe Spring	VC2B-29	<0.001	<0.1	<0.05	0.10	<0.002	<0.002	0.004	<0.005	0.006	0.01
Upper Sulphur Creek	VC2B-30	<0.001	5.6	<0.05	0.05	<0.001	<0.002	<0.002	<0.005	0.006	3.05
Corbin's Cistern	VC2B-31	<0.001	<0.1	<0.05	0.05	<0.001	<0.002	<0.002	<0.005	<0.002	0.06
Footbath Spring	VC2B-32	<0.001	54.9	<0.05	0.01	0.028	0.054	0.120	<0.005	0.016	122
Lower Sulphur Creek	VC2B-33	<0.001	20.9	<0.05	0.04	<0.001	0.007	0.009	<0.005	0.003	17.4
San Antonio Pond (cement make-up water)	VC2B-34	<0.001	<0.1	<0.05	0.13	<0.001	<0.002	<0.002	<0.005	<0.002	0.46
Mud make-up tank	VC2B-35	<0.001	6.3	<0.05	0.05	<0.001	<0.002	<0.002	<0.005	0.016	2.88
Soda Dam, Main Spring	VC2B-36	<0.001	<0.1	1.66	0.44	<0.001	<0.002	0.003	1.660	<0.002	0.05
Panorama Spring	VC2B-37	<0.001	<0.1	<0.05	0.16	<0.001	<0.002	<0.002	<0.005	<0.002	<0.01
McCauley Spring	VC2B-38	<0.001	<0.1	<0.05	<0.01	<0.001	<0.002	<0.002	<0.005	<0.002	0.02
Upper Sulphur Creek	VC2B-39	<0.001	2.4	<0.05	0.05	<0.001	<0.002	<0.002	<0.005	<0.002	2.38
Corbin's Cistern	VC2B-40	<0.001	<0.1	<0.05	0.05	<0.001	<0.002	<0.002	<0.005	<0.002	0.04
Footbath Spring	VC2B-41	<0.001	41.9	<0.1	<0.01	0.200	0.064	6.300	<0.005	0.009	108
Lower Sulphur Creek	VC2B-42	<0.001	5.6	<0.05	0.06	<0.001	0.004	0.004	<0.005	0.004	6.46
VC-2A, cellar water	VC2B-43	<0.001	92.5	<0.1	0.04	<0.002	0.009	0.062	0.120	<0.002	353

TABLE A-III (cont)

Name	Field Number	Ag	Al	As	Ba	Cd	Co	Cr	Cs	Cu	Fe
Steam condensate from VC-2A annulus	VC2B-44	<0.001	<0.1	<0.05	0.02	<0.002	0.004	<0.002	<0.005	<0.002	17.2
Upper Sulphur Creek	VC2B-45	<0.001	0.9	<0.05	0.05	<0.001	0.002	<0.002	<0.002	0.007	0.70
Corbin's Cistern	VC2B-46	<0.001	<0.1	<0.05	0.06	<0.001	<0.002	<0.002	<0.002	0.003	0.07
Footbath Spring	VC2B-47	<0.001	13.5	0.05	0.04	<0.002	0.030	0.014	<0.002	0.036	67.2
Lower Sulphur Creek	VC2B-48	<0.001	4.6	<0.05	0.05	<0.001	0.003	<0.002	<0.002	0.005	4.48
Seep in front of Corbin's cabin	VC2B-49	<0.001	46.6	<0.05	0.05	<0.002	0.006	0.018	0.014	0.004	20.7
Mud make-up tank	VC2B-50	<0.001	0.7	<0.05	0.06	<0.001	<0.002	<0.002	<0.002	0.003	1.27
San Antonio Hot Spring	VC2B-51	<0.001	0.1	0.05	<0.01	<0.001	<0.002	<0.002	0.002	0.003	0.06
Lower Sulfur Spring	VC2B-52	<0.001	7.1	<0.05	0.06	<0.001	<0.002	<0.002	0.002	0.006	4.76
Footbath Spring	VC2B-53	<0.001	14.1	<0.05	0.01	<0.002	0.032	0.014	<0.002	0.059	93.6
Tony's Spring	VC2B-54	<0.001	80.2	<0.05	0.03	<0.002	0.065	0.040	0.052	0.008	101.
Lemonade Spring	VC2B-55	<0.001	51.3	<0.05	0.04	<0.002	0.004	0.008	0.027	0.004	31.7
Electric Spring	VC2B-56	<0.001	138.0	<0.05	0.03	<0.002	0.018	0.040	0.021	0.018	63
Upper Sulphur Creek	VC2B-57	<0.001	4.7	<0.05	0.07	<0.001	<0.002	<0.002	<0.002	<0.002	2.48
Corbin's Cistern	VC2B-58	<0.001	<0.1	<0.05	0.05	<0.001	<0.002	<0.002	<0.002	<0.002	0.05
Lower Sulfur Spring	VC2B-60	<0.001	15.1	<0.05	0.05	<0.001	0.005	0.004	0.002	0.003	8.82
Footbath Spring	VC2B-61	<0.001	19.8	<0.05	0.02	<0.002	0.045	0.020	<0.002	0.005	174
Upper Sulphur Creek	VC2B-62	<0.001	6.3	<0.05	0.06	<0.001	<0.002	<0.002	<0.002	<0.002	3.00
Farmington cement make-up water	VC2B-63	<0.001	<0.01	<0.05	0.10	<0.001	<0.002	<0.002	<0.002	0.003	0.03
Upper Spence Spring	VC2B-63A	<0.001	<0.01	<0.05	<0.01	<0.002	<0.002	<0.002	0.010	0.003	0.02
"Way-up" Spence Spring	VC2B-64	<0.001	<0.01	<0.05	<0.01	<0.002	<0.002	<0.002	0.012	0.003	0.02
Spence Hot Spring	VC2B-65	<0.001	0.2	<0.05	0.01	<0.002	<0.002	<0.002	0.014	0.005	0.06
Soda Dam, Main Spring	VC2B-66	<0.001	<0.1	1.75	<0.01	<0.002	<0.002	<0.002	1.250	0.004	0.07
C Spring	VC2B-67	<0.001	<0.1	0.35	<0.01	<0.002	<0.002	<0.002	0.340	<0.002	2.87
Zia Hot Well	VC2B-68	<0.001	<0.1	0.35	0.02	<0.002	<0.002	<0.002	0.060	<0.002	1.03
Bathhouse Spring	VC2B-69	<0.001	<0.1	<0.05	<0.01	<0.002	<0.002	<0.002	<0.005	0.006	0.01
San Antonio Creek	VC2B-70	<0.001	0.1	<0.05	0.02	<0.002	<0.002	<0.002	<0.005	0.002	0.13
San Antonio Hot Spring	VC2B-71	<0.001	0.2	<0.05	<0.01	<0.002	<0.002	<0.002	<0.005	<0.002	0.01
Pajarito Ski Hill Well	VC2B-72	<0.001	<0.1	<0.05	0.02	<0.002	<0.002	<0.002	<0.005	0.005	0.01

TABLE A-III (cont)

Name	Mn	Mo	NH_4	Ni	NO_3	Pb	PO_4	Rb	Sb	Zn
Upper Sulphur Creek	0.30	<0.002	0.16	<0.002	---	<0.002	---	0.015	<0.05	0.07
Footbath Spring	0.86	<0.002	0.84	0.100	3.2	0.042	<0.4	0.23	<0.05	0.81
Upper Sulphur Creek	0.35	<0.002	0.16	0.021	0.2	<0.002	<0.2	0.018	<0.05	0.03
Corbin's Cistern	0.04	0.003	0.14	0.005	0.4	<0.002	<0.2	<0.005	<0.05	0.03
Lower Sulphur Creek	0.61	<0.002	0.25	0.009	0.6	<0.002	<0.2	0.042	<0.05	0.07
Soda Dam, Main Spring	0.53	<0.002	0.69	0.003	<0.1	<0.002	<0.2	2.59	<0.05	0.05
Travertine Mound Spring	1.96	<0.002	0.50	<0.002	<0.1	<0.002	<0.2	0.91	<0.05	<0.02
Upper Sulphur Creek	0.41	<0.002	0.05	0.005	0.4	<0.002	<0.2	0.038	<0.05	0.13
Corbin's Cistern	0.08	0.004	0.12	0.003	<0.1	<0.002	<0.2	<0.005	<0.05	<0.02
Footbath Spring	0.98	0.003	0.54	0.260	<0.4	0.180	<0.4	0.290	<0.05	1.50
Lower Sulphur Creek	0.90	<0.002	0.26	0.031	<0.2	0.003	<0.2	0.085	<0.05	0.10
Corbin's Lake	1.94	<0.002	0.20	0.058	<0.2	0.022	<0.2	0.210	<0.05	0.33
Dump pond below VC-2B	0.04	0.004	0.43	0.015	0.6	<0.002	<0.2	<0.005	<0.05	0.07
VC-2A well cellar	7.0	<0.002	22.0	0.009	<0.2	<0.002	<0.2	1.08	<0.05	0.12
Baca #3 bailer, 1700 ft	0.03	0.009	0.66	<0.002	<0.2	<0.002	<0.2	2.48	0.06	0.29
Baca #3 *in situ* sampler, 1100 ft	0.53	0.003	0.95	0.008	<0.2	<0.002	<0.2	2.66	<0.05	0.06
Baca #3 *in situ* sampler, 1100 ft	0.30	0.010	0.65	0.010	<0.2	<0.002	<0.2	2.52	0.05	1.20
Baca #3 *in situ* sampler, 1750 ft	0.30	0.009	0.57	0.007	<0.2	<0.002	<0.2	2.52	<0.05	0.03
Valle Grande Spring	<0.01	<0.002	0.10	0.100	1.2	<0.002	<0.2	0.006	<0.05	0.03
Seven Springs	<0.01	<0.002	<0.05	0.012	0.9	<0.002	<0.2	0.010	<0.05	<0.02
Horseshoe Spring	<0.01	<0.002	<0.05	<0.002	1.0	<0.002	<0.2	<0.005	<0.05	0.03
Upper Sulphur Creek	0.44	<0.002	0.21	0.009	0.4	0.004	<0.1	0.032	<0.05	0.20
Corbin's Cistern	0.08	<0.002	<0.05	<0.002	<0.1	0.003	<0.1	0.005	<0.05	0.02
Footbath Spring	0.78	<0.002	0.08	0.230	<0.4	0.120	<0.4	0.40	<0.05	1.04
Lower Sulphur Creek	1.07	<0.002	0.45	0.022	0.4	0.006	<0.1	0.11	<0.05	0.24
San Antonio Pond (cement make-up water)	0.19	<0.002	1.42	<0.002	<0.1	<0.002	<0.1	0.014	<0.05	0.03
Mud make-up tank	0.51	<0.002	0.25	0.011	0.6	0.005	<0.1	<0.005	<0.05	0.20
Soda Dam, Main Spring	0.53	<0.002	0.73	0.014	<0.2	0.003	<0.2	1.580	<0.05	0.04
Panorama Spring	<0.01	0.006	0.11	<0.002	0.4	<0.002	<0.1	0.015	<0.05	<0.01
McCauley Spring	0.01	0.015	0.18	<0.002	0.4	<0.002	<0.1	0.008	<0.05	0.02
Upper Sulphur Creek	0.25	<0.002	0.36	<0.002	0.3	0.002	<0.1	0.018	<0.05	0.13
Corbin's Cistern	0.19	<0.002	0.10	<0.002	0.3	<0.002	<0.1	0.010	<0.1	0.02
Footbath Spring	0.49	<0.002	0.13	1.320	<0.4	0.080	<0.4	<0.005	<0.1	0.88
Lower Sulphur Creek	0.43	<0.002	0.33	0.023	0.2	0.004	<0.1	0.040	<0.05	0.07
VC-2A, cellar water	8.50	<0.002	<0.05	0.057	<0.2	0.010	<0.2	0.480	<0.1	4.20
Steam condensate from VC-2A annulus	0.22	0.006	5.04	0.034	<0.1	0.020	<0.1	<0.005	<0.05	0.02
Upper Sulphur Creek	0.15	0.003	0.25	0.007	0.2	<0.002	<0.1	0.012	<0.1	0.09

TABLE A-III (cont)

Name	Mn	Mo	NH_4	Ni	NO_3	Pb	PO_4	Rb	Sb	Zn
Corbin's Cistern	0.06	0.005	0.22	0.013	<0.1	<0.002	<0.1	0.009	<0.1	0.03
Footbath Spring	0.27	0.005	<0.05	0.054	<0.3	0.042	<0.5	0.067	<0.1	0.48
Lower Sulphur Creek	0.29	<0.002	0.23	0.008	0.2	<0.002	<0.1	0.034	<0.1	0.06
Seep in front of Corbin's cabin	0.88	<0.002	9.80	0.012	0.2	0.016	<0.5	0.240	<0.1	0.18
Mud make-up tank	0.17	<0.002	0.24	0.006	0.3	<0.002	<0.1	0.022	<0.1	0.05
San Antonio Hot Spring	0.02	0.012	0.11	0.015	1.6	<0.002	<0.1	0.014	<0.1	0.03
Lower Sulfur Spring	0.45	<0.002	0.19	0.010	0.2	<0.002	<0.2	0.047	<0.1	0.19
Footbath Spring	0.22	0.002	<0.05	0.062	<0.3	0.072	<0.5	0.088	<0.1	0.57
Tony's Spring	0.18	0.003	2.5	0.110	<0.4	0.170	<1	0.160	<0.1	0.22
Lemonade Spring	2.60	<0.002	7.3	0.036	<0.3	0.010	<1	0.77	<0.1	0.41
Electric Spring	1.54	<0.002	4.6	0.044	<0.3	0.026	<1	0.53	<0.1	0.30
Upper Sulphur Creek	0.25	<0.002	0.09	0.003	<0.1	<0.002	<0.1	0.037	<0.1	0.04
Corbin's Cistern	0.15	0.004	0.14	0.027	0.3	<0.002	<0.1	0.014	<0.1	0.04
Lower Sulfur Spring	0.78	<0.002	0.26	0.014	0.2	0.002	<0.1	0.075	<0.1	0.11
Footbath Spring	0.26	<0.002	<0.05	0.075	<0.3	0.075	<0.5	0.13	<0.1	0.68
Upper Sulphur Creek	0.37	<0.002	0.08	0.005	0.1	<0.002	<0.1	0.033	<0.1	0.12
Farmington cement make-up water	0.04	0.002	0.22	<0.002	<0.3	<0.002	<0.1	0.007	<0.1	0.02
Upper Spence Spring	<0.01	0.043	0.18	<0.002	<0.1	<0.002	<0.1	0.011	<0.1	<0.01
"Way-up" Spence Spring	<0.01	<0.002	0.11	<0.002	<0.1	<0.002	<0.1	0.011	<0.1	<0.01
Spence Hot Spring	<0.01	<0.002	0.16	<0.002	<0.1	<0.002	<0.1	0.013	<0.1	<0.01
Soda Dam, Main Spring	0.50	<0.002	0.78	<0.002	<0.3	<0.002	<0.3	2.100	<0.1	0.02
C Spring	0.72	0.003	0.60	0.024	<0.3	<0.002	<1	0.42	<0.1	<0.01
Zia Hot Well	0.02	<0.002	0.70	0.006	<0.4	<0.001	<1	0.22	<0.1	<0.01
Bathhouse Spring	<0.01	0.008	0.09	<0.002	1.0	<0.002	<0.5	0.015	<0.1	0.04
San Antonio Creek	0.02	0.003	0.07	0.002	0.4	<0.002	<0.5	0.014	<0.1	0.01
San Antonio Hot Spring	<0.01	0.009	0.06	<0.002	1.1	<0.002	<0.5	0.016	<0.1	0.01
Pajarito Ski Hill Well	<0.01	<0.002	0.06	<0.002	1.7	<0.002	<0.5	0.009	<0.1	0.31

TABLE A-IV
HYDROGEN AND OXYGEN ISOTOPES FOR ENVIRONMENTAL SAMPLING
VALLES CALDERA, NEW MEXICO

Name	Field Number	δD	$\delta^{18}O$	Tritium (T.U.)
Upper Sulphur Creek	VC2B-2	-83.5	-11.39	18.30
Footbath Spring	VC2B-4	-92.7	-23.41	5.39
Upper Sulphur Creek	VC2B-5	-80.8	-10.98	20.60
Corbin's Cistern	VC2B-6	-86.7	-11.10	17.80
Lower Sulphur Creek	VC2B-7	-80.3	-10.83	17.90
Soda Dam, Main Spring	VC2B-9	-85.9	-10.09	0.88
Travertine Mound Spring	VC2B-10	-83.0	-10.46	2.34
Upper Sulphur Creek	VC2B-12	-80.3	-10.58	
Corbin's Cistern	VC2B-13	-84.1	-11.02	
Footbath Spring	VC2B-14	-89.0	-22.53	
Lower Sulphur Creek	VC2B-15	-79.1	-10.50	
Baca #3 bailer, 1700 ft	VC2B-23	-80.7	-8.44	0.63
Baca #3 *in situ* sampler, 1100 ft	VC2B-24	-82.2	-8.84	
Baca #3 *in situ* sampler, 1100 ft	VC2B-25	-81.5	-8.85	0.55
Baca #3 *in situ* sampler, 1750 ft	VC2B-26	-81.9	-8.88	
Valle Grande Spring	VC2B-27	-85.4	-12.67	0.83
Seven Springs	VC2B-28	-95.6	-13.79	14.20
Horseshoe Spring	VC2B-29	-89.6	-12.80	2.19
Upper Sulphur Creek	VC2B-30	-73.2	-10.08	20.50
Corbin's Cistern	VC2B-31	-83.3	-11.26	19.20
Footbath Spring	VC2B-32	-71.8	-18.46	17.0
Lower Sulphur Creek	VC2B-33	-70.4	-9.76	21.40
Soda Dam, Main Spring	VC2B-36	-84.9	-10.41	1.01
Panorama Spring	VC2B-37	-89.1	-11.76	1.37
McCauley Spring	VC2B-38	-89.2	-12.46	5.34
Lower Sulphur Creek	VC2B-42	-58.4	-8.28	
Upper Sulphur Creek	VC2B-45	-76.1	-10.20	
Corbin's Cistern	VC2B-46	-78.7	-10.53	18.90
Footbath Spring	VC2B-47	-73.1	-12.33	11.20
Lower Sulphur Creek	VC2B-48	-73.4	-10.27	17.10
Seep in front of Corbin's cabin	VC2B-49	-62.9	-8.72	
San Antonio Hot Spring	VC2B-51	-91.2	-12.74	2.44
Tony's Spring	VC2B-54	-59.8	-11.60	5.57
Lemonade Spring	VC2B-55	-72.7	-11.59	11.80
Electric Spring	VC2B-56	-79.0	-11.56	10.90
Upper Sulphur Creek	VC2B-57			
Corbin's Cistern	VC2B-58			
Lower Sulphur Creek	VC2B-60			
Footbath Spring	VC2B-61			
Upper Sulphur Creek	VC2B-62			
"Way up" Spence Spring	VC2B-64	-86.0	-12.14	0.09
Spence Hot Spring	VC2B-65	-87.4	-12.11	0.42
Soda Dam, Main Spring	VC2B-66			
C Spring	VC2B-67	-87.3	-10.11	1.59
Zia Hot Well	VC2B-68	-91.1	-10.75	0.55
Bathhouse Spring	VC2B-69	-88.6	-12.10	0.06
San Antonio Creek	VC2B-70	-88.9	-12.39	2.39
San Antonio Hot Spring	VC2B-71	-92.4	-12.78	0.60
Pajarito Ski Hill Well	VC2B-72	-83.8	-12.22	42.00

TABLE A-V

MAJOR ELEMENT ANALYSIS FOR BASIC ENVIRONMENTAL SUITE IN SULPHUR SPRINGS AREA
(values in mg/kg)

Field Number	Description	Date	Temp (°C)	B	Ca	Cl	F
VC2B-2	Upper Sulphur Creek	05/26/88	10.8	0.07	16.1	---	0.14
VC2B-5	Upper Sulphur Creek	06/02/88	18.9	0.07	18.6	1.4	0.22
VC2B-12	Upper Sulphur Creek	06/09/88	17.5	0.16	23.4	2.1	0.18
VC2B-30	Upper Sulphur Creek	07/19/88	13.4	<0.02	22.8	1.8	0.23
VC2B-39	Upper Sulphur Creek	08/06/88	13.9	<0.02	14.7	1.9	<0.05
VC2B-45	Upper Sulphur Creek	09/01/88	---	<0.02	12.7	1.9	0.10
VC2B-57	Upper Sulphur Creek	09/21/88	---	<0.02	17.6	1.6	0.14
VC2B-62	Upper Sulphur Creek	10/19/88	4-4.5	<0.02	22.1	2.1	0.19
Average				0.10	18.5	1.8	0.17
Standard Deviation				0.05	3.97	0.3	0.05
VC2B-6	Corbin's Cistern	06/02/88	12.8	0.17	92.1	7.2	0.32
VC2B-13	Corbin's Cistern	06/09/88	13.6	0.16	93.0	7.3	0.32
VC2B-31	Corbin's Cistern	07/19/88	14.1	0.02	101	7.3	0.33
VC2B-40	Corbin's Cistern	08/06/88	13.4	0.03	107	7.8	0.14
VC2B-46	Corbin's Cistern	09/01/88	---	0.04	84.8	7.6	0.32
VC2B-58	Corbin's Cistern	09/26/88	---	<0.02	85.7	8.4	0.28
Average				0.08	93.9	7.6	0.30
Standard Deviation				0.07	7.9	0.4	0.07
VC2B-7	Lower Sulphur Creek	06/02/88	21.6	0.08	46.1	2.2	0.46
VC2B-15	Lower Sulphur Creek	06/09/88	18.8	0.05	69.6	3.1	0.76
VC2B-33	Lower Sulphur Creek	07/19/88	21	<0.02	79.5	4.0	0.75
VC2B-42	Lower Sulphur Creek	08/06/88	16.1	<0.02	29.7	2.2	<0.05
VC2B-48	Lower Sulphur Creek	09/01/88	---	<0.02	23.0	1.9	0.55
VC2B-52	Lower Sulphur Creek	09/21/88	---	<0.02	30.9	2.0	0.54
VC2B-60	Lower Sulphur Creek	10/19/88	7.4	<0.02	56.6	2.7	0.74
Average				0.06	47.9	2.6	0.61
Standard Deviation				0.02	21.6	0.7	0.13
VC2B-4	Footbath Spring	06/02/88	26.1	0.17	49.9	9.5	2.20
VC2B-14	Footbath Spring	06/09/88	31.2	0.25	53.6	8.5	2.49
VC2B-32	Footbath Spring	07/19/88	29.9	0.08	40.2	0.6	0.60
VC2B-41	Footbath Spring	08/06/88	25.9	0.09	27.2	0.8	0.81
VC2B-47	Footbath Spring	09/01/88	---	0.03	12.8	1.3	0.92
VC2B-53	Footbath Spring	09/21/88	---	<0.02	11.5	1.1	0.65
VC2B-61	Footbath Spring	10/19/88	24.3	0.07	14.3	1.2	0.85
Average				0.11	29.9	3.3	1.22
Standard Deviation				0.08	16.7	3.6	0.72

TABLE A-V (cont)

HCO_3	K	Li	Mg	Na	NH_4	Lab pH	SiO_2	SO_4	Sr	TDS
---	5.5	<0.02	2.63	7.4	0.16	---	36	---	0.13	---
0	6.7	<0.02	2.99	8.9	0.16	3.64	52	127	0.12	227.3
0	8.8	<0.02	3.48	10.7	0.05	3.69	57	143	0.12	257.7
0	8.8	0.01	3.48	9.6	0.21	3.49	52	148	0.14	256.6
0	6.0	<0.01	2.32	6.2	0.36	3.30	33	94.0	0.08	163.8
0	5.4	<0.01	2.20	5.2	0.25	3.85	34	58.1	0.09	122.3
0	6.7	<0.01	2.97	7.2	0.09	3.12	42	116	0.12	201.5
0	8.1	<0.01	3.57	9.1	0.08	3.59	50	147	0.15	252.0
	7.0		2.95	8.0	0.17	3.52	44	119	0.12	211.6
	1.4		0.54	1.8	0.10	0.25	9	33	0.02	52.3
212	9.2	0.08	13.6	21.7	0.14	6.94	27	153	0.40	537.6
217	9.6	0.08	14.0	22.3	0.12	7.25	29	151	0.40	544.3
232	8.8	0.08	17.3	20.0	<0.05	6.83	30	169	0.46	586.3
251	10.0	0.08	17.1	22.5	0.10	6.82	32	154	0.44	602.5
228	10.3	0.09	14.4	20.4	0.22	7.51	32	138	0.39	536.9
240	8.9	0.09	14.3	20.7	0.14	8.01	28	124	0.40	532.0
230	9.8	0.08	15.1	21.3	0.14	7.23	30	148	0.42	556.6
13	0.5	0.00	1.5	0.9	0.04	0.43	2	14.0	0.03	27.3
0	9.4	<0.02	6.69	5.0	0.25	3.26	52	230	0.18	367.4
0	13.6	0.03	10.1	12.3	0.26	2.97	56	427	0.28	619.7
0	16.4	0.04	11.3	12.0	0.45	2.66	61	565	0.28	791.3
0	7.7	0.01	4.24	6.9	0.33	3.05	37	195	0.12	296.5
0	6.9	0.01	3.75	5.8	0.23	3.07	38	160	0.12	250.1
0	8.4	<0.01	5.16	7.9	0.19	3.08	51	200	0.16	319.0
0	11.8	0.03	8.89	10.6	0.26	2.88	56	403	0.22	576.3
	10.60	0.02	7.16	8.64	0.28	2.99	50.1	311.4	0.19	460.1
	3.47	0.01	2.98	2.98	0.08	0.19	9.2	153.6	0.06	203.2
0	20.4	0.08	6.88	27.9	0.84	2.18	150	1144	0.32	1520.6
0	24.5	0.07	8.14	29.2	0.54	1.97	176	1660	0.18	2091.7
0	26.8	0.05	7.8	19.6	0.08	1.66	83	2224	0.11	2583.2
0	20.8	0.04	6.48	14.0	0.13	1.82	73	1731	0.08	2034.0
0	9.1	0.02	2.40	4.9	<0.05	2.11	35	1013	0.04	1161.0
0	12.8	0.01	2.20	4.1	<0.05	2.26	33	971	0.05	1145.0
0	23.6	0.02	2.98	4.8	<0.05	2.27	82	1137	0.07	1462.2
	19.7	0.04	5.3	14.9	0.39	2.04	90	1411	0.12	1714
	6.0	0.02	2.4	10.1	0.35	0.21	50	50	0.09	497

TABLE A-VI

CONDUCTIVITY AND PH FOR MUD SAMPLES, CORE HOLE VC2B, VALLES CALDERA, NEW MEXICO

Field Number	Description	Date	Depth (m)	Lab Cond. (mho/cm)	Lab pH
VC2B-M1	Mud, returns	10-AUG-88	304.2	1632	8.74
VC2B-M2	Mud, returns	11-AUG-88	346.8	1337	8.17
VC2B-M3	Mud mix	16-AUG-88	458.1	1068	8.15
VC2B-M4	Mud mix	18-AUG-88	505.3	861	7.95
VC2B-M5	Mud mix	14-AUG-88	403.2	1807	9.21
VC2B-M7	Mud, returns	02-SEP-88	636.4	1118	8.05
VC2B-M8	Mud, returns	02-SEP-88	639.4	866	7.69
VC2B-M9	Mud, returns	03-SEP-88	665.3	1261	7.81
VC2B-M10	Mud, returns	05-SEP-88	807.1	2520	7.63
VC2B-M13	Mud, returns	07-SEP-88	897.0	3290	7.97
VC2B-M19	Mud, Lost Circ. Zone	11-SEP-88	1000.6	2530	8.45
VC2B-M20	Mud, returns	14-SEP-88	1116.4	3510	8.84
VC2B-M22	Mud, returns	15-SEP-88	1153.0	3590	8.64
VC2B-M25	Mud, returns	15-SEP-88	1158.2	4430	8.89
VC2B-M27	Mud, returns	16-SEP-88	1213.9	4350	8.92
VC2B-M28	Mud, returns	16-SEP-88	1220.9	4180	8.77
VC2B-M34	Mud, returns	18-SEP-88	1284.0	4060	8.44
VC2B-M36	Mud, returns	19-SEP-88	1311.5	3560	8.53
VC2B-MR1	Mud, returns	19-SEP-88	1332.8	3380	8.61
VC2B-MR2	Mud, returns	20-SEP-88	1341.9	4080	8.70
VC2B-MR3	Mud, returns	21-SEP-88	1372.4	3540	8.60
VC2B-MR3a	Mud, returns	22-SEP-88	1401.4	3720	8.64
VC2B-MR4	Mud, returns	23-SEP-88	1433.4	4060	8.71
VC2B-MR5	Mud, returns	24-SEP-88	1449.5	3270	8.80
VC2B-MR6	Mud, returns	26-SEP-88	1453.2	4110	8.66
VC2B-MR7	Mud, returns (low visc.)	26-SEP-88	1466.0	3850	8.77
VC2B-MR8	Fresh mud before NH4NO3	27-SEP-88	1508.7	3960	8.68
VC2B-MR9	Fresh Mud after NH4NO3	27-SEP-88	1508.7	4270	8.42
VC2B-MR10	Returns 2.5 hrs after inj.	27-SEP-88	1508.7	5180	8.64
VC2B-MR11	Returns 3.5 hrs after inj.	27-SEP-88	1508.7	5240	8.68
VC2B-MR12	Returns 3.5 hrs after inj.	27-SEP-88	1508.7	5130	8.58
VC2B-MR13	Returns 4.0 hrs after inj.	27-SEP-88	1508.7	5370	8.66
VC2B-MR14	Returns 4.5 hrs after inj.	27-SEP-88	1508.7	5120	8.51
VC2B-MR16	Circ returns after being stuck	29-SEP-88	1519.0	2720	8.16
VC2B-MR17	Polydrill products fresh mud	04-OCT-88	1600.1	3460	7.10
VC2B-MR18	Returns 1 hr after H2S spike	06-OCT-88	1615.3	3670	8.40
VC2B-MR19	Fresh mud	06-OCT-88	1619.6	2740	2.93
VC2B-MR20	Mud, returns	06-OCT-88	1622.6	3600	7.80
VC2B-MR21	Baroid fresh mud	10-OCT-88	1645.8	3160	7.40
VC2B-MR22	Fresh mud	10-OCT-88	1650.7	4070	7.87
VC2B-MR23	Mud, returns after run 744	11-OCT-88	1663.8	3830	8.40
VC2B-MR24	Mud, returns	12-OCT-88	1679.3	4380	8.19
VC2B-MR25	Mud, returns	13-OCT-88	1687.6	4810	7.87
VC2B-MR26	Water (mud separated?)	18-OCT-88	1706.5	3860	8.65
VC2B-MR27	Mud, returns	21-OCT-88	1757.1	6240	8.23

TABLE A-VII

MAJOR ELEMENT ANALYSIS FOR MUD MIX AND RETURNS
COREHOLE VC2B, VALLES CALDERA, NEW MEXICO
(values in mg/kg)

Field Number	Description	Date	Depth (m)	SiO_2	Ca	Mg	Na	K	Li	HCO_3	CO_3	SO_4	Cl	Br	B
VC2B-M1	Mud, returns	10-AUG-88	304.2	27	8.2	1.26	395	4	0.04	464	216	211	6.3	<0.1	<0.1
VC2B-M2	Mud, returns	11-AUG-88	346.8	39	20	2.41	313	8	0.04	427	144	216	5.1	<0.1	<0.1
VC2B-M3	Mud mix	16-AUG-88	458.1	28	1.6	0.18	247	5	0.01	214	126	214	5.9	<0.1	<0.1
VC2B-M4	Mud mix	18-AUG-88	505.3	24	1.0	0.16	203	6	0.01	165	108	168	3.6	<0.1	<0.1
VC2B-M5	Mud mix	14-AUG-88	403.2	25	7.6	1.07	435	5	0.01	378	294	204	6.2	<0.1	<0.1
VC2B-M7	Mud, returns	02-SEP-88	636.4	129	17	0.30	272	3	0.06	439	126	122	3.4	<0.1	<0.1
VC2B-M8	Mud, returns	02-SEP-88	639.4	128	3.8	0.09	203	3	0.03	281	114	105	3.0	<0.1	<0.1
VC2B-M9	Mud, returns	03-SEP-88	665.3	122	10	0.13	305	4	0.13	519	120	121	9.4	<0.1	<0.1
VC2B-M10	Mud, returns	05-SEP-88	807.1	56	7.5	1.20	492	12	0.09	360	126	642	9.4	<0.1	<0.1
VC2B-M13	Mud, returns	07-SEP-88	897.0	65	6.8	0.40	568	10	0.06	659	156	870	5.3	<0.1	<0.1
VC2B-M19	Mud, Lost Circ. Zone	11-SEP-88	1000.6	60	27	0.65	436	10	0.11	628	198	474	5.2	<0.1	<0.1
VC2B-M20	Mud, returns	14-SEP-88	1116.4	92	28	0.24	698	17	0.15	854	384	546	5.7	<0.1	<0.1
VC2B-M22	Mud, returns	15-SEP-88	1153.0	131	33	0.24	737	12	0.12	988	306	614	4.5	<0.1	<0.1
VC2B-M25	Mud, returns	15-SEP-88	1158.2	82	41	0.19	821	10	0.08	1141	390	922	9.8	<0.1	<0.1
VC2B-M27	Mud, returns	16-SEP-88	1213.9	81	51	0.20	880	14	0.11	1250	534	297	8.3	<0.1	<0.1
VC2B-M28	Mud, returns	16-SEP-88	1220.9	120	30	0.20	914	22	0.10	1268	468	253	9.7	<0.1	<0.1
VC2B-M34	Mud, returns	18-SEP-88	1284.0	67	72	0.68	708	24	0.16	1147	420	606	2.9	<0.2	<0.1
VC2B-M36	Mud, returns	19-SEP-88	1311.5	146	138	0.64	644	26	0.06	1183	420	417	2.9	<0.2	<0.1
VC2B-MR1	Mud, returns	19-SEP-88	1332.8	105	155	1.14	642	25	0.12	1440	420	417	3.1	<0.2	<0.1
VC2B-MR2	Mud, returns	20-SEP-88	1341.9	56	147	1.43	708	25	0.16	928	552	512	3.0	<0.2	<0.1
VC2B-MR3	Mud, returns	21-SEP-88	1372.4	81	80	0.53	561	35	0.20	1012	444	425	3.0	<0.2	<0.1
VC2B-MR3a	Mud, returns	22-SEP-88	1401.4	66	96	0.60	526	40	0.16	695	468	679	3.2	<0.2	<0.1
VC2B-MR4	Mud, returns	23-SEP-88	1433.4	90	149	0.70	510	40	0.10	939	540	700	3.0	<0.2	<0.1
VC2B-MR5	Mud, returns	24-SEP-88	1449.5	87	52	0.55	533	32	0.04	436	737	370	5.6	<0.2	<0.1
VC2B-MR6	Mud, returns	26-SEP-88	1453.2	98	155	1.16	539	22	0.08	939	540	750	3.3	<0.2	<0.1
VC2B-MR7	Mud, returns (low viscosity)	26-SEP-88	1466.0	135	326	0.79	516	42	0.08	854	576	650	4.4	<0.2	<0.1
VC2B-MR8	Fresh mud before NH_4NO_3	27-SEP-88	1508.7	30	5.2	1.46	643	20	<0.02	616	570	299	3.9	<0.2	<0.1
VC2B-MR9	Fresh Mud after NH_4NO_3	27-SEP-88	1508.7	29	7.0	1.42	663	24	0.02	781	420	220	3.7	<0.2	<0.1
VC2B-MR10	Returns 2.5 hrs after inj.	27-SEP-88	1508.7	141	228	0.58	531	28	0.14	1269	564	570	2.9	<0.2	<0.1
VC2B-MR11	Returns 3.0 hrs after inj.	27-SEP-88	1508.7	133	190	0.48	544	28	0.14	1281	576	532	2.7	<0.2	<0.1
VC2B-MR12	Returns 3.5 hrs after inj.	27-SEP-88	1508.7	137	123	0.39	538	30	0.14	1110	648	536	2.4	<0.2	<0.1
VC2B-MR13	Returns 4.0 hrs after inj.	27-SEP-88	1508.7	139	216	0.62	564	22	0.18	1939	708	452	3.1	<0.2	<0.1
VC2B-MR14	Returns 4.5 hrs after inj.	27-SEP-88	1508.7	146	190	0.66	531	26	0.10	1525	552	495	4.5	<0.2	<0.1
VC2B-MR16	Circ returns after being stuck	29-SEP-88	1519.0	35	246	2.25	389	14	0.06	2300	282	209	7.0	<0.5	<0.1
VC2B-MR17	Polydrill products fresh mud	04-OCT-88	1600.1	52	3.2	1.29	451	68	0.01	555	0	1200	2.5	<0.5	<0.1

TABLE A-VII (cont)

Field Number	Description	Date	Depth (m)	SiO_2	Ca	Mg	Na	K	Li	HCO_3	CO_3	SO_4	Cl	Br	B
VC2B-MR18	Returns 1 hr after H_2S spike	06-OCT-88	1615.3	73	66	1.59	456	54	0.07	860	330	681	29.0	<0.5	<0.1
VC2B-MR19	Fresh mud	06-OCT-88	1619.6	46	3.9	1.01	78.0	32	<0.01	0	0	967	2.5	<0.5	<0.1
VC2B-MR20	Returns	06-OCT-88	1622.6	78	109	4.21	290	47	0.06	982	300	712	9.6	<0.5	<0.1
VC2B-MR21	Baroid fresh mud	10-OCT-88	1645.8	42	8.8	1.56	436	<5	<0.01	653	0	1049	3.0	<0.5	<0.1
VC2B-MR22	Fresh mud coming out of hole	10-OCT-88	1650.7	91	79	3.07	530	26	0.03	579	498	909	52.0	<0.5	<0.1
VC2B-MR23	Returns after run 744	11-OCT-88	1663.8	144	135	2.96	565	23	0.09	671	300	868	90.0	<0.5	<0.1
VC2B-MR24	Mud, returns	12-OCT-88	1679.3	187	299	5.39	675	26	0.11	2410	312	693	100.0	<0.5	<0.1
VC2B-MR25	Mud, returns	13-OCT-88	1687.6	164	430	5.76	695	32	0.13	2489	336	1000	119.0	<0.5	<0.1
VC2B-MR26	Fluid returns w/mud	18-OCT-88	1706.5	100	26	1.56	724	16	0.04	701	498	700	63.0	<0.5	<0.1
VC2B-MR27	Mud, returns	21-OCT-88	1757.1	109	35	1.14	722	109	0.04	1303	372	1398	27.7	<0.5	<0.1

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