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FINAL REPORT
GEOTHERMAL RESOURCES PROJECT-STAGE ONE

PART 7
GEOCHEMISTRY OF THE NICARAGUAN GEOTHERMAL PROJECT AREA

Prepared for

GOVERNMENT OF NICARAGUA

Ministry of Economy, Industry and Commerce

By

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PREFACE

This Final Report on STAGE ONE of the Nicaraguan GEOTHERMAL RESOURCES PROJECT is submitted to the Government of Nicaragua by TEXAS INSTRUMENTS INCORPORATED in Spanish and English versions.

The report is the work of several authors and consists of ten parts, or chapters, each of which is bound separately, as follows:

Part 1 - PROJECT SUMMARY, by D. E. Heilner and L. T. Braun

Part 2 - REGIONAL GEOLOGY: Thermal Manifestations of Western Nicaragua, by John B. Thigpen

Part 3 - SURFACE GEOLOGY: San Jacinto-Tisate-Najo Area, by John B. Thigpen

Part 4 - SURFACE GEOLOGY: South Volcan Momotombo Fumaroles, by John B. Thigpen

Part 5 - GRAVITY AND MAGNETIC SURVEYS, by Mario Mazzolini

Part 6 - ELECTRICAL GEOPHYSICAL SURVEYS in Relation to the Location of Geothermal Power Resources in Northwestern Nicaragua, by George Keller and Norman Harthill

Part 7 - GEOCHEMISTRY of the Nicaraguan Geothermal Project Area, by R. Bennett

Part 8 - TEMPERATURE GRADIENT WELLS at San Jacinto and South Volcan Momotombo, by R. Bennett

Part 9 - DEEP BOREHOLE TEST at the South Volcan Momotombo Fumarole Area, by John B. Thigpen

Part 10 - CONCLUSIONS AND RECOMMENDATIONS, by Texas Instruments Staff and Consultants

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ABSTRACT

During the geochemical investigation of that part of Western Nicaragua whose geothermal resources were the object of this evaluation, 130 water samples and 52 gas samples were collected and analyzed.

The geochemical results and geologic relationships indicate that the relative importance of the several thermal areas studied, ranked in order of decreasing potential, is as follows:

1. South Volcan Momotombo
2. San Jacinto-Tisate
3. Volcan Casita
4. Volcan Telica-Najo
5. Lake Jiloa - Lake Apoyeque
6. Volcan Mombacho
7. Hacienda California
8. Tipitapa
9. San Luis

GEOCHEMISTRY OF THE NICARAGUAN GEOTHERMAL PROJECT AREA

By R. Bennett

INTRODUCTION

Geoscientific studies of the Nicaraguan Geothermal Project were conducted in a 14,700 square mile area in Western Nicaragua. The eastern boundary is a line extending from Ocotal through Matagalpa, Boaco, Acoyapa, and San Carlos.

Geochemical studies were made in conjunction with geologic and geophysical studies to locate the most favorable geothermal area for exploratory drilling. The final goal of the project was to penetrate a hyperthermal zone containing sufficient energy to drive the steam turbines of an electric power plant.

Geothermal areas are characterized by discharge of thermal water and gases. Analysis of the water and gases in a geothermal area aids in locating the heat source (geothermal cell). Thermal waters and associated nonthermal waters in the project area were sampled. Gases from fumarole areas were sampled where present in sufficient quantity. Sublimates from hot springs and fumaroles were sampled to determine their relation to the gases and water being discharged.

Water, sublimate and incrustation samples were submitted to the Servicio Geologico Nacional laboratory for analysis. Gas samples were analyzed in the field with Drager tubes, and by gas chromatography by Rocky Mountain Technology, Inc., Denver, Colorado, U.S.A.

The regional and detail geologists assisted in water sampling. The assistance of E. Ubeda, Director, and personnel of the Servicio Geologico Nacional, Seccion de Laboratorio is gratefully acknowledged.

GEOLOGIC SETTING

The outstanding geologic features of Western Nicaragua are the northwest trending Nicaraguan depression and the chain of Pleistocene and Recent volcanoes within the depression. On the west side of the depression, Upper Cretaceous to Pliocene sediments are present in the southern part of the project area. Tertiary volcanics with a few Tertiary intrusives cover most of the area east of the depression. Some Paleozoic metamorphics and Miocene sediments are present in the northern part of the area east of the depression. For a detailed description of the geology see McBirney and Williams (1965), and the Regional Geology report which is presented separately as Part 2 of the Final Report.

SAMPLING AND ANALYTICAL METHODS

Water samples were collected in glass bottles with screw caps. The temperature of the water source was recorded and the bottles were totally filled to exclude air.

Gases were sampled from an inverted 12 inch diameter polyethylene funnel used as a gas trap. Drager tubes were stored under refrigeration to prevent deterioration and transported to the field in insulated boxes containing canned refrigerant. The samples for gas chromatography were taken in 250 ml glass gas-collecting tubes.

The water samples were analyzed utilizing the following methods:

Na, K and Li: Flame photometry

Ca and Mg: EDTA titration using Murexide indicator for Ca and erichrome black for Ca + Mg

B: Colorimetric -- carmine

SiO_2: Colorimetric -- heteropoly molybdenum blue

NO_3: Colorimetric -- brucine

F: Colorimetric -- Alizarin red and zirconium chloride

SO_4: Turbidimetry

CO_3: Alkalinity titration -- phenolphthalein

HCO_3: Alkalinity titration -- methyl orange

Cl: Mohr's titration

PO_4: Colorimetric -- heteropoly molybdenum blue

Field analysis of gas samples was performed with Drager tubes. Where water caused interference, phosphorus pentoxide drying tubes were used to dry the gas.

RESULTS

Data from the analysis of water samples are shown in Appendix Table I. Data from the analysis of gas samples are shown in Appendix Table II. Data from analysis of sublimate and incrustation samples had not been received from the SGN laboratory at the time of this report.

DISCUSSION OF RESULTS

Thermal Gases

Seven fumarole areas were visited and sampled. Six were low-temperature: Volcan Casita, Laguna de Jiloa, Volcan Momotombo, San Jacinto, Volcan Telica, and Tisate. Cerro Colorado also was visited but the activity was too weak for sampling. The only high-temperature fumarole area sampled was Volcan Cerro Negro. For a detailed description of the fumarole areas see the geologic reports which are presented separately (Parts 2, 3 and 4).

The most outstanding feature of the analyses is the low concentration of hydrogen sulfide compared to most other geothermal areas (Appendix Table II). However, small incrustations of native sulfur crystals are present arcund fumaroles at Momotombo, Telica, Jiloa and Tisate. Also, pyrite is being formed in the surficial alteration zones at San Jacinto. Thermal gases from the fumarole fields at Ahuachapan, El Salvador, are also anomalously low in hydrogen sulfide (Sigvaldason and Cuellar, 1968).

Hydrogen in thermal gases is considered to be a qualitative indicator of high temperatures (Bodvarsson, 1970). No hydrogen was detected with Drager tubes in the thermal gases. However, small amounts were identified in the samples sent to Denver, U.S.A., for analysis by gas chromatography. All of the values for hydrogen are approximately 0.1 volume percent which is the same value reported for Playon de Ahuachapan by Sigvaldason and Cuellar (1968).

The gas chromatography data, with the exception of two samples, show much

lower values for carbon dioxide and hydrogen sulfide than the Drager tube analyses. The faster flow rate used in sampling for gas chromatography introduced considerable atmospheric contamination into the gas collection tubes.

The noncondensible gas-to-steam ratio at the Momotombo prospect ranges from medium to low (0.70 in the area near gradient well No. 5 to 0.47 in the fumarole area east of gradient well No. 3). The ratio was 0.65 at San Jacinto and 0.83 at Tisate. Lower ratios are considered to be indicators of higher reservoir temperatures but there are exceptions to this rule (White and Waring, 1963).

The Momotombo fumarole areas are characterized by relatively high hydrogen sulfide and carbon dioxide. Hydrogen is not anomalous compared to the other fumarole areas.

The San Jacinto-Tisate fumarole areas have low hydrogen sulfide and medium carbon dioxide with the exception of one fumarole at Tisate which shows high carbon dioxide and hydrogen sulfide. The gas-to-steam ratio ranges from medium to high.

Fumaroles on the north flank of Volcan Telica showed high hydrogen sulfide and medium carbon dioxide values.

Volcan Casita fumaroles had low hydrogen sulfide and all but one were low in carbon dioxide.

The small fumarole area at Laguna de Jiloa was high in hydrogen sulfide and carbon dioxide.

The high-temperature fumaroles in the crater of Cerro Negro and in the lava

flow of 1968 were low in hydrogen sulfide but sulfur dioxide was found to be present. No Drager tubes were available for hydrogen chloride analysis but it was obviously present in large quantity. Tenorite is forming at fumaroles in the lava flow.

Analyses of gases from gradient wells at Momotombo are also listed in Appendix Table II. Sulfur dioxide in concentrations of 10-200 ppm were found present. Hydrogen sulfide ranged from <1 to 600 ppm. The highest values were found in well M-7 which is near a fault zone.

Water Samples

A high priority was given to the sampling and analysis of water from high-temperature springs. High-temperature springs which also have high discharge and chloride content are more reliable than low-temperature springs as geochemical indicators of subsurface temperature (the discharge of the springs listed in Appendix Table I is given in the Appendix of the Regional Geology Report, Part 2, which is presented separately).

The most active hot spring area is at Punta Las Salintas on the south flank of Volcan Momotombo. The springs produce sodium chloride waters with an average pH of 7.7 and total dissolved solids ranging from approximately 5000 to 7000. Silica, Li, and B are high and the temperatures show 101° C at the points of greatest activity. Drainage from the hot springs at Punta Las Salintas and numerous small springs at the edge of Lake Managua produces higher B, Li, Na, K and Cl than in other sections of the lake. The higher nitrate in lake samples distant from Punta Las Salinitas is

produced by sewage from Managua and agricultural sources.

Two lakes, Jiloa and Apoyeque, in the Chiltepe Peninsula southeast of Punta Las Salinitas have hot springs in them. Springs at both lakes discharge Na Cl rich water with medium B values. Silica may be depleted organically in Lake Jiloa, but it is high in Apoyeque. Total dissolved solids range from 3400 to 4000.

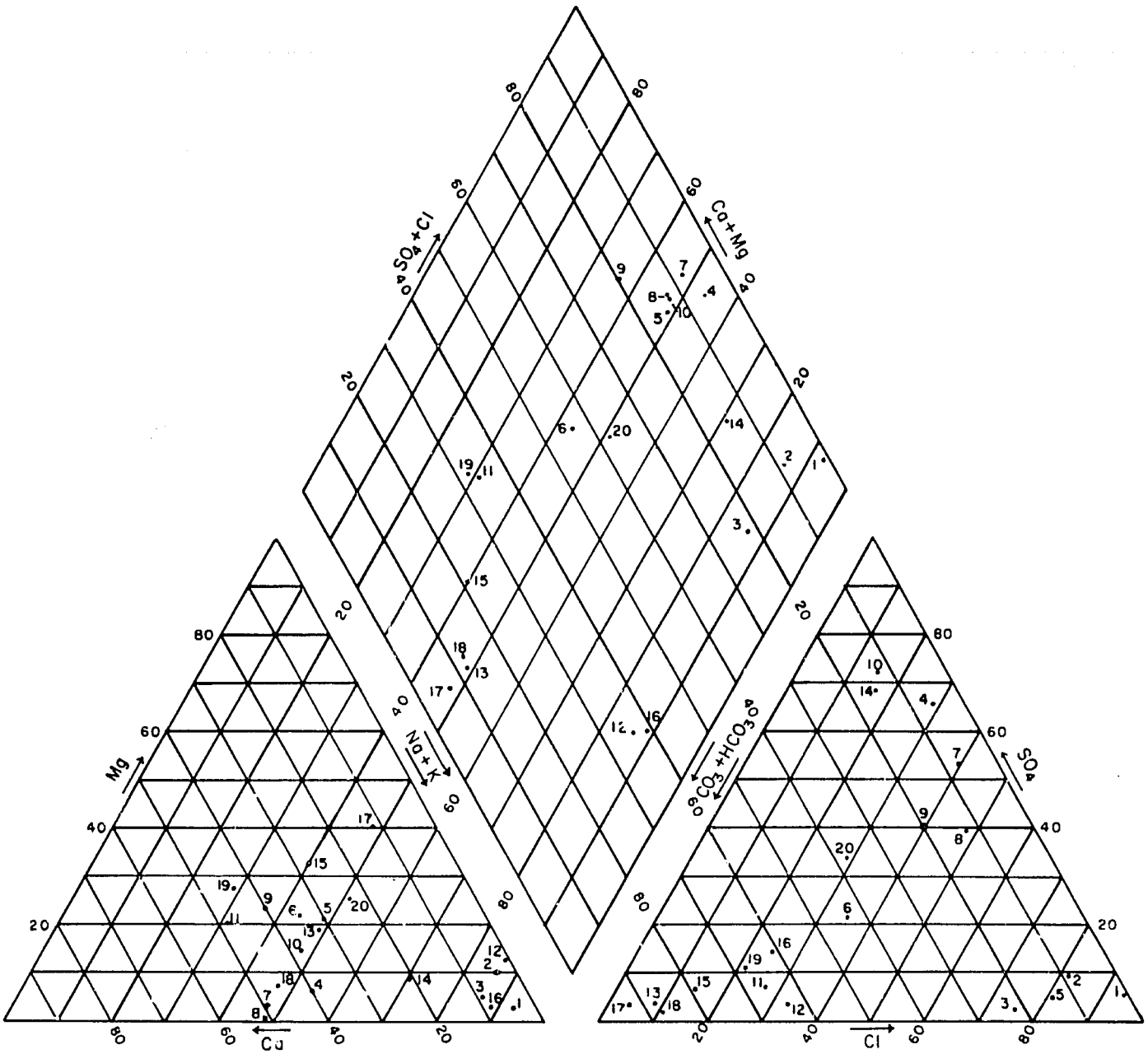
Thermal waters from Tipitapa hot springs at the southeast end of Lake Managua possibly issue from north trending faults from Volcan Santiago. The Na Cl water is high in SiO_2 and low in B. Total dissolved solids are approximately 1000 ppm.

Several springs in the vicinity of Hacienda San Luis on the northeast shore of Lake Managua were sampled. All of the water is Na Ca SO_4 Cl with relatively high SiO_2 , 95-152 ppm, and an average TDS of 1220 ppm.

The San Jacinto-Tisate prospect area had only one high-temperature high-chloride spring. It flows from a fracture in the creek bed between San Jacinto and Tisate. Total dissolved solids are high, 2500 ppm, and it is classified as a Na Ca Cl water. The rest of the waters sampled in the area are Ca HCO_3 with the exception of samples No. 71 and 72 from the fumarole area.

The samples discussed above and other representative samples throughout the project area are plotted in Figure I, a water analysis diagram. Table I, which follows, gives the location of samples plotted in Figure I.

WATER ANALYSIS DIAGRAM



CATIONS PERCENTAGE REACTING VALUES ANIONS

FIGURE I

7a

TABLE I

SAMPLES PLOTTED IN FIGURE I, WATER ANALYSIS DIAGRAM

DIAGRAM NUMBER	LOCATION AND REFERENCE TO CHEMICAL ANALYSIS
1	Volcan Momotombo hot springs area (1)
2	North shore Laguna de Jiloa (40,41)
3	Main spring Tipitapa (49)
4	San Luis (52-61)
5	Spring in stream channel south of Tisate (84)
6	Volcan Mombacho area (62-67)
7	Discharge from shaft of Mina Santa Pancha (102)
8	Spring south of Hacienda Mayocunda (95)
9	Springs near south fumarole, Ñajo (91, 92)
10	Laguna El Playon (100)
11	Lago de Nicaragua (35)
12	Lago de Managua (30-34)
13	Spring south-southeast of El Espino (106)
14	Spring north of Juigalpa (121)
15	Spring Agua Caliente de Acayo (127)
16	Spring west of Ocotal (109)
17	Spring west of Somoto (107)
18	Spring at Monte Fresco (119)
19	San Jacinto-Tisate area (72-83, 85, 86, 88-90)
20	Springs, Rio Agua Caliente, Hacienda California (36-38)

(49) = Sample No. in Appendix Table I

Silica, which was first developed as a geothermometer by Bodvarsson and Palmason (1961), is one of the most dependable indicators of subsurface temperature. The amount of SiO_2 in solution is a function of temperature, and equilibration is very slow. Cooling of thermal waters to 180° C precipitates some SiO_2; this gives us a secondary geothermometer -- siliceous sinter. The presence of siliceous sinter in hot spring areas is evidence of subsurface temperatures of 180° C at some time during the life of the springs. Hot alkaline water in contact with glassy volcanic rocks may lose SiO_2 more rapidly than neutral waters, possibly due to increased availability of Al for formation of zeolites and montmorilionite (White, 1970). Dilution with cold water and the foregoing reaction will produce temperature estimates that are too low.

Sodium/potassium ratios are also strongly temperature dependent. For deep well samples above 200° C the temperature derived from Na/K ratios is as accurate as the temperature derived from the SiO_2 concentration for predicting reservoir temperatures (White, 1970). Silica indicates the temperature as the water enters the well, but Na/K ratios, which do not respond to changes within the reservoir as rapidly as SiO_2 concentration, are more reliable for predicting temperatures at a distance in the reservoir. Waters from basalt and andesite areas which are not in equilibrium with potassium minerals will have a higher Na/K ratio than waters from dacite or rhyolite areas. Sodium/lithium ratios are not well understood but are included for comparison with Na/K ratios. Lithium tends to decrease in concentration in rising thermal water systems due to incorporation in alteration minerals; therefore high Na/Li ratios could

indicate high temperatures.

Magnesium, which is low in concentration relative to calcium in deep thermal waters, is concentrated in the solid phase hydrothermal minerals in subsurface reservoirs and conduits. A low Mg/Ca ratio is more dependable as a qualitative indicator of high temperature in water above 100° C.

Calcite solubility is temperature, pH and salinity dependent, therefore the Ca/HCO_3 ratio has a wide range. The pH can change by wall rock reactions during transport of thermal waters,and CO_2 can be lost by formation of a vapor phase which in turn will raise the pH. In spite of the complications involved, Ca/HCO_3 ratios can be used qualitatively for comparison with SiO_2 concentration and Na/K ratio temperatures.

Sodium/calcium ratios cannot be used where Ca is much greater than HCO_3 but qualitatively a high Na/Ca ratio indicates high subsurface temperatures.

High Cl/F ratios can also be used qualitatively to infer high subsurface temperatures. Fluorite like calcite is less soluble at high temperatures but the major control on fluorite solubility is calcium concentration. The concentration of calcium is controlled in turn by the solubility product for calcite at the given temperature; this produces a complex interrelationship.

The ratio of chloride to carbonate plus bicarbonate is qualitatively high in high-temperature environments. Carbonic acid is only slightly dissociated at higher temperatures, therefore the CO_3 and HCO_3 species are not formed by reaction with silicate minerals.

Samples from favorable geothermal prospect areas and selected samples for comparison are listed in Table 2.

Geochemical Indicators of High Subsurface Temperatures

All of the geochemical indicators in samples from the Momotombo area predict high temperatures at depth. As mentioned above, the Na/K ratio in basaltic rocks is usually high so the true ratio values could be even lower than those listed. Note that the Ca/HCO_3, Cl/F, and Cl/CO_2 ratios from gradient well M-1A are slightly higher than the ratios from sample No. 1; this implies that the reservoir temperature may be higher than indicated by the SiO_2 concentration and Na/K ratio of well M-1A.

The lower Ca/HCO_3, Na/Ca, and Cl/CO_2 ratios and higher Mg/Ca ratio from the saline spring in the San Jacinto-Tisate area are no doubt produced by mixing with HCO_3 rich ground water.

The low Ca/HCO_3 and Cl/CO_2 ratios in Lake Jiloa are produced by the large volume of CO_2 gas bubbling into the water along the north shore. Depletion by biologic activity could have produced the low SiO_2 concentration. In contrast, Lake Apoyeque has 135 ppm SiO_2 versus 10 ppm in Lake Jiloa. The Na/K, Na/Li, Na/Ca, and Mg/Ca ratios are also higher than in Jiloa. The source of water in Lake Apoyeque was definitely higher in Na, Mg and CO_2 but lower in K and SO_4 than the source of water in Lake Jiloa. The fact that the lakes are only one kilometer apart makes the possibility of separate water sources very interesting.

The main spring at Tipitapa could be producing a mixture of hot saline water

TABLE 2

GEOCHEMICAL INDICATORS OF HIGH SUBSURFACE TEMPERATURES

LOCALITY	Temp °C	SiO_2 ppm	Na/K	Mg/Ca	Ca/HCO_3	Na/Ca	Cl/F	Cl[a]/CO_2	Na[b]/Li
V. Momotombo (22) c	89.0	153	15.6d	0.20	7.6	16.9	2460	130	63
V. Momotombo (No. 1)	101.0	135	14.8	.04	6.6	18.9	2240	140	72
Gradient Well M-1A	85.0	125	23.3e	.04	9.7	18.6	2750	193	100
San Jacinto-Tisate (No. 84)	66.5	140	13.3	.60	2.1	1.5	>3385	6	31
Jiloa, North Shore (2)	35.0	10	18.4	2.10	.4	19.9	1382	9	162
Apoyeque (No. 45)	33.0	135	26.4e	7.62	.1	67.5	1627	3	1797
Hacienda California (No. 36)	47.5	150	15.8	1.10	.6	3.5	680	1	71
Tipitapa (No. 49)	72.0	150	26.0e	.83	.5	8.5	127	3	41
Mombacho (No. 65)	54.0	180	8.2	.18	.7	1.6	254	1	>696
Ñajo (Nos. 91, 92)	63.0	178	3.0e	.58	2.2	.7	40	2	174
San Luis (No. 60)	88.5	152	31.6e	.04	36.0	1.0	35	8	50

a. $CO_2 = HCO_3 + CO_3$
b. Included for comparison with Na/K
c. (22) = Number of samples averaged
d. Only 21 samples averaged for Na/K
e. Outside normal significant range of 8-20

from depth and shallow Ca HCO_3 type ground water; SiO_2 is the only temperature indicator that predicts a high temperature at depth.

The sample from Mombacho, like Tipitapa, has low Na/Ca, Ca/HCO_3 , and Cl/CO_2 ratios and a fairly low Cl/F ratio. The Na/K ratio is within the normal significant range but it could have been diluted with ground water similar to sample No. 69 which has a Na/K ratio of 2.7.

The Ñajo samples have a Na/K ratio below the normal significant range, in fact, it is identical to the nonthermal waters in the region. The total dissolved solids were very low. Apparently shallow ground water is being heated by conduction of heat from a fracture that serves as a conduit to the nearby fumaroles.

The San Luis sample has a high Na/K ratio; this is the case in an area where springs have deposited travertine. Only the SiO_2 concentration and the Na/K ratio indicate that the San Luis area may have higher temperatures at depth.

The spring water near Hacienda California (Table 2) could have been produced from high Cl subsurface water mixing with shallow ground water containing Ca, HCO_3 and SO_4 . The probable source of the SO_4 is oxidation of sulfides in volcanics near the surface.

Chemically Predicted Subsurface Temperatures

The temperatures predicted from the concentration of SiO_2 and the Na/K ratios are listed below in Table 3. Temperatures were determined from Figures 2 and 3 of White (1970) assuming that equilibrium with quartz has been attained.

TABLE 3

SUBSURFACE TEMPERATURES PREDICTED FROM SiO_2 AND Na/K

LOCALITY	SiO_2 ppm	T_{SiO_2} °C	Na/K	$T_{Na/K}$ °C
Volcan Momotombo (22)	153	163	15.6	195
San Jacinto-Tisate	140	156	13.3	210
Jiloa (2)	10a	LOW	18.4	180
Hacienda California	150	160	15.8	190
Gradient Well M-1A	125	152	23.3	155
V. Momotombo (Sample No. 1)	135	155	14.8	200
Tipitapa	150	160	26.0b	148
Mombacho	180	170	8.2	285
San Luis	152	162	31.6	132

a Low value possibly produced by biologic activity
b Outside normal significant range of 8-20

Silica concentrations and Na/K ratios indicate a reservoir temperature from 153° to 200° C at Momotombo. Siliceous sinter which indicates a temperature of 180° C is also presently formed at some of the hot springs at Punta Las Salinitas. The temperatures of 152° and 155° C for water erupting from gradient well M-1A at Momotombo are in good agreement with values measured with a thermister cable in a well approximately 90 meters to the south.

The temperatures derived from Na/K ratios for Tipitapa and San Luis are outside of the normal significant range of 8-20, but are reasonably close to the SiO_2 concentration temperatures.

As mentioned previously, the Na/K ratio for Mombacho may be low due to dilution.

SUMMARY AND CONCLUSIONS

One hundred thirty water samples and 52 gas samples were collected and analyzed. The results indicate that the relative importance of the thermal areas is as follows: Volcan Momotombo, San Jacinto-Tisate, Volcan Casita, Volcan Telica-Ñajo, Lake Jiloa-Lake Apoyeque, Volcan Mombacho, Hacienda California, Tipitapa, and San Luis. The areas are ranked according to water and gas analysis data and geologic relationships. The thermal wells and hot springs in the Hacienda Agua Caliente-Villa Salvadorita- San Luis area produce Ca HCO_3 waters that may have been heated by clean steam or by conduction in the fractures that control the thermal waters.

In the event that further exploration for geothermal resources is undertaken, the Volcan Mombacho area should be examined closely.

Also, the faults trending from Tipitapa toward Volcan Santiago and the Masaya Caldera should be examined in detail by geophysical and geochemical methods.

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A P E N D I C E

A P P E N D I X

WATER ANALYSIS DATA

SAMPLE NO.	[illegible]	[illegible]	COND umho	TDS ppm	SiO_2 ppm	B ppm	Ca epm	Mg epm	Li epm	Na epm	K epm	Na/K	CO_3 epm	HCO_3 epm	SO_4 epm	Cl epm	PO_4 epm	NO_3 epm	F epm	REMARKS
																				VOLCAN MOMOTOMBO HOT SPRING AREA
1	101.0	7.8	9900	6300	135	13.2	5.30	.20	1.40	100.43	6.77	14.8	<.10	.80	2.50	112.00	.01	.02	.05	Punta Las Salinitas
2	101.0	7.8	9600	6452	135	12.7	5.20	.80	1.80	111.39	5.85	19.1	<.10	.80	2.08	121.50	.02	.01	.05	" " "
3	87.5	7.3	9600	6552	140	8.8	5.50	.40	1.70	97.39	5.85	16.7	<.10	.80	2.71	106.00	.03	.01	.05	" " "
4	100.5	7.6	9600	6076	135	8.8	5.20	.80	1.70	95.87	5.85	16.4	<.10	.90	2.08	104.00	.03	<.01	.05	" " "
5	96.5	8.2	9600	6340	135	11.0	5.40	.30	1.90	95.87	6.00	16.5	.30	.30	1.46	105.70	.01	<.01	.05	" " "
6	98.0	8.2	9400	6404	145	1.7	5.60	.10	2.00	97.39	6.15	15.9	.60	.40	2.08	106.30	.01	<.01	.04	" " "
7	101.0	8.2	8300	5412	180	6.6	5.00	.30	1.20	82.17	4.46	18.5	.30	1.10	2.08	88.70	.02	.01	.05	" " "
8	33.0	7.6	10000	6808	165	5.5	6.60	.70	1.70	95.87	6.46	14.9	<.10	.60	2.71	107.15	.02	.03	.01	" " "
9	33.0	7.5	10100	6940	180	4.4	6.70	1.00	1.70	89.48	6.46	13.7	<.10	.60	2.08	104.20	.02	.04	.03	" " "
10	100.0	7.6	8900	5668	160	3.3	5.80	.10	.36	77.22	5.85	13.2	<.10	.80	2.71	90.60	.03	<.01	.03	" " "
11	100.5	8.2	8900	6256	115	4.4	7.40	.10	1.37	68.17	3.38	20.2	.30	.60	2.71	93.00	.02	.01	.06	" " "
12	100.0	7.6	9450	6730	160	3.8	5.00	.90	1.41	105.00	6.77	15.6	<.10	.80	2.08	104.00	.02	.06	.01	" " "
13	96.0	7.9	9450	6549	175	3.2	5.00	.80	1.44	101.35	6.46	15.7	.40	.40	2.08	100.00	.01	.05	.02	" " "
14	95.0	7.5	8910	6606	135	11.5	4.10	1.90	1.34	82.17	6.15	13.4	<.10	.80	2.08	101.00	.01	.02	.04	" " "
15	72.0	7.5	8910	6766	150	11.5	3.80	2.30	1.34	82.17	6.15	13.4	<.10	.90	4.16	106.00	.03	.03	.04	" " "
16	94.5	8.1	8910	6962	165	7.0	4.50	.70	1.26	84.91	6.15	13.8	.20	.50	2.08	102.00	.01	.01	.04	" " "
17	101.5	7.6	8730	6146	195	9.0	4.40	1.50	1.26	80.35	3.74	21.5	<.10	.60	4.16	99.00	.02	.01	.03	" " "
18	100.5	7.4	8910	6354	165	9.0	4.20	1.40	1.26	77.61	3.90	19.9	<.10	.80	2.08	100.00	.03	.02	.03	" " "
19	95.0	8.1	8910	6498	160	11.0	4.10	1.80	1.26	84.91	4.31	19.7	.20	.50	2.08	102.00	.02	.03	.03	" " "
20	91.0	7.6	10000	6604	160	9.6	5.60	.20	1.24	100.00	7.69	13.0	<.10	.70	1.00	105.20	.03	.01	.04	" " "
21	82.0	7.4	5300	3248	140	7.7	4.40	.70	.65	40.17	3.26	12.4	<.10	.30	1.25	53.10	.01	.01	.02	" " "
22	79.0	7.3	4950	3704	130	2.3	2.90	.60	.65	36.52	3.10	11.8	<.10	.50	2.08	54.00	.03	.03	.03	" " "
23*	85.0	7.5	(10500)	6670	125	(34)	5.50	.21	1.01	102.5	4.41	23.3	<.30	.57	1.56	110.00	<.01	(.01)	(.04)	Gradient well M-1A
																				LAGO DE MANAGUA
24	34.0	8.8	2250	1504	41	2.5	.90	1.60	.09	15.78	1.67	9.5	1.30	7.50	2.08	19.00	<.01	.10	.03	At Punta Las Salinitas
25	36.0	8.5	2200	1436	55	1.5	.80	2.00	<.01	15.52	1.64	9.5	2.40	6.10	.42	15.10	<.01	.03	.04	" " " "
26	32.0	8.5	2200	1434	55	1.5	.90	1.70	.36	15.52	1.46	10.6	2.20	6.90	.83	12.65	<.01	<.01	.04	" " " "
27	32.0	8.5	2300	1344	50	1.9	.80	1.70	.29	14.61	1.46	10.0	2.40	6.80	.63	12.65	.02	.01	.04	" " " " (No.26 and 27 duplicates)
28	34.0	8.8	1440	880	50	.7	.40	1.60	.17	10.52	1.21	8.7	1.80	7.90	<.01	7.00	<.01	.05	.04	" " " "
29	30.0	8.7	1500	887	40	.6	.50	1.50	<.01	13.22	1.18	11.2	1.30	8.30	.80	6.44	<.01	.05	.03	At Spring 19A
30	31.0	8.8	1400	782	75	.2	.40	1.70	.06	12.17	1.28	9.5	1.50	8.60	.45	5.84	<.01	.03	.04	At Puerto Momotombo
31	30.0	8.9	1300	766	13	.5	.30	1.80	<.01	12.17	1.18	10.3	1.60	8.70	.25	5.08	<.01	.10	.04	At Mateare Beach
32	30.0	8.8	1300	790	16	.6	.30	1.80	<.01	12.52	1.10	10.6	1.50	9.20	.30	5.44	<.01	.19	.04	At Hacienda Los Angeles, Chiltepe
33	31.0	8.8	1300	774	14	0.3	.30	1.70	<.01	12.52	1.18	10.6	1.40	9.00	.40	5.44	<.01	.40	.04	At El Tomagas (Chiltepe)
34	30.0	8.7	1500	848	16	0.6	.50	1.70	<.01	12.87	1.26	10.2	1.50	9.60	.30	5.44	<.01	.23	.05	At San Francisco Del Carnicero
																				LAGO DE NICARAGUA
35	29.0	7.6	210	192	10	<.1	1.50	.60	.10	.65	.22	2.9	.20	1.20	.15	.58	<.01	.06	<.01	At San Jose Del Mombacho

TABLE I (continued)

WATER ANALYSIS DATA

SAMPLE NO.	TEMP C	pH	COND umho	TDS ppm	SiO_2 ppm	B ppm	Ca epm	Mg epm	Li epm	Na epm	K epm	Na/K	CO_3 epm	HCO_3 epm	SO_4 epm	Cl epm	PO_4 epm	NO_3 epm	F epm	REMARKS
																				HACIENDA CALIFORNIA
36	47.5	8.2	1900	1350	150	1.2	3.50	3.80	.17	12.13	.77	15.8	1.30	6.00	5.83	6.80	< .01	.09	.01	Springs on Rio Agua Caliente
37	48.5	8.2	1800	1240	160	.4	4.10	4.70	.32	5.22	.79	6.6	1.60	6.20	7.71	5.35	< .01	.08	.02	" " " " "
38	47.0	7.8	1800	1272	155	< .1	4.40	4.30	.32	5.43	.79	6.9	.70	7.50	6.25	5.35	< .01	.07	.01	" " " " "
39	40.0	7.9	1100	770	140	.2	2.40	3.10	.04	5.39	.77	7.7	.10	3.60	1.30	5.08	< .01	2.16	.03	Well at Hacienda Obraje near 36, 37, 38
																				LAGUNA DE JILOA
40	33.0	7.4	5700	3666	6	6.0	2.80	5.40	.65	46.90	2.94	16.0	< .1	6.10	.75	54.60	< .01	.02	.03	North shore
41	37.0	7.5	5580	3716	15	6.0	2.50	5.50	.65	58.43	2.82	20.7	< .10	6.60	6.25	56.00	< .01	.03	.04	North shore
42	29.0	8.2	5580	3766	15	2.4	2.60	5.60	.65	56.61	2.82	20.0	1.40	5.20	6.25	56.00	< .01	.02	.03	West of center
43	29.5	8.0	6000	3664	11	2.4	3.10	5.20	.49	44.30	3.79	11.7	1.00	5.40	1.85	52.60	< .01	<.01	.03	South shore
																				LAGO DE APOYEQUE
44	32.0	8.8	6500	3846	125	.5	.70	7.20	.05	62.61	2.46	26.4	3.70	15.70	.50	56.40	< .01	<.01	.03	South shore
45	33.0	8.8	5700	3348	135	3.6	.80	6.10	.03	53.91	2.05	26.4	3.70	13.10	.45	48.80	< .01	.02	.03	South shore
46*	37.0	7.7	-	4010	160	12.0	5.50	10.25	.29	71.70	2.56	28.1	<.30	16.40	.31	50.70	-	-	-	North shore
47*	37.0	8.0	-	3480	165	10.0	3.10	11.10	.27	65.20	2.43	26.9	< .30	15.10	1.08	50.00	-	-	-	North shore
																				LAGO DE NEJAPA
48*	29.0	9.2	-	7850	40	1.5	.45	1.39	<.01	144.00	5.75	25.1	23.66	23.80	18.80	49.50	-	-	-	North end of lake
																				TIPITAPA
49	72.0	8.2	1600	1002	150	1.2	1.20	.10	.25	10.13	.39	26.0	.20	2.40	.21	8.89	< .01	<.01	.07	Main spring
50	38.0	8.2	1400	802	115	.8	2.20	.90	.09	7.83	.41	19.1	.30	4.40	.27	6.23	< .01	.06	.05	Pool above bridge
51	76.0	8.2	1200	796	115	.6	.70	.50	.09	8.08	.39	20.7	.40	2.70	.29	7.14	< .01	<.01	.06	North of highway
																				SAN LUIS
52	78.0	8.6	1800	1264	100	< .1	6.10	.50	.17	7.57	.16	47.4	.40	.40	6.25	2.92	< .01	.02	.11	Spring southwest of corral (25B)
53	74.0	8.7	1700	1282	100	< .1	5.50	1.20	.10	7.80	.16	48.8	.40	.40	7.66	5.92	< .01	.02	.13	Spring southwest of corral (25)
54	78.0	8.6	1700	1290	95	< .1	5.20	1.50	.10	7.61	.16	49.0	.50	.50	7.61	5.92	< .01	.02	.12	Spring southwest of corral (24A)
55	75.0	8.5	1700	1187	120	.2	6.80	.30	<.01	8.43	.23	36.7	.50	.20	10.41	3.21	< .01	.02	.16	Spring south of Hacienda (24)
56	48.5	8.2	1600	1125	95	< .1	5.30	2.10	<.01	8.26	.23	35.9	.60	.10	7.29	3.12	< .01	.01	.17	Well at Hacienda San Luis
57	47.0	7.6	1800	1270	60	.6	6.20	1.50	<.01	9.57	.22	43.5	< .10	.50	10.41	3.21	< .01	<.01	.18	Spring north of Hacienda San Luis (21)
58	46.0	7.8	1700	1195	110	< .1	7.30	.70	<.01	9.13	.24	38.0	< .10	.70	7.71	3.21	< .01	.05	.18	Pool north of Hacienda San Luis (21)
59	87.0	8.3	1700	1184	100	.1	6.30	.60	<.01	7.39	.22	33.6	.60	.10	8.33	2.63	< .01	.02	.16	Main spring north of Hacienda San Luis (21)
60	88.5	8.2	1700	1140	152	.5	7.20	.30	.14	6.95	.22	31.6	.30	.20	10.50	3.90	< .01	.03	.12	Spring 20 feet from No. 59 (21)
61	49.0	8.0	1800	1300	95	< .1	6.00	.60	.17	8.00	.15	53.4	.30	.40	6.25	3.00	< .01	.01	.13	Spring on island south of Hacienda San Luis (26)
																				VOLCAN MOMBACHO
62	48.0	6.9	1600	1252	165	.7	4.30	4.00	.15	9.04	1.15	7.9	.20	6.70	1.60	9.36	.01	.03	.02	Spring at Mecatepe (49)
63	43.0	7.1	1600	1232	150	.4	4.60	4.00	.15	8.72	1.38	6.3	< .10	5.60	4.12	6.64	< .01	.04	.02	Spring at Las Plazuelas (48)
64	55.0	6.8	1300	1122	175	.4	4.50	1.10	<.01	6.61	.85	7.8	< .10	6.00	1.50	5.84	< .01	.05	.02	South of La Granja (45)
65	54.0	7.2	1300	1086	180	.2	4.40	.80	<.01	6.96	.85	8.2	< .10	6.10	2.00	5.08	< .01	.03	.02	South of La Granja (45A)
66	46.0	7.6	1400	980	150	.1	8.30	5.20	.06	3.48	.51	6.8	< .10	4.90	2.75	1.16	< .01	<.01	.03	West of crater
67	54.0	7.4	1400	980	155	< .1	8.70	5.80	.06	4.52	.56	8.1	< .10	4.70	4.30	1.16	< .01	<.01	.03	West of crater
68	32.0	7.3	950	702	120	.3	3.30	1.90	.12	4.17	.59	7.1	< .10	5.10	.85	5.08	< .01	.10	.01	Stream draining spring area No. 62
69	36.0	7.5	590	413	25	< .1	3.30	1.90	<.01	.96	.35	2.7	.90	2.50	.80	.39	< .01	<.01	.03	In crater (46)

TABLE 1 (continued)

WATER ANALYSIS DATA

Sample No.	Temp °C	pH	CO2 (T) mmho	TDS ppm	SiO_2 ppm	B ppm	Ca ppm	Mg epm	Li ppm	Na epm	K epm	Na/K	CO_3 epm	HCO_3 epm	SO_4 epm	Cl epm	NO_3 epm	PO_4 epm	F ppm	Remarks
																				SAN JACINTO-TISATE
70	36.0	7.9	460	310	135	.03	3.75	2.38	<.01	1.30	.23	5.7	<.30	5.57	.42	.28	-	-	-	Well near well SJ-1
71	99.0	4.9	450	310	175	<.10	2.00	1.50	<.01	.44	.39	1.1	<.10	.10	4.16	.09	.01	.04	<.01	Red pool in fumarole area
72	100.0	3.3	3420	3410	300	.40	4.00	10.50	.53	3.04	.46	6.6	<.10	<.10	37.50	<.01	.04	.13	.02	Mud pot in fumarole area
73	43.5	6.8	340	244	115	<.10	1.90	.70	.32	.52	.33	1.6	<.10	2.10	.44	.76	<.01	.17	.01	Spring at waterfall
74	41.0	6.9	350	246	120	<.10	1.60	.90	.26	.52	.33	1.6	<.10	2.10	.33	.85	<.01	.12	<.01	Spring at waterfall
75	33.0	7.0	350	258	110	<.10	1.40	1.00	.29	.74	.26	2.8	<.10	2.30	.21	.90	<.01	<.01	.03	Spring south of pump shed
76	34.0	7.0	320	230	110	<.10	1.40	.90	.29	.61	.26	2.3	<.10	1.80	.42	.75	<.01	.23	.02	Large spring south of pump shed
77	36.0	6.8	320	230	110	<.10	1.70	.40	.26	.70	.26	2.7	<.10	1.60	.50	.75	<.01	.21	.02	Spring near pump shed
78	30.0	7.2	390	280	115	.20	1.30	1.70	<.01	.65	.20	3.3	<.10	2.90	.13	.75	<.01	.10	.01	Spring at dam
79	30.0	7.2	350	260	110	<.10	1.70	.80	<.01	.57	.22	2.6	<.10	2.60	<.10	.59	<.01	.11	.01	Spring between San Jacinto and Tisate
80	31.0	7.3	320	240	115	<.10	1.60	.70	.03	.57	.24	2.4	<.10	2.20	<.10	.70	<.01	.23	.01	Spring between San Jacinto and Tisate
81	32.0	7.2	310	225	100	.10	1.50	.70	<.01	.57	.24	2.4	<.10	2.30	<.10	.55	<.01	.19	.01	Spring between San Jacinto and Tisate
82	28.0	7.0	620	450	135	<.10	2.90	1.70	.29	1.30	.21	6.2	<.10	4.80	.21	1.08	<.01	.03	.02	Seep pool south of Tisate
83	30.0	7.1	490	350	110	<.10	2.10	1.80	.29	.61	.25	2.4	<.10	3.50	.21	.85	<.01	.24	.01	Seep pool south of Tisate
84	66.5	6.4	4000	2535	140	3.10	13.00	7.20	.61	18.78	1.41	13.3	<.10	6.10	.42	83.85	<.01	.06	<.01	Spring in stream channel south of Tisate
85	32.0	7.1	320	230	105	<.10	1.50	.80	<.01	.57	.21	2.7	<.10	2.20	<.10	.75	<.01	.16	.01	Spring between San Jacinto and Tisate
86	38.0	7.0	390	270	115	<.10	1.60	1.40	<.01	.61	.21	2.9	<.10	2.30	<.10	1.12	<.01	.40	.02	Well at Hacienda Tisate
87	85.0	6.1	530	370	155	<.10	2.00	1.20	.07	1.61	.41	3.9	<.10	1.00	3.76	.39	<.01	.05	.03	McBirney's drill hole at Tisate
																				ÑAJO
88	47.5	7.1	270	200	115	.15	1.10	.60	<.01	.70	.20	3.5	<.10	1.70	.19	.59	<.01	.13	.02	Spring at Hacienda Santa Clara
89	45.0	7.1	300	230	115	.20	1.20	.90	.01	.65	.20	3.3	<.10	2.00	.29	.55	<.01	.10	.02	Spring at Hacienda Santa Clara
90	43.0	7.1	310	228	115	.15	1.20	1.00	<.01	.61	.20	3.1	<.10	2.00	.33	.55	<.01	.15	.02	Spring at Hacienda Santa Clara
91	66.0	7.1	300	200	175	<.10	1.10	.60	.01	.87	.29	3.0	<.10	.60	1.23	.95	<.01	.10	.02	Spring near south fumarole area (15B)
92	60.0	7.1	320	240	180	.10	1.40	.90	<.01	.87	.29	3.0	<.10	.60	1.32	1.45	<.01	.10	.03	Spring near south fumarole area
																				MISCELLANEOUS SALINE HOT SPRINGS
93	68.0	8.8	1400	975	70	.15	4.00	.10	<.01	6.96	.16	43.5	.60	.10	4.17	1.36	<.01	.01	.11	Spring at Laguna El Tule (9)
94	51.0	8.8	1400	970	80	<.10	4.30	.30	<.01	6.96	.17	39.7	.50	.10	5.62	1.27	<.01	.02	.12	Spring fed pool at Laguna El Tule (9)
95	80.0	8.2	1800	1230	95	.15	8.90	.10	.14	7.83	.28	28.0	.70	.60	4.08	4.90	<.01	.02	.11	Spring south of Hacienda Mayocunda (11)
96	54.0	8.5	1800	1228	110	.15	8.10	.50	.10	7.57	.28	27.1	.50	.90	5.08	4.45	<.01	.02	.13	Outflow from No. 95
97	50.5	8.7	1800	1258	115	.10	8.10	.10	.09	8.09	.28	29.0	.30	.60	5.08	4.90	<.01	.01	.13	Outlet of No. 96 at river
98	33.0	7.8	1300	920	65	.10	5.90	1.90	.01	4.70	.39	12.1	<.10	3.50	7.43	1.95	<.01	.03	.02	Pool in river channel
99	51.5	7.1	1800	1280	55	.90	6.70	.10	<.01	9.39	.32	29.4	<.10	1.40	8.33	1.75	<.01	<.01	.14	Spring fed pool at Palmica (13)
100	74.0	8.8	2000	1652	70	<.10	7.50	3.10	.26	9.65	.16	60.4	.20	.50	16.93	2.62	<.01	.02	.12	Laguna El Playon (30)
101	75.0	8.8	2000	1690	60	<.10	7.60	3.00	.26	9.65	.15	64.3	.10	.40	17.08	2.63	<.01	.02	.13	Laguna El Playon
102	61.5	8.4	2000	1604	125	<.10	9.80	.30	.14	9.13	.33	27.7	.20	.70	6.67	4.90	<.01	.06	.14	Discharge from shaft of Mina Santa Pancha

TABLE I (continued)

CHEMICAL ANALYSES DATA

SAMPLE NO.	pH		Conductivity µmho	TDS ppm	SiO_2 ppm	Ca ppm	Mg ppm	Na ppm	K ppm	Li ppm	B ppm	F ppm	SO_4 epm	HCO_3 epm	SO_4 epm	Cl epm	NO_3 epm	PO_4 epm	[illegible] epm	Locality
																				MISCELLANEOUS SPRINGS AND WELLS
103	50.0	8.0	1000	834	95	0.20	2.70	.10	<.01	6.96	.17	41.0	.20	.80	3.75	1.16	<.01	.01	.06	Spring northeast of Villanueva (4)
104	55.0	8.6	1000	882	85	.15	2.50	.30	.06	7.65	.17	45.0	.40	1.00	2.60	1.56	<.01	<.01	.06	Spring northeast of Villanueva (2)
105	59.0	8.5	1000	846	85	.15	2.50	.40	.06	7.65	.17	45.0	.40	.70	2.35	1.96	<.01	<.01	.07	Spring northeast of Villanueva (3)
106	31.0	7.4	280	244	85	<.10	.90	.60	.09	1.13	.22	5.1	<.10	2.50	.05	.29	<.01	.01	<.01	Spring SSE of El Espino (5)
107	32.0	7.8	620	400	105	<.10	.80	2.60	.09	2.70	.32	8.4	.80	6.00	.25	.29	<.01	.01	<.01	Spring west of Somoto (6)
108	74.0	8.0	1000	670	105	.40	.80	.30	.20	8.35	.41	20.4	.50	4.90	.83	1.96	<.01	.07	.58	Spring west of Ocotal (7)
109	67.0	8.1	950	668	105	.20	.90	.20	.20	8.00	.40	20.0	.70	4.90	1.28	2.32	<.01	<.01	.53	Spring west of Ocotal
110	38.0	7.3	490	404	115	<.10	1.90	1.00	<.01	1.57	.38	4.1	<.10	3.70	.50	.63	<.01	.01	.03	Well at San Lucas (28)
111	37.5	7.4	460	376	115	<.10	1.80	1.00	<.01	1.30	.32	3.9	<.10	3.30	.50	.49	<.01	.10	.04	Well at San Lucas (27)
112	31.0	7.2	510	360	115	<.10	2.20	1.70	<.01	.96	.32	3.0	<.10	4.20	.33	.57	<.01	.10	.02	Spring north of Lomas San Lucas
113	36.0	7.1	950	730	130	.40	3.10	2.70	<.01	3.70	.41	9.0	<.10	7.10	.42	2.34	<.01	.05	.01	Spring near Hacienda Agua Caliente (Fig. 8)
114	40.0	7.0	1000	710	130	.20	3.20	2.30	<.01	5.30	.51	10.4	<.10	7.10	.42	3.73	<.01	.08	.01	Spring near Hacienda Agua Caliente
115	46.0	7.2	430	404	140	<.10	1.80	.80	<.01	1.35	.32	4.2	<.10	3.10	.58	.53	<.01	.05	.03	Well southwest of Las Grietas (22)
116	36.0	8.1	1100	852	85	.30	2.00	5.30	.20	6.20	.79	7.9	.60	11.10	.70	1.96	<.01	.03	.02	Spring at Las Positas (35)
117	37.0	8.0	1100	800	75	.20	1.80	4.70	.23	6.43	.85	7.6	.30	10.80	.70	1.56	<.01	.03	<.01	Well at Hacienda Isabel (near 35)
118	46.5	8.2	1000	714	90	.10	2.80	.40	.07	6.96	.16	43.5	.30	1.10	6.61	2.24	<.01	.03	.05	Spring west of Teustepe (37)
119	38.0	7.9	430	366	130	<.10	1.90	.30	<.01	1.57	.33	4.8	.40	3.90	.10	.49	<.01	.07	<.01	Spring at Monte Fresco (38)
120	34.0	8.3	450	400	155	1.60	2.00	.90	.07	1.57	.26	6.0	.70	3.70	.08	.60	<.01	.12	.02	Spring southwest of Tecolostote (39)
121	62.0	8.3	900	800	110	3.90	2.00	.80	.07	6.09	.16	38.1	.30	1.10	6.25	1.60	<.01	.06	.03	Spring north of Juigalpa (40)
122	35.0	7.1	1100	790	140	.30	2.30	1.20	<.01	7.30	.85	8.6	<.10	6.70	.67	4.29	<.01	<.01	.02	Well at Hacienda Ocoton (41)
123	34.0	7.3	880	810	120	.10	6.50	2.10	<.01	.70	.17	4.1	.10	2.10	2.80	1.16	<.01	.11	.04	Stream from Springs La Calera (44)
124	39.0	7.8	840	588	115	.15	2.50	2.50	.03	4.13	.56	7.4	<.10	7.50	.60	1.60	<.01	.10	.03	Well at Hacienda Santa Rosa (47)
125	35.0	7.1	1300	910	140	.50	5.00	7.30	.03	3.48	.74	4.7	<.10	11.00	1.23	3.12	<.01	<.01	.02	Well near El Hoyo (48)
126	34.0	7.5	1000	700	125	.65	4.30	5.20	.03	2.26	.46	4.9	<.10	9.30	.83	1.96	<.01	2.31	.02	Well at Hacienda Caoba (49)
127	33.0	7.9	460	358	70	1.30	1.30	1.50	<.01	1.74	.08	13.3	.60	3.50	.35	.78	<.01	.04	.01	Spring Agua Caliente De Acayo (50)
128	33.0	7.7	740	518	115	.20	2.30	3.20	.03	2.70	.38	7.1	<.10	6.30	.67	.68	<.01	.46	.02	Well at Hacienda La Esperanza (51)
129	39.5	8.0	810	566	125	.30	2.20	1.90	.06	4.70	.59	8.0	.20	6.70	.68	1.60	<.01	.11	.02	Well at Hacienda Transito (53)
130	40.5	8.2	1500	1050	160	.40	5.40	8.00	.03	4.35	.85	5.1	.60	7.70	1.95	5.08	<.01	.06	.02	Well at Hacienda Baronessa (55)

LEGEND

(55) - Refers to spring or well No. in appendix of Regional Geology Report

* Values in parentheses from SGN Laboratory, other values from Skyline Laboratory, Denver, Colorado, USA

TABLE II

ANALYSIS OF THERMAL GASES

SAMPLE NO.	TEMP °C	H_2 Vol. %	O_2 Vol. %	CO_2 Vol. %	H_2S ppm	LOCATION* AND MISCELLANEOUS ANALYSES
1	101.0		12.5		>2000	V. Momotombo fumarole area A
2	75.0		15.0	0.4	250	V. Momotombo fumarole area A at Spring 19A
3	101.5				3000	Ibid. No. 1
4	101.5				5100	Ibid. No. 1
5	101.5		8.0		6180	Ibid. No. 1; NH_3>7000 ppm
6	94.0		13.0		950	Ibid. No. 2
7	101.0	< 0.2	8.0	42.0	4400	Ibid. No. 1
8	94.0	< 0.2	8.0	< 1.0	800	Ibid. No. 2
9	100.0	< 0.2	10.0	40.0	3800	Ibid. No. 1
10	101.0	< 0.2	10.0	45.0	5400	Ibid. No. 1
11	101.5		8.0	>20.0	3500	V. Momotombo fumarole area C
12	101.0	< 0.2	8.0	38.0	3700	Ibid. Note: 300 ppm H_2S near hot springs
13	101.0		8.0	>20.0	4800	V. Momotombo fumarole area D
14	100.0		10.0		1900	Ibid.
15	94.5		16.0		900	Ibid.
16	101.0	< 0.2	7.0	25.0	10000	Ibid. sample site No. 13
17	101.5		20.0	12.0	80	San Jacinto fumarole area
18	101.5		20.0	17.5	50	Ibid.
19	102.0	< 0.2	8.0	10.0	80	Ibid. sample site No. 17
20	102.0	< 0.2	10.0	15.0	80	Ibid. sample site No. 18
21	100.0	< 0.2	10.0	20.0	100	Ibid.
22	101.0		8.0	>20.0	4600	Tisate fumarole area
23	101.5	< 0.2	8.0	35.0	3600	Ibid.
24	85.0		16.0	< 1.0	2	Ibid. (McBirney's drill hole)
25	100.5		5.0	>20.0	4200	V. Telica fumarole area N. side; NH_3>7000 ppm
26	97.0		11.0	5.0	1	V. Casita fumarole area G (Fig. 7)
27	98.0		12.5		2	Ibid.
28	97.0		15.0	4.5	< 1	V. Casita fumarole area E (Fig. 7)
29	91.5		12.5	15.0	< 1	V. Casita fumarole area C (Fig. 7)
30	87.0		15.0	5.0	< 1	Ibid.
31	98.0		14.0	>5.0	30	V. Casita fumarole area D (Fig. 7)
32	99.0	<0.2	6.0	45.0	35	Ibid.
33	101.0	<0.2	<1.0	60.0	7500	L. Jiloa fumarole area
34	80.0	<0.2	7.0	<1.0	< 1	V. Cerro Negro crater; 10 ppm SO_2
35	≫ 230.0	<0.2	10.0	<1.0	400	Ibid.
36	≫ 100.0	<0.2	15.0	<1.0	< 1	V. Cerro Negro 1968 flow; 65 ppm SO_2
37G	101.0	0.09	14.3	0.38	9	SJ; 12 ppm CH_4; 9 ppm HCl; 50 ppm CO
38G	101.0	0.10	13.9	.28	7	SJ; 9 " " <4 " " <10 " "
39G	100.0	.07	14.3	.13	4	SJ; 23 " " 15 " " <10 " "
40G	100.0	.09	14.2	.07	3	SJ; 20 " " <4 " " <10 " "
41G	95.0	.09	13.7	1.49	4	M-C; 30 ppm CH_4; 8 ppm HCl; 30 ppm CO
42G	95.0	.10	13.9	1.45	13	M-C; 42 " " 13 " " 10 " "
43G	102.0	.07	12.7	18.18	160	M-A; 489 " " 8 " " 360 " "
44G	102.0	.08	12.6	8.44	258	M-A; 240 " " 5 " " 170 " "
45G	101.0	.19	10.2	15.29	313	T; 663 " " 62 " " 360 " "
46G	101.5	.10	12.8	6.12	3	T; 150 " " 31 " " 100 " "
47G	90.0	.09	14.1	.09	3	Well M-1A; CH_4 9; HCl 53; CO <10 in ppm
48	96.0	<0.2	8.0	10.0	1000	Well M-3
49	88.0	<0.2	12.0	<1.0	2	Well M-5; 15 ppm SO_2
50	65.0	<0.2	14.0	<1.0	< 1	Well M-6; 10 ppm SO_2
51	70.0	<0.2	10.0	5.0	600	Well M-7; 200 ppm SO_2

* Location designations, e.g., S19A, refer to appendix tables and text figures in Regional Geology report.

A: fumarole area A
C: fumarole area C
M: Momotombo
SJ: San Jacinto
T: Tisate

G: Samples analyzed by gas chromatography by Rocky Mountain Technology, Inc., Denver, Colorado, U.S.A.