6. Circulation Mechanism of Geothermal Fluid in the Investigation Area

6. Circulation Mechanism of Geothermal Fluid in the Investigation Area

6.1 Hydrological Survey

6.1.1 Purpose and Method of Hydrological Survey

(1) Purpose

For interpretation regarding circulation mechanism of geothermal fluid, it is necessary to study circulation and connection mechanisms of geothermal hot water, hot water and ground water. These mechanisms are composed mainly of permeation of meteoric water or surface water into underground, conversion of underground water into geothermal hot water by heating at depths, ascent of geothermal hot water and formation of hot water by mixing with shallow underground water, and hot springs at the surface.

For this purpose, hydrological survey is required to study precipitations of rain and snow fall, water discharge of river, permeable and gushing amounts of ground water as quantitatively as possible.

Because this survey was conducted during four-month period in summer and with almost nothing of rain fall, it is impossible to study how rain water runs as surface water, or how surface water permeat into underground. However, on the basis of calculations of specific discharge, balance of underground water in the area is roughly understood. This hydrological survey was carried out by measurements of water discharge, calculations of specific discharge, and studied on preservations of water in rocks or strata in relation with geology.

(2) Method

Measurements of water discharge were usually done by current meter. In case of a little water discharge or shallow depth of water, bucket was used. Measuring points were selected at places having more than 10 cm deep and showing uniform current, and graded river bottom if current is not uniform. Measuring intervals at each points were set up a standard as approximately one tenth of river width. Depth of water and velocity of current at each points were measured as follows; namely, one measurement of velocity at depth of 60% from water surface in case of less than 50 cm deep, and two measurements of velocity at 20% and 80% from water surface in case of more than 50 cm deep. Measuring time ranged 30 to 60 seconds and measuring was doubled at each points.

6.1.2 Measurement and Analysis of Water Discharge

(1) Results of measurement of water discharge

Measurements of water discharge were conducted as an object of main rivers in the investigation area such as Ailinco, Manchana Covunco, Aguas Calientes and Covunco Rivers, together with their branch creeks. Total measuring points are 28 points, and Fig. 6-1 and Table 6-1 show their locations and results of measurement of water discharge, respectively.

Because each rivers increased their rates of flow and had unstable current because of melting snow, data considered to be erratic were removed for analysis. Aiming to estimate measuring error, measurements were done at two points apart approximately 10 m each other, and resulted their errors of more or less 5%.

Measured values range from maximum 174,856 l/min to minimum 389 l/min. Branch rivers of Varvarco River, such as Ailinco, Manchana Covunco, Covunco and Atreuco Rivers, have their riverheads in areas outside of the investigation area, and occupy wide drainage basins. Rates of water discharge measured at the confluence of Varvarco River and each branch rivers or lower most streams of each branch rivers give large amounts of 108,168 l/min, 174,856 l/min, 139,867 l/min and 101,866 l/min, respectively. On the contrary, Aguas Calientes River, which has its waterhead at Mt. Domo in the investigation area, gives a limited rate of water discharge of 7,051 l/min.

Daily variations of water discharge were observed at fixed point located at lower streams of Covunco River, and results of each one hour during twenty-four hours gave maximum value of 145,000 l/min at 12 o'clock in the night and minimum value of 134,000 l/min at 6 to 7 o'clock in the evening. Fig. 6-2 shows daily variations of water discharge, water temperature and atmospheric temperature.

(2) Calculations of specific discharge

In order to calculate specific discharge, areas of drainage basins of each river were measured on the basis of topographic maps in scale of 1:25,000 and 1:100,000. Calculation of specific discharge were based on following equation.

$$\text{specific discharge (l/min}\cdot\text{Km}^2) = \frac{\text{rate of water discharge (l/min)}}{\text{area of drainage basin (Km}^2)}$$

Table 6-2 gives results of these calculations, and rates of water discharge, areas of drainage bassin and specific discharge at each two points of upper and lower streams of Ailinco, Manchana Covunco, Aguas Calientes and Covunco Rivers are summarized in Table 6-3.

According to these results, following facts are pointed out. That is, at upper and lower streams of Ailinco and Manchana Covunco Rivers, specific discharges at lower streams are less than those of upper streams, despite rates of water discharge at lower streams are much as compared with those at upper streams. Main reasons of these phenomena are considered to cause from relatively less supplies of water from branch creeks to main rivers between two points, and also it is possible to assume a large amount of permeations of the running water into underground. On the other hand, at upper and lower streams of Aguas Calientes and Covunco Rivers, both rates of water discharge and specific discharge increase at lower streams, especially rates of their increases at Ailinco River are high. These phenomena are clearly understood by large amounts of supplies of water from branch creeks and of spring out of hot water and underground water.

Among drainage systems of western parts of Mt. Domo, ten measuring points at small branch rivers and creeks having their waterheads from Mt. La Papa, Mt. Domo and Mt. Covunco give maximum 1,488 l/min·Km^2, minimum 73 l/min·Km^2 and average 512 l/

Table 6-1 Measurements of the rate of flow

No.	Location	Rate of flow (1/min)	Temperature (°C)	Date and time of measurement	Method
1	A branch of Å Ailinco	1,729	10.5	23/Feb. 10.30	H
2	A branch of Å Ailinco	15,022	13.2	23/Feb. 11.30	H
3	Upstream of Å Ailinco	95,933	10.1	23/Feb. 12.00	H
4	Down stream of Å Ailinco	108,168	15.6	23/Feb. 14.25	H
5	Upstream of Å Manchana Covunco	87,493	5.0	21/Feb. 10.45	H
6	A branch of Å Manchana Covunco	1,116	14.1	21/Feb. 12.30	B
7	A branch of Å Manchana Covunco just at the upper stream of El Humazo	465	15.1	21/Feb. 13.40	H,B
8	A branch of Å Manchana Covunco just at the upper stream of El Humazo	162,567	12.5	21/Feb. 14.25	H
9	Small branch of Å Manchana Covunco	616	11.7	21/Feb. 14.45	B
10	A branch of Å Manchana Covunco at the upper stream of las Olletas	389	15.5	22/Feb. 13.40	B
11	Å Manchana Covunco	174,856	22.7	22/Feb. 15.46	H
12	Å branch near the point 11	3,330	20.5	22/Feb. 16.00	H
13	Å Aguas Frías	742	8.5	19/Feb. 9.20	H
14	Upstream of Å Aguas Calientes	3,669	46.5	19/Feb. 9.50	H
15	Å Aguas Calientes	4,231	43.3	19/Feb. 10.30	H
16	Å Aguas Calientes	4,505	42.7	19/Feb. 13.40	H
17	Å Aguas Calientes	6,743	46.4	19/Feb. 14.40	H
18	Downstream of Å Aguas Calientes	7,051	28.2	19/Feb. 16.00	H
19	Downstream of Å Manchana Covunco	441	17.0	19/Feb. 16.00	B

Table 6-1 Measurements of the rate of flow (Cont'd)

No.	Location	Rate of flow (l/min)	Temperature (°C)	Date and time of measurement	Method
20	Upstream of Å Covunco	72,354	5.0	20/Feb. 10.50	H
21	A branch of Å Covunco	768	6.0	20/Feb. 11.00	B
22	Å Covunco just downstream of Los Tachos	72,743	18.9	20/Feb. 11.30	H
23	Å Covunco	103,563	23.4	20/Feb. 14.00	H
24	A branch of Å Covunco	481	7.0	20/Feb. 9.00	H,B
25	A branch of Å Covunco	5,024	19.4	20/Feb. 15.40	H
26	Å Covunco	139,867	15.0	22/Feb. 10.50	H
27	A branch of Å Covunco	533	11.4	22/Feb. 9.30	H,B
28	Å Atreuco	101,866	8.1	22/Feb. 9.50	H

H: measured by current meter
B: volumetric method

Table 6-2 Rate of flow and specific discharge

No.	Date and time of measurement	Rate of flow ℓ/min	Drainage area km^2	Specific discharge $\ell/m \cdot km^2$
1	23/Feb.	1,729	3.71^+	466^-
2	"	15,022	4.25^+	3535
3	"	95,933	61.85	1551
4	"	108,168	76.2	1420
5	21/Feb.	87,493	21.33	4101
6	"	1,116	0.75	1488
7	"	465	1.86	250
8	"	162,567	44.61	3644
9	"	616	0.75	821
10	22/Feb.	389	3.56	109
11	"	174,856	58.5	2989
12	"	3,330	14.1	236
13	19/Feb.	742	10.20	73
14	"	3,669	10.49	350
15	"	4,231	11.56	366
16	"	4,505	11.83	380
17	"	6,743	13.75	490
18	"	7,051	15.25	462
19	"	441	2.39	185
20	20/Feb.	72,354	38.252	1892
21	"	768	0.678	1133
22	"	72,743	41.76	1742
23	"	103,563	42.53	2435
24	20/Feb.	481	3.05	158
25	"	5,024	7.77	647
26	22/Feb.	139,867	63.2	2213
27	"	533	5.57	96
28	"	101,866	107.7	946
4+11+ 26+28		524,757	305.6	1717

Table 6-3 Summary table of river flows

Name of river	Measure	Up-stream	Down-stream	Difference
	Rate of flow (ℓ/min) / Surface area (km^2) / Specific discharge (ℓ/min.km^2)			
Å Ailinco	Rate of flow (ℓ/min)	95933	108168	2235
	Surface area (km^2)	61.85	76.2	14.35
	Specific discharge (ℓ/min.km^2)	1551	1420	853
Å Manchana Covunco	Rate of flow (ℓ/min)	87493	174856	87363
	Surface area (km^2)	21.33	58.5	37.17
	Specific discharge (ℓ/min.km^2)	4102	2989	2350
Å Aguas Calientes	Rate of flow (ℓ/min)	742	7051	6309
	Surface area (km^2)	10.20	15.25	5.05
	Specific discharge (ℓ/min.km^2)	73	462	389
Å Covunco	Rate of flow (ℓ/min)	72743	139867	67124
	Surface area (km^2)	41.74	63.2	21.46
	Specific discharge (ℓ/min.km^2)	1743	2213	3128
Å Atreuco	Rate of flow (ℓ/min)	-	101866	-
	Surface area (km^2)		107.7	
	Specific discharge (ℓ/min.km^2)		946	
Total & Average	Rate of flow (ℓ/min)	256911	531808	
	Surface area (km^2)	135.12	320.85	
	Specific discharge (ℓ/min.km^2)	1901	1657	

min·Km² of specific discharge. If these values of specific discharge are considered to be averages specific discharge in the investigation area, values of specific discharge at each upper streams of main branch rivers are three to eight times bigger than the above averages. The reasons of these large values are understood by large amount of water supply by melting snow from outside of the investigation area.

6-1-3 Considerations on Results of Hydrological Survey

(1) Hydrological structure of recharge area

Main rivers flowing into Varvarco River have total areas of 321 Km² which generally form western slopes of Domuyo Volcano situated at east of the investigation area. Eternal snow covers Domuyo Volcano and water supply continues on into rivers even summer season of very little rain-falls. Large value of specific discharge of 4,102 l/min·Km² at upper streams of Manchana Covunco is considered to originate mainly from melting snow. In addition, rates of water discharge during late winter to early summer increase much more because of melting snow from highlands of Mt. La Papa, Mt. Domo and Mt. Covunco.

These meteoric water and surface water in rivers becomes underground water penetrating into subsurface of piedmonts of Domuyo Volcano, and most of underground water circulates gradually toward west and a portion reaches at depths. Thus, it can be said there is enough supply to underground water in the region and investigation area.

(2) Structure of aquifer and circulation of underground water

Tables A-2, A-3 and Fig. 3-10 show effective porosity of constituent rocks in the investigation area, and Fig. 6-3 shows schematic columner section of geology and effective porosity.

Penetrated water from the ground surface to shallow subsurface becomes unconfined underground water, and circulates in accordance with geologic structure. Then, a portion of unconfined underground water converts into confined underground water penetrating into more depths. Penetrations and circulations of underground water are conformed by not only effective porosity of rocks, but are depended on permeability of whole rocks and/or strata. However, strata of high porosity such as layer of tuff generally form excellent aquifers. This fact is proved that underground water contained in aquifers within porous pyroclastic members of younger volcanic rocks springs out from and along boundaries between pyroclactic members and granodiorites of the basement.

These pyroclastic rocks gently dip toward west. Because degree of confines is considered to be not so high, it is supposed that velocity of circulation of underground water from east to west is larger than that of usual cases. Ground water near La Bramadora area, which penetrates into and circulates in high porosity members or well fractures parts of Mesozoic formations, flows out from its aquifer in the formation at east of Mt. La Papa. Because basement rocks, especially granodiorites, are of very low effective porosity, rocks themselves cannot become as aquifer. However, depending upon fractures of joint and/or fissure developed in them, some aquifers of various shape and size are formed. At well fractured parts in basement rocks where fracture systems developed at depth, underground water permeates into much deeper sections and circulates rather regionally.

6.2 Hot water and Fumarolic Gas

6.2.1 Purpose and Object Area of Hot Water and Fumarolic Gas Survey

(1) Purpose

At present, success or failure of geothermal development both technically and economically depends upon whether high temperature geothermal fluid such as steam or steam-contained hot water would be obtained from the subsurface.

Hot springs and fumaroles are outcrops on the surface of geothermal system. Therefore, by surveys of hot water and fumarolic gas, it can be presumed characteristics and formation mechanism of geothermal fluid, conditions and scale of geothermal fluid reservoir, and circulation mechanism of geothermal fluid. For instance, temperatures of geothermal hot water when it is formed by reactions between deep ground water and surrounding rocks can be calculated, based on amounts of main soluble ion in hot water. And, it is also possible to presume grades of geothermal activity and location or scale of heat source at depths, on the basis of interpretations regarding formation mechanism of geothermal hot water and hot water through classifications of type of hot water. In addition, based on constituent elements of fumarolic gas, it can be contributed to judge origins and types of geothermal system such as vapor dominated system and water dominated system.

Aiming to analize above-mentioned items, hot water and fumarolic gas survey was conducted.

(2) Object areas of hot water and fumarolic gas survey, and numbers of sample

Areas of geothermal manifestation such as hot springs and fumaroles in the investigation area are following eight areas; namely, Arrojo Ailinco, Rincon de Las Papas, Baños del Agua Caliente, Arroyo Aguas Calientes, Las Olletas, El Humazo, Los Tachos and La Bramadora.

Eighteen samples of hot water, nine samples of fumarolic gas and nine samples of condensed water were taken from eight areas. Fig. 6-6 shows location map of these sampling, and Fig. 6-7 to Fig. 6-15 show detailed sketch maps of each geothermal manifestation areas.

6.2.2 Principal Elements of Hot Water

(1) Elements and methods of chemical analysis of hot water

Measurements of temperature, pH and conductivity were done in the field, and totaling 17 elements of chemical analysis were conducted in the laboratories; namely, Li^+, K^+, Na^+, Ca^{++}, Mg^{++}, Mn^{++}, Total Fe, Al^{+++}, F^-, Cl^-, SO_4^{--}, HCO_3^-, $HAsO_2^-$, HBO_2^-, B^-, NH_4^+ and SiO_2. These analytical methods are shown in Table A-9, and Table 6-4 and Table A-10 give analytical results in Japanese and Argentine laboratories, respectively.

(2) Characteristics of each compositions.

1) Temperature: Temperatures of hot water range from maximum 94.5°C to minimum 23.0°C; namely, Rincon de Las Papas 23.0° ~ 46.0°C, Aguas Calientes 47.0° ~ 79.0°C, Las Olletas 93.5° ~ 94.5°C, El Humazo 97.5°C, Los Tachos 58.4° ~ 93.8°C and La Bramadora 32.7°C.

2) pH: pH of hot water shows weak acidic to weak alkaline ranging from 6.2 to 8.2, and is concentrated into intermediate of pH 7.0. Although no big differences at each areas are observed, hot water of relatively high temperature such as Las Olletas, El Humazo and parts of Los Tachos have values of more than pH 7.0, and that of low temperature such as Rincon de Las Papas, Baños del Agua Caliente and La Bramadora have values of less than pH 7.0. Hot water at Arroyo Aguas Calientes showing rather wide variations of their temperatures range from pH 6.4 to 8.0.

3) Conductivity: Values of conductivity are roughly in proportion to total amounts of soluble ion in hot water. Maximum 8,680 $\mu\mho$ is recorded at RP-2 of Rincon de Las Papas and minimum 1,540 $\mu\mho$ is obtained at AC-2 of Aguas Calientes.

4) Li^+: Values of Li^+ range from 2.5 to 12.1 mg/l except very low value of <0.1 mg/l at LB-1 of La Bramadora.

5) K^+: Values of K^+ range from 22 to 152 mg/l except very low value of 1.6 mg/l at LB-1 of La Bramadora.

6) Na^+: Values of Na^+ range from 280 to 1,570 mg/l except very low value of 15 mg/l at LB-1 of La Bramadora, and values of Na^+ at Aguas Calientes are generally low.

7) Ca^{++}: LB-1 of La Bramadora gives maximum of 491 mg/l. Values of Ca^{++} generally range from 12.5 to 58.0 mg/l except relatively higher values of 102 mg/l at RP-1, 209 mg/l at RP-2 and 70.8 mg/l at RP-3 of Rincon de Las Papas.

8) Mg^{++}: Three samples of Rincon de Las Papas Ranging from 17.2 to 48.0 mg/l give more than ten times higher values than others ranging from 0.3 to 3.6 mg/l.

9) Mn^{++}: Three samples of Los Tachos and La Bramadora give relatively high values of 0.4 mg/l, and others are low as <0.1 mg/l.

10) Total Fe: All samples give values of less than 0.1 mg/l.

11) Al^{+++}: Eleven samples range values from 0.1 to 0.3 mg/l, and remainders are low as <0.1 mg/l.

12) F^-: Values of F^- range from 1 to 4 mg/l except low value of <0.1 mg/l at LB-1 of La Bramadora.

13) Cl^-: Values of Cl^- range from 450 to 2,900 mg/l except extremely low value of 3 mg/l at LB-1 of La Bramadora. Incidentally, an average value of Cl^- of hot water in Japan is 1,260 mg/l.

14) SO_4^{--}: Values of SO_4^{--} range from 18 to 245 mg/l except very high value of 1,040 mg/l at LB-1 of La Bramadora.

15) HCO_3^-: Three samples of Rincon de Las Papas give high values ranging from 740 to 1,300 mg/l, and others give low values ranging from 60 to 180 mg/l.

16) $HAsO_2^-$: Values of $HAsO_2^-$ range from 0.8 to 3.2 mg/l except very low value of H0.2 mg/l at LB-1 of La Bramadora.

17) HBO_2^-: Values of HBO_2^- range from 8.1 to 45.4 mg/l except very low value of <0.1 mg/l at LB-1 of La Bramadora.

18) B^-: Values of B^- range from 2.0 to 11.2 mg/l except very low value of <0.1 mg/l at LB-1 of La Bramadora.

19) NH_4^+: Values of NH_4^+ range from 0.12 to 1.25 mg/l; namely, 0.59 ~ 1.25 mg/l of Rincon de Las Papas, 0.55 mg/l at LT-11 of Los Tachos, 0.42 ~ 0.61 mg/l of El Humazo and Las Olletas, and less than 0.40 mg/l of the remainders.

20) SiO_2: Values of SiO_2 range from 24.8 to 202 mg/l. Among them, lower values of 24.8 mg/l and 68 mg/l are given at LB-1 of La Bramadora and at RP-3 of Rincon de Las Papas, respectively. The remainders are from 115 to 202 mg/l. Although values of SiO_2 in hot water of volcanic origin generally range from 100 to 700 mg/l, depositions of silica occur accompanying with a fall of temperature.

(3) Classification of hot water by main chemical compositions

Characteristics of hot water based on main chemical compositions are summarized as follows;

i) Chemical compositions at LB-1 of La Bramadora are of very peculiar. Namely, values of Li^+, K^+, Na^+, F^-, Cl^-, $HAsO_2^-$, HBO_2^- and SiO_2 are low, and those of Ca^{++}, HCO_3^- and SO_4^{--} are high. Among them, Ca^{++} in cation and SO_4^{--} in anion are dominant. This is characterized by composition of $SO^{--}/Cl^- > 1$ which means hot water of volcanic origin, and is classified into sulphate springs.

Table 6-4 Chemical concentrations of hot water and condensed water

No.	Sample No.	T °C	pH	Li mg/l	K mg/l	Na mg/l	Mg mg/l	Ca mg/l	Mn mg/l	Fe mg/l	Al mg/l	F mg/l	Cl mg/l	SO_4 mg/l	$HAsO_2$ mg/l	HCO_3 mg/l	SiO_2 mg/l	HBO_2 mg/l	B mg/l	NH_3 mg/l	Hg mg/l	Conductivity μ℧
1	RP-1	46.0	6.9	4.1	72	715	17.2	102	<0.1	<0.1	0.2	2	970	115	2.3	740	115	18.8	4.6	0.67	-	4030
2	RP-2	40.2	7.0	10.6	104	1570	50.7	209	<0.1	<0.1	0.3	2	2900	76	0.9	780	123	37.6	9.3	1.25	-	8380
3	RP-3	23.0	6.6	3.9	37	1560	48.0	70.8	<0.1	<0.1	0.1	2	1775	39	1.4	1300	68	45.6	11.2	0.59	-	6670
4	LO-1	94.5	8.0	9.0	53	973	1.1	43.2	<0.1	<0.1	0.1	3	1500	154	2.5	110	200	32.7	8.1	0.61	-	4990
5	LO-2	93.5	7.6	9.7	72	1050	1.1	47.4	<0.1	<0.1	0.1	4	1700	176	3.1	110	197	36.4	9.0	0.42	-	5540
6	EH-1	97.5	7.2	12.1	152	1330	0.2	34.6	<0.1	<0.1	0.1	4	2000	230	3.2	100	240	45.4	11.2	0.52	-	6810
7	EH-2	-	8.2	9.8	127	1130	0.7	36.8	<0.1	<0.1	0.1	4	1775	245	2.6	90	202	39.8	9.8	0.46	-	5590
8	AC-1	79.0	7.4	7.3	51	1090	0.9	34.4	<0.1	<0.1	0.1	3	1265	128	2.2	80	194	27.7	6.8	0.35	-	4150
9	AC-2	62.2	6.9	2.5	22	280	1.5	14.8	<0.1	<0.1	<0.1	1	450	18	0.8	120	162	8.1	2.0	0.15	-	1540
10	AC-3	60.5	8.0	5.6	41	679	1.4	26.0	<0.1	<0.1	<0.1	2	1012	100	1.4	90	172	19.8	4.9	0.21	-	3300
11	AC-4	67.7	6.4	6.3	44	715	2.0	48.6	<0.1	<0.1	0.1	2	1175	118	1.7	140	166	22.4	5.5	0.18	-	3880
12	AC-5	61.0	6.5	6.1	49	729	2.3	58.0	<0.1	<0.1	0.1	2	1200	118	1.8	180	147	22.2	5.5	0.12	-	3910
13	AC-6	66.1	7.1	5.3	46	580	2.0	25.0	<0.1	<0.1	<0.1	1	780	78	1.4	90	192	19.0	4.7	0.28	-	3210
14	AC-7	47.0	7.0	4.5	41	554	2.7	21.6	<0.1	<0.1	<0.1	1	825	88	1.2	100	181	15.9	3.9	0.36	-	3790
15	LT-11	93.8	7.4	10.2	88	1240	1.5	55.6	0.4	<0.1	0.1	4	1900	196	2.6	110	198	36.8	9.1	0.55	-	6090
16	LT-12	64.9	6.4	4.1	55	465	0.3	12.5	0.4	<0.1	<0.1	2	760	78	1.6	60	162	14.2	3.5	0.18	-	2500
17	LT-13	58.4	6.2	4.9	68	537	0.3	14.7	0.4	<0.1	<0.1	2	920	94	2.0	80	164	16.9	4.2	0.19	-	2940
18	LB-1	32.7	6.6	<0.1	1.6	15	3.6	491	0.4	<0.1	<0.1	<1	3	1040	<0.2	180	24.8	<0.1	<0.1	0.25	-	1800
19	CLO-1	-	7.23	0.3	2.3	38	<0.1	0.5	<0.1	<0.1	<0.1	<1	82	6	2.7	20	2.7	0.8	0.2	3.35	0.009	218
20	CLO-2	-	6.97	<0.1	0.3	0.8	<0.1	<0.1	<0.1	<0.1	<0.1	<1	1	<1	<0.005	20	<0.1	0.032	<0.1	3.36	<0.005	23.4
21	CEH-1	-	6.59	<0.1	0.3	1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<1	2	1	<0.005	20	<0.1	0.008	<0.1	3.43	<0.005	27.5

Table 6-4 Chemical concentrations of hot water and condensed water (Cont'd)

No.	Sample No.	T °C	pH	Li mg/l	K mg/l	Na mg/l	Mg mg/l	Ca mg/l	Mn mg/l	Fe mg/l	Al mg/l	F mg/l	Cl mg/l	SO_4 mg/l	$HAsO_2$ mg/l	HCO_3 mg/l	SiO_2 mg/l	HBO_2 mg/l	B mg/l	NH_3 mg/l	Hg mg/l	Conductivity μ℧
22	CEH-2	-	7.19	<0.1	0.2	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<1	<1	<0.005	20	<0.1	0.016	<0.1	3.88	<0.005	24.9
23	CEH-3	-	7.16	<0.1	0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<1	1	<0.005	20	<0.1	0.016	<0.1	3.88	<0.005	28.5
24	CLT-1	-	6.60	<0.1	0.6	5.0	<0.1	<0.1	<0.1	<0.1	<0.1	<1	8	1	<0.005	20	<0.1	0.070	<0.1	3.52	<0.005	53.8
25	CLT-2	-	6.30	<0.1	0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<1	<1	<0.005	10	<0.1	0.016	<0.1	2.10	<0.005	15.7
26	CLT-3	-	6.85	<0.1	0.3	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<1	1	<0.005	20	<0.1	0.020	<0.1	3.85	<0.005	27.3
27	CLB-1	-	7.14	<0.1	0.3	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<1	1	<0.005	30	<0.1	<0.005	<0.1	10.0	<0.005	64.6

No. 1 ∿ 18: Hot water, No. 19 ∿27: Condensed water

ii) Three samples of at RP-1 and RP-2 of Rincon de Las Papas and at RP-3 of Arroyo Ailinco give high values of Ca^{++}, Mg^{++} and HCO_3^-, and are classified into Ca-Mg bicarbonate springs.

iii) AC-2 of Aguas Calientes has less total amounts of soluble ion of more or less 1,000 mg/l as compared with six samples of its surrounding area, and give the lowest value of 1,540 μ in its conductivity. This can be classified into simple springs.

iv) The remainding thirteen samples except LB-1, RP-1, RP-2, RP-3 and AC-2 are under the same level of total amounts of soluble ion in them, and are classified into common salt springs which are characterized by high values of Na^+ of cation and Cl^- of anion.

6.2.3 Analytical Results of Hot Water Survey

(1) Outlines on origin of main compositions in hot water

Hot water is formed by mixture at various rate between geothermal hot water from depths and shallow underground water of surface water. There are big differences of total amounts of soluble ion between geothermal hot water and shallow underground water or surface water.

Namely, geothermal hot water keeps its balance under conditions of temperature and pressure, and shows chemical compositions being reflected in these conditions. Generally, geothermal hot water contains much amounts of Li^+, K^+, Na^+, Cl^-, B^- and SiO_2. These ions are divided into two types; 1) soluble or anti-reflective ion, and 2) reflective ion. Cl^- and B^- belong to the former. Among ions belonging to the later, concentrations of K^+, Na^+ and Li^+ are resulted by reflections with surrounding rocks corresponding with temperature, and concentrations of Ca^{++}, Mg^{++}, F^-, SO_4^{--} and SiO_2 are caused by various degrees of dissolution of minerals such as quartz, calcite, anhydrite and fluorite. Accordingly, as is mentioned later, geochemical geothermometer to presume temperatures when geothermal hot water is formed at depths is presented, in another word to study reflection temperatures between deep hot water and surrounding rocks at depths on the basis of ion-compositions in hot water.

On the other hands, average ion-compositions in surface water of rivers and lakes in the world are known, and a tendency of variations of ion-compositions in shallow underground water which penetrates from the surface to the subsurface is also studied. In general, values of HCO_3^- and SO_4^{--} increase at relatively shallow underground. Thus, values of SO_4^{--} increase both shallow and deep undergrounds, beside they also concentrate by origin of volcanic gas.

(2) Mutual relations between main compositions

Fig. 6-16 shows main ion-compositions in ppm of K^+, Na^+, Ca^{++}, Cl^-, SO_4^{--}, B and SiO_2, and Fig. 6-17 (1) ~ (3) show hyxadiagrams of ion-compositions of main cations and anions in mol.

According to these figures, classifications of hot water described in the forgoing paragraph are more clarified that LB-1 of La Bramadora, RP-1, RP-2 and RP-3 of Rincon de Las Papas and AC-2 of Aguas Calientes show different characteristics as compared with the remainders.

Fig. 6-18 shows diagram of Cl^--HCO_3^--B^- contents of hot water. Ratio of Cl^-/B^- presents a good index to confirm whether hot water system is brought from the same origin; namely, because B is dominant in fumarolic gas, less value of Cl^- and small ratio of Cl^-/B^- are obtained in hot water heated by fumarolic gas. Although it is impossible to calculate in case of LB-1 of La Bramadora because of value of $B^- < 0.1$ mg/l which is lower than detectation limit, ratios of Cl^-/B^- in the others range from 158 to 312. Among them, RP-1 gives minimum of 158 and is followed by 166 at AC-6, and RP-2 gives maximum of 312. The remainding 14 samples concentrate in relatively narrow ranges between 180 and 230 which can be considered to from nearly same hot water system. Besides, it is clearly shown in this diagram that hot water of HCO_3^- type at RP-1, RP-2 and RP-3 of Rincon de Las Papas is plotted apart from the group, and that hot water of simple spring type at AC-2 is also plotted apart from the group because of relatively rich contents of HCO_3^- in less amounts of soluble ion.

(3) Comparison between hot water and sea water

As is mentioned above, among 18 samples of hot water in 8 areas, LB-1 of La Bramadora, RP-1, RP-2 and RP-3 of Lincon de Las Papas and AC-2 of Aguas Calientes are belonging to sulphate, Ca-Mg bicarbonate and simple springs, respectively. And, they have different characteristics from other 13 samples of hot water which presents characteristics of common salt springs.

In order to make clear them in more detail and to sub-divide hot water belonging to common salt springs, studies on comparison between hot water and sea water are conducted as one of the common methods to search its character and origin of salt-water. Namely, values of each ion-compositions in hot water (comparative index) as compared with those in sea water as one are calculated by the following equation.

$$\text{comparative index } \gamma = \frac{M/Cl^- \text{ in hot water}}{M/Cl^- \text{ in sea water}}$$

Cl^- : value of Cl^--concentration (mg/l)
M : value of each ion-composition (mg/l)

These results of comparison between hot water and sea water are shown in Table 6-5 and Fig. 6-19.

According to Fig. 6-19, LB-1 of La Bramadora clearly shows entirely peculiar type from the others because of extremely low value of 3 mg/l in Cl^-. Three samples of Rincon de Las Papas present different type from the remainding 14 samples, even though a little difference are observed within them, and form a group of hot water having compositions of rich in Ca^{++} and HCO_3^- and of poor in SO_4^{--}. Further, because AC-2 of Aguas Calientes has the lowest value of 18 mg/l in SO_4^{--}, it gives different type from 6 samples in its surrounding area.

Table 6-5 Comparison table of chemical compositions between hot water and sea water

	Sea water	Rincon de Las Papas				Å Ailinco		Las Olletas				El Humazo				Aguas Calientes			
		RP-1		RP-2		RP-3		LO-1		LO-2		EH-1		EH-2		AC-1		AC-2	
	mg/l	mg/l	Y	mg/l	Y	mg/l	Y	mg/l	Y	mg/l	Y	mg/l	Y	mg/l	Y	mg/l	Y	mg/l	Y
Cl^-	18,980	970	1	2,900	1	1,775	1	1,500	1	1,700	1	2,000	1	1,775	1	1,265	1	450	1
Na^+	10,560	715	1.33	1,570	0.97	1,560	1.58	973	1.17	1,050	1.11	1,330	1.20	1,150	1.14	1,090	1.55	280	1.12
K^+	380	72	3.71	104	1.79	37	1.42	53	1.77	72	2.12	152	3.80	127	3.58	51	2.02	22	2.44
Ca^{++}	400	102	4.98	209	3.42	70.8	2.58	43.2	1.36	47.4	1.32	34.6	0.82	36.8	0.98	34.4	1.29	14.8	1.56
SO_4^{--}	2,650	115	0.56	76	0.19	39	0.16	154	0.73	176	0.74	230	0.82	245	0.99	128	0.72	18	0.29
HCO_3^-	130	740	0.111	780	0.039	1,300	0.107	110	0.011	110	0.009	100	0.007	90	0.007	80	0.009	120	0.039

	Sea water	Aguas Calientes										Los Tachos						La Branadora	
		AC-3		AC-4		AC-5		AC-6		AC-7		LT-11		LT-12		LT-13		LB-1	
	mg/l	mg/l	Y	mg/l	Y	mg/l	Y	mg/l	Y	mg/l	Y	mg/l	Y	mg/l	Y	mg/l	Y	mg/l	Y
Cl^-	18,980	1,012	1	1,175	1	1,200	1	780	1	825	1	1,900	1	760	1	920	1	3	1
Na^+	10,560	679	1.21	715	1.09	729	1.09	580	1.34	554	1.21	1,240	1.17	465	1.10	537	1.05	15	9.99
K^+	380	41	2.03	44	1.87	49	2.04	46	2.94	41	2.48	88	2.32	55	3.62	68	3.60	1.6	26.67
Ca^{++}	400	26.0	1.22	48.6	1.96	58.0	2.29	25.0	1.52	21.6	1.24	55.6	1.39	12.5	0.78	14.7	0.76	491	7,756
SO_4^{--}	2,650	100	0.71	118	0.72	118	0.70	78	0.71	88	0.76	196	0.74	78	0.73	94	0.73	1,040	2,476
HCO_3^-	130	90	0.013	140	0.017	180	0.022	90	0.017	100	0.018	110	0.008	60	0.012	80	0.013	180	8,790

Comparison index

$$\gamma = \frac{M/Cl^- \text{ in hot water}}{M/Cl^- \text{ in sea water}}$$

Table 6-6 Subsurface temperatures estimated by geochemical geothermometer

No.	Sample	Silica geothermometer					Alkaline geothermometer			
		Cooled adiabatically	Cooled by convection	Mixing model			Na/K (with Ca correction)	Na/K	Na/Li	Li
				Model 1-1	Model 1-2	Model 1				
1	RP1	140°C	145°C	-	183		166	(188)	203	210
2	RP2	144	149	-	193		174	(147)	220	257
3	PR3	(117)	(117)	-	212		(135)	(72)	(133)	(208)
4	LO1	169	180	283	175	210	172	(130)	255	249
5	LO2	168	179	283	175	210	185	(150)	255	253
6	EH1	180	192	-	183	210	223	202	253	265
7	EH2	170	180	-	-		218	200	247	253
8	AC1	167	178	-	183		168	118	218	238
9	AC2	158	166	-	187		183	163	250	189
10	AC3	161	170	-	193		175	139	242	255
11	AC4	159	167	-	187		166	141	249	231
12	AC5	153	160	-	183		166	148	243	229
13	AC6	167	177	-	196		188	164	253	222
14	AC7	164	173	-	220		184	157	240	215
15	LT11	169	179	283	175	210	188	153	241	255
16	LT12	158	166	-	189		214	206	249	210
17	LT13	158	167	-	198		219	214	254	219
18	LB-1	(77)	(72)	-	-		-	-	-	-

Thirteen samples of hot water in Las Olletas, El Humazo, Aguas Calientes and Los Tachos, except the above fine samples of hot water, have been considered to be hot water having almost same characteristics, on the basis of foregoing various studies on chemical compositions in them. However, it is made clear through studies on comparison between hot water and sea water to be able to divide them into two sub-groups. Namely, one sub-group is composed of EH-1 and EH-2 of El Humazo and LT-12 and LT-13 of eastern parts of Los Tachos in central parts of the area, and another sub-group consists the remainding 9 samples of hot water in western parts of the area. Differences between two sub-groups are caused by those of ion-compositions of relatively rich K^+ and relatively poor Ca^{++} in the former as compared with the later. Thus, a group of hot springs belonging to common salt springs situated in areas from central-west to central-south can be sub-divided into common salt springs (a) at east and common salt springs (b) at west.

(4) Geochemical geothermometric temperature of hot water

As is mentioned before, geothermal system is generally classified into vapor dominated system and water dominated system. Because physical or chemical conditions in geothermal fluid reservoir are different from each other, various methods of geochemical geothermometer are applied depending upon those conditions.

In this study, silica geothermometer based on solubility of minerals against deep hot water and alkaline ratio geothermometer based on chemical balance between deep hot water and mineral will be discussed, as usual cases applied to water dominated system including vapor-water dominated system.

1) Silica geothermometer

The fact that SiO_2-concentration in geothermal hot water of high temperature is under balance with quartz has been reported by Mahon (1966) and Foumier·Rooe (1966). Therefore, temperatures of geothermal hot water at depths are presumed by SiO_2-concentration in hot water. Calculations are done by following equations.

$$t\,(^\circ C) = \frac{1{,}533.5}{5.768 - \log SiO_2} - 273.15 \quad \text{.................. equation (1)}$$

$$t\,(^\circ C) = \frac{1{,}315}{5.205 - \log SiO_2} - 273.15 \quad \text{.................. equation (2)}$$

Provided that equation (1) is applied for case of adiabatic cooling, and its error is $\pm$ 2°C at t = 125° ~ 275°C. and, equation (2) is applied for case of conduction cooling, and its error is $\pm$ 0.5°C at t = 125° ~ 250°C. Unit of SiO_2 is ppm.

Temperatures of 16 samples among total 18 samples calculated by these equations range from 140° to 180°C in case of adiabatic cooling, and from 145° to 192°C in case of conduction cooling. The remainding samples of RP-3 and LB-1 are out of effective range (shown in Fig. 6-20). This fact means that an assumption to consider simple ascending of geothermal hot water form its reservoir and reaching to the surface as hot water is unreasonable, and these temperatures of silica geothermometer are lower than those of alkaline ratio geothermometer. Accordingly, it is necessary to calculate by model based on an assumption which SiO_2-concentration under balance condition with quartz in geothermal fluid reservoir changes into that of secondary balance condition with quartz resulted by mixture with underground water in proportion as ascent of deep hot water. At first, because temperature and SiO_2-concentration are obtained ranging 5° to 20°C and 10 to 40 ppm (Singins and Seggiaro, 1982), high temperature as 283°C is calculated, based on mixture model 1-1 which is set by temperature of 20°C and SiO_2-concentration of 10 ppm in underground water. Next, temperatures ranging from 175° to 220°C are calculated based on mixture model 1-2 which is set by an assumption of ascent of deep hot water through process of adiabatic cooling, and these temperatures correspond to the middle between alkaline ratio geothermometers of Na/K method and Li method. Among them, AC-1 to AC-7, RP-1 to RP-3, LT-12 and LT-13 may indicate that hot water under condition of nearly boiling point ascends and is mixed with surface water. In addition, mixture model 2 is silica geothermometer based on relations between entropy and Cl^--concentration, which is applied in case of hot water after separation of steam in it mixturing with surface water. Considering cases of LT-11, LO-1, LO-2 and EH-1 which are accompanying with fumarolic gas and can be considered to be hot springs after separation of steam, their geothermometric temperature are calculated as about 210°C.

Three different kinds of silica geothermometric temperatures of mixture models are shown in Fig. 6-21, 6-22 and 6-23, together with their calculated values in Table 6-6. Combined these results with cases of adiabatic cooling and conduction cooling, it should be pointed out that present hot water may have been formed through much more complicated processes than assumptions settled.

2) Alkaline ratio geothermometer

As alkaline ratio geothermometers, Na-K-Ca method, Na-K method, Na-Li method and Li method are presented. Among them, Na-K-Ca method which is based on Na/K ratio with correction by Ca is common, and it is calculated by the following equation.

$$t\,(^\circ C) = \frac{1{,}647}{\log(Na/K) + \beta \log(\sqrt{Ca}/K) + 2.24} - 273.15 \quad \text{.......... equation (3)}$$

Provided that $\beta = 3/4$in cases of $\sqrt{Ca}/Na > 1$ and $t < 100°C$, and $\beta = 1/3$ in cases of $\sqrt{Ca}/Na < 1$ or $t\beta = 4/3 > 100°C$. Units of Na, K and Ca are moles/l.

Table 6-7 gives calculative results by equation (3). Although LB-1 is out of effective limits and RP-3 has rather low temperature of 135°C, the most of them range from 166° to 223°C. The geothermometric temperatures of four samples, EH-1 and EH-2 of El Humazo, and LT-12 and LT-13 of El Tachos, are of higher than 200°C.

As shown in Table 6-6, temperatures of Na/K ratio without correction by Ca, Na/Li ratio and Li-concentration are lined up together with those of Na-K-Ca method. Temperatures of geothermometer by Na/li and Li methods are higher than those of Na-K-Ca and Na-K methods.

3) As is mentioned above, geochemical geothermometric temperatures are determined by various methods on the basis of chemical compositions in hot water. Among these temperatures, it is considered that results of Na-K-Ca method seem to be most reasonable. Because this method has been usually applied for examinations of geothermometric temperature in vapor-steam mixed-type geothermal system, and is of higher reliability.

6.2.4 Principal Elements and Analytical Results of Fumarolic Gas Survey

(1) Sampling and chemical analysis of fumarolic gas

Fumarolic gas except steam was collected from mouth of fumarole by gas collector, and concentrations of CO_2, CO, O_2, H_2S, SO_2 and NO_2 gases were measured in the field keeping with gas samplings. The samples were supplied to assay laboratory in Japan and chemically analized elements of CO_2, CO, O_2, H_2, N_2 and CH_4 gases. On the other hand, steam in fumarolic gas was collected as its condensed water, and analized in the same way. Ratios of contents between steam and others fumarolic gases were calculated.

(2) Principal elements of fumarolic gas

As is shown in Table 6-7, most of fumarolic gases consist mainly of steam. CO_2, CO, O_2, H_2, N_2, H_2S, SO_2 and CH_4 were detected as fumarolic gases. Because fumarolic gas is a small quantity and was collected by compulsory absorption, O_2 and N_2 of main constituents in the air were also collected together with fumarolic gas.

Main constituents of fumarolic gas are CO_2 gas reaching more than 99% in the remainder except O_2 and N_2 gases. H_2 gas of 0.02 to 0.03% is detected at GLT-1, GLT-3, GEH-2 and GLB-1. CO gas is found 0.7% at GLO-2 and 0.4% at GEH-2. H_2S gas of 0.15% is measured only at GLB-1. SO_2 gas ranging from 0.08% to 0.22% is detected at GLT-3, GEH-1, GEH-2, GEH-3 and GLB-1.

(3) Condensed water

Table 6-4 gives analytical results of condensed water survey.

pH of condenced water is almost neutral ranging from 6.30 to 7.23 with a little inclination toward weak acidic area. Most of conductivity of condensed water are 100 to 200 $\mu\mho$ but values of more than 500 $\mu\mho$ are measured at CLT-1 of Los Tachos and CLB-1 of La Bramadora.

Cations of main elements are rich in Na^+, K^+, Ca^{++} and Li^- at CLO-1 of Las Olletas compared with others, and rich in Na^+ at CLT-1. On the other hand, anions are extremely rich in Cl^- at CLO-1, and relatively rich in Cl^- at CLT-1. Both of Cl^--rich condensed water show Na-Cl type same characteristics as hot water at the same places.

Concentrations of HBO_2^- and Hg which derived from volatile composition are detected relatively rich in HBO_2^- at CLT-1 and in Hg at CLO-1. NH_4^+ concentration at CLB-1 is three to four times higher than others.

Although it is impossible to determine underground temperature based on ion-concentrations in condensed water of these fumarolic gas and steam, it can be assumed that characteristics of higher underground temperatures recognize at areas of La Bramadora, Los Tachos and Las Olletas.

(4) Characteristics and geochemical geothermometric temperatures of fumarolic gas

1) Qualitative characteristics of fumarolic gas

Various types of gas exist together with steam in fumarolic gas at geothermal field.

Because ratio of H_2/CH_4 temperaturely depends upon chemical reaction of $CH_4 + 2H_2O = 4H_2O + CO_2$, high ratio is generally considered to indicate high temperature. Among nine samples of fumarolic gas, H_2 gas was detected from four sumples at GLT-1 and GLT-3 of Los Tachos, GEH-3 of El Humazo, and GLB-1 of La Bramadora. Being CH_4 only detected at the later two, it is difficult to say regarding high or low temperature based on ratio of H_2/CH_4.

Besides, ratio of SO_2/H_2S is sensitive against temperature, and chemical reaction occurs in system of $SO_2 + H_2 \rightleftharpoons H_2S + O_2$. High ratio of SO_2/H_2S depends upon high temperature. SO_2 gas is detected from five samples at GLT-3 of Los Tachos, GEH-1, GEH-2 and GEH-3 of El Humazo, and GLB-1 of La Bramadora. H_2S gas is measured only at GLB-1 of La Bramadora, therefore, it is impossible to determine temperatures based on ratio of SO_2/H_2S in fumarolic gas. However, it seems to be reasonable to consider that five samples of fumarolic gas which were detected SO_2 show higher temperatures than the remainder at GLO-1 and GLO-2 of Las Olletas, and GLT-1 and GLT-2 of Los Tachos having no SO_2.

Accordingly, La Bramadora being detected all of H_2, CH_4, H_2S and SO_2 represents vapor-dominated type, and eastern half of Los Tachos and El Humazo strongly indicate vapor•water-mixed type. The remainders are considered to belong to water-dominated type.

2) Geothermometric temperature by fumarolic gas

In essential vapor-dominated system, temperature and pressure of steam in geothermal fluid reservoir are assumed as approximately 240°C and 34 Kg/cm^2, respectively. In case a small scale of vapor-dominated system forms at shallow depth in water-dominated system, it is tryed to assume geothermometric temperature by fumarolic gas.

As is mentioned beofre, more than 99% of fumarolic gas is steam, and almost all of uncondensed gas in the remainders is CO_2 gas. Although geothermometric temperature is not enough accurate because of mixture of O_2 and N_2 gases, trials are done by H_2S-H_2-CH_4CO_2 geothermometer under condition of the following chemical reaction balances.

$$CaSO_4 + FeS_2 + 3H_2O + CO_2 = CaCO_3 + \frac{1}{3} Fe_3O_4 + 3H_2S + \frac{7}{3} O_2$$

$$C + CO_2 + 6H_2 = 2CH_4 + 2H_2O$$

Table 6-7 Results of gas analysis

No.	Sample No.	Temp. (°C)	H_2O (%)	Non condensable gas									
				H_2	CH_4	CO_2	CO	H_2S	SO_2	O_2	N_2	NO_2	Total
1	GLO-1	94.5	-	-	-	72.0	0.0	0.0	0.00	6.0	18.6	0.0	96.6
2	GLO-2	93.5	96.0	-	-	54.46	0.7	0.0	0.00	9.72	35.8	0.0	100.68
3	GLT-1	93.8	99.9	0.03	-	83.0	0.0	0.0	0.00	3.0	9.54	0.0	95.54
4	GLT-2	92.9	99.8	-	-	89.0	0.0	0.0	0.00	2.5	-	0.0	91.5
5	GLT-3	92.8	99.9	0.02	-	91.0	0.0	0.0	0.08	1.8	6.53	0.0	99.41
6	GEH-1	92.5	99.9	-	-	95.0	0.0	0.0	0.12	1.5	3.30	0.0	99.92
7	GEH-2	88.2	99.7	-	-	15.0	0.4	0.0	0.00	16.2	50.84	0.0	82.44
8	GEH-3	92.5	99.9	0.02	0.25	92.0	0.0	0.0	0.14	2.0	11.43	0.0	105.57
9	GLB-1	101.8	99.7	0.02	0.27	73.7	0.0	0.15	0.22	5.1	19.11	0.0	98.57

It is calculated by the following equation.

$$t\,(^\circ C) = \frac{24{,}775}{\alpha + \beta + 36.05} - 273.15 \quad \text{.......................equation (4)}$$

Provided that $\alpha = 2\log\frac{CH_4}{CO_2} - 6\log\frac{H_2}{CO_2} - 3\log\frac{H_2S}{CO_2}$

$\beta = -7\log Pco_2$

Units of CO_2, H_2S and CH_4 are volume %, and Pco_2 = 0.1 atm is presumed.

As a result of calculations, 109°C at CEH-3 and 135°C at GLB-1 are obtained. However, because of above-mentioned reasons, it seems to be no high reliability.

6.3 Considerations on Circulation Mechanism of Geothermal Fluid

6.3.1 Areal Distributions and Characteristics of Hot Springs Classified by Chemical Composition and Geochemical Geothermo-Temperature

Fig. 6-24 shows composite map of zoning of hot spring – fumarole and geochemical geothermo – temperature. The following explanations present based on this figure.

(1) Classification and zoning of hot water

Classification of hot water by main chemical compositions and zoning of hot springs belonging to each types are summarized as follows;

1) Sulphate springs: LB-1 of La Bramadora presents this hot spring. It is rich in Ca^{++} and SO_4^{--}, and is characterized by volcanic hot spring having ratio of $SO_4^{--}Cl^- > 1$ and consisting mainly of fumarolic gas.

2) Common salt springs (a): Four hot springs of EH-1 and EH-2 of El Humazo, and LT-12 and LT-14 of eastern Los Tachos belongs to this hot spring. They are rich in Na^+ and Cl^- with relatively high in K^+ and low in Ca^{++}, and consist of hot water together with a large amount of fumarolic gas.

3) Common salt springs (b): LT-11 of western most of Los Tachos, LO-1 and LO-3 of Las Olletas, AC-1 and AC-3 to AC-7 of Arroyo Aguas Calientes and Baños del Agua Caliente represent this hot springs. In comparison with hot springs of type 2), they are characterized by relatively low K^+ and high Ca^{++} and by much hot water without or a very little fumarolic gas.

4) Simple hot springs: AC-2 of Arroyo Aguas Calientes contains less soluble ions in it, especially poor in Cl^-. This hot spring is considered to have the same origin as surrounding hot springs, however, it is resulted to form simple hot spring by dilution of a large amount of shallow underground water.

5) Ca-Mg bicarbonate hot springs: Three hot springs at RP-1, RP-2 and RP-3 of Rincon de Las Papas and Arroyo Ailinco belong to this hot spring. The one characterized by soluble ions of rich in Ca^{++} and HCO_3^- and poor in SO_4, and by hot springs without fumarolic gas.

Hot springs in the investigation area are classified into the above-mentioned types, and their regional zoning are clearly summarized as follows;

i) Sulphate hot springs of La Bramadora characterized by vapor-dominated type located at central-eastern area.

ii) Common salt hot spring (a) of El Humazo and most of Los Tachos characterized by vapor•water-mixed type located at central area.

iii) Common salt hot springs (b) of western margin of Los Tachos, Las Olletas, Arroyo Aguas Calientes (including AC-2 of simple hot spring) and Baños del Agua Caliente characterized by water-dominated type located at areas from central to central western parts and,

iv) Ca-Mg bicarbonate hot springs of Rincon de Las Papas and Arroyo Ailinco characterized by water-dominated type located at northern area.

(2) Zoning of hot springs and geothermo-temperature

There are good mutual relations between zoning of hot springs and alkaline ratio geothermo-temperatures of Na-K-Ca method, and quantative characteristics of fumarolic gas. They are summarized as follows;

i) La Bramadora consisting mainly of fumarolic gas represents vapor-dominated type. Although its geothermo-temperature cannot obtain by hot water because of its out of effective limit, it quantitatively shows high temperature based on all of detected H_2, CH_4, H_2S and SO_2 in fumarolic gas.

ii) Geothermo-temperatures of four hot springs belonging to common salt springs of vapor•water-mixed type range from 214° to 223°C. Namely, all of them concentrate in the narrow area having temperatures of more than 200°C, and form a group of the highest temperature of hot springs.

iii) Nine hot springs belonging to common salt springs together with one simple spring characterized by water-dominated type give their geothermo-temperatures ranging from 160° to 188°C, and form a group of intermediate temperature of hot springs.

iv) Three hot springs belonging to Ca-Mg bicarbonate springs characterized by water-dominated type have the lowest geothermo-temperatures ranging from 135° to 174°C.

(3) Distribution limit of fumaroles

Distribution limit between hot springs with and without fumarolic gas is situated at slightly western side of boundary between common hot springs (a) and (b). In fact, hot springs at western margin of Los Tachos and at Las Olletas which belong to common salt spring (B) of water-dominated type are accompanied with some or a little amount of fumarolic gas.

6.3.2 Relation between Circulation Mechanism of Hot Water•Fumarolic Gas and Heat Flow Structure

(1) Relation between hot water•fumarolic gas and alteration zone

As is described in paragraph 5.1.4 regarding considerations on hydrothermal and solfataric alterations as geothermal manifestations, characteristics and distributions of alteration zone and travertine are pointed out as follows, taking their general views in the investigation area. Namely, they change, in proportion to areas from La Bramadora at central-east to Baños del Agua Caliente at central-west, from vapor-dominated system under acidic conditions of high to low temperature to water dominated system under alkaline to intermediate conditions of low temperature with overlapped system under acidic conditions of low temperature. Besides, at western margin of Arroyo Ailinco area in northwestern parts, alteration zones which yield opal indicating very low temperature are recognized.

Thus, above-mentioned regional zonings of alteration zone and their characteristics of formative condition show well correspondences to regional distributions of hot springs and fumaroles as outcrops on the surface in geothermal field, and to characteristics of their geothermo-temperature.

(2) Relation between hot water•fumarolic gas and anomalous area of ground temperature• geochemistry

As is also described before, mutual relations between geothermal manifestations such as hot springs or fumaroles and anomalous areas of ground temperature, and those of Hg-CO_2 concentration are pointed out as follows; Namely, decrease of their mutual relations have a tendency to decrease from relations of 1) geothermal manifestations and ground temperature anomalies, 2) ground temperature and Hg-concentration anomalies, 3) ground temperature and CO_2-concentration anomalies, to 4) Hg and CO_2-concentration anomalies. In addition, these anomalous areas of ground temperature and geochemistry are strongly indicated to correspond to trends of fracture systems at depths. Besides, magma reservoirs related to younger volcanism of Quaternary age in the area are inferred as heat source which brings present geothermal phenomena, and one of the volcanic centers is assumed to exist and expand at depths near La Bramadora area at eastern portion of the area.

Thus, it was made clear that heat flow structure, anomalous areas of ground temperature and geochemistry, and geothermal manifestations of hot water and fumarolic gas are one in flesh and spirit three-dimensionally. Namely, there are inseparable relations from each other between heat source at depths and anomalous areas originated from acsending geothermal hot water and fumarolic gas, and underground informations obtained by analyses and considerations on hot water and fumarolic gas as geothermal outcrops on the surface.

6.3.3 Basic Idea on Circulation Mechanism of Geothermal Fluid, Hot Water, Underground Water and Surface Water

Magma reservoir as heat source at depths is assumed to situate at several to ten kilometers depth and to have several kilometers in diameter, and to keep temperatures of 800° to 1,000°C. Deep underground water which penetrated into depths spending long time has been heated by heat of thermal conductivity of rocks and heat of thermal transfer medium such as gas, steam and a little amount of magmatic water. As a result of chemical reactions with surrounding rocks, heated deep underground water becomes deep geothermal hot water. This deep geothermal hot water accompanying with gas and steam forms geothermal fluid reservoir at two to three kilometers depth with temperatures of 200° to 300°C. Geothermal fluid ascending from its reservoir through fracture systems meats shallow underground water which originated from meteoric water and/or surface water, and circulates as hot water mixing each other at shallow subsurface. Finally, hot water with gas and steam reaches to the surface, and forms geothermal outcrops of hot springs and fumaroles.

Elcidations regarding circulation mechanism of geothermal fluid which are consisting of formation and ascent of geothermal hot water, formation and spring out of hot water, penetration and circulation of meteoric and surface water, etc. are essential problems to develop geothermal energy. If deep geothermal hot water which can be considered to contain no shallow underground water is sampled by deep drill holes or steam wells of more than 2,000 meters deep, its characteristics and geothermo-temperatures can be made clear. Based on these analyses, it is possible to obtain more accurate data how present hot water and fumarolic gas have been formed by mixture of various ratios between deep geothermal hot water and shallow underground water.

6.4 Summary on Circulation Mechanism of Geothermal Fluid

(1) In the investigation area forming western slopes of Domuyo Volcano, there is running water in the rivers through the whole year which is supplied by melting snow. This river water penetrates into underground, and forms aquifers in strata or rocks having high effective porosity and/or high permeability. Although most of shallow underground water circulates in aquifers and flows out the surface, some of water reaches to more depths through fracture systems. Thus, shallow and deep underground water is very important to form hot water and deep geothermal hot water, and there is enough supplies in the area.

(2) Hot springs in the investigation area can be classified and divided into zonal distributions on the basis of chemical compositions of each hot water and relations with fumarolic

gas as well as their geothermo-temperatures. They are summarized as follows;

i) Sulphate hot spirngs of La Bramadora located at central-eastern area are rich in Ca^{++} and SO_4^{--}, and are characterized by vapor-dominated type consisting mainly of volcanic hot springs having ratio of $SO_4^{--}/Cl^- > 1$ of fumarolic gas. And, they are considered to be high temperature qualitatively based on compositions of fumarolic gas.

ii) Common salt hot springs (a) of El Humazo and most of Los Tachos located at central area are rich in Na^+ and Cl^- with relatively rich in K^+ and poor in Ca^{++}, and are characterized by vapor·water-mixed type consisting mainly of hot springs and a large amount of fumarolic gas. And, they form a group of hot springs having the highest geothermo-temperatures ranging from 214° to 223°C.

iii) Common salt hot springs (b) of western most of Los Tachos, Las Olletas, Arroyo Aguas Calientes excluding AC-2 and Baños del Agua Caliente located at central-western area are also rich in Na^+ and Cl^- with relatively poor in K^+ and rich in Ca^{++}, and are characterized by water-dominated type consisting mainly of a large amount of hot springs without or with a very little fumarolic gas. And, their geothermo temperatures range from 160° to 188°C.

iv) Hot spring of AC-2 at Arroyo Aguas Calientes is so-called simple hot spring containing less soluble ions in it, and its geothermo-temperature shows 183°C. This has no different origin from its surrounding hot springs, but it is formed by mixture of a large amount of underground water.

v) Ca-Mg bicarbonate hot springs of Rincon de Las Papas and Arroyo Ailinco are rich in Ca^{++} and HCO_3^-, and poor in SO_4^{--}. And, their geothermo-temperatures are low as 135° to 174°C.

(3) Fumarolic gas are observed in hot springs of vapor-dominated type at central-eastern area and of vapor·water-mixed type at central area. More than 99% of fumarolic gas is steam, and most of remainder is uncondensed CO_2 gas. Although it is impossible to search quantative geothermo-temperatures of fumarolic gas based on its concentration and ratio of constituent gas, qualitatively they are not inconsistent with classification and zoning of hot springs.

(4) Mutual relations between geothermal manifestation and hydrothermal alteration zones are summarized as follows; Namely, alteration zones indicating acidic condition of intermediate to high temperature well correspond to hot springs and fumaroles of vapor-dominated type at La Bramadora area, those indicating acidic condition of low to intermediate temperature well correspond to hot springs and fumaroles of vapor·water-dominated

type at El Humazo and Los Tachos area, and those indicating intermediate to alkaline condition of low temperature overlapped by alterations under acidic condition of low temperature well correspond to hot springs of water-dominated type at Las Olletas, Arroyo Aguas Calientes and Banos del Aguas Calientes at central-western area. In addition, alteration zones including opal indicating very low temperature are recognized at western most area of Arroyo Ailinco, and low geothermo-temperatures well correspond to temperatures of hot springs in this area.

(5) It was made clear that there are three-dimensionally inseparable relations each other between magma reservoir as heat source at depth and anomalous areas of ground temperature and of Hg-CO_2 geochemistry, and geothermal manifestations of hot spring and fumarole.

7. Model of Geothermal System

7. Model of Geothermal System

7.1 Model of Geologic Structure

Synthetic interpretation map of geologic structure shown in Fig. 7-1 is composite map made summarizing by the following geological and stractural factors. Namely, they are 1) distributions of older formations such as basement rocks and Mesozoic formations together with faults which are confirmed by geological survey, 2) high and low gravimetric anomalous areas and gravimetric transition zone together with gravimetric lineaments and gravimetric anticlinal and synclinal structures which are searched by gravity prospecting, 3) fracture systems assumed by trends of anomalous areas of ground temperature and Hg-CO_2 geochemistry, and 4) distributions of geothermal manifestations of hot spring and fumarole.

7.1.1 Model of Geologic Structure based on Stratigraphic Sequence and Gravity Anomaly

(1) Characteristics of geologic structure based on geological distributions and physical properties of constituent rocks

Geologic structure in the investigation area is divided into eastern and western halves based on geological distributions and physical properties of constituend rocks.

In the western half, basement rocks exist in relative shallow portions and younger volcanic rocks widely overlie on them, which form two-layer structure consisting of lower layer represented by high density and low effective porosity and of upper layer represented by low density and high effective porosity.

On the other hand, in the eastern half, the area is occupied by Mesozoic formations of intermediate density and effective porosity as lower layer and by younger volcanic rocks of low density and high effective porosity as upper layer, and basement rocks is assumed to be latent at great depths.

(2) Characteristics of geologic structure based on Bouguer anomalies of gravity

Geologic structure in the investigation area based on distributions of Bouguer anomaly is divided into three areas, namely, high gravity anomalous area at west, low gravity anomalous area at east and gravity transition zone between two anomalous areas.

There is a good harmony in the western area tectomically between distribution of high gravity anomalous area and geologic structure where basement rocks exist in shallow depths, and also there is no big inconsistency between volues of Bouguer anomaly at transition zone and distributions of Mesozoic formations. Low gravity anomalous area at east, which is bordered on the west by large fault zone inferred through gravimetric lineaments of great gradients, is not agreed with geological distributions on and near the surface. Therefore, it cannot be interpreted structurely, if an existence of rocks or strata of low gravity expanding widely and deeply at depths.

As tectonical factors to form low gravity anomalous area at east, it may be possible to consider structurely that acidic porphyrys of relatively low gravity which correspond to intrusive facies of Domuyo Volcanic Complex underlie Mesozoic formation and expand widely at depths.

7.1.2 Model of Geologic Structure based on Fault and Fracture Systems

(1) Characteristics of fault systems by geology and fracture system by gravity

Fault systems of N-S direction are of large scale regionally, and are common to be developed through whole formations of the oldest to the yougest in geological age, and those of E-W direction mainly develope in older rocks. Besides, fault systems of NW-SE and NE-SW trend are also recognized forming conjugating systems with those of N-S direction.

Although fault systems of N-S and E-W directions are observed in the investigation area as shown in Fig. 7-1, fault systems of NW-SE direction and of NE-SW direction including NNE-SSW, NE-SW and ENE-WSW directions are dominant in the area.

Geologic structure based on gravimetric lineaments is tectonically characterized by fracture systems of N-S direction which are bordering on the both sides of gravity transformable zone. They are formed by combinations of N-S fault with NW-SE and NE-SW faults. Gravimetric lineaments corresponding to faults are also recognized in other areas, and gravimetric anticlinal and synclinal structures of NW-SE and NE-SW directions characterize geologic structure in the investigation area.

(2) Characteristics of fracture systems based on anomalous areas of ground temperature and geochemistry as well as geothermal manifestations.

On the basis of anomalous areas of ground temperature at 1 m depth and those of Hg and CO_2-concentrations, fracture systems of NE-SE direction are dominant together with accessary systems of NW-SE, N-S and E-W directions in central and eastern portions of the area, and those of NW-SE direction with accessory NE-SW direction are common in western portions.

Next, fracture systems based on distributions of geothermal manifestation such as hot springs and fumaroles are generally characterized by these trends of E-W direction from Rincon de Las Papas to Arroyo Ailinco, the same direction from La Bramadora through El Humazo to Las Olletas, ENE-WSW dirction from Las Olletas through Arroyo Aguas Calientes to Banos del Agua Caliente, and E-W direction at Lost Tachos.

If trends of each geothermal manifestations are studied individually, it is made clear that they are structurely controlled by fracture systems confirmed through interpretations on faults, gravimetric lineaments, gravimetric anticlinal and synclinal structures, and/or by those assumed by trends of anomalous areas of ground temperature and geochemistry. Especially, intersections of fracture systems of two ore more and their surrounding areas are considered to be most favorable for geothermal manifestations.

7.2 Model of Heat Flow Structure

Synthetic interpretation map of heat flow structure shown in Fig. 7-2 is composite may made summarizing by the following geothermal structural factors. Namely, they are 1) classifications and zonings of geothermal manifestations such as hot springs and fumaroles based on their chemical compositions and geothermo-temperatures, together with boundaries of fumaroles and non-fumaroles, 2) trends of anomalous areas of ground temperature at 1 m depth and of Hg and CO_2 concentrations, and 3) zonings of hydrothermal alteration zone.

7.2.1 Plane Model of Heat Flow Structure

(1) Characteristics of heat flow structure based on volcanism

As heat source bringing present geothermal phenomena in the investigation area, magma reservoirs related to younger volcanism of Quaternary age can be assumed in connection with activity of Domo Volcano taken place during periods of 700 to 100 thousand years ago. These activities have occurred centering around plural places in southeast areas of the investigation area. And, one of them is considered to exist at depths near La Briamadora and its vicinity, and its heat supplies from east to west and upward. Accordingly, the model of heat flow structure in the area which heat supply is most active at central-eastern parts and becomes to decrease toward western parts.

(2) Characteristics of heat flow structure based on hot water and fumarolic gas

Hot water from each springs can be classified by their chemical compositions and relations with or without fumarolic gas, and their areal zonings are possible. They are summarized by their classification and zoning together with their geothermometric temperatures by alkaline ratio geothermometer.

i) Sulphate hot springs at La Bramadora of central-east parts being rich in Ca^{++} and SO_4^{--} and showing volcanic hot spring of $SO_4^{--}/Ce^{-} > 1$ are characterized by vapor-dominated type, and their temperatures are considered to be high qualitatively by compositions of fumarolic gas.

ii) Common salt hot spring (a) at El Humazo and most of Los Tachos of central parts being rich in Na^{+} and Cl^{-} with relatively rich in K^{+} and poor in Ca^{++} are characterized by vapor-water-dominated type hot springs accompanying with large amounts of fumarolic gas, and their geothermo-temperatures are high as more than 200°C.

iii) Common salt hot spring (b) at western margin of Los Tachos, Las Olletas, Arroyo Aguas Calientes and Banos del Agua Caliente of central-western parts being rich in Na^{+} and Cl^{-} with relatively poor in K^{+} and rich in Ca^{++} are characterized by water-dominated type hot springs with very little amounts of fumarolic gas, and their geothermo-temperatures are less than 200°C. Hot spring AC-2 of Arroyo Aguas Calientes is simple hot spring which has no different origin from its surounding hot springs, but it is formed by mixture of a large amount of underground water.

iv) Ca-Mg bicarbonate hot springs at Rincon de La Papas and Arroyo Ailinco of northern parts being rich in Ca^{++} and HCO_3^{-} are characterized by water-dominated type hot spring without fumarolic gas, and their geothermo-temperatures are about 170°C or less than that.

Plane model of heat flow structure based on grades of goethermal activity, which are studied by classification and zoning of hot springs, their geothermo-temperature and compositions of fumarolic gas, shows semi-dome structure having an axis of E-W direction and inclining toward west. At northern wing of semi-dome structure, grades of geothermal activity tends to decrease rapidly.

(3) Characteristics of heat flow structure based on hydrothermal alteration zones, and anomalous areas of ground temperature and geochemistry

As zonings of hydrothermal alteration in the investigation area, kaoline-alunite zone indicating acidic condition of intermediate to high temperature occupies areas centering around La Bramadora, and kaoline zone indicating acidic condition of low to intermediate temperature surrounds it. And, alteration zones of montmorillonite indicating intermediate to alkaline condition of low temperature, overlapped by crystobalite zone indicating acidic condition of low temperature, distribute further outside of them. This boundary between kaoline zone and monmorillonite-crystobalite zone is very close to boundary between vapor• water-mixed type common salt hot springs (a) and water-dominated type common hot springs (b), which shows semi-dome structure inclining toward west.

Alteration zones of very low temperature accompanying with opal distribute at west of hot spring RC-3 of Arroyo Ailinco which is of the lowest temperature.

Thus, zonal distributions of hydrothermal alteration is quite in agreement with tendencies of grade of geothermal activity indicated by characteristics of hot water and fumarolic gas. Namely, both of them form model of heat flow structure in the investigation area having semi-dome structure inclined toward west radically.

In addition, characteristics of heat flow structure based on anomalous areas of ground temperature and geochemistry are summarized as follows; Namely, three anomalous areas of ground temperature at 1 m depth and Hg-CO_2 concentrations are almost identical with each other, in eastern parts of the area, and they prove their high intensities and high grades of geothermal activity. On the other hand, in westen parts of the area, three anomalous areas distribute separately decreasing their intensities, and they indicate lower grades of geothermal activity. Furthermore, no anomalous area of ground temperature and geochemistry is recognized at Rincon de Las Papas and Arroyo Ailinco.

As is described above, there are relations of the Trinity between heat flow structures based on anomalous areas of ground temperature and geochemistry, classifications and zonings of hot water and fumarolic gas, and hydrothermal alteration zones.

7.2.2 Sectional Model of Heat Flow Structure

Fig. 7-3 and Fig. 7-4 show model of circulation mechanism of geothermal fluid and geothermal reservoir structure at E-W and NW-SE sections. In these figures, boundaries of classification of hot springs and existences of fumarolic gas are shown modefining vertically.

As shown in Fig. 7-3, heat supplies from magma reservoir which is inferred to exist at depths near La Bramadara. Because its supply decrease in propotion to westward and upward, heat flow structure having semi-dome structure inclined toward west horizontally is assumed vertically to be sectional model of heat flow structure having arc-shaped zonings centering arround magma reservoir.

On the other hand, as shown in Fig. 7-4, sectional model of heat flow structure presents modified variations from vapor•water-dominated type common hot springs (a) of high temperature at Los Tachos, through water-dominated type common hot springs (b) of relatively low temperature at Las Olletas, to water-dominated type Ca-Mg biocarbonate hot springs of rather low temperature at Arroyo Ailinco.

7.3 Model of Circulation Mechanism of Geothermal Fluid and Geothermal Reservoir Structure

7.3.1 Model of Formation of Deep Geothermal Hot Water

As genesis of hot water in the geothermal field, various theories have been presented. Namely, 1) meteoric water origin presents that hot water has been formed from underground water originated from rain water and surface water and heated by heat source at depths, 2) magmatic water origin, and 3) mixed origin of 1) and 2). Recently, trials to research on genesis of hot water are carried out by studies on ion-concentrations and isotopes of δO^{18} and δD in hot water.

As a results of these studies, very low ratio of magmatic water in the whole hot water is made clear. And, the following interpretation regarding genesis of hot water is accepted. Namely, deep underground water which penetrated into depths spending long time has been heated by heat of thermal conductivity of rocks and heat of thermal transfer medium such as gas, steam and a little amount of magmatic water. Then, heated deep underground water has reacted chemically with its surrounding rocks, and converted into deep geothermal hot water. This deep geothermal hot water accompanying with gas and steam ascends from its geothermal fluid reservoir through fracture system, and hot water has been formed from relatively a little amount of deep geothermal hot water mixed with a large amount of shallow underground water.

Main ion-concentrations in river water is known as 5 ~ 10 mg/l in Na^+, Ca^{++} and Cl^-, 1 mg/l in K^+, and 15 ~ 20 mg/l in SO_4^{--} and HCO_3^-. In case this river water penetrates into subsurface and converts to shallow underground water, general tendencies of changes of ion-concentrations in it is also know as increasing in Na^+ and HCO_3^-, decreasing in Ca^{++} and SO_4^{--}, and almost no change in K^+ and Cl^-.

Accordingly, ion-concentrations in deep geothermal hot water, which shallow underground water converts into deep underground water penetrating more deeply and is heated, are results of chemical reactions with surrounding rocks at depths under balance conditions of temperature, pressure and solubility of minerals. Generally, deep geothermal hot water is characterized by high salinity of rich in Na^+ and Cl^-, and contains Li^+, K^+, Ca^{++}, Mg^{++},

SO_4^{--}, B^-, HBO_3^-, Fe, SiO_2 and Hg. And, it is called "chloride water".

Deep geothermal hot water, having these chemical compositions and accompanying with SO_2 and CO_2 of volcanic gas and steam, is considered to form geothermal fluid reservoir at two to three kilometers deep having its temperatures of 200° to 300°C. Fig. 7-3 shows models of heat supplies from magma reservoir, flows of shallow and deep underground water, and geothermal fluid reservoirs of deep geothermal hot water together with gas and steam.

7.3.2 Model of Circulation Mechanism of Geothermal Fluid

Geothermal fluid consisting of deep geothermal hot water, gas and steam ascends from geothermal fluid reservoir through fracture systems reached to depths. In proportion to shallow subsurface, it mixed with shallow underground water in various ratios and forms shallow geothermal fluid reservoirs in aquifers of high porosity strata or of permeable strata and rocks. Temperatures in shallow geothermal fluid reservoir are assumed to be 100° to 200°C.

In case amounts of geothermal hot water of high temperature are relatively abundant with low mixture of shallow underground water, vapor-dominated system is formed consisting mainly of steam accompanying with fumarolic gas. In proportion to decrease amounts of shallow underground water, it converts into vapor · water-mixed system and finally into water-dominated system without steam and fumarolic gas.

Furthermore, shallow geothermal fluid ascends from its reservoirs, and mixes with unconfined underground water originated from meteoric water and/or river water. As a result of this mixture, temperatures decrease and ion-concentrate of HCO_3^-increase. Finally, hot water and fumarolic gas reaches to the surface and forms geothermal outcrops of hot spring and fumarole. Fig. 7-3 and Fig. 7-4 also show models of ascents of deep geothermal hot water, formations of shallow geothermal fluid by mixture with shallow underground water, conditions of shallow geothermal fluid reservoir, and classifications of hot water and its spring out.

7.3.3 Model of Geothermal Fluid Reservoir Structure

(1) Characteristics of structure of deep geothermal fluid reservoir

Deep geothermal fluid reservoirs considered to be formed at two to three kilometers deep from the surface are existing in basement rocks and/or near bottoms of intrusive rocks. In these rocks, it is very difficult to consider that these reservoirs have large expansions horizontally because rocks are of very low effective porosity and of usually massive body.

Accordingly, shapes of deep geothermal fluid reservoir are interpreted to have shapes of plate or pipe elongating vertically.

(2) Characteristics of shallow geothermal fluid reservoir based on stratigraphic sequence

As shallow geothermal fluid reservoirs in the investigation area based on stratigraphic sequence are considered as follows; Namely, they are 1) pyroclastic rocks in younger volcanic formation of Quaternary age, and 2) pyroclastic rocks in Tertiary and upper Mesozoic formations.

As shown in schematic columnar section of effective porosity of Fig. 6-3, pumice tuff, scoria tuff and some of andesite lava among younger volcanic formations have high porosity as maximum of more than 30%, and the former two show high valus as average of 20 to 30%. On the other hand, andesitic tuff breccia of Tertiary formations and dacitic tuff of upper Tordillo Formation of Mesozoic have porosities of maximum 30% and averages of 15 to 25%. Because unpermeable strata such as lava flows and beds of welded tuff overlie on each permeable strata, it is considered to be favorable strata to form aquifers having cap rocks.

If unconformable planes accompany with conglomerate or coarse sandstone, it is reported that these planes form strata-bound aquifers in some of geothermal fields. However, in the investigation area, Mesozoic formations unconformably overlie on the basement without conglomerate or coarse sandstone, but lava flows of basalt and andesite with their pyroclastic rocks directly cover it. Beside beds of limestone in Mesozoic formations are lithologically compact and of rather thin. Thus, these planes and beds are considered unfavorable for aquifers.

(3) Characteristics of geothermal fluid reservoir formed in and along fracture system

Distributions of present geothermal manifestation in the area generally trend in E-W direction. However, in case of search them individually, they are structurally controled by faults, gravimetric lineaments, gravimetric anticlinal and synclinal structures, and fracture systems assumed by anomalous areas of ground temperature and geochemistry. And, superior hot springs and fumaroles are distributed at intersections of two or three fracture systems or their vicinities.

This fact indicates that structures of shallow geothermal fluid reservoir present shapes of plate, pipe and pocket. In case these vertically elongated reservoirs having some widths interesect with above-mentioned strata having possibility to form strata-bound aquifers stratigraphically, these places are of the most favorable to form geothermal fluid reservoirs.

8. Summary and Conclusion

8. Summary and Conclusion

8.1 Summary of the First and Second Phase Surveys

8.1.1 Purpose and Circumstance of the Geothermal Development Project

The survey for "The Geothermal Development Project of the Northern Part of the Province of Neuquén, Argentine Republic" is implemented in conformity with the Scope of Work signed 25 February 1982 by the Governments of Japan and Argentine.

The first phase survey was carried out in February and March of 1982. It consists of the satellite (LANDSAT) image interpretation covering an area of 15,000 Km^2 and aerial photograph interpretation covering an area of 5,000 Km^2 in the northern part of the Province of Neuquén in addition to the compilation and analysis of the existing bibliography and reconnaissance field survey. As a result of this survey the promising area for geothermal development was narrowed down and an extent of 200 Km^2 was selected as object of the second phase survey.

The second phase survey commenced with the topographical mapping prior to the field survey and was carried out from November 1982 to March 1983. The second phase survey covers geological survey, petrological survey and tests, gravity prospecting, alteration survey, 1 meter depth ground temperature survey, geochemical survey, hydrological survey and hot spring & fumarolic gas survey. The geology, geological structure, geothermal structure and geothermal fluid structure of the survey area are elucidated and furthermore the geological structure model, plan & cross sectional models of the geothermal structure, hot-water formation model, geothermal fluid circulation model and geothermal reservoir model are prepared through a comprehensive analysis of the results of the survey.

This survey is implemented with three principal purposes, i.e., to pick up the issues for future geothermal development of the survey area, to select the area to be covered by the third phase survey and to propose concrete measures related to the implementation of the third phase survey, based on the above-mentioned analyses and discussions.

8.1.2 Summary of Analytical Results of the Second Phase Survey

The results of the second phase survey are summarized as follows.

(1) Geological structure

1) Geological stratigraphy of the survey area

The survey area consists of superposed formations of Mesozoic formations and Tertiary systems on a basement of metamorphic rocks of the Permian and Triassic systems and Varvarco granodiorites. Furthermore, there are distributions of younger volcanic rocks, whose activity took place from the late Pliocene to the Pleistonece, that cover the above-mentioned layers.

2) Geologic structure based on geological distribution and petrological properties

The west half of the survey area forms a two-layered structure where basement rocks with physical property of high density and low porosity are located shallow beneath younger volcanic rocks with physical property of low density and high effective porosity. On the other hand, the east half has a two-layered structure consisting of a Mesozoic formations and Tertiary system with medium density and medium effective porosity properties located beneath younger volcanic rocks, while basement rocks are presumed to be located deep in the underground.

3) Geologic structure based on the distribution of Bouguer anomalies

The survey area is divided in three distinct parts, i.e., the high gravity anomaly area located in the western part, the low gravity anomaly area located in the eastern part and the gravity transition band extending in the N-S direction in the form of stripe. There is concordance between the Bouguer anomaly distribution of the high gravity anomaly area and the gravity transition band and the underground structure seen from the standpoint of geological distribution and physical properties of the rocks. In the low gravity anomaly area however, it is necessary to suppose a geological structure as consists of intrusive facies of acidic porphyries of the Domuyo Volcano Complex spreading deep in the underground widely.

4) Faults and fracture systems

There are faults of the N-S system accompanied with wide area folding structures, faults of the E-W system perpendicular to the former ones and also faults of the NW-SE system and NE-SW system conjugating with the former ones. The gravimetric lineament and gravimetric anticlinal and synclinal structures caused by the undulations of the basement coincide with the above-mentioned fault systems and fracture systems. Furthermore, the fracture systems estimated from ground temperature, geochemical anomalies or distribution and arrangement of geothermal manifestations tend to coincide with faults and fracture systems as well.

(2) Geothermal structure

1) Geothermal structure based on the volcanic activities

It is presumed that the magma reservoir related to the younger volcanic activities including the Domo Volcano that was in activity approximately 700,000 to 100,000 years ago is the heat source that brings about the geothermal phenomena of the survey area. In this connection, it is presumed that the heat source spreads out to the deep underground in the environs of La Bramadora, in the eastern part of the survey area.

2) Geothermal structure based on the distributions of hot springs and fumaroles

The survey area is divided in four distinct parts, i.e., eastern part with sulfate hot springs of the vapor-dominated type, central parts with vapor•water-mixed type salt hot springs (a), western part with hot water-dominated type salt hot springs (b) and northern part with water-dominated type Ca-Mg bicarbonate hot springs. These areas have a three-dimensional semi-dome structure inclined to the west and axis in the E-W direction. The intensity of the geothermal activity decreases in the west and north directions.

3) Geothermal structure based on the distribution of ground temperature and geochemical anomalies

The zoning from the standpoint of mineral combination of the hydrothermal alteration zones and the zoning from the standpoint of the 1-meter depth ground temperature anomalies and geochemical anomalies of Hg concentration and CO_2 concentration and the respective properties coincide with the zoning from the standpoint of hot springs and fumaroles and its property, forming therefore a trinity relationship.

(3) Structure of geothermal fluid

1) Circulation of geothermal fluid

Deep hot water, gas and steam goes up passing through fracture systems reaching deep underground geothermal reservoirs, and when they reach the shallow underground aquifiers they form shallow geothermal reservoirs by mixing with shallow ground water with various proportions. Distinct kinds of systems, such as vapour-dominated system, water-dominated system, etc., and distinct temperatures come about depending with the mixing proportion with shallow ground water.

2) Geothermal outcrop of hot springs and fumaroles

Geothermal fluids going up further from shallow geothermal reservoirs get mixed with non-pressure ground water originated by rain water and river water. The temperature falls and it reaches the ground surface in the form of hot spring rich in HCO_3^- and accompanied with fumarole.

(4) Structure of geothermal reservoirs

1) Structure of geothermal fluid reservoirs

Geothermal fluid reservoirs presumed to be located 2 to 3 m under the ground surface are estimated to spread vertically in the form of plates or pipes, along fracture systems developed in the interior of basement rocks or along the crossings of the said fracture systems, rather than spreading out in the form of plane surfaces.

2) Structure of shallow geothermal reservoirs seem from the stratigraphical standpoint

From the stratigraphical and petrographical standpoints the shallow geothermal reservoir of the survey area consists of clastics of young volcanic rocks of the Quaternary and pyroclastic rocks of the Tertiary system and Upper Mesozoic sandwiched by impermeable lava and other kinds of rock from the upper and lower sides. Such being the case, it is presumably suited for formation of a shallow geothermal reservoir with plane spreading.

3) Structure of the shallow geothermal reservoir formed in the fracture system

The pronounced geothermal manifestations observed at the present time suffer the structural restriction of fracture systems estimated from faults, gravimetric lineaments and ground temperature and geochemical anomalies. Furthermore they are distributed in the crossings of fracture systems developing in 2 or 3 directions and in the environs of the said crossings.

Places where the occurrence of geothermal reservoirs formed in fracture systems developed in vertical direction (plate shape, pipe shape or pocket shape) coincide with the occurrence of geothermal reservoirs with plane spreading seen from the stratigraphical standpoint are best suited for formation of shallow geothermal reservoirs.

4) Determination of the basic course and concrete measures for implementation of the next phase survey

The three-dimensional geothermal structure model in the survey area is prepared as a result of the discussion of the various structural models mentioned above. Then, the area to be covered by the next phase survey is selected and concrete measures for its implementation are planned.

8.2 Possibility and First Priority Target Area of Geothermal Energy Development

After making a comprehensive judgement taking into consideration the aspects of geology, geological structure, thermal structure, thermal fluid structure and geothermal reservoir structure, we come to the conclusion that the geothermal resources of the survey area have high potential, with extremely promising possibility of development, and as a consequence we consider it indispensable to carry out the third phase survey. The following extent is mentioned in the first place as most promising area for geothermal development which should be investigated in further details in the next phase survey.

The area in question has an extension over 40 Km^2, with 9 Km in the E-W direction from La Bramadora in the eastern part to Las Olletas in the western part passing through El Humazo and approximately 5 Km in the N-S direction, including El Humazo and Los Tachos. This area comprises the district with distribution of vapour-dominated type sulfate hot springs located in La Bramadora, the district with distribution of water•vapour-mixed type salt hot springs (a) comprising most of El Humazo and Los Tachos, and the district with distribution of hot springs accompanied with fumaroles like those ones of the western extremity of Los Tachos and Las Olletas, among the water-dominated type salt hot springs (b).

This area composes the core of the thermal structure and geothermal fluid structure which has its axis in the E-W direction and semi-dome structure inclined to the west. Particularly the area located east of the line drawn between the centers of El Humazo and Los Tachos has high temperature hot springs accompanied with strong fumaroles and is presumed to have the most intense geothermal activities. Therefore, it is the most promising area in terms of possibility of occurrence of high temperature geothermal fluid indispensable for geothermal development.

The runner-up is the area comprising Las Olletas and Aguas Calientes, which corresponds to the outside of the thermal structure and geothermal fluid structure with semi-dome configuration. This area loses in terms of order of priority because its hot springs are not accompanied with fumaroles in most of the case, but it should be studied with sufficient care because it is located in the western extension of the geothermal structure that crosses the survey area in the E-W direction.

8.3 Object of Further Geothermal Development Survey

8.3.1 Principle of the Third Phase Survey

A survey area over 40 Km^2 located at the center of the second phase survey was selected as a result of the first and second phase surveys. The issues related to this area requiring future elucidation are as follows.

(1) Detailed survey of the basement structure

The area located west of the line drawn between the centers of El Humazo and Los Tachos has shallow basement. At the east side of that line however, the gravimetric tilting rises abruptly, passing therefore to a gravimetric transition zone. It is presumed that the coincidence of the gravimetric lineament in the N-S direction that indicates the structural change of the gravity basement with the boundary of the A-class geothermal activity accompanied with vigorous fumaroles has an important meaning. Therefore, in the third phase survey it is indispensable to carry out an detailed investigation to elucidate the basement structure comprising the aforementioned gravimetric transition zone.

(2) Detailed survey of the fracture systems

The most important structural factor that determines the geothermal structure is the fracture system that develops in deep underground. The outline of the fracture systems of the survey areas have been identified as a result of the surveys carried out so far. However, there are many unknown details about the fracture systems of the basement located beneath the younger volcanic rocks and fracture systems located in Mesozoic formations. Therefore, one of the key points of the third phase survey will be the detailed investigation of the fracture systems.

(3) Survey of alteration zones and low electric resistivity zones located deep underground

The analyses of the hydrothermal alteration zones located on the ground surface and travertine carried out in the second phase survey contributed to elucidate the regional zoning, the geothermal structure and the geothermal fluid structure but they are not sufficient to bring out information about heat and geothermal fluid at deep places. Therefore, it is indispensable to carry out investigations about the alteration zones and low electric resistivity zones related to geothermal phenomena at deep places, including the identification of the characteristics of the alteration zone expected to be located beneath the younger volcanic rocks.

(4) Survey of the heat flow

The 1 meter depth ground temperature survey of the second phase barely succeeded at identifying roughly the tendency of the ground temperature distribution in the survey area. The heat flow survey by drilling heat flow measurement holes is a method used widely to investigate directly the geothermal structure. In the third phase survey we consider it indispensable to carry out the heat flow survey, principally in the most promising area and also in its environs.

(5) Drilling and logging

It is possible to confirm the stratigraphy, make core tests of various kinds (rocks, alterations, density, effective porosity, magnetic susceptibility, electric conductivity, seismic wave propagation velocity, thermal conductivity, etc.), well logging (electric well logging and thermal well logging) and to collect information of various kinds from underground that will function as basic data for the next stage, by drilling prospecting wells with several hundred meters depth.

(6) Comprehensive analysis

The comprehensive evaluation of the geothermal resource potential of the survey area will be carried out by making a comprehensive analysis of the results of the third phase survey and the results of the other surveys of various kinds carried out so far.

8.3.2 Proposed Working Plan of the Third Phase Survey

The following survey methodology is proposed in order to make the concrete elucidation of the future issues described in the preceeding section.

(1) Seismic reflection method

Seismic reflection method is an effective means to investigate accurately the basement structure and the fracture systems, which are expressly mentioned as key issues to be considered futurely. It is recommendable to carry out the prospection by setting the trunk measuring line in the E-W direction at the center of the 40 Km^2 survey area of the third phase survey and several measurement lines crossing with that trunk line.

(2) Schlumberger geoelectrical prospecting

The electrical prospecting by means of the Schlumberber method is an effective means to obtain information about alteration zones and low electric resistivity zones located at deep places. The prospecting should be carried out for maximum depths of approximately 1,000 m with maximum value of AB/2 of the order of 2,000 m. It is recommendable to carry out the electrical prospecting by using the measuring lines of the seismic reflection method ing for the sake of comparing both results.

(3) Heat flow survey by means of 100 m temperature gradient wells

It is recommendable to drill approximately 10 temperature gradient wells with 100 m depth in the 40 Km^2 survey area of the third phase survey because this methodology is effective to identify the geothermal structure through the investigation of the heat flow.

(4) Drilling of 400 m-class well

According to the results of the second phase survey, first site recommended to drill the 400 m-class well is located at the northern side of the east half of Los Tachos. Fracture systems of various kinds and various directions (e.g. fracture system inferred from faults, gravimetric lineaments, ground temperature anomalies, geochemical anomalies, etc.) are crossing at that site.

(5) Draft plan of the third phase survey

We consider it indispensable to discuss in details the plan of the third phase survey described in (1) to (4) above from the standpoints of the local topography and other factors related to its implementation. Nevertheless, the draft plan is shown in the Fig. 8-1.

Appendix

LIST OF TABLES

Table A-1(1) Results of microscopic observation of thin sections

Sample No.	Rock name	Phenocryst, Fragment, etc.													Groundmass, Matrix													Alteration										Remarks
		q	kf	pl	bi	ho	au	hy	ol	Fe	Pu	Da	An	etc	q	kf	pl	bi	ho	au	hy	ol	gl	cr	tr	Fe	etc	q	cr	tr	k	se	ch	m	ca	ep	ze	
F-1	Granodiorite	○	•	○	•									ap ∘ zi ∘ sp ∘																	∘	•	○		∘	○		
F-3	Dacitic welded tuff			○			∘	•		∘		•	•		•		•				∘		◎			∘												
F-5	Andesitic vitric tuff			○			•	•		•	•	•	•				∘			∘	∘		◎	∘?		•			∘?									
F-8	Basaltic tuff breccia			○			•	•	•				○	Ba•	•		•			•	•	•	○			•												lithic tuff
F-9	Aplite	○	○	◎																												∘				•		
F-14	Quartz diorite porphyry			○	•	•				∘					◎	•	•									∘	ap∘ zi∘						∘					m-gr-tex, boulder rock
F21	Dacite	•	•	○		•				∘					◎	•?	○									∘												fl-tex
F-22	Dacite	•		○		∘	∘			•					◎		•		∘					•		∘			•									sph-tex
F-23	Rhyolite			•		∘	∘			•							∘			∘			◎			∘												fl-tex
F-25	Dacite	•		○	•					∘					∘?	?	∘						○	•		∘			•									sph-tex
F-26	Granodiorite	○	•	○	•	∘				∘				ap∘ sp∘																		○	○		∘	∘		
F-27	Aplite	○	○	○	•					•																					∘	∘	•			∘		
F-28	Hornfels	○		•						∘				bi ○ chl •																								zi ∘, sp ∘ original rock: tuff
F-29	Hornfels	○								•				mu ○ ch ○																								to ∘, zi ∘, sp ∘
F-31	Dacitic lapilli tuff	•	∘	○						•		◎	•		◎		•									•		∘				∘	∘		•			
F-32	Andesite			◎			maf-○										○			maf-○						○	sp•					•	○					alt-S, Basaltic
F-33	Andesitic tuffaceous sandstone			◎						○			○	Ba•	•		◎									∘	zi∘					∘						
F-35	Andesitic tuff			○			maf-∘			•		∘	•		∘?		○						•			•												
F-40	Andesitic sandy tuff	∘		◎	∘	∘	•	•		•	∘	∘	◎	Ba∘			∘	∘					○			∘								∘?			?	
F-40-2	Andesite			•			maf-∘								•		◎			maf-•						∘	zi∘	•				∘	∘?					
F-41	Andesite			○		•		•		•					∘		◎				∘					∘												
F-41-2	Andesitic tuff breccia	∘		•	•						◎	•	•	Ss•	∘		∘						◎			∘								∘			∘?	
F-42	Dacitic tuff breccia	•		•	•	•	•	•		•	○	○	○	Ss• Ms•	∘		•	•					○			•									•			
F-42-2	Granodiorite	○	•	◎	•	○								ap∘ zi∘ sp∘																		•	•			∘		
F-43	Pyroxene andesite			○			•	•		•							◎			•			○			○												int-tex
F-43-2	Hornfels	◎								•				mu○																								original rock: Ss
F-44	Dacite	○		○	•										○		◎			maf-∘						•	ap∘					∘						
F-44-2	Dacite			•	•										•		◎						○			•		•										fl-tex
F-45	Andesitic tuff breccia	•		○	•	•		•		∘	○	•	•	Ss• Ms∘	•		•						◎			•									•			
F-46	Dacite			○			•	∘		•					•		•			∘	∘		◎			•												hyal-tex, Andesitic
F-48	Dacitic sandy tuff	•		○	∘					•		•	•		•		•	∘					◎			∘									∘			
F-50	Dacite			○	∘			•		•		◎					○						○			∘												
F-55	Pyroxene andesite			◎			•	•		•							○			•	•		○				○											hyal-tex

Table A-1(2) Results of microscopic observation of thin sections

Sample No.	Rock name	Phenocryst, Fragment, etc.													Groundmass, Matrix													Alteration										Remarks
		q	kf	pl	bi	ho	au	hy	ol	Fe	Pu	Da	An	etc	q	kf	pl	bi	ho	au	hy	ol	gl	cr	tr	Fe	etc	q	cr	tr	k	se	ch	m	ca	ep	ze	
F-56	Andesite			◎		•		•		•							◎				•		•			•												hyal-tex
F-57	Pyroxene andesite			◎			○	○		•					•		◎			•	•		•			•	ap∘											int-tex
F-59	Pumiceous vitric tuff	○		○							○	•	•	Ms•	•		•						◎			•												
F-60	Dacitic vitric tuff	•		•							•	•	•		•		•						◎			•												
F-105	Andesite			◎			maf-	○		•					•		◎			maf-	•		?			•					∘?	∘	•?					
F-110	Crystalline limestone		ca-	◎																																		
F-159	Andesitic sandy tuff	•		○						•		•	•	ca•	∘		•									•						•		○?	•			
F-160	Andesite			•			maf-	•		•					◎		•			maf-	•					•	sp•	◎				•						alt-S
F-162	Basalt			◎				•?	○	○							◎				•?	○				○												int-tex
TM-1	Dacite	•		○	•	∘				•													•	○		•			○									sph-tex
TM-4	Dacite			○		•				•					?		•						○	•		∘			•									sph-tex
TM-6	Dacitic tuff			○			∘	•		•		•	•		∘		•			•	•		◎			•												
TM-8	Granodiorite	○	•	○	•					•				ap∘ zi∘																		∘	•			•		
TM-9	Basalt			•			maf-	•		•							○			maf-	○					•	sp•						○		∘			int-tex
TM-11	Granodiorite	○	•	○	•	•				∘				ap∘																	•	•	•			•		
TM-12	Dacite			◎		•				∘					•	∘	○	∘								•						∘	•					m-gr-tex, boulder rock groundmass:coase grain
TM-13	Rhyolitic tuff breccia	•		○	•					•		◎											•	○		∘			○									sph-tex
TM-14	Dacite (Perlite)			○	•	•				∘											∘		◎	•		•	ap∘ zi∘		•									Per-tex, sph-tex
TM-15	Dacite (perlite)	∘	∘?	•	∘					•								∘	∘				○	○		•			○									Per-tex, sph-tex
TM-16	Granodiorite	○	○	◎	○					•				ap∘ zi∘																	∘	∘	○		•	•		
TM-18	Dacitic welded tuff			○			∘	•		•		•	•	Ss∘ Mg∘			∘				∘		◎			∘												
TM-19	Dacitic tuff breccia	•	∘	•		•		•				○			∘?		•						○			•			•									
TM-20	Andesitic tuff			○	•	•	∘	•		∘		•	○				∘	∘	∘	∘	∘		◎			•			•									
TM-21	Dacitic tuff			○			•	•		•		∘	•		∘?		•			∘	∘		◎			∘												
TM-22	Dacite		∘	○		∘		•								?	○							•	∘	•			•	∘								sph-tex
TM-23	Dacite		∘	•	•	•		•		•							•		•					○	∘	•	zi∘		○	•								sph-tex
TM-24	Dacitic tuff	∘		•			maf-	•		•		○	•	Ss•	◎		•						•			•		•				•						
TM-25	Dacite	○		○											◎		•									•		○			•?	○						alt-S
TM-26	Dacite	•		○	•	•		∘		∘						?	•						•	○		•			○									sph-tex
TM-27	Granodiorite	○	•	◎	•	•?								ap∘ zi∘ ep∘																		•	○			∘		
TM-30	Andesitic tuff			○								•	○		•		•						◎			•												
TM-31	Andesite			◎		•	○	○		•							◎			•	•		•			•	zi∘											
TM-35	Andesitic tuff			○			•	•		•		•	○				∘			•	•		○			•												

Table A-1(3) Results of microscopic observation of thin sections

Sample No.	Rock name	Phenocryst, Fragment, etc.													Groundmass, Matrix													Alteration										Remarks
		q	kf	pl	bi	ho	au	hy	ol	Fe	Pu	Da	And	etc	q	kf	pl	bi	ho	au	hy	ol	gl	cr	tr	Fe	etc	q	cr	tr	k	se	ch	m	ca	ep	Ze	
TM-39	Dacitic tuff breccia	•				maf-•				•		•	•		◎		•			maf-•						•	cl•	○					•			•		alt-S
TM-40	Dacite	∘	∘	○		•	•			•							○		•					•	•	•			•	•								
TM-43	Dacite			○											◎											∘		◎				•						alt-S
TM-44	Andesitic tuff			○			•	•		•		•	◎	q di·po •			•			∘	∘		◎			•												
TM-45	Pyroxene andesite			○	·	∘?	•	•		∘							○			∘			○			•							∘		•			hyal-tex
TM-46	Sandstone	•		○						○		∘	∘	ca○	∘		•									•	ca○ cl•											
TM-47	Dacitic tuff	•		○	•					•	○	○	∘	Ms•	∘		•						◎			•								•			•	
TM-48	Granodiorite porphyry			◎			maf-•								•	•	○	∘	∘?							•							•		•			m-gr-tex
TM-50	Rhyolite	•		○		•										•	•							○	•	•			○	•								sph-tex
TM-52	Andesite			○			maf-•			•							◎			maf-•						○												
TM-53	Rhyolite			○		•	∘			•							•			∘			◎			∘												fl-tex
TM-55	Dacitic tuff	∘		•								○	•		○		•									○		○				∘						
TM-56	Dacitic tuff	○		○	∘			∘				○	•		○		•									•						∘						
TM-57	Dacite	•		○			maf-•			∘					•		◎			maf-•						•	zi∘	∘										
TM-59	Sandstone	◎		•						•				mu○	•											○	se○											
TM-60	Dacitic tuff	•		•			maf-∘			∘	○	•	•		•		•						◎			•	Pu•											
TM-61	Dacite			○	•			•		•					?		∘						○	○		•			○									sph-tex, fl-tex
TM-64	Pyroxene andesite			◎			•	○		•							•			•	•		◎			•												hyal-tex
TM-65	Andesite	∘		◎		∘		•		•					•		◎				•					•							∘					
TM-66	Hornfels	◎		•	•					○				mu○																								original rock: SS
TM-68	Andesite			•			maf-∘								○		◎									∘		○					•?					
TM-69	Pyroxene andesite			◎			○	•		•							◎			•	•		•			•												int-tex
TM-71	Augite andesite			○			•			•							◎			•?						○					∘?			•?				pilo-tex
TM-74	Dacitic tuff breccia			○			maf-•				•	◎			◎		•			maf-•						•		◎					•		•			alt-S
TM-77	Andesite			○			maf-•			•					•		◎			maf-•						○	ap∘	•					∘		•			
RM-80	Andesite			○	•		maf-•			•					○		◎	∘								•	ap∘	○							∘			Pilo-tex
TM-83	Andesite			◎		∘	○	•									◎			•	•					•									•			Pilo-tex
TM-84	Dacite			○	?	•				•						○	•							○		∘	zi∘		○									sph-tex
TM-86	Dacite			•	∘		•	•		•							•				∘			○	∘	∘			○	∘								sph-tex
TM-87	Dacite			○	∘		•	•		•							•				∘		○	○		•			○									sph-tex
TM-88	Andesite			○			maf-•			•					•		◎			maf-•			○			•												hyal-tex
TM-89	Pyroxene andesite			◎			•	○		•							◎			∘	•		○			•					∘						∘?	hyal-tex
TM-90	Andesite			◎		○	•	•		•							○		•	•	•		○			•												hyal-tex

Table A-1(4) Results of microscopic observation of thin sections

Sample No.	Rock name	Phenocryst, Fragment, etc.													Groundmass, Matrix													Alteration										Remarks
		q	kf	pl	bi	ho	au	hy	ol	Fe	Pu	Da	And	etc	q	kf	pl	bi	ho	au	hy	ol	gl	cr	tr	Fe	etc	q	cr	tr	k	se	ch	m	ca	ep	Ze	
TM-92	Pyroxene andesite			◎			○	○		•							○			•	•		○			•												int-tex
TM-93	Andesite			○		•	∘	•		•					•		◎			?	•					•												pilo-tex
TM-94	Pyroxene andesite			◎		•	○	•		•					•		◎			•	∘					•												pilo-tex
TM-102	Pyroxene andesite			◎	∘		•	•		•					•		◎			∘	∘		○			•	ap∘											hyal-tex
TM-106	Tuffaceous sandstone	•		•			maf- •				•	•	•	Hs• Ss∘ mu•	○		•									•	cl○											
TM-110	Sandstone	◎	•	•								•	•		○		•									∘	mu∘											arkosic SS
TM-114	Sandstone	•	•	○								•	•	ca•	•		•									•	ca○ cl○											
TM-201	Granodiorite porphyry			○											•	•	○		•	maf- •						•						•	•		•			m-gr-tex
RLB-1	Andesite			○				maf- •							○		○			maf- ∘						•	ap∘ sp•	○					•?		∘			
83-2-12-4	Sandstone	◎	•	•						•				mu•	•											•	cl○ zi∘											
83-2-12-5	Granodiorite	○	•	◎	○					•				ap∘ zi∘ sp∘																	∘	∘	○		•			

Table A-2 (1) Results of measurement of physical properties

No.	Sample No.	Rock Name	Density (g/cm^3)			Porosity (%)	Susceptibility (emu/cc)$\times 10^{-6}$	Resistivity		Thermal Conductivity (cal/cm.sec.°C) $\times 10^{-3}$
			natural condition	water saturated	oven dry			(%)	ρ (Ω-m)	
1	F-1	Granodiorite	2.69	2.69	2.68	1.07	57	1.5	859	7.572
2	F-3	Dacitic welded tuff	2.52	2.54	2.51	2.69	1,108	1.3	322	2.952
3	F-5	Andesitic vitric tuff	1.60	1.88	1.59	28.99	776	2.1	108	1.194
4	F-8	Basaltic tuff breccia	2.00	2.17	1.92	25.07	1,119	1.3	62	2.529
5	F-9	Aplite	2.64	2.64	2.63	1.35	55	2.1	698	7.033
6	F-14	Quartz diorite porphyry	2.48	2.50	2.47	3.01	533	3.1	1,571	5.062
7	F-21	Dacite	2.32	2.33	2.31	1.93	312	2.2	5,874	4.021
8	F-22	Dacite	2.26	2.33	2.26	6.68				
9	F-23	Rhyolite	1.54	1.64	1.53	11.56	211	1.0	515	1.292
10	F-25	Dacite	2.14	2.23	2.12	10.43	126	1.3	1,783	2.749
11	F-26	Granodiorite	2.61	2.62	2.60	1.58	69	2.8	3,182	7.860
12	F-27	Aplite	2.58	2.58	2.57	1.02	48	2.9	4,892	8.116
13	F-28	Hornfels	2.70	2.71	2.70	0.27	58	1.6	24,607	11.150
14	F-29	Hornfels	2.72	2.72	2.72	0.27				
15	F-31	Dacitic lapilli tuff	2.56	2.58	2.55	2.88	83	2.4	10,129	8.913
16	F-32	Andesite	2.69	2.69	2.68	1.54	58	1.4	330	5.081
17	F-33	Andesitic tuffaceous sandstone	2.65	2.66	2.63	3.31	58	2.4	385	5.141
18	F-35	Andesitic tuff	2.21	2.24	2.20	3.75				
19	F-40	Andestic sandy tuff	2.59	2.60	2.59	0.86	63	2.0	3,020	8.355
20	F-40-2	Andesite	1.94	2.08	1.82	26.06				
21	F-41	Andesite	2.44	2.48	2.41	7.69	961	1.9	703	4.273
22	F-41-2	Andesitic tuff breccia	1.47	1.76	1.38	37.94	654	1.8	45	1.658

Table A-2 (2) Results of measurement of physical properties

No.	Sample No.	Rock Name	Density (g/cm^3)			Porosity (%)	Susceptibility (emu/cc)x10^{-6}	Resistivity		Thermal Conductivity (cal/cm.sec.°C) x10^{-3}
			natural condition	water saturated	oven dry			(%)	ρ (Ω-m)	
23	F-42	Dacitic tuff breccia	1.78	1.96	1.71	25.70	199	1.0	60	
24	F-42-2	Granodiorite	2.72	2.73	2.72	0.76				
25	F-43	Pyroxene andesite	2.54	2.55		-				
26	F-43-2	Hornfels	2.64	2.65	2.64	1.15	30	3.3	7,479	13.710
27	F-44	Dacite	2.62	2.63		-				
28	F-44-2	Dacite	2.29	2.34	2.26	8.23	306	1.0	223	3.653
29	F-45	Andesitic tuff breccia	1.69	1.88	1.56	29.89	255	1.0	61	1.547
30	F-46	Dacite	2.50	2.53		-				
31	F-48	Dacitic sandy tuff	1.55	1.70	1.46	23.29	44	1.0	46	1.754
32	F-50	Dacite	2.25	2.33	2.25	8.10				
33	F-55	Pyroxene andesite	2.68	2.69	2.67	1.52				
34	F-56	Andesite	2.45	2.49	2.44	5.77				
35	F-57	Pyroxene andesite	2.53	2.56	2.51	5.46				
36	F-59	Pumiceous vitric tuff	1.41	1.70	1.38	31.62				
37	F-60	Dacitic vitric tuff	1.43	1.73	1.36	36.83	88	1.4	35	1.385
38	F-105	Andesite	2.51	2.56	2.50	5.60				
39	F-110	Crystalline limestone	2.62	2.64	2.62	2.22				
40	F-159	Andesitic sandy tuff	2.64	2.64	2.63	1.22				
41	F-160	Andesite	2.57	2.59	2.55	3.94	59	2.8	859	6.678
42	F-162	Basalt	2.74	2.76	2.73	2.53				
43	TM-1	Dacite	2.33	2.38	2.33	4.90				
44	TM-4	Dacite	2.23	2.29	2.22	7.31				

Table A-2 (3) Results of measurement of physical properties

No.	Sample No.	Rock Name	Density (g/cm^3)			Porosity (%)	Susceptibility (emu/cc)$\times10^{-6}$	Resistivity		Thermal Conductivity (cal/cm.sec.°C) $\times10^{-3}$
			natural condition	water saturated	oven dry			(%)	ρ (Ω-m)	
45	TM-6	Dacitic tuff	2.56	2.58	2.55	3.18	1,261	1.2	751	4.199
46	TM-8	Granodiorite	2.56	2.59	2.59	-				
47	TM-9	Basalt	2.70	2.70	2.70	-				
48	TM-11	Granodiorite	2.69	2.70	2.69	0.95	417	2.1	1,311	7.772
49	TM-12	Dacite	2.47	2.49		-				
50	TM-13	Rhyolitic tuff breccia	2.20	2.29	2.18	10.38	311	1.7	528	3.853
51	TM-14	Dacite (Perlite)	2.21	2.26	2.20	6.55				
52	TM-15	Dacite (Perlite)	2.19	2.25	2.16	8.58	363	2.1	538	3.113
53	TM-16	Granodiorite	2.67	2.68	2.67	0.72	330	1.5	2,851	7.544
54	TM-18	Dacitic welded tuff	1.93	2.02	1.81	21.07				
55	TM-19	Dacitic tuff breccia	2.02	2.16	2.16	-				
56	TM-20	Andesitic tuff	1.39	1.70	1.37	32.74	1,170			0.582
57	TM-21	Dacitic tuff	2.54	2.56	2.52	3.42				
58	TM-22	Dacite	2.32	2.37	2.37	-				
59	TM-23	Dacite	2.25	2.28	2.24	4.11	356	1.2	4,412	2.136
60	TM-24	Dacitic tuff	2.60	2.60		-				
61	TM-25	Dacite	2.58	2.59		-				
62	TM-26	Dacite	2.04	2.11	2.03	7.85				
63	TM-27	Granodiorite	2.69	2.70	2.68	1.30	60	1.6	1,060	6.946
64	TM-30	Andesitic tuff	2.10	2.22	2.09	13.44				
65	TM-31	Andesite	2.65	2.66	2.63	2.26	1,690	0.7	558	4.631
66	TM-35	Andesitic tuff	1.98	2.14	1.92	22.32	600	2.3	155	1.906

Table A-2 (4) Results of measurement of physical properties

No.	Sample No.	Rock Name	Density (g/cm^3)			Porosity (%)	Susceptibility (emu/cc)x10^{-6}	Resistivity		Thermal Conductivity (cal/cm.sec.°C) x10^{-3}
			natural condition	water saturated	oven dry			(%)	ρ (Ω-m)	
67	TM-39	Dacitic tuff breccia	2.60	2.61		-				
68	TM-40	Dacite	2.07	2.17	2.07	10.51	197	2.9	513	2.144
69	TM-43	Dacite	2.27	2.36	2.26	9.18				
70	TM-44	Andesitic tuff	2.08	2.21	2.03	17.48	1,782	1.1	83	2.351
71	TM-45	Pyroxene andesite	2.52	2.53	2.51	2.04	1,642	1.1	1,311	4.294
72	TM-46	Sandstone	2.46	2.49	2.45	4.27	54	1.2	120	5.287
73	TM-47	Dacitic tuff	1.47	1.73	1.43	30.56	372	2.1	69	1.510
74	TM-48	Granodiorite porphyry	2.45	2.46	2.43	3.41	1,073	2.5	806	5.133
75	TM-50	Rhyolite	2.11	2.21	2.11	10.32	137	3.8	413	1.727
76	TM-52	Andesite	2.49	2.50	2.49	1.06	1,693	2.1	8,244	4.328
77	TM-53	Rhyolite	2.02	2.05	2.01	4.01	157	2.1	5,193	2.081
78	TM-55	Dacitic tuff	2.58	2.61	2.57	3.51	82	1.4	2,232	7.173
79	TM-56	Dacitic tuff	2.51	2.55		-				
80	TM-57	Dacite	2.59	2.60	2.59	0.77	80	2.5	11,728	6.468
81	TM-59	Sandstone	2.68	2.70	2.68	2.27	46	1.0	323	10.850
82	TM-60	Dacitic tuff	2.09	2.21	2.04	16.58				
83	TM-61	Dacite	2.38	2.43		-				
84	TM-64	Pyroxene andesite	2.42	2.45	2.41	4.85	1,705	1.8	588	3.094
85	TM-65	Andesite	2.57	2.58		-				
86	TM-66	Hornfels	2.70	2.71	2.70	0.84	35	0.9	1,644	12.870
87	TM-68	Andesite	2.60	2.60	2.59	0.26	64	1.6	19,499	8.064
88	TM-69	Pyroxene andesite	2.63	2.63	2.61	2.05	590	0.7	317	4.393
89	TM-71	Augite andesite	2.63	2.63	2.62	0.79	1,548	0.8	1,292	4.305

Table A-2 (5) Results of measurement of physical properties

No.	Sample No.	Rock Name	Density (g/cm^3)			Porosity (%)	Susceptibility (emu/cc)x10^{-6}	Resistivity		Thermal Conductivity (cal/cm.sec.°C) x10^{-3}
			natural condition	water saturated	oven dry			(%)	ρ (Ω-m)	
90	TM-74	Dacitic tuff breccia	2.03	2.19	2.01	17.78	20	1.7	85	3.736
91	TM-77	Andesite	2.27	2.38		-				
92	TM-80	Andesite	2.33	2.41	2.30	10.34	1,174	1.8	102	3.211
93	TM-83	Andesite	2.62	2.64		-				
94	TM-84	Dacite	2.21	2.28		-				
95	TM-86	Dacite	2.22	2.30	2.21	8.75	764	1.3	462	2.894
96	TM-87	Dacite	2.35	2.39	2.34	5.36	343	1.7	244	3.781
97	TM-88	Andesite	2.21	2.29		-				
98	TM-89	Pyroxene andesite	2.69	2.69	2.68	0.84	2,505	0.8	1,060	4.293
99	TM-90	Andesite	2.39	2.43	2.37	5.94				
100	TM-92	Pyroxene andesite	2.48	2.49	2.48	1.47	2,631	1.6	1,393	2.860
101	TM-93	Andesite	2.55	2.57	2.54	3.73				
102	TM-94	Pyroxene andesite	2.64	2.66	2.63	3.17	1,814	1.0	292	4.191
103	TM-102	Pyroxene andesite	2.45	2.48		-				
104	TM-106	Tuffaceous sandstone	2.64	2.64	2.62	1.40	77	1.0	550	7.058
105	TM-110	Sandstone	2.41	2.47	2.40	6.84	27	3.2	357	6.690
106	TM-114	Sandstone	2.62	2.63	2.61	1.78	70	1.8	550	5.757
107	TM-201	Granodiorite porphyry	2.43	2.45		-				
108	RLB-1	Andesite	2.18	2.30	2.16	14.09				
109	83-2-12-4	Sandstone	2.61	2.64		-				
110	83-2-12-5	Granodiorite	2.65	2.66		-				

Table A-3 (1) Results of measurement of density in natural condition (g/cm^3)

Rock facies	Geological Unit		Number	Average R.f.	Average G.u.		Maximum R.f.	Maximum G.u.	Minimum R.f.	Minimum G.u.
Rhyolite	V	V-2	2	1.78	2.19		2.02	2.62	1.54	1.54
Dacite			16	2.25			2.62		2.04	
Dacitic tuff breccia (1)			1	2.09			-		-	
Dacitic tuff breccia (2)			4	2.17			2.32		2.02	
Pumice tuff		V-1	2	1.40	2.22		1.41	2.74	1.39	1.39
Welded tuff			3	2.54			2.56		2.52	
Andesitic tuff breccia			1	2.00			-		-	
Scoria tuff			8	1.91			2.21		1.43	
Andesite			13	2.48			2.74		1.47	
Andesite	T		8	2.47	2.35		2.62	2.62	2.27	1.69
Andesitic tuff breccia			4	2.13			2.59		1.69	
Sandstone, Mudstone	J	J-3	2	2.54	2.42	2.03	2.62	2.62	2.46	2.41
Tuff			3	1.68			2.03		1.47	
Sandstone		J-2	1	2.41		2.52	-	2.62	-	2.41
Limestone			1	2.62			-		-	
Sandstone, Mudstone (Basalt)		J-1	3	2.64		2.54	2.65	2.69	2.64	2.18
Andesite Basalt			4	2.52			2.69		2.18	
Pyroclastics			9	2.51			2.60		2.27	
Granodiorite	B		7	2.66	2.66		2.72	2.72	2.56	2.56
Metamorphosed rocks			4	2.69			2.72		2.64	
Aplite			2	2.61			2.64		2.58	
Dacite dike	D		3	2.46	2.52		2.53	2.70	2.39	2.39
Basalt dike			3	2.66			2.70		2.60	
Granodiorite porphyry			4	2.46			2.48		2.43	

R.f.: Rock facies

G.u.: Geological unit

Table A-3 (2) Results of measurement of density in water saturated condition (g/cm^3)

Rock facies	Geological Unit		Number	Average R.f.	Average G.u.	Average G.u.	Maximum R.f.	Maximum G.u.	Minimum R.f.	Minimum G.u.
Rhyolite	V	V-2	2	1.85	2.26		2.05	2.63	1.64	1.64
Dacite			16	2.31			2.63		2.11	
Dacitic tuff breccia (1)			1	2.21			-		-	
Dacitic tuff breccia (2)			4	2.25			2.33		2.16	
Pumice tuff		V-1	2	1.70	2.32		1.70	2.76	1.70	1.70
Welded tuff			3	2.56			2.58		2.54	
Andesitic tuff breccia			1	2.17			-		-	
Scoria tuff			8	2.06			2.24		1.73	
Andesite			13	2.52			2.76		1.76	
Andesite	T		8	2.50	2.41		2.64	2.64	2.38	1.88
Andesitic tuff breccia			4	2.23			2.60		1.88	
Sandstone, Mudstone	J	J-3	2	2.56	2.47	2.15	2.63	2.63	2.49	1.70
Tuff			3	1.87			2.19		1.70	
Sandstone		J-2	1	2.47		2.56	-	2.64	-	2.47
Limestone			1	2.64			-		-	
Sandstone, Mudstone (Basalt)		J-1	3	2.65		2.56	2.66	2.69	2.64	2.30
Andesite Basalt			4	2.56			2.69		2.30	
Pyroclastics			9	2.54			2.61		2.34	
Granodiorite	B		7	2.67	2.67		2.73	2.73	2.59	2.58
Metamorphosed rocks			4	2.70			2.72		2.65	
Aplite			2	2.61			2.64		2.58	
Dacite dike	D		3	2.49	2.54		2.56	2.70	2.43	2.43
Basalt dike			3	2.67			2.70		2.60	
Granodiorite porphyry			4	2.48			2.50		2.45	

R.f.: Rock facies

G.u.: Geological unit

Table A-3 (3) Results of rock measurement of density in oven dry condition (g/cm^3)

Rock facies	Geological Unit		Number	Average			Maximum		Minimum	
				R.f.	G.u.		R.f.	G.u.	R.f.	G.u.
Rhyolite	V	V-2	2	1.77	2.16		2.01	2.37	1.53	1.53
Dacite			13	2.21			2.37		2.03	
Dacitic tuff breccia (1)			1	2.04			-		-	
Dacitic tuff breccia (2)			4	2.19			2.31		2.12	
Pumice tuff		V-1	2	1.38	2.18		1.38	2.73	1.37	1.36
Welded tuff			3	2.53			2.55		2.51	
Andesitic tuff breccia			1	1.92			-		-	
Scoria tuff			8	1.86			2.20		1.36	
Andesite			11	2.48			2.73		1.38	
Andesite	T		3	2.43	2.22		2.51	2.59	2.30	1.56
Andesitic tuff breccia			4	2.07			2.59		1.56	
Sandstone, Mudstone	J	J-3	2	2.53	2.37	1.99	2.61	2.61	2.45	1.43
Tuff			3	1.63			2.01		1.43	
Sandstone		J-2	1	2.40		2.51	-	2.62	-	2.40
Limestone			1	2.62			-		-	
Sandstone, Mudstone (Basalt)		J-1	3	2.63		2.51	2.63	2.68	2.62	2.16
Andesite Basalt			4	2.51			2.68		2.16	
Pyroclastics			5	2.45			2.59		2.26	
Granodiorite	B		7	2.66	2.66		2.72	2.72	2.59	2.57
Metamorphosed rocks			4	2.69			2.72		2.64	
Aplite			2	2.60			2.63		2.57	
Dacite dike	D		3	2.44	2.52		2.51	2.70	2.37	2.37
Basalt dike			3	2.66			2.70		2.59	
Granodiorite porphyry			2	2.45			2.47		2.43	

R.f.: Rock facies

G.u.: Geological unit

Table A-3 (4) Results of measurement of porosity (%)

Rock facies	Geological Unit		Number	Average			Maximum		Minimum	
				R.f.	G.u.		R.f.	G.u.	R.f.	G.u.
Rhyolite	V	V-2	2	7.79	8.00		11.56	11.56	4.01	1.93
Dacite			12	7.42			10.51		4.11	
Dacitic tuff breccia (1)			1	16.58			-		-	
Dacitic tuff breccia (2)			3	7.58			10.43		1.93	
Pumice tuff		V-1	2	32.18	13.33		32.74	37.94	31.62	0.79
Welded tuff			3	3.10			3.42		2.69	
Andesitic tuff breccia			1	25.07			-		-	
Scoria tuff			8	21.24			36.83		3.75	
Andesite			11	5.86			37.94		0.79	
Andesite	T		3	4.48	11.08		10.34	29.89	1.06	0.86
Andesitic tuff breccia			4	16.04			29.89		0.86	
Sandstone, Mudstone	J	J-3	2	3.03	7.32	15.54	4.27	30.56	1.78	1.78
Tuff			3	23.88			30.56		17.78	
Sandstone		J-2	1	6.84		4.53	-	6.84	-	2.22
Limestone			1	2.22			-		-	
Sandstone, Mudstone (Basalt)		J-1	3	1.98		4.36	3.31	14.09	1.22	0.77
Andesite Basalt			4	5.46			14.09		1.54	
Pyroclastics			5	4.91			9.18		0.77	
Granodiorite	B		6	1.06	0.94		1.58	1.58	0.72	0.27
Metamorphosed rocks			4	0.63			1.15		0.27	
Aplite			2	1.19			1.35		1.02	
Dacite dike	D		3	5.72	3.73		5.94	5.94	5.46	0.26
Basalt dike			2	1.27			2.27		0.26	
Granodiorite porphyry			2	3.21			3.41		3.01	

R.f.: Rock facies

G.u.: Geological unit

Table A-3 (5) Results of measurement of susceptibility ($\times 10^{-6}$ emu/cm^3)

<table>
<tr><th rowspan="2">Rock facies</th><th colspan="2" rowspan="2">Geological Unit</th><th rowspan="2">Number</th><th colspan="3">Average</th><th colspan="2">Maximum</th><th colspan="2">Minimum</th></tr>
<tr><th>R.f.</th><th colspan="2">G.u.</th><th>R.f.</th><th>G.u.</th><th>R.f.</th><th>G.u.</th></tr>
<tr><td>Rhyolite</td><td rowspan="9">V</td><td rowspan="4">V-2</td><td>2</td><td>184</td><td colspan="2" rowspan="4">298</td><td>211</td><td rowspan="4">764</td><td>157</td><td rowspan="4">126</td></tr>
<tr><td>Dacite</td><td>6</td><td>360</td><td>764</td><td>137</td></tr>
<tr><td>Dacitic tuff breccia (1)</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Dacitic tuff breccia (2)</td><td>3</td><td>250</td><td>312</td><td>126</td></tr>
<tr><td>Pumice tuff</td><td rowspan="5">V-1</td><td>1</td><td>1170</td><td colspan="2" rowspan="5">1290</td><td>-</td><td rowspan="5">2631</td><td>-</td><td rowspan="5">88</td></tr>
<tr><td>Welded tuff</td><td>2</td><td>1185</td><td>1261</td><td>1108</td></tr>
<tr><td>Andesitic tuff breccia</td><td>1</td><td>1119</td><td>-</td><td>-</td></tr>
<tr><td>Scoria tuff</td><td>4</td><td>812</td><td>1782</td><td>88</td></tr>
<tr><td>Andesite</td><td>7</td><td>1635</td><td>2631</td><td>590</td></tr>
<tr><td>Andesite</td><td colspan="2" rowspan="2">T</td><td>3</td><td>1503</td><td colspan="2" rowspan="2">855</td><td>1693</td><td rowspan="2">1693</td><td>1174</td><td rowspan="2">63</td></tr>
<tr><td>Andesitic tuff breccia</td><td>4</td><td>370</td><td>961</td><td>63</td></tr>
<tr><td>Sandstone, Mudstone</td><td rowspan="7">J</td><td rowspan="2">J-3</td><td>2</td><td>62</td><td rowspan="7">205</td><td rowspan="2">112</td><td>70</td><td rowspan="2">372</td><td>54</td><td rowspan="2">20</td></tr>
<tr><td>Tuff</td><td>3</td><td>145</td><td>372</td><td>20</td></tr>
<tr><td>Sandstone</td><td rowspan="2">J-2</td><td>1</td><td>27</td><td rowspan="2">-</td><td>-</td><td rowspan="2">-</td><td>-</td><td rowspan="2">-</td></tr>
<tr><td>Limestone</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Sandstone, Mudstone (Basalt)</td><td rowspan="3">J-1</td><td>2</td><td>68</td><td rowspan="3">277</td><td>77</td><td rowspan="3">1690</td><td>58</td><td rowspan="3">58</td></tr>
<tr><td>Andesite Basalt</td><td>3</td><td>602</td><td>1690</td><td>58</td></tr>
<tr><td>Pyroclastics</td><td>4</td><td>138</td><td>306</td><td>80</td></tr>
<tr><td>Granodiorite</td><td colspan="2" rowspan="3">B</td><td>5</td><td>187</td><td colspan="2" rowspan="3">116</td><td>417</td><td rowspan="3">417</td><td>57</td><td rowspan="3">30</td></tr>
<tr><td>Metamorphosed rocks</td><td>3</td><td>41</td><td>58</td><td>30</td></tr>
<tr><td>Aplite</td><td>2</td><td>52</td><td>55</td><td>48</td></tr>
<tr><td>Dacite dike</td><td colspan="2" rowspan="3">D</td><td>-</td><td>-</td><td colspan="2" rowspan="3">429</td><td>-</td><td rowspan="3">1073</td><td>-</td><td rowspan="3">46</td></tr>
<tr><td>Basalt dike</td><td>2</td><td>55</td><td>64</td><td>46</td></tr>
<tr><td>Granodiorite porphyry</td><td>2</td><td>803</td><td>1073</td><td>533</td></tr>
</table>

R.f.: Rock facies

G.u.: Geological unit

Table A-3 (6) Results of measurement of frequency effect (%)

Rock facies	Geological Unit		Number	Average			Maximum		Minimum	
				R.f.	G.u.		R.f.	G.u.	R.f.	G.u.
Rhyolite	V	V-2	2	1.6	1.9		2.1	3.8	1.0	1.0
Dacite			6	2.2			3.8		1.2	
Dacitic tuff breccia (1)			-	-			-		-	
Dacitic tuff breccia (2)			3	1.7			2.2		1.3	
Pumice tuff		V-1	-	-	1.4		-	2.3	-	0.7
Welded tuff			2	1.3			1.3		1.2	
Andesitic tuff breccia			1	1.3			-		-	
Scoria tuff			4	1.7			2.3		1.1	
Andesite			7	1.2			1.8		0.7	
Andesite	T		3	1.7	1.6		2.1	2.1	1.1	1.0
Andesitic tuff breccia			4	1.5			2.0		1.0	
Sandstone, Mudstone	J	J-3	2	1.5	1.8	1.6	1.8	2.1	1.2	1.0
Tuff			3	1.6			2.1		1.0	
Sandstone		J-2	1	3.2		-	-	-	-	-
Limestone			-	-			-		-	
Sandstone, Mudstone (Basalt)		J-1	2	1.7		1.7	2.4	2.8	1.0	0.7
Andesite Basalt			3	1.6			2.8		0.7	
Pyroclastics			4	1.8			2.5		1.0	
Granodiorite	B		5	1.9	2.0		2.8	3.3	1.5	0.9
Metamorphosed rocks			3	1.9			3.3		0.9	
Aplite			2	2.5			2.9		2.1	
Dacite dike	D		-	-	2.1		-	3.1	-	1.0
Basalt dike			2	1.3			1.6		1.0	
Granodiorite porphyry			2	2.8			3.1		2.5	

R.f.: Rock facies

G.u.: Geological unit

Table A-3 (7) Results of measurement of resistivity (Ω - m)

Rock facies	Geological Unit		Number	Average R.f.	Average G.u.		Maximum R.f.	Maximum G.u.	Minimum R.f.	Minimum G.u.
Rhyolite	V	V-2	2	2854	1861		5193	5874	515	244
Dacite			6	1097			4412		244	
Dacitic tuff breccia (1)			-	-			-		-	
Dacitic tuff breccia (2)			3	2728			5874		528	
Pumice tuff		V-1	-	-	465		-	1393	-	35
Welded tuff			2	537			751		322	
Andesitic tuff breccia			1	62			-		-	
Scoria tuff			4	95			155		35	
Andesite			7	712			1393		45	
Andesite	T		3	3219	1929		8244	8244	102	60
Andesitic tuff breccia			4	961			3020		60	
Sandstone, Mudstone	J	J-3	2	335	1881	174	550	550	120	46
Tuff			3	67			85		46	
Sandstone		J-2	1	357		-	-	-	-	-
Limestone			-	-			-		-	
Sandstone, Mudstone (Basalt)		J-1	2	468		2999	550	11728	385	223
Andesite Basalt			3	582			859		330	
Pyroclastics			4	6078			11728		223	
Granodiorite	B		5	1853	4858		3182	24607	859	698
Metamorphosed rocks			3	11243			24607		1644	
Aplite			2	2795			4892		698	
Dacite dike	D		-	-	5550		-	19499	-	323
Basalt dike			2	9911			19499		323	
Granodiorite porphyry			2	1189			1571		806	

R.f.: Rock facies
G.u.: Geological unit

Table A-3 (8) Results of measurement of thermal conductivity ($x10^{-3}$ cal/cm·sec·°C)

Rock facies	Geological Unit		Number	Average R.f.	Average G.u.		Maximum R.f.	Maximum G.u.	Minimum R.f.	Minimum G.u.
Rhyolite	V	V-2	2	1.687	2.708		2.081	4.021	1.292	1.292
Dacite			6	2.633			3.781		1.727	
Dacitic tuff breccia (1)			-	-			-		-	
Dacitic tuff breccia (2)			3	3.541			4.021		2.749	
Pumice tuff		V-1	1	0.582	2.793		-	4.393	-	1.194
Welded tuff			2	3.576			4.199		2.952	
Andesitic tuff breccia			1	2.529			-		-	
Scoria tuff			4	1.709			2.351		1.194	
Andesite			7	3.542			4.393		1.658	
Andesite	T		3	3.944	4.335		4.328	8.355	3.211	1.547
Andesitic tuff breccia			3	4.725			8.355		1.547	
Sandstone, Mudstone	J	J-3	2	5.522	5.302	3.609	5.757	5.757	5.287	1.754
Tuff			3	2.333			3.736		1.754	
Sandstone		J-2	1	6.690		-	-	-	-	-
Limestone			-	-			-		-	
Sandstone, Mudstone (Basalt)		J-1	2	6.100		6.088	7.058	8.913	5.141	3.653
Andesite Basalt			3	5.463			6.678		4.631	
Pyroclastics			4	6.552			8.913		3.653	
Granodiorite	B		5	7.539	9.057		7.860	13.710	6.946	6.946
Metamorphosed rocks			3	12.577			13.710		11.150	
Aplite			2	7.575			8.116		7.033	
Dacite dike	D		-	-	7.277		-	10.850	-	5.062
Basalt dike			2	9.457			10.850		8.064	
Granodiorite porphyry			2	5.098			5.133		5.062	

R.f.: Rock facies

G.u.: Geological unit

Table A-4 Terrain correction of gravity prospecting

Area name	Range of correction	Interval of grid	Scale of map
A	<60 km	3'(E-W) x 2'(N-S)	1 : 500,000
B	21'(E-W) x 16'(N-S)	45"(E-W) x 30"(N-S)	1 : 100,000
C	5.25'(E-W) x 4'(N-S)	11.25"(E-W) x 7.5"(N-S)	1 : 100,000
D	500 m ∿ C	Pentahedral approximation	1 : 100,000
E	20 m ∿ 500 m	See figure below.	1 : 25,000
F	< 20 m	Based on sketch	-

Area name	Range of correction	Nos. of compartment
E_1	20 ∿ 70 m	6
E_2	70 ∿ 155 m	8
E_3	155 ∿ 290 m	10
E_4	290 ∿ 500 m	12

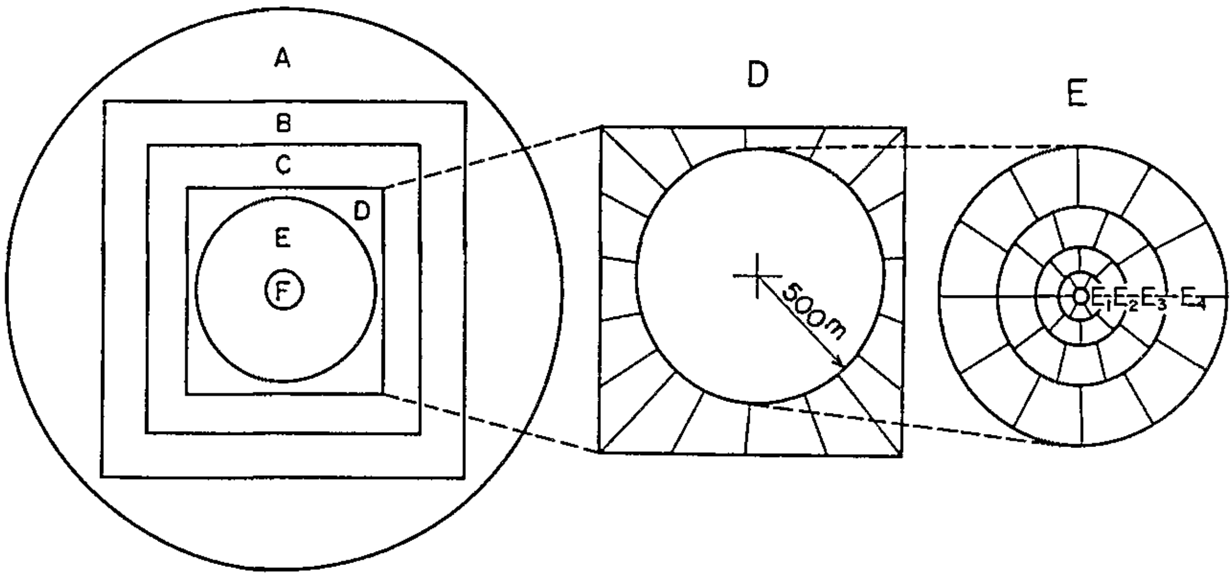

Table A-5

Obtained data and calculated correction values of all stations

(Density = 2.00 g/cm^3)

S.T. NO	Station Number
OBS.DAY	Day of measurement
LAT.	Latitude
LONG.	Longitude
LEVEL	Altitude
ABS.G	Gravity value (gal)
C.20M	Terrain correction of area F (mgal)
TERR.C	Total value of terrain correction (mgal)
F.E.C	Free air correction (mgal)
B.G.C	Bouguer correction (mgal)
NORM.G	Normal gravity value (gal)
ANOM.F	Free air anomaly (mgal)
ANOM.B	Bouguer anomaly (mgal)

83(YEAR) ***** THE LIST OF GRAVITY SURVEY ***** DOMUYO AREA DENSITY = 2.00 (G/CM**3) PAGE= 1

ST.NO	OBS.DAY	LAT.	LONG.	LEVEL	ABS.G	C.20M	ETC	*	TERR.C	F.E.C	B.G.C	NORM.G	ANOM.F	ANOM.B
1	83 120	-3643.08	-7037.87	1800.67	979.373482	.002	L L	*	7.884	555.686	-150.896	979.892578	44.474	-106.422
2	83 120	-3642.86	-7037.26	1762.60	979.377927	.008	L L	*	5.894	543.938	-147.706	979.892261	35.498	-112.208
3	83 120	-3642.77	-7036.68	1851.29	979.361285	.002	L L	*	6.929	571.307	-155.138	979.892132	47.389	-107.749
4	83 120	-3642.62	-7036.20	1883.09	979.354072	0.000	L L	*	7.052	581.122	-157.803	979.891915	50.331	-107.472
5	83 120	-3642.71	-7035.54	1926.85	979.345695	0.000	L L	*	6.637	594.625	-161.470	979.892045	54.911	-106.558
6	83 120	-3642.61	-7034.98	1980.75	979.332642	.008	L L	*	6.503	611.260	-165.987	979.891901	58.504	-107.483
7	83 121	-3642.63	-7034.41	1915.00	979.349311	.002	L L	*	5.346	590.969	-160.477	979.891930	53.697	-106.780
8	83 121	-3642.54	-7033.80	2041.00	979.322844	.002	L L	*	4.643	629.853	-171.036	979.891800	65.539	-105.497
9	83 121	-3642.35	-7033.29	2139.33	979.302441	.023	L L	*	4.726	660.197	-179.276	979.891527	75.837	-103.439
10	83 121	-3642.34	-7032.89	2374.47	979.245680	.309	L L	*	8.386	732.763	-198.981	979.891512	95.316	-103.665
11	83 120	-3642.11	-7032.35	2160.75	979.289287	.002	L L	*	6.552	666.808	-181.071	979.891181	71.467	-109.604
12	83 121	-3642.59	-7037.97	1595.27	979.415527	.043	L L	*	4.485	492.310	-133.683	979.891872	20.439	-113.244
13	83 121	-3642.28	-7037.40	1788.54	979.376547	0.000	L L	*	6.305	551.943	-149.879	979.891426	43.369	-106.511
14	83 121	-3642.31	-7036.67	1839.88	979.366451	.009	L L	*	5.979	567.786	-154.182	979.891469	48.747	-105.435
15	83 121	-3642.18	-7036.22	1911.28	979.347759	0.000	L L	*	6.280	589.822	-160.166	979.891282	52.579	-107.586
16	83 121	-3642.07	-7035.71	1953.10	979.339020	0.000	L L	*	6.330	602.728	-163.670	979.891123	56.954	-106.716
17	83 121	-3642.04	-7035.30	1987.15	979.332761	0.000	L L	*	5.361	613.235	-166.523	979.891080	60.277	-106.246
18	83 121	-3642.16	-7034.87	2013.03	979.326847	0.000	L L	*	5.265	621.222	-168.692	979.891253	62.082	-106.610
19	83 121	-3642.16	-7034.52	2052.00	979.316913	0.000	L L	*	4.999	633.247	-171.958	979.891253	63.906	-108.051
20	83 120	-3641.77	-7034.15	2063.62	979.314605	.002	L L	*	4.152	636.833	-172.931	979.890691	64.899	-108.032
21	83 121	-3642.16	-7034.03	2122.11	979.300310	.012	L L	*	5.472	654.884	-177.833	979.891253	69.413	-108.420
22	83 120	-3641.84	-7033.38	2104.67	979.304234	.003	L L	*	4.555	649.501	-176.371	979.890792	67.497	-108.874
23	83 120	-3641.65	-7032.75	2155.61	979.292598	0.000	L L	*	5.290	665.222	-180.640	979.890519	72.591	-108.049
24	83 120	-3641.74	-7032.39	2190.35	979.285125	0.000	L L	*	6.069	675.941	-183.551	979.890648	76.487	-107.065
25	83 121	-3642.11	-7037.84	1650.97	979.402002	.014	L L	*	6.347	509.489	-138.351	979.891181	26.657	-111.694
26	83 121	-3642.17	-7037.33	1768.01	979.378023	.181	L L	*	7.834	545.609	-148.159	979.891267	40.198	-107.962
27	83 121	-3642.02	-7036.80	1818.24	979.369756	.040	L L	*	6.235	561.108	-152.368	979.891051	46.048	-106.320
28	83 126	-3641.72	-7036.52	1838.44	979.364660	.023	L L	*	4.631	567.343	-154.061	979.890619	46.014	-108.047
29	83 126	-3641.74	-7035.83	1919.48	979.344688	.006	L L	*	5.688	592.352	-160.853	979.890648	52.080	-108.772
30	83 120	-3641.72	-7035.17	1955.84	979.339465	.002	L L	*	5.896	603.573	-163.900	979.890619	58.315	-105.585
31	83 120	-3641.66	-7034.60	2013.70	979.327843	.002	L L	*	4.531	621.428	-168.748	979.890533	63.269	-105.479
32	83 126	-3641.46	-7034.10	2062.27	979.315806	.002	L L	*	4.507	636.417	-172.818	979.890245	66.485	-106.333
33	83 126	-3641.43	-7033.59	2091.24	979.307067	0.000	L L	*	4.503	645.357	-175.246	979.890202	66.725	-108.521
34	83 126	-3641.36	-7032.93	2136.24	979.294914	.007	L L	*	5.016	659.244	-179.017	979.890101	69.074	-109.943
35	83 126	-3641.15	-7032.67	2285.18	979.258835	.145	L L	*	7.636	705.207	-191.498	979.889799	81.879	-109.619
36	83 127	-3641.71	-7038.23	1582.91	979.416850	.005	L L	*	5.088	488.486	-132.648	979.890605	19.820	-112.828
37	83 117	-3641.58	-7037.49	1718.43	979.385765	.023	L L	*	6.807	530.307	-144.004	979.890418	32.462	-111.543
38	83 117	-3641.46	-7037.01	1749.71	979.380623	.002	L L	*	3.870	539.961	-146.626	979.890245	34.208	-112.418
39	83 2 9	-3641.44	-7036.56	1837.01	979.363574	.009	L L	*	4.494	566.902	-153.942	979.890216	44.753	-109.189
40	83 117	-3641.32	-7035.87	1948.96	979.337929	0.000	L L	*	3.941	601.449	-163.323	979.890043	53.276	-110.047
41	83 119	-3641.25	-7035.32	1997.18	979.328408	.002	L L	*	3.546	616.329	-167.364	979.889943	58.340	-109.023
42	83 119	-3641.16	-7034.74	2051.81	979.316856	.002	L L	*	4.420	633.188	-171.942	979.889813	64.651	-107.290
43	83 119	-3641.02	-7034.24	2109.49	979.303103	0.000	L L	*	3.769	650.987	-176.775	979.889612	68.248	-108.527
44	83 118	-3640.97	-7034.00	2134.92	979.296498	0.000	L L	*	3.720	658.837	-178.906	979.889540	69.516	-109.391
45	83 118	-3640.91	-7033.72	2151.16	979.291853	.013	L L	*	3.822	663.847	-180.267	979.889453	70.069	-110.198
46	83 118	-3640.75	-7032.97	2232.94	979.273511	0.000	L L	*	4.319	689.086	-187.121	979.889223	77.694	-109.427
47	83 118	-3640.77	-7032.46	2319.58	979.251821	.018	L L	*	5.594	715.823	-194.381	979.889252	83.986	-110.395
48	83 118	-3640.64	-7032.06	2447.15	979.222381	.004	L L	*	5.582	755.191	-205.071	979.889064	94.090	-110.982
49	83 127	-3641.33	-7038.04	1578.04	979.416778	.051	L L	*	5.561	486.983	-132.240	979.890058	19.264	-112.976
50	83 127	-3641.13	-7037.76	1603.68	979.411370	.002	L L	*	5.125	494.896	-134.388	979.889770	21.621	-112.768

ST.NO	OBS.DAY	LAT.	LONG.	LEVEL	ABS.G	C.20M	ETC	*	TERR.C	F.E.C	B.G.C	NORM.G	ANOM.F	ANOM.B
51	83 117	-3641.15	-7037.36	1512.06	979.427007	.173	L L	*	6.266	466.622	-126.711	979.889799	10.096	-116.614
52	83 117	-3641.00	-7036.98	1733.90	979.380425	.002	L L	*	7.318	535.082	-145.301	979.889583	33.242	-112.059
53	83 117	-3640.90	-7036.47	1763.11	979.376476	.032	L L	*	5.394	544.095	-147.748	979.889439	36.526	-111.222
54	83 117	-3640.85	-7036.11	1915.52	979.342937	.002	L L	*	5.406	591.128	-160.520	979.889367	50.105	-110.415
55	83 119	-3640.67	-7035.46	2022.41	979.318539	.002	L L	*	4.110	624.115	-169.478	979.889108	57.657	-111.821
56	83 119	-3640.55	-7034.98	2054.61	979.313516	.002	L L	*	3.800	634.054	-172.177	979.888935	62.434	-109.743
57	83 119	-3640.60	-7034.07	2122.10	979.297631	.002	L L	*	3.472	654.881	-177.832	979.889007	66.977	-110.855
58	83 118	-3640.42	-7033.83	2150.26	979.291515	.022	L L	*	3.739	663.571	-180.192	979.888748	70.078	-110.115
59	83 118	-3640.46	-7033.26	2196.66	979.279246	.002	L L	*	4.315	677.889	-184.080	979.888805	72.645	-111.435
60	83 118	-3640.28	-7032.68	2314.83	979.252802	.023	L L	*	5.876	714.357	-193.983	979.888546	84.490	-109.493
61	83 118	-3640.18	-7032.25	2458.99	979.218554	.005	L L	*	6.342	758.843	-206.063	979.888402	95.336	-110.727
62	83 127	-3640.62	-7038.05	1561.14	979.417324	.010	L L	*	4.920	481.767	-130.823	979.889036	14.976	-115.847
63	83 117	-3640.57	-7037.19	1591.54	979.412264	.002	L L	*	4.714	491.148	-133.371	979.888964	19.163	-114.208
64	83 117	-3640.46	-7036.63	1743.47	979.379685	.007	L L	*	4.399	538.035	-146.103	979.888805	33.314	-112.789
65	83 122	-3640.56	-7036.20	1815.41	979.364959	.011	L L	*	3.751	560.236	-152.131	979.888949	39.996	-112.135
66	83 122	-3640.45	-7035.46	1953.00	979.334728	.086	L L	*	4.667	602.696	-163.661	979.888791	53.299	-110.362
67	83 119	-3640.16	-7034.81	2075.69	979.307229	0.000	L L	*	3.962	640.557	-173.943	979.888373	63.375	-110.568
68	83 119	-3640.04	-7034.23	2132.89	979.294427	0.000	L L	*	4.055	658.209	-178.736	979.888201	68.490	-110.246
69	83 119	-3639.84	-7033.77	2170.73	979.286023	0.000	L L	*	4.633	669.887	-181.907	979.887913	72.629	-109.278
70	83 119	-3639.83	-7033.35	2263.10	979.266235	.002	L L	*	5.010	698.392	-189.648	979.887898	81.739	-107.909
71	83 118	-3639.90	-7032.70	2323.89	979.251601	.005	L L	*	6.023	717.152	-194.742	979.887999	86.777	-107.965
72	83 118	-3639.80	-7032.02	2542.98	979.197509	.021	L L	*	7.159	784.763	-213.101	979.887855	101.575	-111.526
73	83 127	-3640.21	-7038.05	1587.36	979.410136	.009	L L	*	5.241	489.860	-133.021	979.888445	16.791	-116.230
74	83 117	-3640.18	-7037.33	1620.17	979.405478	.002	L L	*	4.127	499.985	-135.770	979.888402	21.188	-114.582
75	83 117	-3640.12	-7036.73	1686.59	979.391257	.023	L L	*	4.870	520.483	-141.337	979.888316	28.294	-113.043
76	83 122	-3640.09	-7036.11	1869.91	979.352923	.020	L L	*	4.496	577.054	-156.698	979.888273	46.201	-110.498
77	83 122	-3640.01	-7035.69	1938.26	979.337112	.005	L L	*	4.564	598.147	-162.426	979.888157	51.666	-110.760
78	83 122	-3639.84	-7035.12	1935.22	979.336634	.004	L L	*	5.295	597.208	-162.171	979.887913	51.225	-110.946
79	83 119	-3639.87	-7034.55	2109.27	979.298637	0.000	L L	*	5.170	650.920	-176.757	979.887956	66.771	-109.985
80	83 119	-3639.66	-7034.03	2152.26	979.288326	0.000	L L	*	5.661	664.189	-180.360	979.887654	70.522	-109.838
81	83 119	-3639.50	-7033.48	2215.77	979.274984	0.000	L L	*	6.299	683.788	-185.682	979.887423	77.647	-108.035
82	83 118	-3639.46	-7033.06	2307.77	979.252493	.003	L L	*	6.934	712.178	-193.391	979.887366	84.239	-109.152
83	83 118	-3639.33	-7032.45	2323.54	979.247246	.023	L L	*	8.996	717.044	-194.713	979.887179	86.108	-108.605
84	83 127	-3639.87	-7038.01	1563.48	979.413510	.004	L L	*	5.716	482.491	-131.020	979.887956	13.761	-117.259
85	83 125	-3639.75	-7037.33	1611.75	979.406430	.015	L L	*	4.527	497.387	-135.065	979.887783	20.561	-114.504
86	83 117	-3639.62	-7036.77	1624.79	979.403413	.023	L L	*	5.264	501.410	-136.157	979.887596	22.492	-113.666
87	83 122	-3639.54	-7036.24	1772.34	979.371875	.001	L L	*	3.970	546.945	-148.522	979.887481	35.310	-113.212
88	83 122	-3639.44	-7035.70	1752.46	979.374963	.003	L L	*	4.747	540.809	-146.856	979.887337	33.182	-113.674
89	83 122	-3639.38	-7035.30	1841.77	979.356679	.014	L L	*	5.124	568.370	-154.340	979.887251	42.922	-111.418
90	83 127	-3639.22	-7038.32	1593.43	979.405864	.002	L L	*	5.696	491.733	-133.530	979.887020	16.273	-117.257
91	83 127	-3639.47	-7037.88	1558.79	979.414060	.025	L L	*	5.440	481.042	-130.626	979.887380	13.161	-117.465
92	83 125	-3639.32	-7037.31	1649.58	979.396565	.002	L L	*	4.372	509.059	-138.235	979.887164	22.832	-115.402
93	83 125	-3639.11	-7036.77	1656.53	979.396301	.004	L L	*	4.425	511.204	-138.817	979.886862	25.067	-113.749
94	83 122	-3639.11	-7036.34	1708.54	979.383765	.005	L L	*	4.192	527.255	-143.176	979.886862	28.350	-114.626
95	83 122	-3639.05	-7035.74	1732.98	979.378376	.031	L L	*	5.090	534.797	-145.224	979.886776	31.487	-113.736
96	83 2 7	-3638.88	-7035.35	1809.54	979.362360	0.000	L L	*	4.816	558.423	-151.639	979.886531	39.068	-112.571
97	83 2 7	-3638.79	-7034.55	1993.35	979.321209	.040	L L	*	6.291	615.147	-167.043	979.886401	56.246	-110.797
98	83 2 7	-3638.82	-7034.13	2166.18	979.283839	.002	L L	*	6.424	668.482	-181.526	979.886445	72.301	-109.225
99	83 2 7	-3638.86	-7033.54	2239.91	979.266856	.005	L L	*	8.280	691.235	-187.704	979.886502	79.669	-107.835
100	83 2 7	-3638.66	-7032.98	2460.75	979.213243	.092	L L	*	11.694	759.386	-206.210	979.886214	98.108	-108.102

83(YEAR) ***** THE LIST OF GRAVITY SURVEY ***** DOMUYO AREA DENSITY = 2.00 (G/CM**3) PAGE= 3

ST.NO	OBS.DAY	LAT.	LONG.	LEVEL	ABS.G	C.20M	ETC	*	TERR.C	F.E.C	B.G.C	NORM.G	ANOM.F	ANOM.B
101	83 127	-3636.90	-7038.52	1644.61	979.394209	.009	L L	*	5.530	507.528	-137.819	979.886560	20.707	-117.112
102	83 213	-3638.88	-7037.94	1526.00	979.418769	0.000	L L	*	5.982	470.924	-127.879	979.886531	9.143	-118.736
103	83 125	-3636.84	-7037.58	1605.38	979.404163	.002	L L	*	4.456	495.421	-134.531	979.886473	17.567	-116.964
104	83 125	-3636.79	-7036.93	1666.11	979.393973	0.000	L L	*	3.979	514.161	-139.620	979.886401	25.712	-113.908
105	83 125	-3638.72	-7036.49	1692.12	979.387557	.005	L L	*	4.192	522.189	-141.800	979.886301	27.638	-114.162
106	83 125	-3638.56	-7035.96	1756.67	979.373671	.006	L L	*	4.237	542.107	-147.209	979.886070	33.945	-113.264
107	83 210	-3638.47	-7035.56	1811.76	979.361982	0.000	L L	*	3.983	559.108	-151.825	979.885941	39.131	-112.694
108	83 210	-3638.39	-7035.04	1950.05	979.330513	.095	L L	*	4.864	601.785	-163.414	979.885826	51.337	-112.078
109	83 2 7	-3636.54	-7034.48	2144.06	979.289751	0.000	L L	*	5.830	661.656	-179.672	979.886042	71.195	-108.477
110	83 2 7	-3638.18	-7033.67	2305.01	979.253751	.015	L L	*	7.796	711.327	-193.160	979.885524	87.350	-105.810
111	83 2 7	-3638.07	-7033.25	2469.54	979.213609	.065	L L	*	10.111	762.099	-206.947	979.885365	100.453	-106.494
112	83 127	-3638.56	-7038.67	1713.74	979.377901	.008	L L	*	5.258	528.861	-143.612	979.886070	25.950	-117.062
113	83 213	-3638.43	-7038.10	1551.00	979.412931	.002	L L	*	5.890	478.639	-129.974	979.885883	11.576	-118.397
114	83 125	-3638.39	-7037.72	1700.05	979.382679	.004	L L	*	4.774	524.636	-142.464	979.885826	26.264	-116.201
115	83 125	-3638.31	-7037.22	1713.91	979.382086	0.000	L L	*	3.912	528.911	-143.625	979.885711	29.199	-114.426
116	83 125	-3638.34	-7036.57	1748.44	979.376337	.006	L L	*	3.597	539.567	-146.519	979.885754	33.747	-112.772
117	83 213	-3638.25	-7036.00	1762.80	979.371842	.041	L L	*	4.562	544.000	-147.723	979.885624	34.780	-112.943
118	83 125	-3638.05	-7035.41	1859.57	979.351302	.002	L L	*	4.043	573.863	-155.832	979.885337	43.871	-111.961
119	83 210	-3638.07	-7035.02	1888.63	979.344157	0.000	L L	*	4.520	582.831	-158.267	979.885365	46.143	-112.125
120	83 210	-3638.10	-7034.60	2027.38	979.314468	.001	L L	*	4.994	625.650	-169.895	979.885408	59.703	-110.191
121	83 210	-3637.78	-7033.72	2244.84	979.265812	.070	L L	*	7.631	692.758	-188.118	979.884948	81.254	-106.864
122	83 210	-3637.66	-7033.46	2332.26	979.243202	.002	L L	*	8.693	719.736	-195.443	979.884775	86.856	-108.587
123	83 128	-3637.99	-7038.14	1653.35	979.391198	.038	L L	*	5.747	510.224	-138.551	979.885250	21.920	-116.631
124	83 128	-3637.95	-7037.75	1691.74	979.384207	.013	L L	*	4.600	522.070	-141.768	979.885193	25.684	-116.084
125	83 128	-3637.84	-7037.45	1734.57	979.375819	.005	L L	*	3.839	535.287	-145.357	979.885034	29.911	-115.446
126	83 128	-3637.69	-7036.90	1751.85	979.372853	.008	L L	*	4.285	540.620	-146.805	979.884819	32.940	-113.865
127	83 125	-3637.87	-7036.00	1859.05	979.349937	.004	L L	*	6.157	573.701	-155.788	979.885078	44.717	-111.071
128	83 125	-3637.54	-7035.01	1833.80	979.355461	.005	L L	*	4.392	565.910	-153.672	979.884603	41.160	-112.512
129	83 210	-3637.42	-7035.02	1991.37	979.320896	.008	L L	*	5.995	614.536	-166.877	979.884430	56.997	-109.879
130	83 210	-3637.48	-7034.45	2025.92	979.313111	.023	L L	*	5.625	625.199	-169.772	979.884516	59.418	-110.354
131	83 210	-3637.40	-7033.95	2132.77	979.289582	.009	L L	*	6.487	658.171	-178.726	979.884401	69.839	-108.887
132	83 128	-3637.51	-7038.20	1666.41	979.388414	.040	L L	*	6.085	514.254	-139.645	979.884560	24.194	-115.451
133	83 128	-3637.67	-7037.89	1703.59	979.381776	0.000	L L	*	4.301	525.728	-142.761	979.884790	27.016	-115.745
134	83 128	-3637.54	-7037.46	1777.25	979.367177	.007	L L	*	3.846	548.458	-148.933	979.884603	34.878	-114.055
135	83 128	-3637.29	-7036.86	1804.94	979.361532	.027	L L	*	3.440	557.003	-151.254	979.884243	37.732	-113.522
136	83 128	-3637.19	-7036.28	1783.92	979.365516	.002	L L	*	3.877	550.517	-149.492	979.884099	35.811	-113.682
137	83 128	-3637.09	-7035.73	1779.11	979.365656	.006	L L	*	4.325	549.033	-149.089	979.883955	35.059	-114.030
138	83 128	-3637.17	-7035.33	1857.65	979.349261	.002	L L	*	4.541	573.271	-155.671	979.884070	43.002	-112.669
139	83 210	-3637.15	-7034.40	2051.51	979.308231	.004	L L	*	6.152	633.095	-171.916	979.884042	63.437	-108.479
140	83 210	-3637.06	-7033.75	2207.18	979.271206	.004	L L	*	7.078	681.137	-184.962	979.883912	75.509	-109.453
141	83 210	-3637.09	-7033.27	2322.46	979.242418	.003	L L	*	8.444	716.711	-194.622	979.883955	83.617	-111.005
142	83 128	-3637.31	-7038.32	1722.54	979.376163	.005	L L	*	5.621	531.576	-144.349	979.884272	29.089	-115.260
301	83 2 3	-3638.84	-7031.66	2482.64	979.202473	.010	L L	*	9.837	766.143	-208.045	979.886473	91.979	-116.066
302	83 2 3	-3639.18	-7031.69	2523.10	979.196985	.007	L L	*	9.609	778.629	-211.436	979.886963	98.260	-113.176
303	83 2 3	-3639.50	-7031.81	2622.34	979.178772	.011	L L	*	8.174	809.254	-219.752	979.887423	108.777	-110.975
304	83 2 3	-3639.82	-7031.77	2604.81	979.181737	.065	L L	*	8.117	803.845	-218.283	979.887884	105.815	-112.468
305	83 2 3	-3640.14	-7031.78	2605.47	979.182776	.023	L L	*	7.479	804.049	-218.339	979.888345	105.960	-112.379
306	83 2 3	-3640.41	-7031.58	2589.90	979.187517	.010	L L	*	6.934	799.244	-217.034	979.888733	104.963	-112.071
307	83 2 3	-3639.32	-7032.19	2457.35	979.216152	.018	L L	*	9.011	758.339	-205.926	979.887164	96.337	-109.589
308	83 2 3	-3639.60	-7032.27	2474.57	979.213733	.015	L L	*	8.075	763.653	-207.369	979.887567	97.893	-109.476

83(YEAR) ***** THE LIST OF GRAVITY SURVEY ***** DOMUYO AREA DENSITY = 2.00 (G/CM**3)

ST.NO	OBS.DAY	LAT.	LONG.	LEVEL	ABS.G	C.20M	ETC	*	TERR.C	F.E.C	B.G.C	NORM.G	ANOM.F	ANOM.B
309	83 2 3	-3639.97	-7032.41	2434.05	979.224216	.005	L L	*	6.284	751.147	-203.973	979.888100	93.547	-110.426
310	83 2 3	-3640.36	-7032.08	2485.57	979.212684	.009	L L	*	5.916	767.046	-208.290	979.888661	96.984	-111.306
311	83 2 7	-3638.32	-7033.11	2459.73	979.217795	.015	L L	*	9.292	759.071	-206.125	979.885725	100.433	-105.692
312	83 2 7	-3638.59	-7033.33	2339.45	979.245872	.079	L L	*	8.603	721.955	-196.046	979.886114	90.316	-105.730
313	83 2 3	-3639.40	-7032.73	2274.48	979.259153	.002	L L	*	7.631	701.905	-190.601	979.887279	81.410	-109.192
314	83 2 3	-3640.06	-7032.81	2310.92	979.254576	.009	L L	*	5.709	713.151	-193.655	979.888229	85.206	-108.449
315	83 2 3	-3640.49	-7032.61	2306.80	979.255092	.015	L L	*	5.637	711.878	-193.310	979.888848	83.758	-109.551
316	83 2 4	-3640.94	-7032.79	2216.44	979.277846	.024	L L	*	4.462	683.994	-185.738	979.889496	76.805	-108.933
317	83 2 4	-3641.52	-7032.22	2187.40	979.283758	.019	L L	*	7.642	675.031	-183.304	979.890331	76.099	-107.205
318	83 2 7	-3638.62	-7033.85	2204.72	979.276473	.009	L L	*	6.261	680.377	-184.756	979.886157	76.955	-107.801
319	83 2 5	-3639.25	-7033.81	1963.90	979.323166	.130	L L	*	9.669	606.059	-164.575	979.887064	51.831	-112.744
320	83 2 3	-3639.64	-7033.68	2202.65	979.278872	0.000	L L	*	5.479	679.737	-184.582	979.887625	76.463	-108.119
321	83 2 3	-3640.01	-7033.10	2247.54	979.269146	.018	L L	*	5.123	693.592	-188.344	979.888157	79.703	-108.641
322	83 2 3	-3640.20	-7033.50	2180.27	979.283783	.002	L L	*	4.356	672.830	-182.706	979.888431	72.537	-110.169
323	83 2 4	-3640.97	-7033.26	2194.79	979.282016	.005	L L	*	4.184	677.312	-183.923	979.889540	73.973	-109.950
324	83 2 4	-3641.24	-7033.26	2108.45	979.302488	0.000	L L	*	4.152	650.668	-176.688	979.889928	67.380	-109.308
325	83 2 4	-3641.66	-7033.12	2124.11	979.299203	.002	L L	*	4.520	655.502	-178.001	979.890533	68.691	-109.310
326	83 2 4	-3641.96	-7032.72	2151.15	979.296046	.009	L L	*	5.006	663.846	-180.267	979.890965	73.932	-106.334
327	83 2 7	-3638.29	-7034.19	2165.04	979.285111	.012	L L	*	5.996	668.131	-181.430	979.885682	73.556	-107.874
328	83 2 5	-3639.29	-7034.11	1964.45	979.326613	.083	L L	*	8.547	606.230	-164.621	979.887121	54.269	-110.352
329	83 2 4	-3639.81	-7034.08	2153.65	979.289393	.006	L L	*	4.595	664.615	-180.476	979.887870	70.733	-109.743
330	83 2 4	-3640.04	-7033.90	2157.15	979.288715	.002	L L	*	4.125	665.697	-180.769	979.888201	70.337	-110.432
331	83 2 3	-3640.59	-7033.61	2148.71	979.292797	.002	L L	*	3.817	663.090	-180.061	979.888992	70.712	-109.350
332	83 2 4	-3641.10	-7033.51	2093.42	979.306434	.004	L L	*	4.229	646.031	-175.429	979.889727	66.967	-108.462
333	83 2 4	-3641.69	-7033.76	2071.95	979.310915	.014	L L	*	4.736	639.403	-173.629	979.890576	64.479	-109.151
334	83 2 7	-3638.72	-7034.93	1957.49	979.329669	.065	L L	*	5.470	604.082	-164.038	979.886301	52.921	-111.117
335	83 2 7	-3639.26	-7034.43	1986.49	979.323639	.016	L L	*	5.863	613.031	-166.468	979.887078	55.454	-111.014
336	83 2 5	-3639.47	-7034.35	1933.73	979.334111	.153	L L	*	8.939	596.750	-162.047	979.887380	52.420	-109.627
337	83 2 5	-3639.49	-7034.67	1869.24	979.348829	.033	L L	*	7.238	576.846	-156.642	979.887409	45.504	-111.138
338	83 2 4	-3639.65	-7034.29	2111.18	979.297596	.006	L L	*	6.537	651.510	-176.917	979.887639	68.004	-108.913
339	83 2 4	-3640.20	-7034.55	2090.57	979.304342	0.000	L L	*	3.763	645.149	-175.190	979.888431	64.823	-110.367
340	83 2 4	-3640.47	-7034.55	2087.31	979.306847	.002	L L	*	3.486	644.143	-174.916	979.888820	65.656	-109.261
341	83 2 4	-3640.69	-7034.46	2092.21	979.306458	0.000	L L	*	3.435	645.657	-175.328	979.889136	66.414	-108.913
342	83 2 4	-3641.16	-7034.42	2045.36	979.319472	.004	L L	*	3.634	631.199	-171.401	979.889813	64.492	-106.909
343	83 2 4	-3641.19	-7033.88	2065.06	979.314342	0.000	L L	*	3.765	637.276	-173.052	979.889856	65.527	-107.525
344	83 2 7	-3639.13	-7035.43	1707.77	979.381861	.051	L L	*	7.162	527.018	-143.111	979.886891	29.149	-113.962
345	83 2 7	-3639.16	-7034.99	1862.40	979.351576	.009	L L	*	5.251	574.737	-156.069	979.886934	44.630	-111.440
346	83 2 5	-3639.65	-7035.00	1886.41	979.346517	.005	L L	*	5.765	582.147	-158.081	979.887639	46.789	-111.292
347	83 2 4	-3639.91	-7034.84	2088.20	979.302685	0.000	L L	*	5.717	644.419	-174.991	979.888014	64.807	-110.184
348	83 2 4	-3640.32	-7035.13	2049.57	979.312657	0.000	L L	*	4.104	632.497	-171.754	979.888604	60.655	-111.099
349	83 2 9	-3640.83	-7034.86	2070.93	979.312812	.002	L L	*	3.538	639.087	-173.544	979.889338	66.100	-107.444
350	83 2 9	-3641.07	-7035.06	2016.79	979.324133	.009	L L	*	3.620	622.381	-169.007	979.889684	60.451	-108.556
351	83 2 4	-3641.41	-7034.40	2028.32	979.323168	.003	L L	*	4.470	625.938	-169.973	979.890173	63.403	-106.570
352	83 2 5	-3639.20	-7033.38	2013.75	979.310390	.099	L L	*	10.995	621.442	-168.752	979.886992	55.834	-112.917
353	83 2 7	-3638.97	-7036.05	1664.95	979.392222	.007	L L	*	5.431	513.803	-139.523	979.886661	24.796	-114.727
354	83 2 7	-3639.31	-7036.00	1730.52	979.379642	.007	L L	*	4.401	534.037	-145.017	979.887150	30.931	-114.087
355	83 2 5	-3639.69	-7035.68	1818.87	979.362474	.017	L L	*	4.347	561.303	-152.421	979.887697	40.428	-111.994
356	83 2 4	-3640.24	-7035.43	1978.84	979.327866	.005	L L	*	4.171	610.670	-165.827	979.888489	54.218	-111.609
357	83 2 9	-3640.89	-7035.33	2022.37	979.322584	0.000	L L	*	3.703	624.104	-169.475	979.889424	60.967	-108.507
358	83 2 5	-3639.78	-7036.18	1811.97	979.364196	.012	L L	*	4.211	559.173	-151.843	979.887826	39.754	-112.089

83(YEAR) ***** THE LIST OF GRAVITY SURVEY ***** DOMUYO AREA DENSITY = 2.00 (G/CM**3)

ST.NO	OBS.DAY	LAT.	LONG.	LEVEL	ABS.G	C.20M	ETC	*	TERR.C	F.E.C	B.G.C	NORM.G	ANOM.F	ANOM.B
359	83 2 5	-3640.20	-7036.41	1776.25	979.373449	.006	L L	*	4.632	548.151	-148.850	979.888431	37.802	-111.048
360	83 2 4	-3640.34	-7035.75	1916.95	979.342055	.055	L L	*	4.407	591.571	-160.640	979.888633	49.400	-111.241
361	83 2 9	-3640.97	-7035.76	1987.04	979.326915	.004	L L	*	4.021	613.201	-166.514	979.889540	54.597	-111.917
362	83 2 9	-3641.10	-7036.12	1939.72	979.337759	.009	L L	*	4.482	598.599	-162.549	979.889727	51.113	-111.436
363	83 2 5	-3639.82	-7036.56	1697.07	979.389394	.011	L L	*	4.861	523.715	-142.214	979.887884	30.087	-112.128
364	83 2 5	-3640.69	-7036.42	1807.00	979.366352	.022	L L	*	4.610	557.640	-151.427	979.889136	39.465	-111.961
365	83 2 9	-3641.11	-7036.68	1762.55	979.377448	.006	L L	*	3.758	543.923	-147.702	979.889741	35.387	-112.315
366	83 2 9	-3641.44	-7036.25	1908.58	979.347893	.002	L L	*	4.433	588.989	-159.939	979.890216	51.099	-108.840
367	83 2 3	-3639.01	-7032.03	2416.82	979.223161	.006	L L	*	9.135	745.829	-202.529	979.886718	91.408	-111.121
368	83 2 7	-3638.96	-7034.40	2081.89	979.303403	.018	L L	*	6.399	642.470	-174.462	979.886646	65.625	-108.837
369	83 2 5	-3639.10	-7033.07	2049.17	979.301973	.225	L L	*	10.476	632.374	-171.720	979.886848	57.976	-113.745
370	83 213	-3637.70	-7034.77	1948.54	979.329984	.009	L L	*	5.045	601.319	-163.288	979.884833	51.516	-111.772
371	83 213	-3637.64	-7035.29	1873.63	979.347265	.026	L L	*	4.649	578.202	-157.010	979.884747	45.369	-111.641
372	83 213	-3638.07	-7036.77	1706.69	979.384032	.007	L L	*	3.637	526.684	-143.021	979.885365	28.988	-114.033
373	83 213	-3637.79	-7036.40	1691.16	979.386338	.045	L L	*	4.278	521.891	-141.719	979.884962	27.544	-114.175
374	83 213	-3637.52	-7036.09	1740.21	979.374410	.060	L L	*	4.177	537.027	-145.829	979.884574	31.040	-114.789
375	83 213	-3641.72	-7037.06	1775.58	979.375386	.002	L L	*	4.310	547.943	-148.793	979.890619	37.019	-111.774
376	83 213	-3641.91	-7037.59	1732.88	979.382488	.056	L L	*	7.546	534.767	-145.215	979.890893	33.908	-111.307
501	83 124	-3641.25	-7030.21	2449.75	979.216373	.008	L L	*	8.345	755.993	-205.289	979.889943	90.769	-114.520
502	83 124	-3641.51	-7029.84	2671.00	979.169265	.062	L L	*	8.566	824.271	-223.830	979.890317	111.784	-112.045
503	83 124	-3641.80	-7029.47	2843.00	979.134884	.040	L L	*	6.549	877.350	-238.243	979.890735	128.048	-110.196
504	83 124	-3641.96	-7029.91	2886.00	979.127916	.011	L L	*	8.263	890.620	-241.847	979.890965	135.834	-106.013
505	83 124	-3641.85	-7030.33	2864.00	979.132486	.002	L L	*	8.470	883.830	-240.003	979.890807	133.980	-106.023
506	83 124	-3641.83	-7030.79	2889.00	979.128419	.101	L L	*	11.143	891.545	-242.098	979.890778	140.330	-101.768
507	83 124	-3641.56	-7031.02	2813.00	979.138381	.020	L L	*	11.594	868.092	-235.729	979.890389	127.678	-108.051
508	83 124	-3641.49	-7031.38	2767.00	979.150415	.025	L L	*	10.969	853.896	-231.875	979.890288	124.992	-106.882
509	83 124	-3641.82	-7031.58	2768.00	979.150506	.025	L L	*	12.059	854.205	-231.958	979.890763	126.007	-105.952
510	83 124	-3642.08	-7031.20	2835.00	979.140426	.002	L L	*	10.799	874.881	-237.573	979.891138	134.968	-102.605
511	83 124	-3642.12	-7031.68	2523.00	979.211036	.094	L L	*	8.492	778.598	-211.427	979.891195	106.931	-104.496
512	83 124	-3642.31	-7032.08	2275.00	979.274351	.002	L L	*	6.031	702.065	-190.645	979.891469	90.978	-99.667
513	83 131	-3641.37	-7032.46	2077.49	979.304857	.088	L L	*	9.510	641.114	-174.094	979.890115	65.366	-108.728
514	83 131	-3641.26	-7031.94	2133.11	979.286213	.111	L L	*	13.079	658.277	-178.755	979.889957	67.612	-111.142
515	83 131	-3641.06	-7031.55	2240.36	979.263556	.065	L L	*	10.173	691.376	-187.743	979.889669	75.436	-112.307
516	83 131	-3641.13	-7031.11	2340.28	979.242843	.014	L L	*	8.174	722.211	-196.116	979.889770	83.457	-112.658
517	83 131	-3641.21	-7030.70	2426.31	979.224678	.003	L L	*	6.660	748.760	-203.325	979.889885	90.213	-113.112
518	83 131	-3640.93	-7029.77	2494.56	979.198352	.024	L L	*	10.722	769.820	-209.044	979.889482	89.412	-119.632
519	83 131	-3640.80	-7030.29	2466.00	979.211039	.005	L L	*	8.407	761.008	-206.651	979.889295	91.158	-115.492
520	83 131	-3640.42	-7030.16	2602.00	979.178105	.034	L L	*	8.004	802.977	-218.048	979.888748	100.339	-117.709
521	83 131	-3640.09	-7030.00	2740.00	979.143944	.023	L L	*	9.058	845.564	-229.612	979.888273	110.294	-119.318
522	83 131	-3640.53	-7030.59	2591.00	979.182845	.024	L L	*	6.812	799.583	-217.126	979.888906	100.333	-116.792
523	83 131	-3640.56	-7031.00	2637.00	979.176772	.023	L L	*	6.738	813.778	-220.981	979.888949	108.339	-112.642
524	83 131	-3640.69	-7031.34	2531.00	979.200784	.090	L L	*	7.602	781.067	-212.098	979.889136	100.317	-111.781
525	83 131	-3640.81	-7031.69	2449.92	979.219259	.035	L L	*	6.434	756.046	-205.303	979.889309	92.430	-112.873
526	83 131	-3640.97	-7032.11	2430.10	979.225311	.015	L L	*	6.806	749.929	-203.642	979.889540	92.506	-111.136
527	83 2 1	-3639.01	-7032.36	2309.82	979.246419	.016	L L	*	8.963	712.811	-193.563	979.886718	81.476	-112.087
528	83 2 1	-3638.72	-7032.10	2349.01	979.234296	.005	L L	*	9.194	724.903	-196.847	979.886301	82.093	-114.754
529	83 2 1	-3638.41	-7031.95	2350.88	979.230044	.094	L L	*	10.930	725.482	-197.004	979.885855	80.601	-116.403
530	83 2 1	-3638.10	-7031.77	2274.56	979.238796	.025	L L	*	14.004	701.930	-190.608	979.885408	69.321	-121.287
531	83 2 1	-3637.81	-7031.63	2362.00	979.219635	.059	L L	*	12.514	728.913	-197.936	979.884991	76.071	-121.865
532	83 2 1	-3637.55	-7031.30	2542.00	979.179944	.013	L L	*	8.106	784.461	-213.020	979.884617	87.894	-125.126

83(YEAR) ***** THE LIST OF GRAVITY SURVEY ***** DOMUYO AREA DENSITY = 2.00 (G/CM**3)

ST.NO	OBS.DAY	LAT.	LONG.	LEVEL	ABS.G	C.20M	ETC	*	TERR.C	F.E.C	B.G.C	NORM.G	ANOM.F	ANOM.B
533	83 2 1	-3637.40	-7030.83	2724.00	979.141218	.011	L L	*	8.383	840.626	-228.271	979.884401	105.826	-122.445
534	83 2 1	-3637.39	-7030.43	2868.00	979.107894	.021	L L	*	10.210	885.065	-240.338	979.884387	118.782	-121.556
535	83 2 1	-3637.72	-7030.65	2790.00	979.127107	.023	L L	*	8.532	860.994	-233.802	979.884862	111.772	-122.030
536	83 2 1	-3637.86	-7031.03	2690.00	979.150594	.009	L L	*	8.775	830.134	-225.422	979.885063	104.440	-120.982
537	83 2 1	-3638.02	-7031.37	2508.00	979.190445	.004	L L	*	7.919	773.969	-210.170	979.885293	87.040	-123.131
538	83 2 2	-3636.47	-7032.21	2435.13	979.209344	.003	L L	*	6.570	751.482	-204.064	979.883063	84.333	-119.731
539	83 2 2	-3636.45	-7032.69	2280.71	979.244635	.053	L L	*	7.762	703.828	-191.124	979.883034	73.190	-117.933
540	83 2 2	-3636.64	-7033.11	2186.47	979.269123	.005	L L	*	7.271	674.746	-183.226	979.883308	67.833	-115.394
541	83 2 2	-3636.71	-7033.46	2162.80	979.279041	.002	L L	*	6.495	667.439	-181.242	979.883408	69.566	-111.676
542	83 2 2	-3636.34	-7031.12	2714.00	979.143893	.051	L L	*	7.393	837.540	-227.433	979.882876	105.950	-121.483
543	83 2 2	-3636.39	-7030.64	2897.00	979.101569	.041	L L	*	9.952	894.014	-242.769	979.882948	122.587	-120.182
544	83 2 2	-3636.50	-7030.21	3039.00	979.068473	.033	L L	*	11.832	937.835	-254.668	979.883106	135.035	-119.633
545	83 2 2	-3636.42	-7029.69	3241.00	979.022027	.094	L L	*	14.435	1000.173	-271.596	979.882991	153.644	-117.952
546	83 2 2	-3636.84	-7030.14	2923.00	979.092684	.040	L L	*	9.776	902.038	-244.947	979.883596	120.902	-124.046
547	83 2 2	-3637.15	-7030.12	3005.00	979.075809	.007	L L	*	11.087	927.343	-251.819	979.884042	130.197	-121.622
548	83 2 2	-3636.96	-7030.54	2933.00	979.092636	.013	L L	*	11.072	905.124	-245.785	979.883768	125.064	-120.722
549	83 2 2	-3636.79	-7030.98	2794.00	979.125799	.042	L L	*	9.537	862.228	-234.137	979.883524	114.040	-120.097
550	83 2 2	-3637.12	-7031.04	2735.00	979.139418	.011	L L	*	8.256	844.021	-229.193	979.883998	107.696	-121.497
551	83 2 2	-3637.14	-7031.49	2499.00	979.189422	0.000	L L	*	8.239	771.191	-209.416	979.884027	84.825	-124.591
552	83 2 2	-3636.81	-7031.42	2509.00	979.185605	.016	L L	*	8.076	774.277	-210.254	979.883552	84.406	-125.848
553	83 2 2	-3636.47	-7031.68	2698.00	979.149091	.064	L L	*	9.053	832.603	-226.092	979.883063	107.683	-118.409
554	83 2 8	-3638.20	-7031.07	2631.00	979.163776	.086	L L	*	7.734	811.927	-220.478	979.885552	97.885	-122.593
555	83 2 8	-3638.07	-7030.65	2716.00	979.142559	.003	L L	*	7.563	838.158	-227.601	979.885365	102.915	-124.686
556	83 2 8	-3637.87	-7030.28	2849.00	979.110639	.022	L L	*	9.468	879.201	-238.746	979.885078	114.232	-124.515
557	83 2 8	-3637.76	-7029.74	3037.00	979.068128	.014	L L	*	11.759	937.218	-254.501	979.884919	132.185	-122.315
558	83 2 8	-3638.06	-7029.55	2883.00	979.099389	.052	L L	*	10.800	889.694	-241.595	979.885351	114.532	-127.063
559	83 2 8	-3638.33	-7029.84	2821.00	979.115638	.012	L L	*	8.773	870.561	-236.400	979.885739	109.231	-127.168
560	83 2 8	-3638.17	-7030.15	2830.00	979.116441	.017	L L	*	9.156	873.338	-237.154	979.885509	113.426	-123.728
561	83 2 8	-3638.41	-7030.26	2724.00	979.139679	.015	L L	*	7.696	840.626	-228.271	979.885855	102.146	-126.125
562	83 2 8	-3636.34	-7030.65	2700.00	979.148826	.002	L L	*	7.457	833.220	-226.260	979.885754	103.749	-122.511
563	83 2 8	-3638.31	-7031.61	2470.00	979.202945	.012	L L	*	8.995	762.242	-206.986	979.885711	88.471	-118.515
564	83 2 9	-3641.53	-7034.88	1871.00	979.357586	.006	L L	*	5.661	577.391	-156.790	979.890346	50.291	-106.499
565	83 210	-3637.82	-7034.18	2074.00	979.303045	.023	L L	*	6.116	640.036	-173.801	979.885006	64.192	-109.609
566	83 210	-3637.35	-7033.29	2329.00	979.239880	.002	L L	*	8.574	718.729	-195.170	979.884329	82.854	-112.316
567	83 210	-3636.94	-7034.34	2027.79	979.313149	.010	L L	*	5.817	625.776	-169.929	979.883739	61.002	-108.927
568	83 215	-3638.05	-7032.59	2761.00	979.139326	.044	L L	*	15.530	852.045	-231.372	979.885337	121.564	-109.808
569	83 215	-3637.71	-7032.55	2903.00	979.105502	.040	L L	*	17.754	895.866	-243.271	979.884847	134.274	-108.997
570	83 215	-3637.40	-7032.37	2999.00	979.080520	.003	L L	*	21.012	925.491	-251.316	979.884401	142.622	-108.694
571	83 215	-3637.12	-7032.20	2983.00	979.082805	.002	L L	*	21.035	920.554	-249.975	979.883998	140.395	-109.580
572	83 215	-3636.96	-7031.87	2918.00	979.094962	.229	L L	*	18.973	900.495	-244.528	979.883768	130.661	-113.867
573	83 215	-3638.34	-7032.81	2557.00	979.193656	.010	L L	*	11.406	789.090	-214.277	979.885754	106.399	-105.878
574	83 216	-3640.76	-7029.40	2584.00	979.175933	.069	L L	*	11.029	797.422	-216.539	979.889237	95.148	-121.392
575	83 216	-3640.89	-7028.89	2676.00	979.157291	.087	L L	*	9.780	825.814	-224.249	979.889424	103.460	-120.788
576	83 216	-3640.94	-7028.40	2755.00	979.141446	.044	L L	*	7.992	850.193	-230.869	979.889496	110.135	-120.734
577	83 216	-3640.56	-7028.89	2782.00	979.133767	.044	L L	*	9.062	858.525	-233.132	979.888949	112.405	-120.726
578	83 216	-3640.27	-7028.86	2976.00	979.091013	.011	L L	*	8.886	918.394	-249.389	979.888532	129.761	-119.627
579	83 216	-3640.06	-7028.95	3125.00	979.060326	.094	L L	*	10.412	964.375	-261.875	979.888229	146.884	-114.991
580	83 216	-3639.76	-7028.93	3379.00	978.999003	.134	L L	*	18.136	1042.759	-283.160	979.887798	172.101	-111.059
581	83 216	-3640.51	-7029.62	2709.00	979.149907	.023	L L	*	8.200	835.997	-227.014	979.888877	105.228	-121.786
582	83 216	-3640.63	-7029.90	2719.00	979.151619	.032	L L	*	6.998	839.083	-227.852	979.889050	108.651	-119.201

83(YEAR) ***** THE LIST OF GRAVITY SURVEY ***** DOMUYO AREA DENSITY = 2.00 (G/CM**3) PAGE= 7

ST.NO	OBS.DAY	LAT.	LONG.	LEVEL	ABS.G	C.20M	ETC	*	TERR.C	F.E.C	B.G.C	NORM.G	ANOM.F	ANOM.B
583	83 217	-3640.30	-7031.16	2845.00	979.123873	.045	L L	*	11.639	877.967	-238.411	979.888575	124.904	-113.507
584	83 217	-3640.07	-7030.78	3009.00	979.082774	.099	L L	*	14.157	928.577	-252.154	979.888244	137.264	-114.890
585	83 217	-3639.75	-7030.57	3169.00	979.043178	.080	L L	*	16.988	977.953	-265.562	979.887783	150.337	-115.225
586	83 217	-3639.43	-7030.53	3270.00	979.015484	.002	L L	*	19.299	1009.122	-274.026	979.887323	156.583	-117.443
587	83 217	-3639.39	-7030.15	3291.00	979.012217	.005	L L	*	19.613	1015.603	-275.786	979.887265	160.168	-115.018
588	83 217	-3639.51	-7029.71	3219.00	979.030745	.032	L L	*	14.873	993.383	-269.752	979.887438	151.563	-118.189
589	83 217	-3639.69	-7029.42	3342.00	979.000996	.009	L L	*	20.364	1031.341	-280.060	979.887697	165.004	-115.055
590	83 217	-3639.18	-7030.45	3349.00	976.989863	.075	L L	*	27.344	1033.501	-280.646	979.886963	163.746	-116.901
591	83 217	-3638.94	-7030.76	3080.00	979.053712	.171	L L	*	17.016	950.488	-258.104	979.886617	134.598	-123.506
592	83 217	-3639.36	-7030.99	3137.00	979.049812	.040	L L	*	17.194	968.078	-262.881	979.887222	147.862	-115.019
593	83 217	-3639.77	-7031.10	3026.00	979.081170	.009	L L	*	13.292	933.824	-253.579	979.887812	140.474	-113.105
594	83 217	-3640.04	-7031.43	2899.00	979.111375	.065	L L	*	12.846	894.631	-242.936	979.888201	130.654	-112.283
595	83 218	-3638.79	-7029.24	3122.00	979.049777	.035	L L	*	14.242	963.449	-261.624	979.886401	141.067	-120.557
596	83 218	-3638.48	-7029.38	2981.00	979.079929	.030	L L	*	11.649	919.937	-249.808	979.885955	125.560	-124.248
597	83 218	-3638.80	-7029.93	2792.00	979.121853	.081	L L	*	10.793	861.611	-233.970	979.886416	107.842	-126.128
598	83 218	-3639.15	-7029.82	2886.00	979.103931	.087	L L	*	11.265	890.620	-241.847	979.886920	118.897	-122.950

Table A-6

List of Bouguer anomalies for five densities

D = 2.20

D = 2.30

D = 2.40

D = 2.50

D = 2.67

ST.NO	D= 2.20	D= 2.30	D= 2.40	D= 2.50	D= 2.67	ST.NO	D= 2.20	D= 2.30	D= 2.40	D= 2.50	D= 2.67
1	-120.723	-127.874	-135.025	-142.175	-154.331	51	-128.659	-134.681	-140.703	-146.726	-156.963
2	-126.389	-133.480	-140.570	-147.661	-159.715	52	-125.857	-132.756	-139.655	-146.554	-158.263
3	-122.570	-129.980	-137.390	-144.801	-157.399	53	-125.457	-132.575	-139.693	-146.811	-158.911
4	-122.547	-130.084	-137.622	-145.160	-157.973	54	-125.927	-133.682	-141.438	-149.194	-162.378
5	-122.042	-129.783	-137.525	-145.267	-158.428	55	-128.358	-136.626	-144.894	-153.163	-167.219
6	-123.432	-131.406	-139.380	-147.354	-160.910	56	-126.580	-134.999	-143.418	-151.837	-166.149
7	-122.293	-130.050	-137.806	-145.563	-158.749	57	-128.291	-137.009	-145.727	-154.445	-169.266
8	-122.136	-130.456	-138.776	-147.095	-161.239	58	-127.760	-136.583	-145.405	-154.228	-169.226
9	-120.894	-129.621	-138.349	-147.076	-161.913	59	-129.412	-138.400	-147.388	-156.376	-171.656
10	-122.724	-132.254	-141.784	-151.314	-167.514	60	-128.304	-137.710	-147.115	-156.520	-172.509
11	-127.056	-135.782	-144.508	-153.234	-168.068	61	-130.699	-140.685	-150.671	-160.657	-177.633
12	-126.164	-132.624	-139.084	-145.544	-156.526	62	-128.438	-134.733	-141.028	-147.323	-158.025
13	-120.868	-128.047	-135.226	-142.404	-154.608	63	-127.074	-133.507	-139.939	-146.372	-157.308
14	-120.255	-127.665	-135.075	-142.486	-155.083	64	-126.959	-134.045	-141.130	-148.215	-160.260
15	-122.975	-130.669	-138.363	-146.058	-159.138	65	-126.973	-134.392	-141.811	-149.230	-161.842
16	-122.450	-130.318	-138.185	-146.052	-159.425	66	-126.261	-134.211	-142.161	-150.111	-163.625
17	-122.362	-130.420	-138.478	-146.536	-160.235	67	-127.566	-136.065	-144.564	-153.063	-167.511
18	-122.953	-131.124	-139.296	-147.467	-161.358	68	-127.714	-136.448	-145.182	-153.916	-168.764
19	-124.747	-133.095	-141.443	-149.791	-163.982	69	-127.005	-135.869	-144.733	-153.596	-168.665
20	-124.910	-133.349	-141.788	-150.227	-164.573	70	-126.372	-135.604	-144.836	-154.068	-169.762
21	-125.656	-134.274	-142.892	-151.510	-166.161	71	-126.837	-136.273	-145.709	-155.145	-171.186
22	-126.056	-134.647	-143.238	-151.828	-166.433	72	-132.121	-142.418	-152.715	-163.012	-180.517
23	-125.584	-134.351	-143.119	-151.886	-166.791	73	-129.008	-135.397	-141.786	-148.175	-159.037
24	-124.813	-133.687	-142.561	-151.435	-166.521	74	-127.747	-134.329	-140.911	-147.493	-158.683
25	-124.895	-131.495	-138.095	-144.695	-155.916	75	-126.690	-133.513	-140.336	-147.160	-158.759
26	-121.994	-129.010	-136.027	-143.043	-154.971	76	-125.718	-133.328	-140.938	-148.548	-161.485
27	-120.933	-128.240	-135.547	-142.853	-155.275	77	-126.547	-134.440	-142.333	-150.226	-163.644
28	-122.990	-130.461	-137.933	-145.404	-158.106	78	-126.634	-134.478	-142.321	-150.165	-163.500
29	-124.289	-132.047	-139.805	-147.563	-160.752	79	-127.144	-135.723	-144.303	-152.882	-167.467
30	-121.385	-129.285	-137.185	-145.086	-158.516	80	-127.308	-136.043	-144.778	-153.513	-168.362
31	-121.900	-130.111	-138.322	-146.533	-160.491	81	-125.973	-134.942	-143.912	-152.881	-168.128
32	-123.164	-131.580	-139.996	-148.411	-162.718	82	-127.798	-137.120	-146.443	-155.766	-171.615
33	-125.595	-134.132	-142.669	-151.206	-165.720	83	-127.177	-136.463	-145.748	-155.034	-170.820
34	-127.344	-136.044	-144.744	-153.444	-168.234	84	-129.789	-136.055	-142.320	-148.585	-159.236
35	-128.005	-137.198	-146.392	-155.585	-171.213	85	-127.558	-134.085	-140.612	-147.139	-158.234
36	-125.584	-131.962	-138.340	-144.718	-155.561	86	-126.755	-133.300	-139.845	-146.389	-157.515
37	-125.262	-132.122	-138.982	-145.842	-157.504	87	-127.668	-134.895	-142.123	-149.350	-161.637
38	-126.693	-133.831	-140.969	-148.107	-160.241	88	-127.885	-134.990	-142.096	-149.201	-161.281
39	-124.133	-131.606	-139.078	-146.551	-159.254	89	-126.340	-133.800	-141.261	-148.722	-161.405
40	-125.985	-133.954	-141.923	-149.892	-163.440	90	-130.040	-136.432	-142.823	-149.215	-160.081
41	-125.405	-133.596	-141.787	-149.978	-163.902	91	-129.984	-136.243	-142.502	-148.762	-159.403
42	-124.042	-132.418	-140.795	-149.171	-163.410	92	-128.789	-135.482	-142.175	-148.868	-160.246
43	-125.828	-134.478	-143.129	-151.779	-166.484	93	-127.189	-133.908	-140.628	-147.347	-158.771
44	-126.909	-135.669	-144.428	-153.187	-168.078	94	-128.724	-135.673	-142.622	-149.572	-161.365
45	-127.843	-136.665	-145.487	-154.309	-169.307	95	-127.750	-134.756	-141.763	-148.770	-160.681
46	-127.707	-136.847	-145.987	-155.127	-170.665	96	-127.254	-134.595	-141.936	-149.277	-161.757
47	-129.273	-138.713	-148.152	-157.592	-173.638	97	-126.872	-134.909	-142.947	-150.985	-164.648
48	-130.930	-140.905	-150.879	-160.854	-177.810	98	-126.735	-135.490	-144.245	-153.000	-167.884
49	-125.644	-131.978	-138.312	-144.645	-155.413	99	-125.778	-134.749	-143.720	-152.691	-167.942
50	-125.694	-132.157	-138.620	-145.084	-156.071	100	-127.554	-137.280	-147.005	-156.731	-173.265

83(YEAR) ***** THE LIST OF BOUGUER ANOMALY ***** DOMUYO AREA FOR FIVE DENSITIES

ST.NO	D= 2.20	D= 2.30	D= 2.40	D= 2.50	D= 2.67	ST.NO	D= 2.20	D= 2.30	D= 2.40	D= 2.50	D= 2.67
101	-130.340	-136.955	-143.569	-150.184	-161.428	309	-130.195	-140.079	-149.963	-159.848	-176.651
102	-130.925	-137.020	-143.115	-149.210	-159.571	310	-131.543	-141.662	-151.781	-161.900	-179.101
103	-129.972	-136.475	-142.979	-149.483	-160.539	311	-125.376	-135.217	-145.059	-154.901	-171.631
104	-127.472	-134.254	-141.036	-147.818	-159.348	312	-124.474	-133.846	-143.218	-152.591	-168.523
105	-127.923	-134.803	-141.683	-148.564	-160.260	313	-127.489	-136.637	-145.786	-154.934	-170.487
106	-127.561	-134.709	-141.858	-149.007	-161.159	314	-127.244	-136.641	-146.039	-155.436	-171.412
107	-127.478	-134.870	-142.262	-149.654	-162.221	315	-128.319	-137.702	-147.086	-156.469	-172.422
108	-127.933	-135.860	-143.788	-151.715	-165.192	316	-127.060	-136.124	-145.188	-154.252	-169.660
109	-125.861	-134.553	-143.245	-151.938	-166.714	317	-124.771	-133.554	-142.337	-151.121	-166.052
110	-124.347	-133.615	-142.883	-152.151	-167.907	318	-125.650	-134.575	-143.500	-152.424	-167.596
111	-126.178	-136.019	-145.861	-155.703	-172.434	319	-128.235	-135.980	-143.725	-151.470	-164.637
112	-131.497	-138.415	-145.333	-152.251	-164.011	320	-126.029	-134.984	-143.939	-152.894	-168.118
113	-130.806	-137.010	-143.214	-149.418	-159.966	321	-126.963	-136.124	-145.285	-154.446	-170.020
114	-129.970	-136.854	-143.739	-150.623	-162.327	322	-128.004	-136.921	-145.839	-154.756	-169.916
115	-128.398	-135.383	-142.369	-149.355	-161.230	323	-127.924	-136.911	-145.898	-154.885	-170.163
116	-127.064	-134.210	-141.357	-148.503	-160.651	324	-126.562	-135.189	-143.816	-152.442	-167.108
117	-127.259	-134.417	-141.575	-148.733	-160.902	325	-126.658	-135.332	-144.006	-152.680	-167.426
118	-127.140	-134.729	-142.318	-149.908	-162.810	326	-123.860	-132.623	-141.386	-150.149	-165.047
119	-127.499	-135.187	-142.874	-150.561	-163.630	327	-125.418	-134.189	-142.961	-151.733	-166.645
120	-126.681	-134.926	-143.171	-151.416	-165.433	328	-125.959	-133.763	-141.567	-149.370	-162.637
121	-124.912	-133.937	-142.961	-151.985	-167.327	329	-127.331	-136.125	-144.919	-153.713	-166.663
122	-127.262	-136.600	-145.937	-155.275	-171.148	330	-128.097	-136.929	-145.761	-154.593	-169.608
123	-129.912	-136.552	-143.192	-149.832	-161.120	331	-126.974	-135.786	-144.599	-153.411	-168.392
124	-129.800	-136.659	-143.517	-150.376	-162.035	332	-125.582	-134.142	-142.702	-151.262	-165.814
125	-129.598	-136.674	-143.749	-150.825	-162.854	333	-126.040	-134.485	-142.929	-151.374	-165.730
126	-128.117	-135.243	-142.369	-149.495	-161.610	334	-126.974	-134.902	-142.831	-150.759	-164.237
127	-126.034	-133.516	-140.997	-148.479	-161.197	335	-127.074	-135.105	-143.135	-151.165	-164.817
128	-127.440	-134.904	-142.368	-149.832	-162.521	336	-124.938	-132.593	-140.249	-147.904	-160.918
129	-125.968	-134.012	-142.056	-150.100	-163.775	337	-126.078	-133.549	-141.019	-148.489	-161.188
130	-126.768	-134.976	-143.183	-151.390	-165.343	338	-125.951	-134.470	-142.989	-151.508	-165.990
131	-126.111	-134.723	-143.335	-151.947	-166.587	339	-127.509	-136.081	-144.652	-153.223	-167.795
132	-128.807	-135.485	-142.163	-148.841	-160.194	340	-126.404	-134.975	-143.547	-152.118	-166.690
133	-129.591	-136.514	-143.437	-150.360	-162.129	341	-126.103	-134.697	-143.292	-151.886	-166.497
134	-128.564	-135.818	-143.073	-150.327	-162.660	342	-123.686	-132.074	-140.463	-148.851	-163.111
135	-128.303	-135.694	-143.084	-150.475	-163.039	343	-124.454	-132.918	-141.383	-149.847	-164.236
136	-128.243	-135.524	-142.805	-150.086	-162.463	344	-127.557	-134.354	-141.152	-147.949	-159.505
137	-128.507	-135.745	-142.983	-150.221	-162.526	345	-126.522	-134.062	-141.603	-149.144	-161.964
138	-127.782	-135.338	-142.895	-150.451	-163.297	346	-126.524	-134.139	-141.755	-149.371	-162.318
139	-125.055	-133.344	-141.632	-149.920	-164.010	347	-127.112	-135.576	-144.039	-152.503	-166.892
140	-127.241	-136.135	-145.030	-153.924	-169.044	348	-127.864	-136.247	-144.629	-153.012	-167.262
141	-129.623	-138.932	-148.241	-157.550	-173.375	349	-124.444	-132.944	-141.445	-149.945	-164.395
142	-129.133	-136.069	-143.006	-149.942	-161.734	350	-125.095	-133.365	-141.634	-149.903	-163.961
301	-135.887	-145.797	-155.708	-165.618	-182.466	351	-123.120	-131.395	-139.670	-147.945	-162.013
302	-133.359	-143.450	-153.542	-163.633	-180.788	352	-128.693	-136.581	-144.469	-152.357	-165.766
303	-132.133	-142.712	-153.291	-163.870	-181.854	353	-128.136	-134.840	-141.545	-148.249	-159.647
304	-133.485	-143.993	-154.501	-165.010	-182.874	354	-128.148	-135.179	-142.210	-149.241	-161.193
305	-133.465	-144.008	-154.551	-165.094	-183.017	355	-126.801	-134.205	-141.608	-149.012	-161.598
306	-133.081	-143.586	-154.091	-164.596	-182.455	356	-127.775	-135.858	-143.940	-152.023	-165.764
307	-129.281	-139.126	-148.972	-158.818	-175.556	357	-125.084	-133.373	-141.662	-149.950	-164.041
308	-129.405	-139.370	-149.334	-159.299	-176.239	358	-126.852	-134.234	-141.615	-148.997	-161.546

ST.NO	D= 2.20	D= 2.30	D= 2.40	D= 2.50	D= 2.67	ST.NO	D= 2.20	D= 2.30	D= 2.40	D= 2.50	D= 2.67
359	-125.470	-132.681	-139.892	-147.103	-159.361	533	-144.434	-155.428	-166.423	-177.417	-196.108
360	-126.864	-134.676	-142.487	-150.299	-163.579	534	-144.569	-156.076	-167.582	-179.089	-196.649
361	-128.166	-136.291	-144.416	-152.540	-166.352	535	-144.557	-155.821	-167.084	-178.348	-197.496
362	-127.243	-135.146	-143.049	-150.953	-164.388	536	-142.647	-153.479	-164.311	-175.144	-193.559
363	-125.863	-132.730	-139.598	-146.466	-158.141	537	-143.356	-153.468	-163.581	-173.693	-190.885
364	-126.643	-133.984	-141.324	-148.665	-161.145	538	-139.480	-149.355	-159.230	-169.105	-185.891
365	-126.709	-133.906	-141.103	-148.301	-160.536	539	-136.269	-145.438	-154.606	-163.774	-179.359
366	-124.391	-132.166	-139.941	-147.717	-160.935	540	-132.989	-141.787	-150.585	-159.383	-174.339
367	-130.461	-140.130	-149.800	-159.470	-175.908	541	-129.151	-137.889	-146.626	-155.363	-170.217
368	-125.643	-134.046	-142.449	-150.853	-165.138	542	-143.487	-154.489	-165.492	-176.494	-195.197
369	-129.869	-137.931	-145.994	-154.056	-167.761	543	-143.463	-155.104	-166.745	-178.386	-198.175
370	-127.596	-135.508	-143.420	-151.333	-164.783	544	-143.917	-156.059	-168.201	-180.342	-200.984
371	-126.877	-134.495	-142.113	-149.731	-162.682	545	-143.668	-156.526	-169.384	-182.242	-204.101
372	-127.971	-134.941	-141.910	-148.879	-160.727	546	-147.563	-159.321	-171.080	-182.838	-202.828
373	-127.919	-134.791	-141.663	-148.536	-160.218	547	-145.695	-157.731	-169.768	-181.805	-202.267
374	-126.954	-136.037	-143.119	-150.202	-162.242	548	-144.193	-155.929	-167.665	-179.400	-199.351
375	-126.222	-133.446	-140.671	-147.895	-160.176	549	-142.557	-153.787	-165.017	-176.247	-195.338
376	-125.074	-131.958	-138.841	-145.725	-157.427	550	-143.591	-154.638	-165.685	-176.731	-195.511
501	-134.215	-144.062	-153.909	-163.756	-180.497	551	-144.709	-154.768	-164.827	-174.886	-191.986
502	-133.572	-144.335	-155.098	-165.861	-184.159	552	-146.066	-156.175	-166.284	-176.393	-193.578
503	-133.365	-144.950	-156.534	-168.119	-187.813	553	-140.113	-150.965	-161.817	-172.669	-191.118
504	-129.371	-141.050	-152.729	-164.408	-184.263	554	-143.868	-154.505	-165.142	-175.779	-193.862
505	-129.176	-140.753	-152.330	-163.906	-183.587	555	-146.690	-157.692	-168.694	-179.696	-198.399
506	-124.864	-136.412	-147.959	-159.507	-179.138	556	-147.442	-158.906	-170.370	-181.834	-201.323
507	-130.465	-141.672	-152.878	-164.085	-183.137	557	-146.590	-158.727	-170.864	-183.001	-203.634
508	-128.973	-140.018	-151.063	-162.109	-180.886	558	-150.143	-161.682	-173.222	-184.762	-204.379
509	-127.942	-138.937	-149.932	-160.927	-179.618	559	-149.931	-161.312	-172.694	-184.075	-203.423
510	-125.283	-136.621	-147.960	-159.299	-178.574	560	-146.528	-157.928	-169.327	-180.727	-200.107
511	-124.790	-134.937	-145.084	-155.230	-172.480	561	-148.182	-159.211	-170.240	-181.269	-200.017
512	-118.128	-127.359	-136.589	-145.820	-161.512	562	-144.391	-155.331	-166.271	-177.211	-195.810
513	-125.187	-133.416	-141.645	-149.874	-163.864	563	-138.314	-148.214	-158.113	-168.013	-184.842
514	-127.710	-135.994	-144.277	-152.561	-166.644	564	-121.612	-129.168	-136.724	-144.281	-157.127
515	-130.064	-138.942	-147.821	-156.699	-171.793	565	-126.377	-134.762	-143.146	-151.530	-165.783
516	-131.452	-140.849	-150.247	-159.644	-175.619	566	-130.976	-140.306	-149.636	-158.966	-174.826
517	-132.779	-142.612	-152.445	-162.279	-178.995	567	-125.338	-133.544	-141.749	-149.955	-163.904
518	-139.464	-149.380	-159.296	-169.212	-186.070	568	-131.392	-142.184	-152.976	-163.769	-182.115
519	-135.317	-145.229	-155.141	-165.053	-181.904	569	-131.549	-142.825	-154.100	-165.376	-184.545
520	-138.713	-149.215	-159.717	-170.220	-188.073	570	-131.725	-143.240	-154.755	-166.270	-185.846
521	-141.374	-152.401	-163.429	-174.457	-193.204	571	-132.474	-143.921	-155.368	-166.815	-186.275
522	-137.824	-148.340	-158.855	-169.371	-187.248	572	-136.423	-147.700	-158.978	-170.256	-189.426
523	-134.066	-144.778	-155.491	-166.203	-184.413	573	-126.165	-136.309	-146.452	-156.596	-173.840
524	-132.231	-142.455	-152.680	-162.905	-180.287	574	-141.943	-152.218	-162.494	-172.769	-190.237
525	-132.760	-142.704	-152.647	-162.591	-179.495	575	-142.235	-152.959	-163.682	-174.406	-192.635
526	-130.820	-140.662	-150.504	-160.346	-177.077	576	-143.021	-154.165	-165.309	-176.453	-195.397
527	-130.547	-139.777	-149.007	-158.237	-173.928	577	-143.133	-154.337	-165.540	-176.744	-195.790
528	-133.519	-142.902	-152.284	-161.667	-177.617	578	-143.678	-155.703	-167.728	-179.753	-200.196
529	-135.010	-144.314	-153.618	-162.922	-178.738	579	-140.137	-152.711	-165.284	-177.857	-199.231
530	-138.947	-147.778	-156.608	-165.438	-180.450	580	-137.562	-150.813	-164.064	-177.316	-199.843
531	-140.407	-149.678	-158.949	-168.220	-183.981	581	-143.668	-154.609	-165.549	-176.490	-195.089
532	-145.617	-155.863	-166.108	-176.354	-193.772	582	-141.287	-152.329	-163.372	-174.415	-193.187

ST.NO	D= 2.20	D= 2.30	D= 2.40	D= 2.50	D= 2.67	ST.NO	D= 2.20	D= 2.30	D= 2.40	D= 2.50	D= 2.67
583	-136.184	-147.523	-158.861	-170.200	-189.476						
584	-138.690	-150.589	-162.489	-174.389	-194.619						
585	-140.083	-152.512	-164.940	-177.369	-198.498						
586	-142.916	-155.652	-168.389	-181.125	-202.777						
587	-141.235	-154.044	-166.852	-179.661	-201.435						
588	-143.677	-156.421	-169.165	-181.908	-203.573						
589	-141.025	-154.010	-166.995	-179.979	-202.053						
590	-142.231	-154.896	-167.561	-180.226	-201.757						
591	-147.614	-159.669	-171.723	-183.777	-204.270						
592	-139.587	-151.872	-164.156	-176.440	-197.324						
593	-137.134	-149.148	-161.162	-173.177	-193.601						
594	-135.291	-146.796	-158.300	-169.805	-189.362						
595	-145.295	-157.664	-170.033	-182.402	-203.430						
596	-148.064	-159.972	-171.880	-183.788	-204.031						
597	-148.446	-159.605	-170.763	-181.922	-200.892						
598	-146.008	-157.537	-169.066	-180.595	-200.195						

Table A-7(1) Results of X-ray diffractive analysis

No.	Sample No.	Rock Name, etc. / Constituent Minerals	m	mix	ch	se	k	ha	al	cli	heu	gy	anh	ca	ara	cr	tr	q	kf	pl	op	py	etc.	Remarks
1	XS-1	Dacite	•				∘							∘				◎	∘	∘		∘		
2	XS-2	"	∘															◎	•	•				
3	XS-3	"	∘					∘						∘		•	∘		•	○				EG, H
4	XS-4	"	∘				∘									○				○				
5	XS-5	"	•															∘		◎				
6	XS-7	"														•	•			◎				
7	XS-8	"														•	∘			◎				
8	XS-9	"	∘				•									○	∘		•	∘				EG
9	XS-10	"	∘				∘											◎	○					
10	XS-11	"					∘									○	•			○				
11	XS-12	"					◎																Fe? •	high BG
12	XS-13	"	•		∘		•												○	•				high BG, HCl, EG
13	XS-14	"					•							∘		•				◎			Fe ∘	high BG, HCl, H
14	XS-15	"					∘									○			∘	◎				
15	XS-16	"					∘							∘		○				○				
16	XS-17	"	∘											•		○				○				EG
17	XS-18	"					∘									•	•	•		○				
18	XS-19	"		∘*												○	∘	∘		○				*EG d=13.18Å→{10.7Å, 9.82Å}
19	XS-20	"	○																•	•		∘	Fe •	high BG, EG
20	XS-21	"	◎																				Fe •	high BG
21	XS-22	"	∘													•				◎		∘		EG
22	XS-23	"		•**						•										◎				**EG d=13.6Å→{17.3Å, 12.1Å}
23	XS-24	"	∘	?			∘							∘		○	∘	∘	∘	○		∘		EG
24	XS-25	"						•								•		∘	○	○				H
25	XS-26	"	∘				•									○			•	•				HCl, EG
26	XS-27	Tuff breccia																◎		•				
27	XS-28	Lithic tuff	∘				○											○		∘				high BG
28	XS-29	Travertine												◎				•						
29	XS-30	Tuff breccia				∘												◎		•				
30	XS-31	?												•				○	○	∘				
31	XS-32	Travertine												◎				∘						
32	XS-33						∘?							∘				◎						
33	XS-34							∘								•	∘	○	•	•				H
34	XS-35					∘												◎	•	∘				

Table A-7(2) Results of X-ray diffractive analysis

No.	Sample No.	Rock Name, etc. \ Constituent Minerals	m	mix	ch	se	k	ha	al	cli	heu	gy	anh	ca	ara	cr	tr	q	kf	pl	op	py	etc.	Remarks
35	XS-36	Tuff					∘							∘				◎		•				
36	XS-37	Tuff breccia								◎										•				
37	XS-38	Tuff	∘							○										○				
38	XS-39	Tuff breccia						∘						∘				◎		○				H
39	XS-40													∘		•				∘	◎			
40	XS-41		○			∘	•											•	∘	∘	•?			high BG
41	XS-42	Soil ?	∘													○		∘		○				
42	XS-44							∘								◎			•	•				H
43	XS-45	Perlite						∘								•				•	◎			H
44	XS-46													∘				∘			◎		rho? ∘	
45	XS-47	Travertine												◎		∘		∘	∘	∘				
46	XS-48	Dacite																○	○	•				
47	XS-49		∘				∘											○	∘	○				EG
48	XS-50	?				○	○											•						H
49	XS-51	?				∘	•											◎				∘		
50	XS-52	Andesite				∘	•											◎				∘		high BG
51	XS-53	Dacite	∘				∘											◎	•	•				
52	XS-54	"				∘	•											◎						
53	XS-55	"				∘	∘											◎						
54	XS-56	?				○	•											○						
55	XS-57	Soil	∘	∘		∘	∘											◎		•				
56	XS-58	?				∘	•											◎				∘		
57	XS-59	Andesite				∘	•											◎						
58	XS-60	Soil	•			•	•											○				∘		high BG
59	XS-61	?				∘	○											◎						H
60	XS-62	?				∘	∘											◎						H
61	XS-63	Tuff breccia					∘									○				○				
62	XS-64	"												∘				◎	∘	•				
63	XS-65	Dacite	∘							∘								•		◎				
64	XS-66				∘													•		◎		∘		high BG, HCl
65	XS-67		○											∘				•	•	•		∘		
66	XS-68									•						∘		•	•	○				
67	XS-69	Soil	•											•				◎		∘		∘		high BG
68	XS-70		∘							∘								○	∘	◎				

Table A-7(3) Results of X-ray diffractive analysis

No.	Sample No.	Rock Name,etc. \ Constituent Minerals	m	mix	ch	se	k	ha	al	cli	heu	gy	anh	ca	ara	cr	tr	q	kf	pl	op	py	etc.	Remarks
69	XS-71	Travertine												◎										
70	XS-72	"												◎										
71	XS-73																	○	•	•				
72	XS-74	Dacite												•				○	•	•				
73	XS-75	Travertine												◎				○						
74	XS-76	"												◎				∘						
75	XM-1	Soil	∘				∘											◎	∘			∘		high BG, HCl, EG
76	XM-2	"	∘				∘											◎	∘			∘		high BG, EG
77	XM-3	Altered rock	∘				•											◎		∘				high BG, EG
78	XM-4	Travertine							∘									•			◎			
79	XM-5	Altered rock					∘											◎	•					
80	XM-6	"																◎	•			∘		
81	XM-7	"		∘*			∘											◎	∘					*EG d=11.8Å→{12.6Å, 9.8Å}
82	XM-8	"	∘				•											◎	∘					HCl, EG
83	XM-9	"	∘				∘											◎		○		∘		EG
84	XM-10	"	∘				∘				∘ ?					•				∘	○			HCl
85	XM-11	"	∘								•					○*			•	○				*B-Cr ?
86	XM-12	"	•			∘					∘			∘		•		∘	•	•		∘		
87	XM-13	Travertine					∘							•		∘				∘	◎			
88	XM-14	Soil	•													•			○	•	•			high BG
89	XM-15	"	•				○									∘		∘	•	∘				high BG, EG
90	XM-16	Tuff ?	•							•						•				○	•			
91	XM-17	" ?								∘						•				◎				
92	XM-18																	•	?	◎				
93	XM-19	Travertine												◎										
94	XM-20	Altered rock				•*												◎		∘				*1M (polytype)
95	XM-21	"				∘	∘											○		○				
96	XM-22	"				∘	∘											○		○				
97	XM-24	"				∘	∘											◎		∘				
98	XM-25	"												∘		○		•		○				
99	XM-26	Andesite	∘											∘		•				◎				
100	XM-27	"	∘													○				○	•			
101	XM-28	Pumice tuff	∘							•						•				•	○			
102	XM-29	Granodiorite			∘	∘												○	•	•				

Table A-7(4) Results of X-ray diffractive analysis

No.	Sample No.	Rock Name, etc. \ Constituent Minerals	m	mix	ch	se	k	ha	al	cli	heu	gy	anh	ca	ara	cr	tr	q	kf	pl	op	py	etc.	Remarks
103	XM-30	Andesite	∘													•		•		○				
104	XM-31	"	∘					∘						∘		∘		○		○				H
105	XM-32	"	∘				∘							∘				○		○				EG
106	XM-33	"	∘															◎		○				
107	XM-34	"	∘															◎		○				
108	XM-35	Andesitic tuff breccia	•															○		○				high BG
109	XM-36	"	•															•		•	○			
110	XM-37-1	Dacitic tuff breccia				∘												◎	•	•				H
111	XM-37-2		○											•				○		∘				high BG
112	XM-38	Dacitic lapilli tuff				∘												◎	∘	•				high BG
113	XM-39	Andesitic coarse tuff												∘				◎	∘	•				
114	XM-40	?				∘												•		◎				H
115	XM-41											◎	•					∘		∘				
116	XF-1	Travertine												○		∘					○		rho •	
117	XF-2	"												○		•					◎		rho ∘	
118	XF-3	"														∘				∘	◎			
119	XF-4	"												•		∘		∘		•	○			
120	XF-5	"														•				∘	◎			
121	XF-6	"												○				∘		∘	○			
122	XF-7	"												○							○		rho ∘	
123	XF-8	"												○		∘				∘	○			
124	XF-9	"														∘				•	◎			
125	XF-10	"												○						∘	○			
126	XF-11	"												∘		∘				∘	◎			high BG
127	XF-12	"												◎						•		∘		
128	XF-13	"												◎										
129	XLB-1													○	○									
130	XLB-2						∘											◎						
131	XLB-3					∘	∘		∘									◎						H
132	XLB-4		•															◎		∘				high BG, H
133	F-11	Altered rock	∘											∘				○	•	•				H
134	F-12	"	∘															◎		○				
135	TM-76	Sandy tuff	∘		∘									•				•		•			ho ∘	
136	TM-78	?	∘			∘												○		○				

Table A-7(5) Results of X-ray diffractive analysis

No.	Sample No.	Rock Name, etc. \ Constituent Minerals	m	mix	ch	se	k	ha	al	cli	heu	gy	anh	ca	ara	cr	tr	q	kf	pl	op	py	etc.	Remarks
137	RP-1	Travertine												◎										
138	RP-2	"												◎										
139	RP-3	"												◎										
140	RP-4	"					∘ ?							◎						•				
141	RP-5	?	∘											•		∘		∘		◎				
142	RP-6	Travertine												◎						∘				
143	TM-13	Dacitic tuff breccia														○				○			bi ∘	microscopic obseration
144	TM-15	Dacite														○			∘	○			bi ∘	" "
145	TM-22	"														•	∘		∘	○				" "
146	TM-23	"														○	∘		∘	○			bi ∘	" "
147	TM-40	"														•	•		∘	○			ho ∘	" "
148	TM-50	"														○	•		•	○				" "
149	TM-84	"														○			○	○			bi ∘ ?	" "
150	TM-86	"														○				◎				" "

Table A-8 (1) Results of 1 meter depth survey

No.	Sample No.	T (°c)	CO_2 (%)	Hg (ppb)	Depth (m)	A (m)	Coordinates Y	X
1	A10	14.8	0.07	4.5	1.03	2085	21.62	1.25
2	A11	14.6	0.06	15.7	0.90	2140	23.61	1.35
3	A12	13.2	0.06	9.1	1.00	2170	26.45	1.84
4	A13	13.4	0.06	29.3	1.00	2245	27.84	0.91
5	A14	13.0	0.08	14.0	1.00	2325	29.80	0.48
6	A15	15.0	0.05	13.2	0.90	2465	33.34	1.62
7	A16	12.6	0.10	10.7	0.90	2415	35.18	1.49
8	A17	12.8	0.10	10.7	1.00	2445	36.61	1.57
9	A18	9.0	0.17	7.4	0.90	2480	38.69	1.37
10	B1	16.4	0.10	7.0	1.00	1795	1.00	3.43
11	B2	15.0	0.09	6.4	0.90	1815	2.53	4.06
12	B3	15.8	0.09	8.3	1.00	1835	4.96	4.10
13	B4	14.6	0.09	7.1	1.00	1925	7.55	4.04
14	B5	13.5	0.06	7.4	1.00	1935	9.30	4.07
15	B6	16.2	0.05	14.4	0.90	1985	12.72	3.96
16	B7	15.6	0.04	8.9	1.00	2025	14.40	3.37
17	B8	13.5	0.05	12.0	1.00	2060	16.75	3.10
18	B9	14.3	0.05	11.2	1.00	2105	18.90	3.43
19	B10	12.5	0.04	5.4	1.00	2160	20.79	4.01
20	B11	11.2	0.11	8.7	1.00	2070	23.88	3.08
21	B12	13.5	0.07	9.1	1.00	2170	25.86	2.30
22	B13	11.5	0.10	12.8	1.00	2210	27.71	3.12
23	B14	13.6	0.11	8.3	1.00	2280	29.67	3.38
24	B15	14.5	0.09	11.1	0.95	2380	33.36	3.93
25	B16	10.1	0.11	12.0	1.00	2335	34.62	3.61
26	B17	16.5	0.12	16.1	0.80	2365	35.96	3.24
27	B18	8.5	0.15	13.8	0.90	2590	39.34	3.29
28	D1	19.0	0.10	7.7	0.90	1615	0.07	7.68
29	D2	17.2	0.10	10.7	1.00	1780	3.36	7.38
30	D3	16.5	0.08	16.9	1.00	1825	5.12	7.47
31	D4	16.4	0.09	14.4	1.00	1875	7.23	7.69
32	D5	18.0	0.07	9.9	0.80	1975	9.86	7.60
33	D6	15.4	0.05	9.1	1.00	2005	12.13	7.87
34	D7	12.5	0.05	15.3	1.00	2020	14.27	7.31
35	D8	13.0	0.06	33.8	1.00	2070	16.74	7.55
36	D9	15.2	0.08	13.8	1.00	2130	18.85	7.48
37	D10	14.3	0.06	13.2	1.00	2160	20.75	6.69
38	D11	14.8	0.09	14.0	0.85	2165	23.96	8.49
39	D12	12.0	0.06	13.2	0.90	2150	25.69	7.80
40	D13	12.5	0.05	13.2	1.00	2180	27.79	7.13
41	D14	9.4	0.10	19.0	1.00	2220	30.28	7.18
42	D15	13.5	0.05	20.6	0.80	2290	32.24	7.91
43	D16	8.7	0.12	16.1	1.00	2290	34.71	7.79
44	D17	9.2	0.12	14.9	1.00	2325	36.58	8.13
45	D18	12.6	0.10	18.0	0.90	2435	38.89	8.25
46	D23	10.5	0.03	17.2	0.95	2595	49.51	8.41
47	D24	12.3	0.11	6.9	0.70	2590	52.61	8.20
48	C1	18.3	0.10	15.6	0.90	1740	1.24	6.01
49	C2	17.0	0.16	8.1	0.90	1780	2.71	5.21
50	C3	18.3	0.08	11.9	0.80	1865	5.35	5.41

T:Temperature, A:Altitude, Y:abiscissa, X:ordinate

Table A-8 (2) Results of 1 meter depth survey

No.	Sample No.	T (°c)	CO_2 (%)	Hg (ppb)	Depth (m)	A (m)	Coordinates Y	Coordinates X
51	C4	11.5	0.05	13.6	1.00	1870	7.97	5.74
52	C5	10.7	0.11	8.4	1.00	1900	10.18	5.81
53	C6	15.3	0.05	15.7	1.00	1965	12.10	5.88
54	C7	12.4	0.09	8.1	1.00	1975	14.41	5.10
55	C8	14.0	0.04	7.4	1.00	2070	16.73	4.97
56	C9	14.2	0.05	8.2	1.00	2100	18.88	5.03
57	C10	14.3	0.05	8.7	0.90	2155	21.04	5.48
58	C11	13.4	0.06	7.0	1.00	2180	23.23	5.22
59	C12	12.0	0.08	12.0	1.00	2240	25.86	5.21
60	C13	12.5	0.06	18.2	1.00	2235	27.83	4.88
61	C14	15.4	0.09	13.2	1.00	2235	30.22	5.99
62	C15	12.3	0.08	17.3	1.00	2260	32.58	6.04
63	C16	13.0	0.04	19.8	0.80	2305	34.13	5.45
64	C17	11.5	1.03	33.0	1.00	2340	36.75	5.45
65	C18	13.6	0.03	12.4	0.90	2490	38.24	5.09
66	E1	17.5	0.08	13.8	0.90	1650	-0.01	9.97
67	E2	16.3	0.08	19.0	1.00	1795	3.05	8.98
68	E3	16.8	0.08	31.5	1.00	1855	5.41	9.52
69	E4	14.6	0.11	14.3	1.00	1900	7.36	9.63
70	E5	19.7	0.05	12.8	0.50	1980	9.97	9.16
71	E6	16.5	0.08	20.6	1.00	2000	11.55	8.97
72	E7	15.3	0.06	19.0	1.00	2030	14.37	8.68
73	E8	13.7	0.08	16.0	1.00	2040	16.45	9.24
74	E9	14.4	0.06	5.0	0.90	2080	18.30	9.04
75	E10	16.0	0.06	12.8	0.60	2110	20.27	8.97
76	E11	14.9	0.10	31.4	0.80	2170	23.18	10.01
77	E12	16.2	0.04	26.4	0.50	2205	26.23	9.07
78	E13	15.5	0.09	26.8	0.80	2235	28.43	8.93
79	E14	15.2	0.07	20.2	0.90	2225	30.66	9.05
80	E15	10.5	0.22	3.2	1.00	2250	31.52	10.58
81	E16	10.5	0.08	6.3	1.00	2265	34.07	10.81
82	E17	15.2	0.08	14.0	0.80	2300	37.92	10.70
83	E18	17.0	0.04	18.6	0.80	2450	39.93	9.13
84	E20	14.2	0.07	11.7	1.00	2450	44.08	10.69
85	E21	9.0	0.12	4.1	1.00	2490	45.55	10.40
86	E22	13.1	0.10	4.5	1.00	2580	48.11	10.39
87	E22-1	12.5	0.05	25.4	0.50	2545	47.56	9.50
88	F23	13.0	0.11	13.5	1.00	2590	50.15	9.77
89	E24	10.5	0.07	11.5	0.90	2630	52.38	10.08
90	E27	14.5	0.06	27.8	0.60	2800	60.08	9.67
91	F2	18.0	0.09	11.7	0.90	1805	3.86	12.11
92	F3	16.0	0.14	7.5	0.90	1850	6.04	12.71
93	F4	14.5	0.14	10.4	1.00	1850	7.09	12.66
94	F5	14.0	0.16	5.8	1.00	1945	10.02	11.99
95	F6	14.5	0.07	6.9	1.00	2000	11.84	12.19
96	F7	15.5	0.14	25.9	0.95	2050	14.45	12.41
97	F8	13.6	0.10	9.5	1.00	2080	16.61	12.50
98	F10	17.6	0.07	19.0	0.50	2105	20.77	11.27
99	F11	13.3	0.18	16.6	0.75	2170	23.58	12.13
100	F12	14.5	0.06	12.5	0.55	2205	25.90	11.97

Table A-8 (3) Results of 1 meter depth survey

No.	Sample No.	T (°c)	CO_2 (%)	Hg (ppb)	Depth (m)	A (m)	Coordinates Y	X
101	F13	10.6	0.15	59.9	1.00	2230	28.18	11.93
102	F14	11.3	0.12	17.2	1.00	2255	30.20	11.82
103	F15	20.7	0.12	10.6	1.00	2280	32.09	12.34
104	F16	13.5	0.11	8.3	1.00	2395	34.67	12.96
105	F17	12.0	0.10	8.3	1.00	2345	36.05	11.18
106	F18	10.0	0.12	20.3	1.00	2430	39.57	11.30
107	F19	12.0	0.15	36.6	1.00	2430	41.41	11.93
108	F20	11.1	0.29	52.0	1.00	2425	43.90	12.04
109	F21	13.3	0.15	10.8	1.00	2530	46.12	11.23
110	F23	12.0	0.05	2.6	1.00	2660	49.47	12.42
111	F24	10.1	0.05	12.6	1.00	2780	52.88	12.28
112	F25	11.3	0.06	23.4	0.80	2715	55.25	11.87
113	F26	10.6	0.14	19.9	0.85	2770	56.87	11.79
114	F27	13.0	0.10	34.4	0.75	2780	58.46	11.24
115	G1	25.5	0.05	26.8	0.60	2580	2.87	13.88
116	G3	15.5	0.07	30.3	0.90	1820	5.64	14.05
117	G4	16.2	0.12	6.4	1.00	1820	7.59	14.93
118	G5	17.5	0.18	6.4	1.00	1840	9.30	14.56
119	G6	11.6	0.21	7.7	1.00	1980	12.13	14.13
120	G7	13.9	0.10	8.1	1.00	2060	14.45	14.50
121	G8	15.0	0.15	12.1	1.00	2080	16.37	14.52
122	G9	14.7	0.15	10.9	1.00	2125	18.71	14.58
123	G10	16.5	0.13	15.9	1.00	2170	20.74	14.52
124	G11	14.5	0.13	12.0	1.00	2240	22.94	14.56
125	G12	13.5	0.13	17.2	1.00	2265	26.08	14.80
126	G13	10.2	0.11	9.4	1.00	2260	27.96	14.23
127	G14	15.5	0.08	14.0	1.00	2325	29.28	15.22
128	G15	9.7	0.19	7.4	1.00	2340	31.95	14.87
129	G16	13.6	0.18	14.0	1.00	2370	34.17	14.31
130	G17	12.6	0.10	33.7	1.00	2360	36.33	13.77
131	G18	12.0	0.12	5.5	1.00	2495	38.61	14.14
132	G19	9.8	0.08	6.2	1.00	2575	40.95	13.62
133	G20	10.5	0.15	2.7	0.95	2630	42.92	14.28
134	G23	9.5	0.05	24.3	1.00	2750	50.10	14.25
135	G24	11.5	0.06	20.3	0.90	2740	52.68	13.97
136	H2	21.0	0.07	3.1	0.90	1630	3.83	16.03
137	H3	21.2	0.15	14.2	0.95	1580	5.40	16.24
138	H4	17.6	0.07	15.2	0.90	1810	8.42	16.10
139	H5	17.3	0.10	19.0	1.00	1840	10.13	16.33
140	H6	14.9	0.19	9.2	1.00	1840	11.76	16.28
141	H7	14.6	0.10	10.0	1.00	2045	14.27	16.53
142	H8	12.5	0.11	8.0	1.00	2080	16.46	16.66
143	H9	14.1	0.15	4.3	1.00	2125	19.22	16.60
144	H10	12.4	0.18	5.0	1.00	2150	20.91	16.43
145	H11	14.4	0.17	14.1	1.00	2230	23.35	16.06
146	H12	14.5	0.11	8.0	1.00	2260	25.58	16.03
147	H13	12.6	0.10	26.5	1.00	2280	27.82	16.51
148	H14	13.0	0.10	9.6	1.00	2320	30.18	16.32
149	H15	15.0	0.15	18.6	1.00	2355	32.45	16.74
150	H16	11.5	0.15	14.3	1.00	2390	34.35	16.58

Table A-8 (4) Results of 1 meter depth survey

No.	Sample No.	T (°c)	CO_2 (%)	Hg (ppb)	Depth (m)	A (m)	Coordinates Y	X
151	H17	7.5	0.43	7.2	0.90	2455	36.87	15.89
152	H18	7.7	0.05	2.5	0.90	2610	39.31	17.09
153	H19	10.3	0.05	10.3	0.90	2625	40.59	16.71
154	H20	12.7	0.05	14.9	0.70	2790	43.41	17.25
155	I2	21.6	0.04	7.7	0.70	1630	2.81	18.43
156	I3	21.2	0.05	14.4	0.85	1530	5.56	19.21
157	I4	19.6	0.07	15.8	0.90	1575	6.85	18.36
158	I5	15.7	0.12	25.7	1.00	1815	9.19	18.45
159	I6	16.5	0.30	6.3	1.00	1820	11.56	18.58
160	I7	15.0	0.20	8.6	1.00	2005	14.02	18.33
161	I8	13.0	0.19	8.6	1.00	2050	16.58	18.87
162	I9	14.5	0.15	15.9	1.00	2160	19.12	19.34
163	I10	15.6	0.12	20.8	1.00	2185	20.78	18.24
164	I11	13.6	0.11	6.9	0.90	2180	22.81	19.22
165	I12	10.7	0.10	56.3	0.90	2240	25.61	18.25
166	I13	11.0	0.35	13.4	1.00	2280	27.97	18.49
167	I14	12.6	0.10	25.4	1.00	2320	29.99	18.72
168	I15	12.0	0.11	28.9	1.00	2315	32.22	18.84
169	I16	11.7	0.10	15.3	1.00	2345	34.43	18.83
170	I17	10.4	0.06	26.0	0.90	2480	36.74	19.29
171	I18	10.7	0.09	11.9	0.90	2590	38.60	18.84
172	I19	8.2	0.06	27.0	0.90	2680	40.78	19.00
173	I20	12.7	0.04	18.2	0.55	2800	43.02	18.63
174	J2	18.0	0.07	5.9	0.85	1555	3.21	21.53
175	J3	16.0	0.11	8.7	1.00	1545	5.23	20.88
176	J4	17.6	0.10	11.6	1.00	1580	7.64	20.87
177	J5	18.0	0.10	9.5	1.00	1685	9.80	20.78
178	J6	17.2	0.20	7.8	0.92	1810	12.55	21.32
179	J7	16.0	0.12	10.4	0.90	1890	14.45	21.28
180	J8	15.5	0.27	9.8	0.90	1955	16.22	21.75
181	J9	13.9	0.16	5.3	0.90	2060	18.61	21.62
182	J10	14.2	0.10	10.0	0.90	2170	20.96	21.18
183	J11	15.0	0.10	9.8	0.90	2215	23.46	21.03
184	J12	14.2	0.10	17.5	0.90	2235	25.36	21.27
185	J13	9.7	0.42	18.9	0.90	2285	27.89	20.95
186	J14	8.6	0.12	2.9	1.00	2320	30.28	21.21
187	J15	8.2	0.13	23.6	1.00	2365	32.31	21.14
188	J16	11.7	0.13	14.6	1.00	2420	34.51	21.22
189	J17	13.0	0.09	18.9	0.80	2520	37.24	21.34
190	J18	11.3	0.06	49.5	0.90	2585	38.86	21.09
191	J19	11.5	0.07	61.1	0.90	2710	41.42	20.87
192	J20	13.0	0.10	22.7	0.90	2775	43.61	21.70
193	K2	18.1	0.10	5.4	0.85	1545	3.34	23.10
194	K3	18.4	0.11	13.8	0.75	1590	5.91	23.76
195	K4	15.5	0.10	14.4	1.00	1650	7.83	22.88
196	K5	15.8	0.07	12.4	1.00	1670	9.60	23.30
197	K6	13.6	0.19	8.3	1.00	1805	12.03	23.60
198	K7	16.5	0.16	9.3	0.92	1890	14.11	23.44
199	K8	14.0	0.13	8.6	0.90	1955	16.13	23.30
200	K9	15.3	0.15	6.9	0.90	2060	19.01	23.76

Table A-8 (5) Results of 1 meter depth survey

No.	Sample. No.	T (°c)	CO_2 (%)	Hg (ppb)	Depth (m)	A (m)	Coordinates Y	X
201	K10	14.4	0.13	7.6	0.90	2080	20.79	23.18
202	K11	13.7	0.09	8.3	0.90	2225	23.59	23.17
203	K12	11.2	0.11	4.4	0.90	2230	25.22	22.59
204	K13	12.3	0.16	18.1	0.90	2295	27.99	23.03
205	K14	11.0	0.15	41.3	1.00	2330	29.92	23.33
206	K15	12.1	0.13	16.6	1.00	2380	31.90	23.88
207	K16	11.8	0.16	48.6	1.00	2450	34.70	22.81
208	K17	14.5	0.06	27.0	0.75	2495	36.49	22.58
209	K18	11.1	0.09	14.4	0.90	2565	38.67	23.15
210	K19	13.5	0.16	417.2	0.90	2680	41.58	22.96
211	K20	23.2	0.06	363.0	0.90	2780	43.26	23.56
212	N2	17.7	0.10	6.8	0.95	1625	3.90	29.48
213	N3	16.8	0.08	9.0	1.00	1605	4.90	29.92
214	N4	18.6	0.08	13.5	1.00	1680	7.90	30.45
215	N5	17.7	0.03	9.4	1.00	1675	9.67	30.52
216	N6	16.3	0.11	7.4	1.00	1705	12.30	30.15
217	N7	17.5	0.20	8.8	1.00	1760	14.23	29.81
218	N8	15.5	0.22	8.6	1.00	1835	16.56	30.08
219	N9	18.5	0.08	8.3	1.00	1840	18.95	30.32
220	N10	16.5	0.13	7.4	1.00	1925	20.86	29.85
221	N11	20.8	0.06	8.1	0.50	1980	23.44	29.79
222	N12	14.4	0.11	11.9	1.00	2050	25.27	30.45
223	N13	11.5	0.11	8.6	1.00	2120	27.33	30.12
224	N14	12.5	0.14	7.3	1.00	2200	29.27	30.68
225	N15	9.6	0.12	5.3	1.00	2320	32.39	30.99
226	N16	10.7	0.10	2.7	0.90	2425	34.03	30.90
227	N18	12.2	0.12	21.2	1.00	2400	39.90	29.08
228	N19	14.3	0.12	14.6	0.95	2450	41.21	29.66
229	N20	15.2	0.06	22.3	0.85	2520	43.76	29.80
230	N21	12.0	0.08	11.5	1.00	2620	45.60	29.45
231	N25	8.7	0.10	8.6	1.00	2870	54.67	30.58
232	N26	11.5	0.10	9.6	0.70	2935	56.38	30.51
233	M2	17.5	0.10	11.7	0.85	1615	3.42	27.53
234	M3	19.6	0.10	16.9	0.47	1580	5.82	27.21
235	M4	16.3	0.14	8.8	1.00	1630	7.70	27.81
236	M5	16.5	0.08	8.0	1.00	1635	9.79	28.21
237	M6	17.0	0.29	6.6	1.00	1755	12.59	27.77
238	M8	16.5	2.09	5.5	1.00	1860	16.83	27.70
239	M9	19.0	0.19	7.5	0.90	1900	18.80	28.07
240	M10	15.5	0.13	9.5	1.00	1970	21.20	27.66
241	M11	21.2	0.28	3.4	0.97	2000	22.56	27.04
242	M14	14.4	0.13	3.8	0.80	2290	30.22	27.03
243	M15	13.5	0.13	15.0	1.00	2340	32.73	27.00
244	M16	13.3	0.13	22.3	1.00	2410	35.05	26.94
245	M17	14.8	0.06	74.4	1.10	2320	37.35	27.22
246	M18	16.3	0.05	48.9	1.00	2315	38.67	27.51
247	M19	18.5	0.61	213.2	0.55	2520	41.78	27.25
248	M20	12.5	0.14	12.8	1.00	2545	42.87	28.61
249	M21	13.0	0.62	19.8	1.00	2630	46.12	27.30
250	L2	17.9	0.09	6.8	0.95	1610	3.85	24.97

Table A-8 (6) Results of 1 meter depth survey

No.	Sample. No.	T (°c)	CO_2 (%)	Hg (ppb)	Depth (m)	A (m)	Coordinates Y	X
251	L3	19.3	0.11	39.6	0.87	1590	6.03	25.94
252	L4	17.5	0.07	22.1	0.75	1645	7.87	25.92
253	L5	12.5	0.11	13.2	1.00	1655	9.64	25.13
254	L6	15.0	0.30	7.2	1.00	1730	11.72	25.68
255	L7	17.5	0.15	3.7	0.90	1900	14.36	25.12
256	L8	16.5	0.11	10.6	0.90	1950	16.63	26.08
257	L9	15.6	0.13	9.6	0.90	1970	19.02	25.34
258	L10	17.0	0.12	20.6	1.10	2040	21.91	25.92
259	L11	22.0	0.13	6.2	1.00	2045	22.80	26.08
260	L12	18.3	0.08	25.6	0.85	2260	25.49	24.53
261	L13	13.2	0.10	14.4	0.90	2295	28.54	25.21
262	L14	12.2	0.13	15.1	1.00	2335	29.97	25.14
263	L15	10.7	0.10	28.8	1.00	2385	32.62	25.47
264	L16	11.4	0.12	27.0	1.00	2415	34.74	25.39
265	L17	11.5	0.03	17.3	1.00	2440	37.11	25.58
266	L18	11.2	0.09	33.0	1.00	2500	39.80	25.97
267	L19	11.8	0.11	56.0	1.00	2635	41.64	25.49
268	L20	12.0	0.03	43.2	0.80	2705	43.11	25.20
269	L21	7.0	0.05	10.7	0.80	2695	45.14	26.28
270	02	16.2	0.09	1.8	1.00	1655	2.48	32.27
271	03	17.3	0.15	3.2	1.00	1620	4.76	31.93
272	04	17.7	0.62	8.1	0.90	1630	7.98	32.36
273	05	18.3	0.11	9.6	0.90	1700	10.16	32.28
274	06	18.0	0.11	3.9	1.00	1650	11.48	31.41
275	07	16.0	0.20	6.7	1.00	1785	14.66	31.95
276	08	15.0	0.23	2.6	1.00	1785	16.57	32.49
277	09	18.5	0.12	30.5	1.00	1775	18.83	32.93
278	010	15.3	0.05	7.9	1.00	1930	21.75	32.92
279	011	14.4	0.03	11.7	1.00	1955	22.98	32.08
280	012	11.5	0.15	17.9	0.86	2015	24.83	32.54
281	013	12.6	0.10	8.0	1.00	2260	28.16	31.90
282	014	11.1	0.15	6.6	1.00	2305	29.93	32.47
283	015	11.5	0.16	8.0	1.00	2360	32.07	32.64
284	016	8.7	0.17	4.0	1.00	2430	34.31	32.39
285	017	8.6	0.10	4.0	0.90	2580	36.93	32.71
286	018	10.7	0.10	2.7	0.90	2620	38.34	32.94
287	019	17.6	0.11	8.0	1.00	2380	42.39	31.61
288	020	12.3	0.10	10.6	1.00	2350	42.95	32.96
289	021	13.0	0.12	16.5	1.00	2615	45.63	32.31
290	022	11.3	0.08	13.6	1.00	2635	48.21	32.89
291	023	10.5	0.15	8.6	1.00	2720	49.50	32.88
292	024	7.2	0.04	6.2	1.00	2835	52.17	32.41
293	025	7.8	0.04	19.3	1.00	2865	54.52	31.78
294	026	8.6	0.04	8.6	1.00	2975	56.86	32.00
295	027	8.5	0.03	7.6	1.00	2985	59.18	32.21
296	P2	17.3	0.11	1.4	0.90	1660	2.89	34.80
297	P3	17.7	0.07	6.9	1.00	1555	5.74	34.96
298	P4	18.5	0.08	6.9	0.85	1623	7.70	34.49
299	P5	18.0	0.04	12.5	0.90	1705	9.92	34.54
300	P6	17.2	0.03	8.8	1.00	1742	12.21	34.95

Table A-8 (7)   Results of 1 meter depth survey

No.	Sample No.	T (°c)	CO_2 (%)	Hg (ppb)	Depth (m)	A (m)	Coordinates Y	X
301	P7	18.0	0.06	21.7	0.85	1763	14.52	34.60
302	P8	17.7	0.12	10.0	1.00	1805	16.95	34.58
303	P9	16.8	0.28	7.5	1.00	1855	18.92	34.83
304	P10	14.5	0.03	6.9	0.85	1922	21.71	33.83
305	P11	15.4	0.10	5.6	1.00	1945	22.84	35.01
306	P12	16.3	0.06	10.0	0.98	2075	25.26	35.00
307	P13	16.3	0.08	9.3	0.60	2309	27.99	34.46
308	P14	11.3	0.35	6.0	0.70	2313	29.88	34.84
309	P15	10.5	0.17	9.9	0.90	2325	32.39	34.21
310	P16	12.5	0.10	3.1	1.00	2465	34.44	34.82
311	P17	11.2	0.07	5.0	1.00	2630	36.32	35.60
312	P18	11.7	0.07	8.8	0.70	2730	38.63	35.11
313	P20	13.6	0.10	9.9	0.85	2365	43.86	33.67
314	P21	12.5	0.03	15.9	0.95	2415	45.69	34.90
315	P23	9.8	0.05	8.3	0.90	2775	50.91	34.52
316	P24	11.3	0.03	12.6	0.90	2890	52.74	34.58
317	P25	8.0	0.10	13.8	1.00	2945	54.67	34.31
318	P26	13.7	0.05	1.3	0.60	3125	57.65	34.09
319	Q3	15.6	0.15	10.0	1.00	1585	5.28	36.92
320	Q4	17.5	0.05	6.9	1.00	1680	7.64	36.76
321	Q5	17.0	0.05	8.1	1.00	1705	10.03	36.58
322	Q6	17.7	0.06	36.2	0.95	1755	12.52	36.55
323	Q7	16.5	0.11	4.0	1.00	1783	14.52	36.55
324	Q8	14.7	0.11	2.5	1.00	1825	16.85	36.93
325	Q9	16.5	0.10	6.9	0.85	1885	18.64	36.45
326	Q10	15.8	0.10	6.9	1.00	1935	21.33	37.00
327	Q11	18.5	0.09	5.6	0.70	1980	23.13	36.93
328	Q12	14.5	0.13	10.9	1.00	2085	25.39	37.01
329	Q13	12.7	0.08	7.3	1.00	2135	27.39	37.68
330	Q14	11.0	0.10	2.0	1.00	2280	29.57	36.65
331	Q15	11.6	0.10	6.6	0.90	2385	31.68	36.23
332	Q16	10.0	0.10	6.0	0.90	2540	34.54	37.20
333	Q21	12.4	0.08	9.9	0.90	2450	46.42	36.08
334	Q22	14.8	2.15	8.0	0.85	2470	47.09	36.96
335	Q23	8.5	0.03	6.9	0.95	2860	51.13	36.08
336	Q24	15.5	0.14	0.7	0.60	2950	53.14	36.74
337	Q25	10.2	0.03	24.1	0.85	2970	54.79	36.63
338	Q26	12.6	0.04	12.4	0.75	3095	56.65	36.90
339	Q27	10.0	0.03	22.7	0.80	3220	58.34	36.88
340	R3	19.6	0.10	13.2	0.80	1593	5.43	39.13
341	R4	16.0	0.04	3.8	1.00	1730	7.79	38.77
342	R5	15.5	0.08	8.1	1.00	1775	9.83	39.17
343	R6	15.7	0.09	9.8	1.00	1795	11.36	39.29
344	R7	15.5	0.14	7.5	1.00	1825	14.36	39.04
345	R8	16.1	0.10	5.8	1.00	1840	16.78	38.77
346	R9	14.0	0.22	1.3	1.00	1895	19.61	39.20
347	R10	15.1	0.05	13.1	1.00	1990	21.54	38.85
348	R11	12.7	0.06	1.3	1.00	1990	23.14	39.62
349	R12	13.5	0.25	7.6	1.00	2025	25.41	39.07
350	R13	16.4	0.07	11.3	1.00	2145	27.62	39.49

Table A-8 (8) Results of 1 meter depth survey

No.	Sample No.	T (°c)	CO_2 (%)	Hg (ppb)	Depth (m)	A (m)	Coordinates Y	X
351	R14	12.1	0.12	15.2	1.00	2185	29.74	38.84
352	R15	11.2	0.13	6.0	1.00	2255	31.92	39.33
353	R16	11.8	0.12	9.9	1.00	2410	34.18	39.58
354	R17	8.1	0.11	3.3	1.00	2515	36.03	39.55
355	R22	10.8	0.10	8.6	1.00	2570	47.77	38.66
356	R24	10.0	0.03	7.6	1.00	2910	53.09	38.61
357	R25	9.4	0.03	9.6	0.75	2925	54.11	38.88
358	R26	11.2	0.03	15.8	0.75	3130	56.69	38.35
359	S3	15.9	0.15	10.3	1.00	1605	6.03	40.75
360	S4	18.5	0.20	15.8	1.00	1645	8.18	41.46
361	S5	16.3	0.15	8.6	1.10	1670	9.67	41.69
362	S6	15.0	0.13	3.4	1.00	1723	12.55	41.78
363	S7	18.7	0.08	9.8	0.70	1755	14.35	41.70
364	S8	18.0	0.12	4.4	0.95	1795	16.30	41.29
365	S9	14.6	0.08	4.9	0.95	1895	18.85	41.00
366	S10	15.8	0.10	5.6	1.00	1910	20.21	41.48
367	S11	16.0	0.09	9.0	0.85	1985	23.45	41.58
368	S12	15.4	0.14	11.3	1.00	2028	25.06	40.67
369	S13	14.2	0.05	11.6	0.95	2105	27.85	42.04
370	S14	11.6	0.07	3.1	1.00	2165	30.32	41.33
371	S15	11.9	0.10	4.3	1.00	2265	32.77	41.76
372	S16	13.6	0.09	5.5	1.00	2345	34.70	41.26
373	S17	9.0	0.23	8.6	1.00	2520	36.58	41.24
374	S18	11.5	0.09	8.0	1.00	2550	38.22	42.11
375	S22	9.0	0.14	10.3	0.95	2651	49.14	41.95
376	S23	11.2	0.11	18.5	0.95	2775	50.65	40.79
377	S24	10.8	0.04	11.9	1.00	2895	52.05	41.81
378	S25	13.8	0.07	51.2	0.60	3065	54.43	41.48
379	S26	11.7	0.07	1.9	0.75	3090	56.37	41.37
380	S27	9.5	0.08	12.5	0.60	3265	58.53	4[illegible].87
381	T2	16.2	0.16	8.8	0.85	1585	4.23	42.81
382	T3	20.5	0.06	8.8	0.55	1728	6.04	43.87
383	T4	15.6	0.07	8.1	1.00	1745	7.43	43.60
384	T5	14.4	0.10	6.1	1.00	1775	9.66	43.76
385	T6	16.0	0.17	3.4	0.95	1755	12.58	43.59
386	T7	14.0	0.16	4.7	1.00	1750	14.67	43.28
387	T8	18.0	0.10	8.8	0.90	1775	16.91	44.04
388	T9	17.9	0.60	8.9	1.00	1800	18.25	42.89
389	T10	15.7	0.20	7.6	0.95	1905	21.17	44.20
390	T11	14.2	0.10	3.4	1.00	2010	23.73	43.18
391	T12	12.8	0.09	7.4	1.00	2045	25.54	43.07
392	T13	13.5	0.03	8.0	1.00	2125	28.01	43.92
393	T14	13.5	0.05	4.3	1.05	2145	29.74	43.30
394	T15	13.2	0.11	6.4	1.00	2220	31.88	43.78
395	T16	12.2	0.10	3.7	1.00	2310	34.63	43.88
396	T17	12.0	0.10	5.7	0.85	2425	36.52	43.82
397	T18	10.4	0.11	5.5	1.00	2510	38.32	44.42
398	T23	10.5	0.06	35.7	0.80	2685	50.57	43.30
399	T24	10.9	0.11	127.2	1.00	2885	52.37	43.89
400	T25	7.5	0.05	55.5	0.95	2990	54.83	43.65

Table A-8 (9) Results of 1 meter depth survey

No.	Sample No.	T (°c)	CO_2 (%)	Hg (ppb)	Depth (m)	A (m)	Coordinates Y	X
401	T26	8.9	0.03	5.7	1.00	3055	57.45	42.83
402	T27	5.8	0.03	16.6	0.80	3075	58.84	42.95
403	U2	17.0	0.05	9.6	1.00	1570	4.19	45.09
404	U3	18.5	0.10	8.3	1.00	1650	5.78	46.34
405	U4	16.9	0.05	13.5	1.00	1755	7.71	46.06
406	U5	15.5	0.08	7.0	1.00	1825	9.90	45.91
407	U6	16.0	0.10	5.1	0.95	1835	12.39	46.09
408	U7	17.6	0.08	5.7	1.00	1820	14.38	46.06
409	U8	18.0	0.12	8.1	1.00	1825	16.78	45.78
410	U9	17.5	0.10	22.3	0.90	1815	19.10	46.05
411	U10	15.2	0.12	5.6	1.00	1885	21.33	45.84
412	U11	14.5	0.03	10.8	1.00	1955	23.63	45.69
413	U12	13.3	0.10	7.7	1.00	2030	25.76	45.09
414	U13	15.0	0.08	8.3	0.95	2075	28.13	45.61
415	U14	15.4	0.08	4.3	0.92	2155	29.80	45.12
416	U15	14.9	0.09	8.9	0.90	2270	32.38	45.41
417	U16	11.6	0.10	3.8	1.00	2315	34.20	45.76
418	U17	10.4	0.05	5.5	0.95	2400	36.52	45.42
419	U18	10.5	0.12	6.9	1.00	2575	39.83	45.13
420	U19	11.0	0.12	6.2	0.90	2625	41.40	45.22
421	U20	8.8	0.10	14.4	1.00	2625	43.34	46.64
422	U23	7.7	0.10	176.6	1.00	2690	51.36	46.15
423	U27	10.2	0.03	24.2	0.98	3215	59.18	45.64
424	U29	7.0	0.03	56.3	0.50	3525	62.80	45.55
425	V2	15.0	0.13	5.1	1.00	1560	3.95	48.95
426	V3	16.3	0.07	10.2	0.90	1745	5.98	48.53
427	V4	14.5	0.05	8.9	1.00	1742	7.63	48.47
428	V5	14.5	0.05	11.5	1.00	1770	10.21	47.60
429	V6	13.0	0.19	17.9	0.95	1795	12.03	48.11
430	V7	13.8	0.06	4.5	0.96	1860	14.57	48.36
431	V8	15.6	0.06	5.7	1.00	1900	16.51	48.97
432	V9	15.5	0.09	5.7	1.00	1883	18.44	47.72
433	V10	15.8	0.13	7.0	1.00	1855	20.46	47.63
434	V11	17.9	0.05	14.0	0.95	1885	23.25	47.54
435	V12	14.5	0.12	7.1	1.00	2005	26.20	47.57
436	V13	16.4	0.06	9.3	1.00	2075	28.12	47.86
437	V14	16.2	0.11	5.7	1.00	2123	30.63	47.79
438	V15	15.5	0.10	10.0	0.95	2155	32.15	48.05
439	V16	13.5	0.09	6.4	0.98	2235	34.47	47.46
440	V17	13.5	0.09	9.3	1.00	2283	37.02	48.27
441	V18	12.6	0.16	5.7	1.00	2308	38.86	47.98
442	V19	13.3	0.10	6.3	0.90	2373	41.11	47.75
443	V20	12.6	0.10	6.4	0.90	2460	43.23	49.00
444	V21	9.2	0.06	15.0	1.00	2595	46.07	48.15
445	V22	10.0	0.20	5.6	1.00	2635	47.24	48.22
446	V24	9.9	0.05	30.8	1.00	2815	53.60	47.20
447	V25	9.2	0.03	5.2	0.85	2950	55.00	47.27
448	V26	10.6	0.03	18.5	1.00	3030	56.50	48.26
449	V29	6.5	0.03	14.0	0.60	3510	64.08	47.24
450	H10-1	18.8	0.08	10.1	0.70	2210	22.02	17.41

Table A-8 (10) Results of 1 meter depth survey

No.	Sample No.	T (°c)	CO_2 (%)	Hg (ppb)	Depth (m)	A (m)	Coordinates Y	Coordinates X
451	H11-1	16.2	0.10	11.1	0.90	2220	24.40	17.50
452	H11-2	14.2	0.09	1.9	1.00	2220	22.76	15.77
453	H12-1	13.0	0.14	11.6	1.00	2265	26.70	17.47
454	H12-2	15.4	0.07	10.1	1.00	2255	24.54	15.54
455	H13-1	13.0	0.09	28.5	1.00	2295	28.85	17.50
456	H14-1	16.5	0.11	3.9	1.00	2335	31.11	15.51
457	H14-2	15.5	0.09	9.7	0.75	2330	31.12	17.49
458	H16-1	17.2	0.59	9.7	0.60	2415	35.54	15.72
459	H16-2	11.5	0.16	5.8	1.00	2395	35.54	17.45
460	H17-1	10.8	0.11	7.7	1.00	2495	37.41	17.20
461	I15-1	9.6	0.18	3.6	1.00	2380	33.36	18.09
462	I16-1	14.2	0.17	11.3	1.00	2425	35.55	19.76
463	I17-1	11.0	0.16	11.3	1.00	2540	37.82	19.76
464	J7-1	15.9	0.11	4.8	1.00	1905	15.28	21.99
465	J9-1	18.7	0.05	6.2	0.85	2145	19.87	21.40
466	J11-1	14.1	0.10	8.9	1.00	2215	24.28	21.89
467	J11-2	11.2	0.08	2.1	1.00	2215	24.25	20.33
468	J11-3	12.5	0.10	14.4	1.00	2195	22.53	20.05
469	J11-4	15.7	0.12	4.1	1.00	2195	22.30	22.09
470	J12-1	12.0	0.15	15.8	0.90	2260	26.75	18.48
471	J12-2	11.0	0.16	14.4	1.00	2265	26.72	20.50
472	J12-3	14.0	0.11	8.9	1.00	2255	26.48	21.98
473	J14-1	11.4	0.20	23.4	1.00	2320	31.09	20.02
474	J14-2	12.7	0.09	15.1	1.00	2295	29.05	19.42
475	J15-1	11.8	0.10	12.5	0.85	2395	33.40	22.10
476	J15-2	13.8	0.12	17.9	1.00	2395	33.22	20.71
477	J16-1	16.5	0.08	8.1	0.80	2470	35.56	21.96
478	J17-1	11.4	0.19	12.2	1.00	2545	37.91	22.01
479	L11-1	18.5	0.11	11.0	0.55	2235	24.21	24.79
480	E16-1	36.7	2.60	180.0	1.00	2190	34.80	9.49
481	E17-1	57.0	0.30	1824.2	0.90	2270	36.61	10.43
482	E17-2	25.1	0.07	368.1	0.70	2270	37.21	10.70
483	F17-1	12.5	0.09	8.6	0.95	2385	36.91	12.16
484	E16-2	14.8	0.10	14.9	0.92	2335	35.35	10.46
485	E15-1	12.0	0.12	5.0	1.05	2300	33.07	10.31
486	J9-2	22.0	0.06	12.2	1.00	2015	18.13	21.03
487	J8-1	31.3	0.10	163.4	0.80	1960	17.05	21.08
488	J8-2	28.2	0.03	7.2	1.00	1945	16.34	20.42
489	I7-1	20.4	0.07	66.6	1.00	1900	15.18	19.52
490	I7-2	36.2	0.09	1.8	0.80	1875	14.47	19.36
491	I6-1	37.5	0.07	9.5	1.00	1840	13.06	18.93
492	I6-2	23.0	0.10	21.6	1.00	1740	11.10	19.80
493	I5-1	18.0	0.93	14.4	1.00	1635	9.23	19.84
494	K8-1	15.2	0.08	6.9	1.00	2050	17.50	22.97
495	K9-1	18.0	0.05	4.1	0.85	2080	19.69	22.37
496	K14-1	14.3	0.10	35.8	1.00	2325	29.29	22.34
497	K14-2	7.3	0.32	2.8	1.00	2305	29.10	24.16
498	K14-3	12.8	0.11	13.1	1.00	2365	31.23	24.32
499	K14-4	14.3	0.13	55.0	1.00	2355	31.12	22.31
500	K15-1	16.7	0.08	8.1	0.80	2395	33.37	24.24
501	K16-1	10.0	0.11	10.8	1.00	2450	35.58	24.21
502	L28	0.0	0.00	2308.3	0.00	3310	61.06	26.14

Table A-9 Analytical methods of hot spring water and condensed water

Element	Analytical method	Instruments
pH	PH meter	TOA electronics Ltd., Model HM-20E
NH_4	Absorptimetry	Photo-colorimeter
$HAsO_2$		
Hg	Atomic absorption method (Flameless)	Nippon Jarrell Ash Co. Ltd., Model AMD-F2
Ca	Inductive coupled plasma emission method	Nippon Jarrell Ash Co. Ltd., Model ICAP-575
Mg		
Mn		
Al		
SiO_2		
HBO_2		
Fe		
Li	Flame emission method	-
K		
Na		
HCO_3^- Cl^- F^- SO_4^{2-}	Ion chromatograph method	-
Conductivity	Conductivity meter	TOA Electronics Ltd., Model CM-7B

Table A-10 Chemical concentration of hot water and condensed water (by Argentine team)

Sample	Li (Li^+)	K (K^+)	Na (Na^+)	Ca (Ca^{++})	Mg (Mg^{++})	B (B^-)	Cl (Cl^-)	SO_4 (SO_4^{2})	CO_3^- (CO_3^c)	CO_3H^- (CO_3^{ca})
AC-1	6.4	41	600	20	0.71	6.9	1184	110	8	34
AC-2	1.9	22.7	300	20	0.72	2.2	371	35	24	93
AC-3	6.4	37	600	10	1.02	5.8	914	93	20	62
AC-4	1.1	41	700	30	1.76	6.3	1104	97	28	115
AC-5	7.5	43	700	40	3	6.12	1024	93	28	149
AC-6	5.45	38	600	10	1.17	5.2	753	98	8	83
AC-7	5.2	37	900	30	1.50	4.5	713	72	12	85
LO-1	8.3	58	400	30	0.72	8.5	1335	125	16	44
LO-2	9.8	61	1020	40	0.81	9.75	1536	142	20	42
LT-11	10.5	65	1120	50	1.2	10.3	1526	138	28	32
LT-12	4.2	43	410	5	0.09	4.4	632	71	12	28
LT-13	4.5	55	530	6	0.12	4.8	829	78	16	24
EH-1	10	146	1170	20	0.05	11.6	1870	166	20	34
EH-2	12.2	114	1020	20	0.36	9.75	1536	235	20	18
LB-1	0	1.4	15.2	200	3.9	0.5	6	1100	16	222
RP-1	3.9	57	600	90	19	5.1	833	100	20	544
RP-2	11.2	97	1300	160	67	9.75	2278	73	16	238
RP-3	3.7	26	1140	50	51	10.5	1667	32	147	887

Unit: ppm

Table A-11 Results of gas analysis (by Argentine team)

Sample	CO_2	CH_4	N_2	H_2
GLB-1	90.3	0.7	9	0.046
GAC-1	41.2	0.45	58.3	0.26
GLO-1	94.3	ND	5.6	0.078
GLT-3	93.2	0.45	6.3	0.033
GLT-1	90.99	ND	9	0.045
GLT-2	97.9	ND	2.1	0.036
GEH-2	53.3	1.02	45.74	0.09