1.5 Alteration Zones

Hydrothermal alteration in the area is generally characterized by intense argillization propilitization and silicification and in a few places with the introduction of gypsum-anhydrite veinlets, particularly at nearby dacite plugs.

A detailed survey was done from the Itogon bridge to Balatoc and Batuang. Altered rocks were sampled for alteration mineral identification by means of X-ray diffraction method (Table III–1–5) and petrographic analysis.

Studies reveal that the area is extensively argillized. However, some of the mineralized vein deposits observed around Balatoc and Batuang areas show quartz veins being deposited along open fractures. Some are granulated along fault zones associated with gougy materials and gypsum-anhydrite veinlets.

The alteration minerals identified were: abundant α-quartz; moderate to minor amounts of sericite; abundant to minor quantities of chlorite; minor amounts of montmorillonite; kaolinite; jarosite; pyrite; and mixed-layer minerals of sericite and montmorillonite. Other minerals identified were: meta-halloysite; chlinochlore; mixed-layers of chlorite and montmorillonite; potash-feldspar; gypsum, calcite; goethite; todorokite and magnetite. Presence of analcime, laumontite, pyrophyllite and stercosite was uncertain.

According to the classification by Utada (1974), the hydrothermal alteration in the survey area is an admixture of:

(i) acid-type, characterized by kaolinite and jarosite; and

(ii) neutral-type, characterized by potash feldspar, sericite and α-quartz (Fig. III–1–6a and -b).

Neutral-type hydrothermal alteration is more widespread than the acid-type around Itogon bridge (Fig. III–1–6b). Furthermore, alteration in the Balatoc-Batuang vicinity is characterized by gypsum-anhydrite and calcite (Fig. III–1–6c).

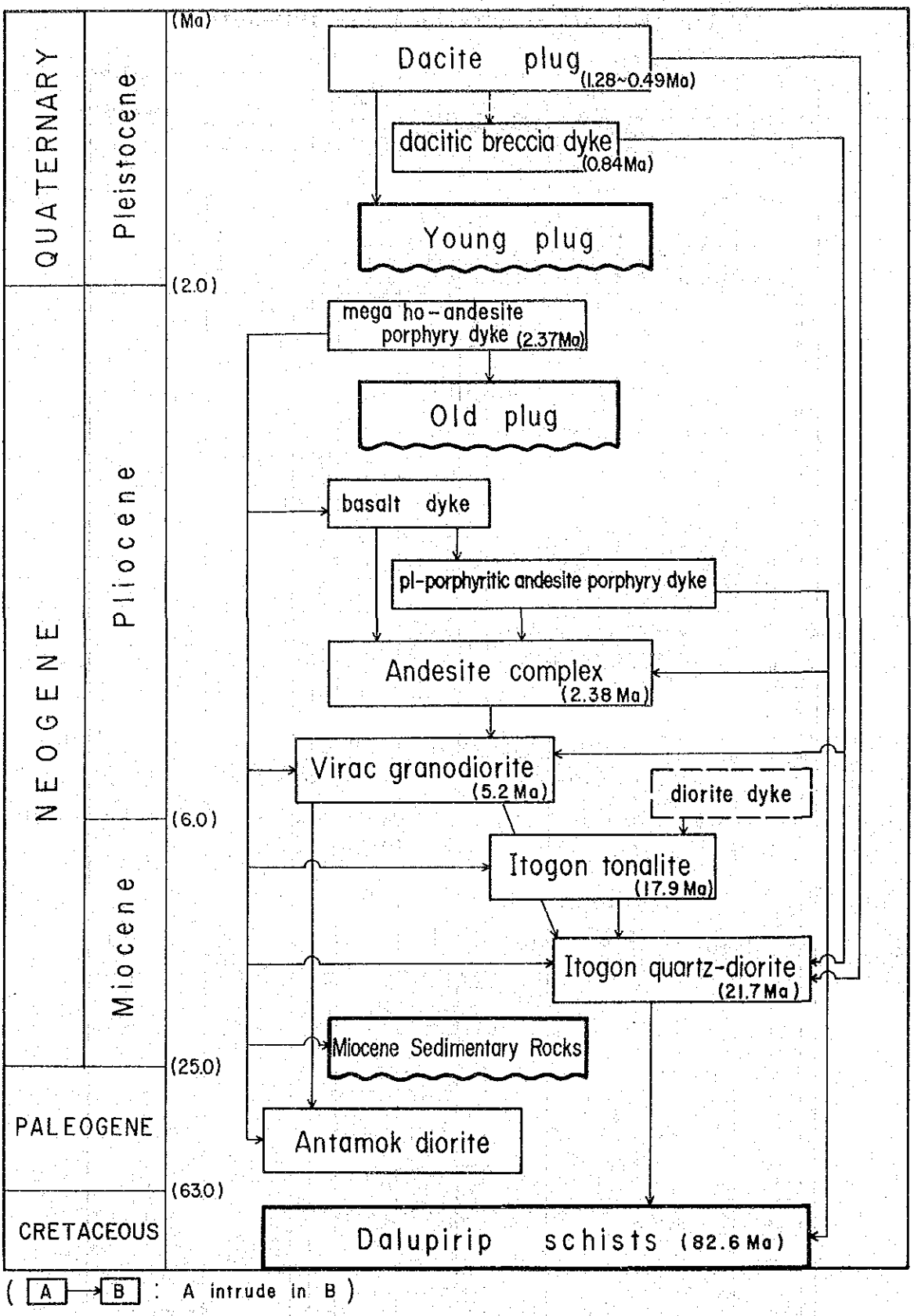

Fig. Ⅲ-1-5 History of Igneous Activity

Table Ⅲ-1-5 Results of X-ray Diffraction

Sample No.	Silicate Minerals: Clay minerals: montmorillonite	meta-halloysite	kaolinite	sericite	chlorite	clinochlore	pyrophyllite	sericite/montmorillonite	chlorite/montmorillonite	Zeorite minerals: zeolite	analcime	laumontilite	Silica m.: α-quartz	Others: plagioclase	k-feldespar	amphibole	Sulfate minerals: jarosite	gypsum	bassanite	Carb. m.: calcite	pyrite	Oxide minerals: geothite	stercosite	todorokite	magnetite	Note
H－1				△	△		?					?	◎	◎							△					
H－2				△	△							?	◎	○	△											
H－3	△		△	△	△								◎	◎			△									
H－4	△			△	△								◎	◎		△						?				
H－5				△	△			△					◎				△									
H－6	△			△	○					?			◎	◎				△		△						
H－7				○		△		△					◎	◎	△						△			△		
H－8	△			△	△								◎	◎		△				△	△					
H－9	△		△	△	◎			△					◎	◎						△	△					
H－10	△			△	○								◎	◎				△		△	△					
H－11			△	△	○			△					◎	○			△									
H－12	△			△	◎								◎	◎	△			△		△						
H－13				△	△							?	◎	◎				△								
H－14	△		△	△	◎			△					◎	◎	△			△		△	△					
H－15	△		△	○	◎			△					◎	◎						△	△					
H－16			△	○	△								◎	◎			△									
H－17				○	○								◎	◎						△	△					
H－18	△			◎	○								◎	△			△			△	△	?				
H－19	△			△	◎								◎	◎				△			△					
H－20				△	○								◎				△				△	?				
H－21	△		△	○	○								◎	◎		△					△					
H－22	△			△	◎								◎	◎			△				△					
H－23	△			○	◎			△					◎				△				△	?				
H－24			△	○	○			△					◎				△				△					
H－25	△		△	○	○								◎				△					?				
H－26				○	○			△					◎	△	△		△				△					
H－27	△	△		○									◎		△							△				
I－2				○	◎			△					◎				△				△	?				
I－3				○	△			△					◎				△									
I－4	△		△	△	△								○	◎		◎										
I－7	△		△	△				△					◎		△							△		△		
I－9	△		△	△	○								◎	◎		△					△					
I－10				△	△								◎				△					?				
I－13	△			◎	△								◎				△					?				
I－18	△			○	○								◎	○							△					
I－21				△	△					?			◎	◎		◎				△						
I－22	△		△	△	○								◎			△	△				△					
I－24	△		△	△	◎								◎													
I－28	△		△	○		△							◎	△			△									
I－32	△			△	△								◎	◎		○										
I－34	△			△	△								○	◎		○										
I－38	△		△	○	△								◎	△	△		△					△	?			
I－39	△		△		△								◎	△			△				△					
I－41	△		△		△								◎	◎	△											
I－45		△											◎				△					△				
I－46	△		△		△			△					◎	△							○					
I－50	△		△		○								◎	△			△									
E－40													△					?	◎							calcite sinter
F－146													△					?	◎							calcite sinter

◎: abundant, ○: common, △ ; rare. ?: inaccuracy.

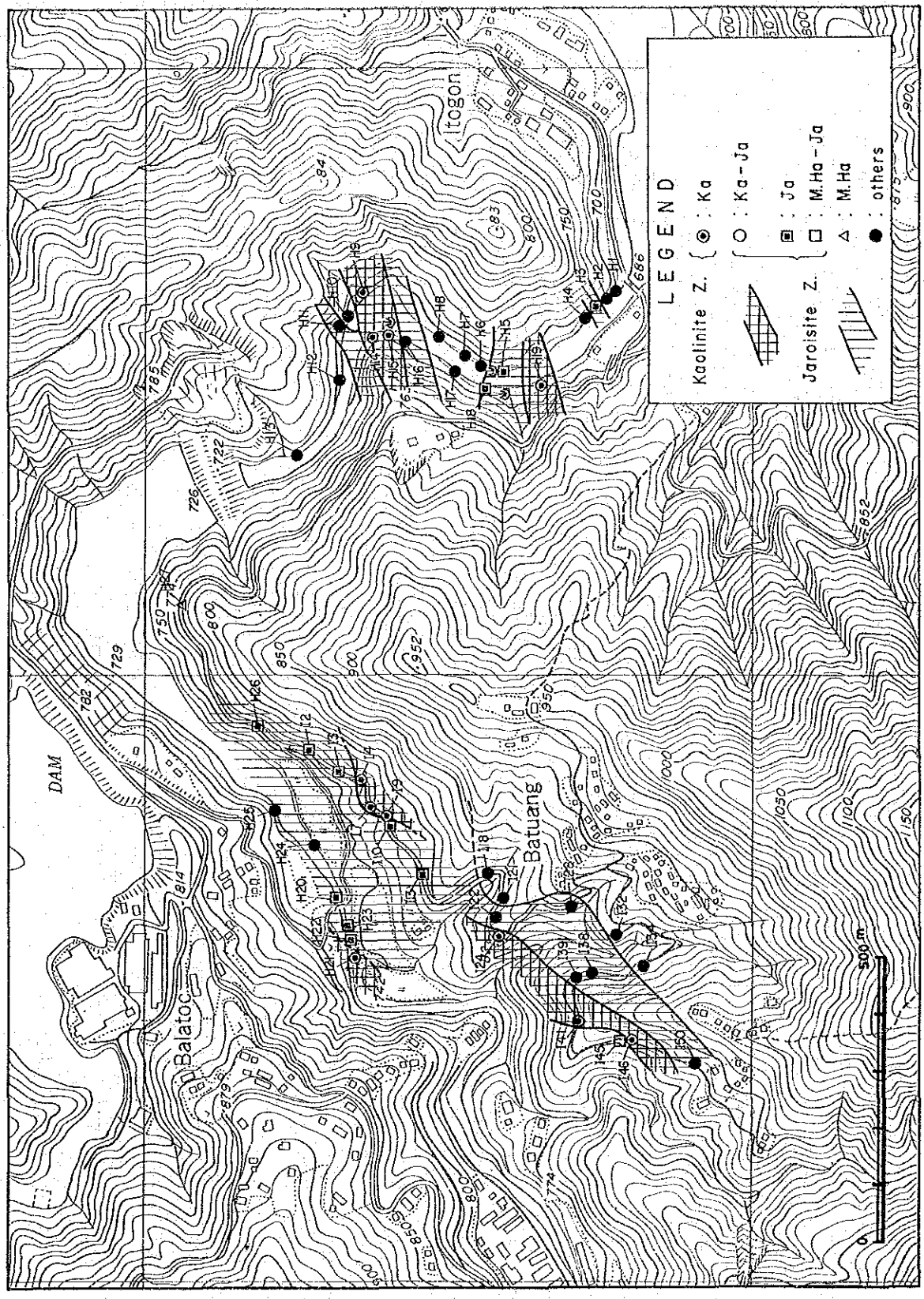

Fig. Ⅲ-1-6(a) Distribution of Alteration Minerals (Acid Hydrothermal Alteration Zone)

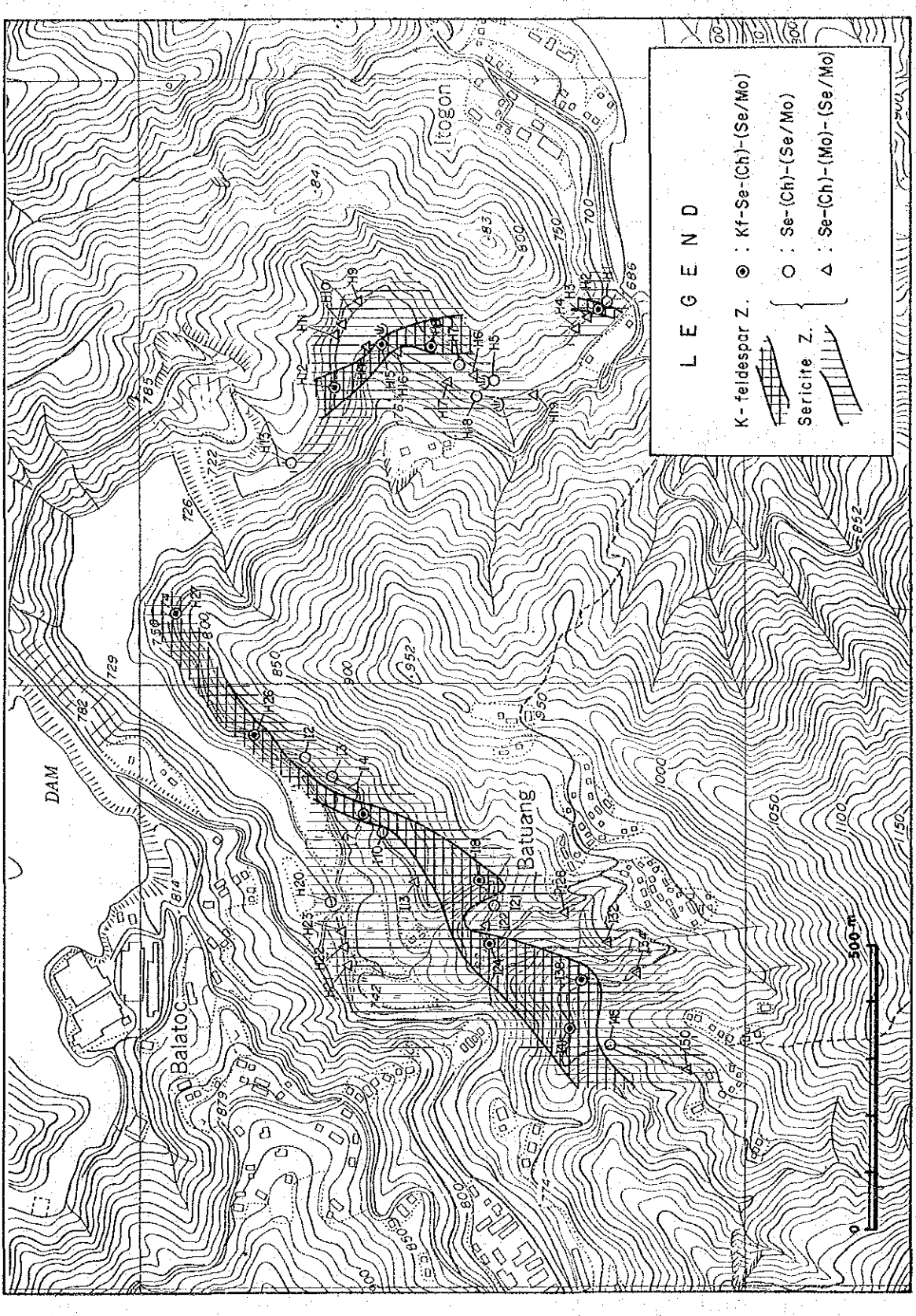

Fig. Ⅲ-1-6(b) Distribution of Alteration Minerals
(Neutral Hydrothermal Alteration Zone)

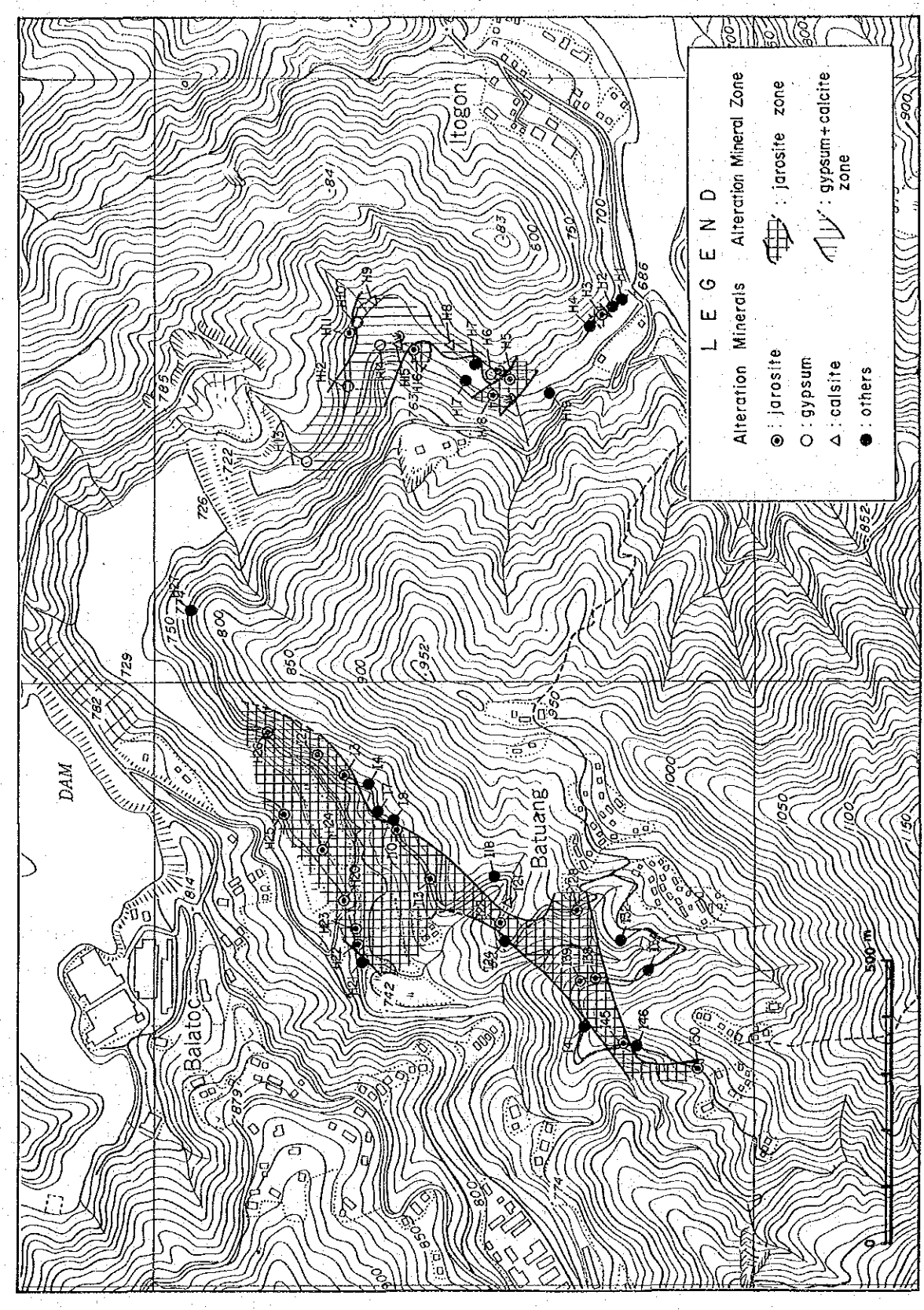

Fig. Ⅲ-1-6(c) Distribution of Alteration Minerals
(Jarosite Zone and Gypsum + Calcite Zone)

Both types of alteration tend to co-exist around Balatoc and Batuang. The distribution of jarosite has widely extent (Fig. III–1–6c) and localized along the northeast southwest fractures which runs almost parallel to the gold vein system of Acupan-Itogon mine area.

1.6 Geological Structure

On a regional scale, the survey area is situated at boundary between the western side of the north-south trending central uplift zone and the eastern periphery of the west downthrown block. As mentioned before, the area is generally characterized by the intersection of the north-south, northeast-southwest and northwest-southeast faults.

Folding is also recognized in the Dalupirip schists and the Miocene Sedimentary Rocks

1.6.1 Fold Structure

In the Dalupirip schists, the anticlinal axis is north-south which runs parallel to the intrusional trend of the Itogon quartz diorite. This anticlinal structure could have been formed during the uplift of the central Cordillera by the combined effect of plutonic-Tectonic events in the past.

The northeast-southwest trending anticlines and synclines with intervals of 300–400 meters are found in the Miocene Volcano-Sedimentary Complex. The fold axes plunge to the northeast. The fold structures do not conform with the trend of intrusion of the Itogon quartz diorite. The folding of the Miocene sediments could have been formed by the later crustal movement which generated compressional stresses coming from the northwest and southeast.

1.6.2 Fault Structure

Three sets of faults are defined in the survey area: The first has north-south trend; and the second and third are conjugate fault system trending northeasterly and northwesterly, respectively.

The north-south fault system dissects the northeastern part of the area. The fracture zone (50–100 meter in width) represents the geologic boundary between the Dalupirip schist and the Itogon quartz diorite. This structural contact generally has a north-south strike. It extends to the north running parallel to the fold axis of the schist.

The northeast-southwest structures are defined in Balatoc-Acupan mine area and its vicinity. The fault strikes are parallel to the direction of the gold veins system of Acupan mine. The well defined northeasterly trending fault cutting through the Batuang area is called the 'Star Fault'. Horsetailing mineralized vein system of the Star Fault are presently being explored for gold by Benguet Corporation.

1.6.3 Fractures

Post-Pliocene andesitic dikes and quartz veins related to mineralization are observed the survey area. A fracture analysis of the structures has been undertaken.

Locations of the dikes and quartz vein identified in the geological survey are shown in Fig. III–1–7. Figs. III–1–8 and III–1–10 show the projected dikes on the Wulff net for the dikes and quartz veins, respectively. Figs. III–1–9 and III–1–11 are the Rose diagrams showing the frequencies of the strikes.

On the basis of these figures, the following prominent dip and strike for dikes are obtained: from the Wulff net, the dominant dip is 90° north-south; and from the rose diagram the prominent strikes are N70E, N40E, N50W, EW and NS.

ACUPAN—ITOGON

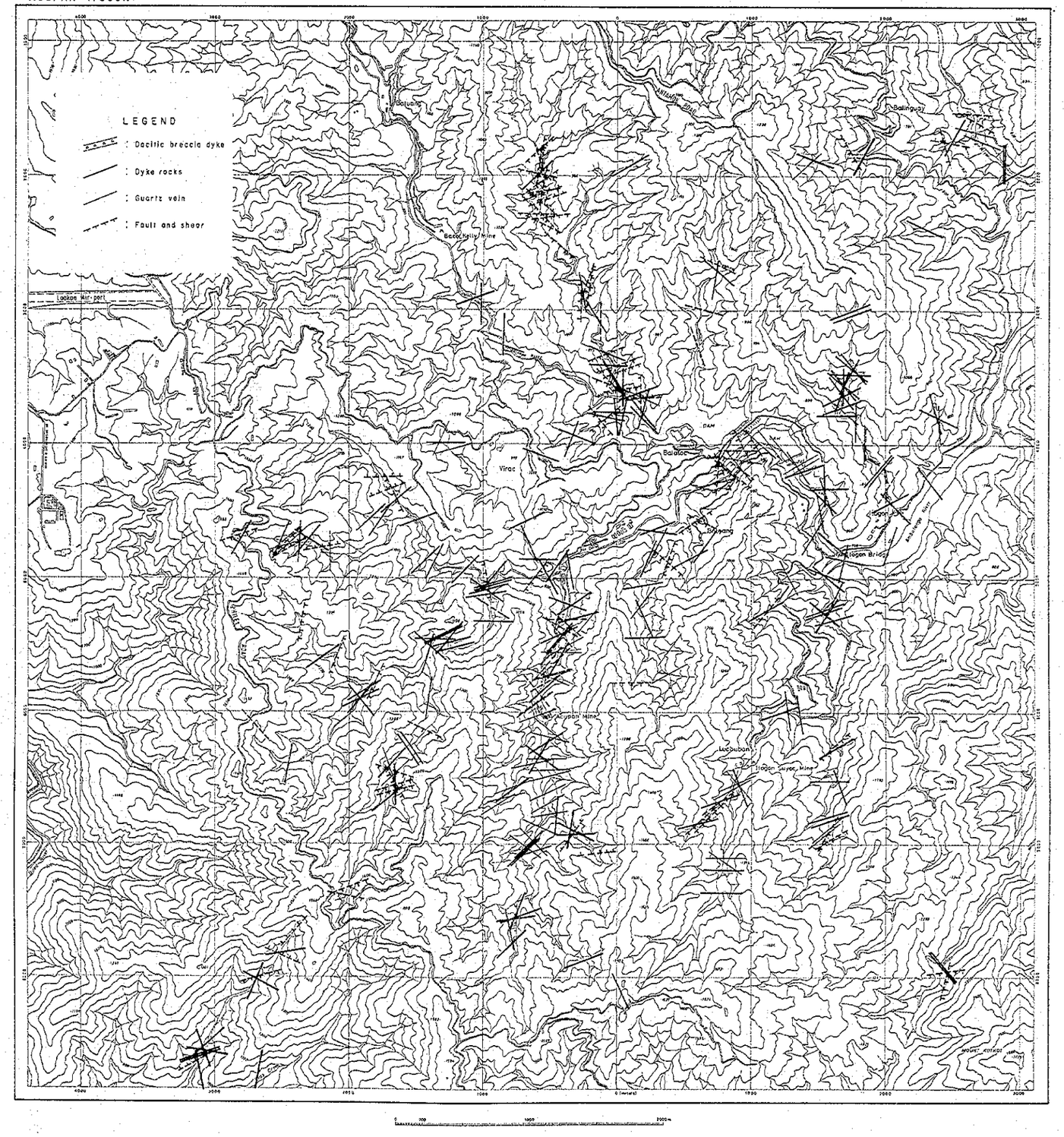

Fig. Ⅲ-1-7 Distribution of Dyke Rocks, Quartz Veins and Fractures

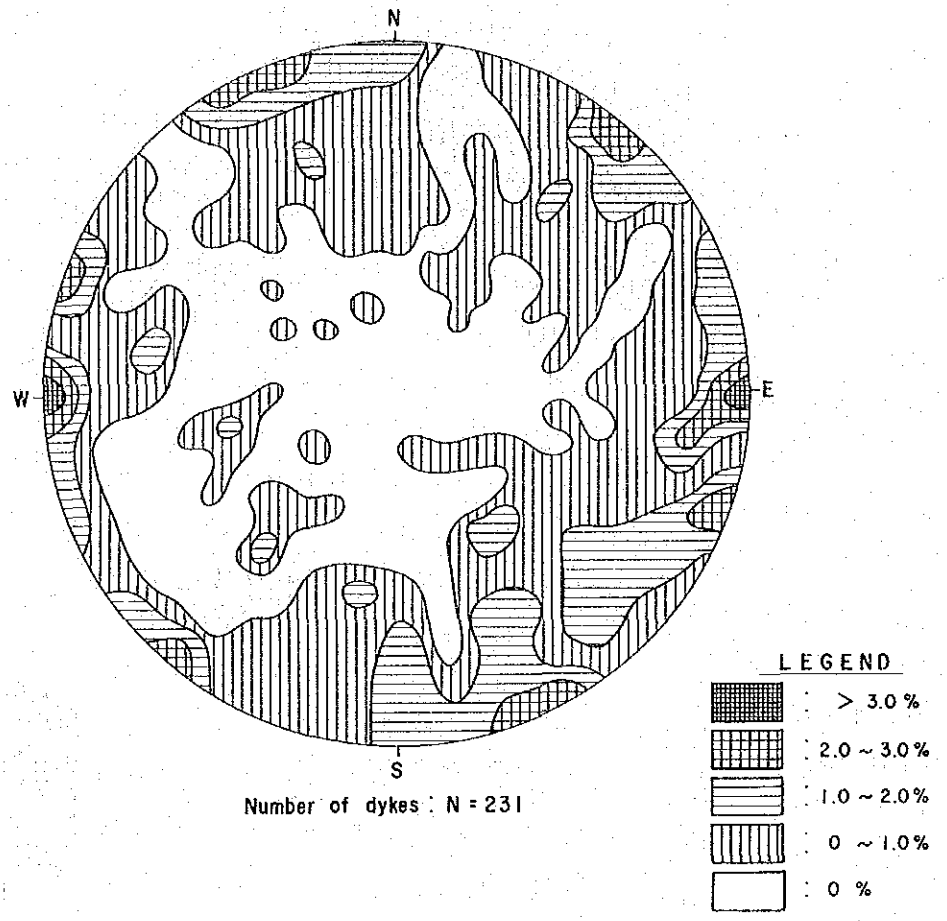

Fig. Ⅲ-1-8 Frequency Distribution Diagram of Dyke Rocks

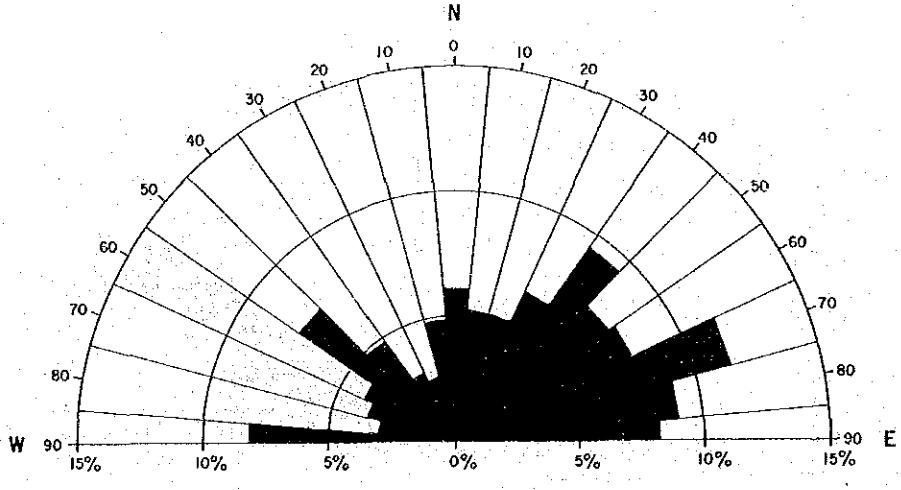

Fig. Ⅲ-1-9 Rose Diagram of Dyke Rocks

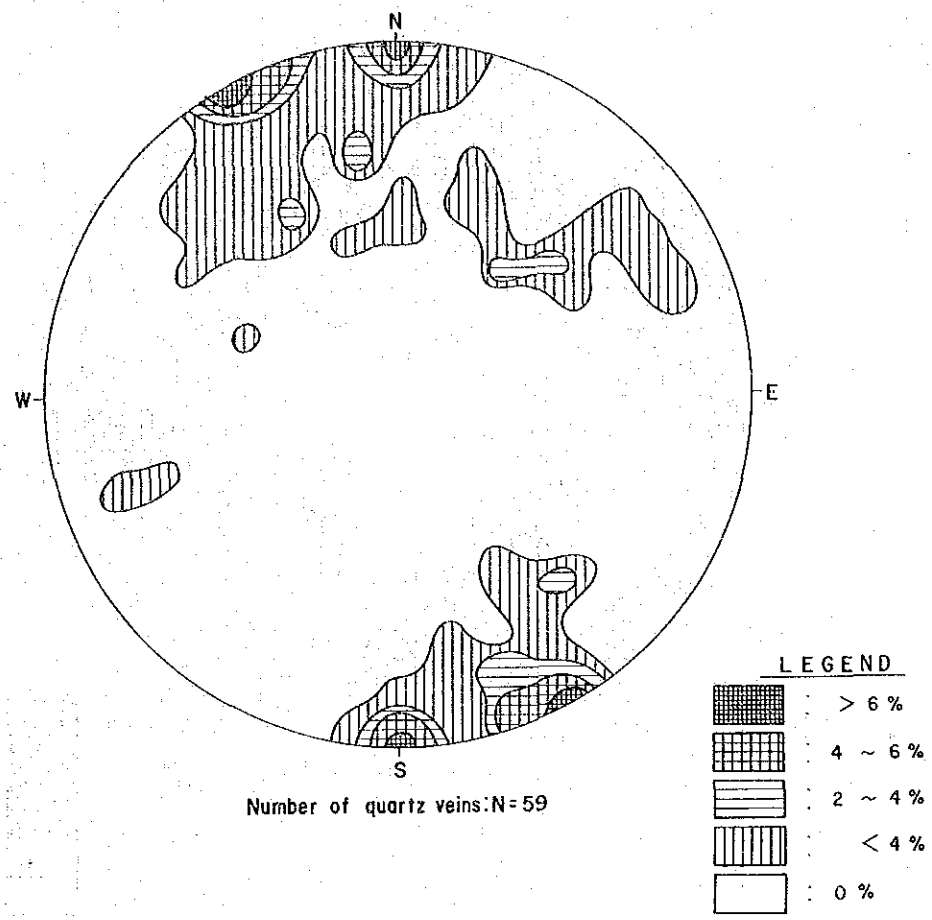

Fig. Ⅲ-1-10 Frequency Distribution Diagram of Quartz Veins

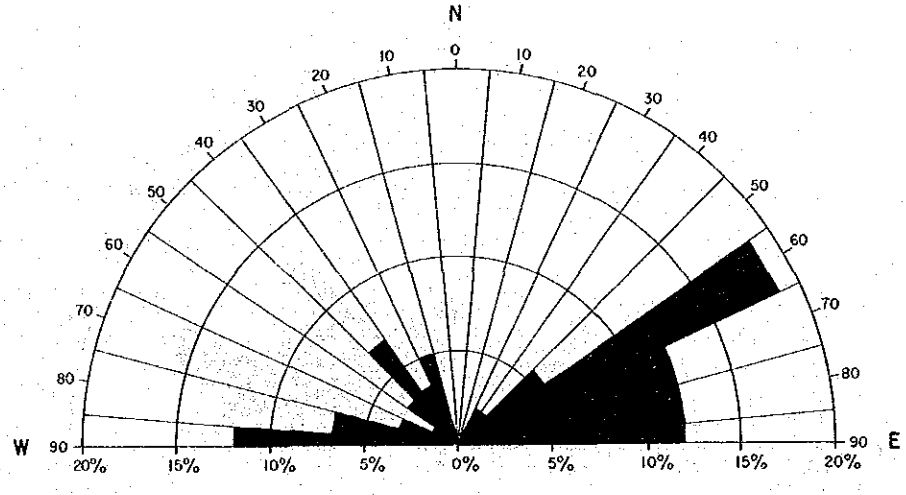

Fig. Ⅲ-1-11 Rose Diagram of Quartz Veins

As to the quartz veins, prominent dip obtained from the Wulff net are almost vertical (90°); the less prominent ones range from 70° to 60° to the south. Prominent direction of the strikes obtained from the Rose diagram are N60°E, EW, N70°E and N40°W in the order of frequency.

Assuming that these prominent directions of dikes and quartz veins reflect the basic fracture systems of the area, the estimated fracture structure is given below:

(a) The NS fracture system are estimated from the dominant trend of the dikes occurring within the central part of the survey area. The occurrence of the dikes are at intervals of 400–1000 meters. The NS trending dikes however are not very widespread in occurrence in the Itogon quartz diorite and Antamok diorite;

(b) The northeasterly fracture system cut into the Virac granodiorite and Andesite complex, which is observable within the area bounded by the dacite plugs of Acupan and Itogon. Fractures of the same system also partially extend into the Antamok diorite and Itogon quartz diorite. These fractures run parallel to the Acupan quartz-gold veins system which are generally localized around and inside the Balatoc Plug; and

(c) The northwest-southeast dikes are found concentrated mainly in the northeastern part of the survey area.

1.7 Considerations

Regional geological structure in the northern part of the Luzon Island is characterized by the NS fault block and the intersections of the conjugate northeasterly and northwesterly trending fractures. The said NS block comprises the central uplift and downthrown sections. The Acupan-Itogon area is located within the transitional zone of the central uplift and the west downthrown blocks.

The central uplift zone is composed of the Late Cretaceous Dalupirip schists, Late Oligocene Antamok diorite and Miocene Itogon quartz diorite. The west

downthrown section is underlain by Miocene Sedimentary Rocks. The Early Pliocene Virac granodiorite and Late Pliocene Andesite Complex are widely distributed at the central part of the area.

The geological setting in the area is marked mainly by north-south and northeast-southwest trending and fold structures with northeast-southwest trend. On the basis of strike frequencies of dikes and mineralized quartz veins, it may be inferred that the north-south, northeast-southwest and northwest-southeast fracture systems control the geological emplacement of the Virac granodiorite, Andesite Volcanics, dikes and plugs in Acupan area. The geological structures in the area are shown in Fig. III–1–12.

The trend of the lithological contact of the Miocene-Sedimentary Rocks exposed at the western part of the downthrown section, exhibited a north-south trend at its southern part; northeast-southwest trend at the central part; and northwest-southeast trend at the northern part. The contacts could be atrributed to the structural boundary of faults having the same directions.

Based on the analysis of the faults and dikes distribution in the area, the development of significant structural network seems to be concentrated within the transition zone centrally located at the lithological boundaries between the Andesite Complex and Virac granodiorite; and the Antamok-Itogon diorite and Andesite Complex. It is inferred that the igneous activities are mainly controlled by the north-south, northeast-southwest and northwest-southeast trending fracture system as evidenced by the alignment of dacite/andesite breccia plugs found in the Acupan Mine, Itogon Bridge and along Kennon Road which are generally localized at the intersection of north-south, northwest-southeast and the northeasterly trending conjugate faults.

Similarly, the geothermal manifestations in the area such as hot springs or thermally altered grounds are closely related to the northeast-southwest faults which develop in and around the plugs. It may be said that upheavals of the central uplift zone as well as the associated structures have induced the hypabyssal intrusion of the Pleistocene dacite plug, considered as the possible heat source of the geothermal system in Acupan-Itogon prospect area.

ACUPAN-ITOGON

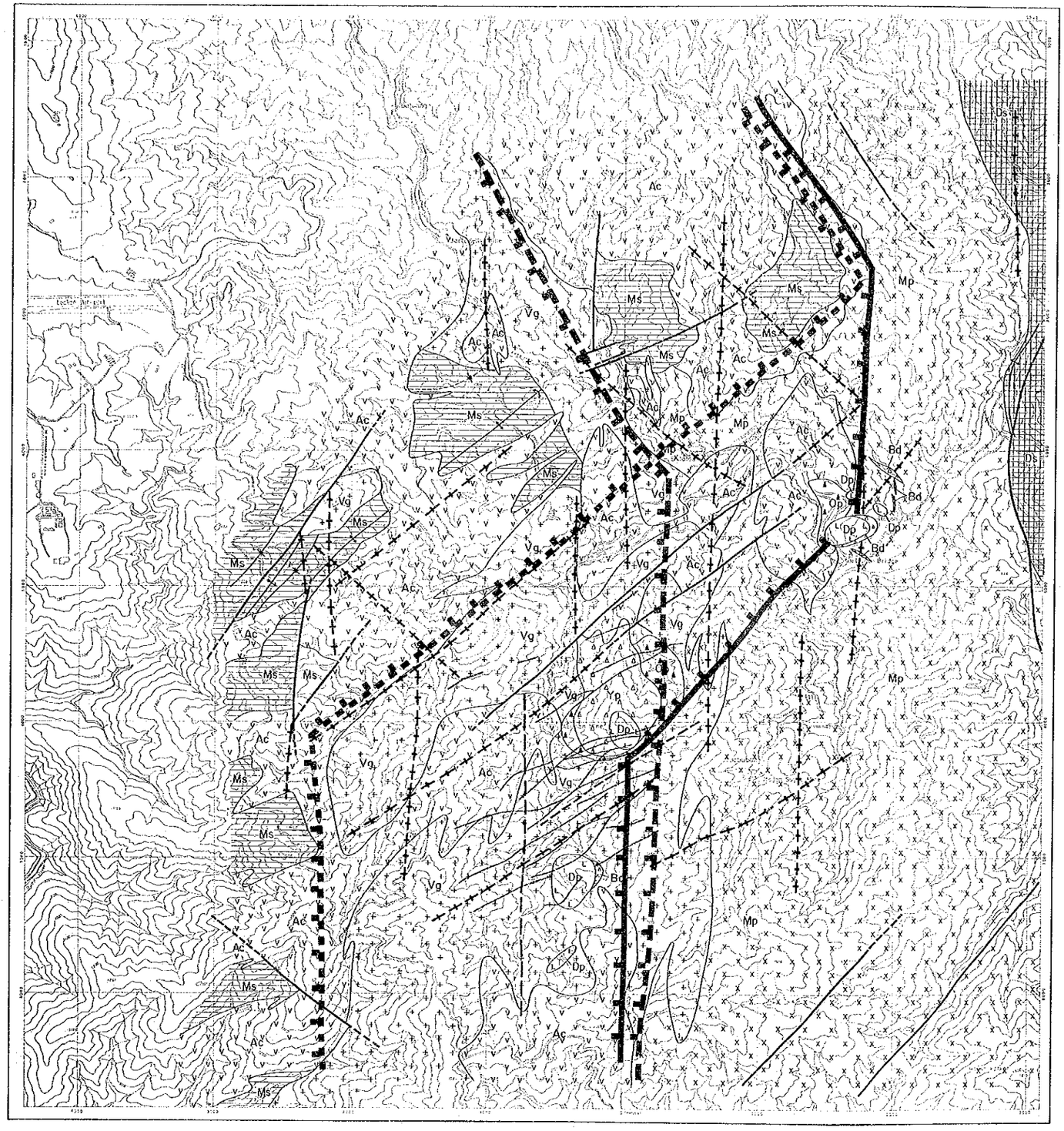

Fig. Ⅲ-1-12 Schematic Tectonic Map

2. GEOCHEMICAL SURVEY

2 GEOCHEMICAL SURVEY

2.1 Purpose of the Survey

In the project Phase-I, the respective surveys and exploration were carried out on an introductory basis and the potential of such endeavors were reviewed. At the same time, existing data were gathered and the geothermal system underground was evaluated through a comprehensive analysis of those data. The purpose of the Phase-II activity was to undertake detailed geochemical survey on the delineated ten (10) kilometer square prospective area with a view of reconstructing the geochemical model of the geothermal system in Acupan-Itogon prospect. The survey includes the following:

(a) Ground geochemical survey (199 stations);
- soil temperatures;
- mercury concentration in soil; and
- radon gas concentration in soil-air.

(b) O/H isotope analysis of hot spring water (15 samples).

2.2 Methodology

2.2.1 Ground Geochemical Survey

The survey area was grid with 250 meters spacing. Each grid station was set up along roads, ridges and creeks, and located far from artificial structures. The location of every survey station was plotted on a topographic map with a scale of 1:10,000. The elevation of each station based on the topographic map and ground control, slope, vegetation, air temperature, etc. were entered in the data sheet.

(a) Soil temperature measurement: The method is the most direct way to detect anomalous heat flux to the surface brought about by geothermal activity underneath. Since the method is simple and economical, it is one of the exploratory

tools that have long been used. It is, however, occasionally influenced by irregular or unusual phenomena near the ground surface.

In this survey, the method was used to possibly delineate the extent of geothermal anomaly in Acupan-Itogon. At each station, the ambient temperature was measured. A hole was drilled with hand auger for the measurment of soil temperature, initially at the depth of 60 centimeters (Table III–2–1). A thermistor sensor (Type D-611) was inserted about 20–30 millimeter into the bottom of the hole and was kept standing for 3–5 minutes until the bottom temperature stabilized. The temperature indicated in the digital meter was recorded. Then, the hole was deepened to 100 centimeters and the bottomhole temperature was measured in the same manner as above.

The daily variation in the bottom temperature at the base point was monitored during the period October 6 to November 21. The effect of elevation differences upon soil temperatures was also studied.

(b) Determination of Mercury content in soil: It is generally said that the quantity of mercury in surface soil of non-geothermal field is 0.002–0.005 ppm. In the case of geothermal field, the quantity is 100–1,000 times more concentrated. These unusual figures are considered to be indications of underground geothermal fluid and a good fracture system which serves as channelway for ascending thermal fluid. However, the concentration of mercury in soil reflects the sum result of its dissipation and accumulation with time, and does not always indicate the present underground activities.

The residual soil formation is generally poor in the survey area, and as such, it was difficult to obtain samples from the A_1 horizon. Hence, sampling was carried out in bulk of more than 500 grams from a depth of 10–20 centimeters below the surface excluding the A_0 horizon (humic layer). The sampling date, sample number, soil color, dryness, size of soil particles, etc. were noted. The soil samples were put in sealed vinyl bags and were kept in a dark place. The bags were then transported to the BED laboratory in Manila where the samples were air-dried in preparation for mercury analysis.

Mercury Analysis: After the collected soil was air-dried for 1–2 weeks, sorting was made using Tyler's sieve of 80-mesh.

The following are the pre-treatments done on the samples prior to the analysis:

(i) Two (2) grams of the 80-mesh sieved sample is put in a beaker. Twelve (12) millimeter of nitric acid and sulfuric acid (HNO_3 and H_2SO_4 in the proportion of 2:1) and 5 ml. of potassium permanganate solution (5% KM_nO_4) are added to the sample.

(ii) The beaker is placed in a water bath at 50–60°C for two hours. The color of potassium permanganate is maintained by the addition of the save every time that the color disappears.

(iii) The content is cooled to room temperature and 2–3 drops of hydrozylamine hydrochloride (30% $NH_2OH \cdot HCl$) solution are added.

(iv) The solution is transferred to a 100 ml. measuring flask, and water is added to dilute the solution to the 100 ml.

(v) After shaking the flask thoroughly, the solution is filtered using No. 2 filter paper.

(vi) 10–50 ml. of the filtrate is transferred to a flask, and the total volume is made 105 ml. with the addition of water.

(vii) Ten (10) ml of reducing liquid is added to the solution, which will be used for the measurement. [To prepare the reducing liquid, 50 mg. of stannous chloride ($SnCl_2 \cdot 2H_2O$) is completely dissolved in 130 ml. of sulfuric acid solution (H_2O and H_2SO_4 in the proportion of 1:1); then water is added to make the solution to 200–300 ml. and allowed to stand until it becomes clear. The solution is made up to a final volume of 500 ml. with water]. The flask containing the filtrate and recuding liquid is

set in the mercury analyzer (Hiranuma HG-1 type) and the mercury content is determined.

The following are the specifications of the analytical equipment:

Measurement method: Mercury analysis by reduction-aeration method.

Luminous source: Low-voltage mercury vapor lamp.

Luminous receiver: Photoelectric tube

Detection sensitivity: 0.005 μg.

Accuracy of repeated measurements: 3% or less

Full scale: 0.5, 1, 2, 3, and abs. 1 (five-step changeover)

Output terminal: 10 mV full scale (for recorder)

Power source: AC 100 V ± 10 V

(c) Determination of Radon Gas

content in soil-air: Radon (atomic weight 222) is produced as alpha decay product of Radium (atomic weight 236) in the course of radioactive disintegration of Uranium (atomic weight 238). Theoretically, the origin of Radon is attributed to Radon in groundwater (Horiuchi and Murakami, 1978) or in granites (Belir, 1959; Sugihara, 1978), although its distribution is greatly influenced by variations in geological nature. Nevertheless, anomaly in Radon gas occurs immediately above the geothermal system and is controlled by fracture systems because of its short half-life and comparatively small dispersion.

The Radon track-etch cup, a product of Terradex Corporation, U.S.A., was used for the measurement of Radon gas being emitted from the ground. The cup was buried inside a hole of 60 cm. depth drilled by hand auger (Fig. III–2–2). Easily

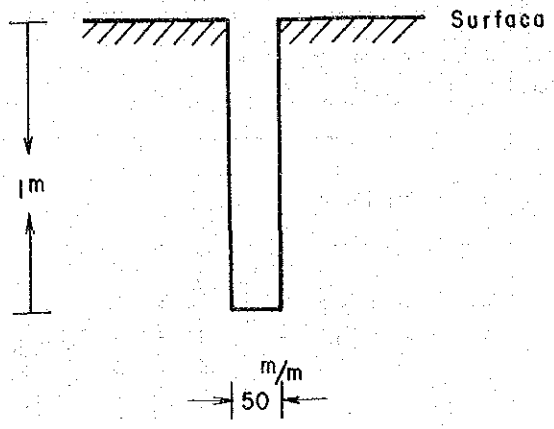

Fig. Ⅲ-2-1 Profile of Hole for Temperature Measurement

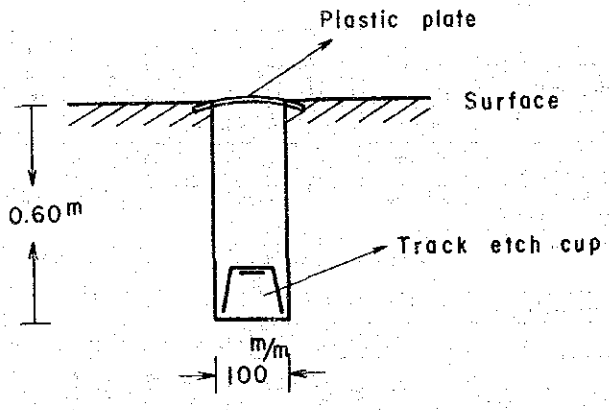

Fig. Ⅲ-2-2 Planting of Track Etch Cup

Table Ⅲ-2-1 Geochemical Data Sheet for 1-m Depth Measurements

No. 1

Point Sample No.	Date		Nos. of Days Exposed	Rn. Cup No.	Cup Recovered					Temperature (℃)		Sample Appearance												Geology	Topography						Vegetation		
												Soil Colour					Humidity Block					Grain size			Elevation (m)	Slope							
	measurement of 1m depth temp.	Rn. cup recovered			fine	disturbed	dirty	dewed	submerged	ambient	bottom (60cm-depth /1m-depth)	black	blackish brown	brown	reddish brown	yellowish brown	wet	intermediate	dried	many	few	none	sandy	clayey			flat	moderate	steep	dipping	sunniness	forestal	grassy	naked rock
1	Oct. 6. 83 8:41	Nov. 2. 83	27	566361	○					24.1	23.3/22.3			○					○	○			○		andesite porphyry	1140			○	N	○		○	○
2	Oct. 6. 83 9:50	Nov. 2. 83	27	566363	○					30.5	24.7/25.1				○			○				○		○	conglo, Pyroclasitic rock	1065			○	S	◎	○	○	
3	Oct. 6. 83 9:25	Nov. 2. 83	27	566362	○					23.4	22.4/22.7			○					○		○		○		andesite porphyry	1075		○		N	○		○	○
4	Oct. 6. 83 10:00	Nov. 2. 83	27	566364	○					29.0	24.5/24.7				○			○				○		○	conglo, Pyroclasitic rock	1050			○	S	◎	○	○	
5	Oct. 7. 83 8:28	Nov. 3. 83	27	566351					○	24.7	24.8/24.4				○			○			○			○	andesite porphyry	1100		○		SE	◎	○	○	
6	Oct. 7. 83 8:56	Nov. 3. 83	27	566352	○					25.1	24.2/24.1				○			○		○			○		andesite porphyry	1090			○	NE	◎	○	○	
7	Oct. 6. 83 10:15	Nov. 2. 83	27	566365				○		30.3	26.1/25.9				○			○				○		○	conglo, Pyroclasitic rock	1040		○		S	◎	○	○	
8	Oct. 17. 83 8:34	Nov. 8. 83	22	566438	○					25.8	23.4/23.5				○			○			○			○	andesite porphyry	1050			○	NE	◎	○		
9	Oct. 7. 83 9:20	Nov. 3. 83	27	566353		○			○	23.5	22.8/22.8				○			○			○			○	andesite porphyry	1085			○	NE	○	○	○	
10	Oct. 7. 83 9:35	Nov. 3. 83	27	566354	○					27.7	24.2/24.1			○				○			○		○		andesite porphyry	1075			○	S	◎	○	○	
11	Oct. 6. 83 10:50	Nov. 2. 83	27	566347				○		29.5	27.3/26.8				○			○				○		○	conglo, Pyroclasitic rock	1000		○		E	◎		○	
12	Oct. 6. 83 10:30	Nov. 2. 83	27	566366				○		31.8	26.8/26.8				○			○				○		○	conglo, Pyroclastic rock	1010		○		SE	◎		○	
13	Oct. 17. 83 8:46	Nov. 8. 83	22	566439	○					26.5	23.2/23.2				○			○				○		○	andesite porphyry	1000			○	SE	○		○	
14	Oct. 7. 83 10:10	Nov. 3. 83	27	566356	○					27.6	24.5/24.7				○			○			○			○	andesite porphyry	1040			○	E	◎	○	○	
15	Oct. 7. 83 9:50	Nov. 3. 83	27	566355		○			○	29.6	25.3/25.4				○			○		○			○		andesite porphyry	1060			○	N	◎	○	○	
16	Oct. 24. 83 11:24	Nov. 17. 83	24	566481	○					28.4	22.4/23.2		○					○		○			○		andesite porphyry	940			○	SE	○	○	○	
17	Oct. 6. 83 11:15	Nov. 2. 83	27	566368				○		30.2	27.6/26.3					○		○				○		○	andesite porphyry	995	○			S	◎		○	
18	Oct. 6. 83 12:35	Nov. 2. 83	27	566369				○		30.8	26.1/26.3				○			○				○		○	conglo, Pyroclasitic rock	990			○	E	◎		○	
19	Oct. 17. 83 9:20	Nov. 8. 83	22	566440				○		26.6	25.3/25.9				○			○				○		○	conglo, Pyroclastic rock	1005			○	N	○	○	○	
20	Oct. 7. 83 10:43	Nov. 3. 83	27	566357				○		26.5	27.8/26.7				○			○				○		○	granodiorite	995			○	SE	◎	○	○	

◎ : much ○ : common × : little

Point Sample No.	Date		Nos. of Days Exposed	Rn. Cup No.	Cup Recovered					Temperature (°C)		Sample Appearance											Geology	Topography						Vegeta-tion		
												Soil Colour					Humidity		Block			Grain size			elevation (m)	Slope			dipping	sunniness			
	measure-ment of 1m depth temp.	Rn. cup recovered			fine	disturbed	dirty	dewed	submerged	ambient	bottom (60cm-depth /1m-depth)	black	blackish brown	brown	reddish brown	yellowish brown	wet	intermediate	dried	many	few	none	sandy	clayey			flat	moderate	steep			forestal	grassy	naked rock
21	Oct. 7. 83 11:01	Nov. 3. 83	27	566358				○		28.2	26.0/25.5			○				○			○		○		granodiorite	950			○	SW	◎	○		
22	Oct. 24. 83 11:50	Nov. 17. 83	24	566482	○					27.3	24.0/24.6		○					○		○	○		○		granodiorite	910			○	NW	◎		○	
23	Oct. 24. 83 12:45	Nov. 17. 83	24	566484				○		29.3	23.6/24.2		○					○		○			○		granodiorite	950			○	W	◎		○	
24	Oct. 24. 83 13:55	Nov. 17. 83	24	566485	○					28.5	22.5/22.2			○				○			○			○	granodiorite	970			○	NW	◎	○	○	
25	Oct. 10. 83 11:00	Nov. 4. 83	25	566381				○		25.2	21.8/22.0				○			○			○		○		granodiorite	1185	○			NE	○	○	○	
26	Oct. 10. 83 10:40	Nov. 4. 83	25	566380				○		23.6	22.8/23.2			○				○			○		○		andesite porphyry	1225	○			N	◎	○		
27	Oct. 10. 83 10:00	Nov. 4. 83	25	566377				○		24.7	24.0/24.9				○			○			○		○		andesite porphyry	1320		○		N	◎	○	○	
28	Oct. 10. 83 9:40	Nov. 4. 83	25	566376	○					24.0	23.0/23.1			○				○				○	○		andesite porphyry	1350		○		N	◎	○	○	
29	Oct. 10. 83 9:00	Nov. 4. 83	25	566374				○		20.1	21.6/21.5			○				○				○	○		andesite porphyry	1380			○	W	◎	○	○	
30	Oct. 18. 83 8:32	Nov. 9. 83	22	566426	○					24.6	23.2/23.7			○				○			○			○	granodiorite	910			○	N	◎		○	
31	Oct. 6. 83 12:58	Nov. 2. 83	27	566370				○		29.6	24.0/24.2				○			○				○		○	andesite rock	960			○	S	◎	○	○	
32	Oct. 17. 83 9:40	Nov. 8. 83	22	566421				○		28.3	26.7/26.7				○			○				○		○	granodiorite	1010		○		E	◎		○	
33	Oct. 17. 83 9:58	Nov. 8. 83	22	566422	○					32.7	25.4/25.4			○					○			○	○		granodiorite	980			○	S	◎		○	
34	Oct. 7. 83 11:30	Nov. 3. 83	27	566359			○			29.0	24.0/24.2					○		○		○			○		granodiorite	890			○	SW	◎			○
35	Oct. 10. 83 13:25	Nov. 4. 83	25	566386				○		28.7	24.3/25.3		○					○			○		○		granodiorite	1000			○	NE	◎		○	
36	Oct. 10. 83 13:10	Nov. 4. 83	25	566385				○		31.7	25.7/25.4			○				○			○		○		granodiorite	1050			○	NE	◎		○	
37	Oct. 10. 83 11:35	Nov. 4. 83	25	566383				○		27.7	24.2/23.6		○					○			○		○		granodiorite	1100		○		NE	◎		○	
38	Oct. 10. 83 11:15	Nov. 4. 83	25	566382				○		28.0	22.8/22.7			○				○			○		○		granodiorite	1140		○		NE	○	○	○	
39	Oct. 10. 83 10:30	Nov. 4. 83	25	566379				○		26.1	23.1/23.0			○				○		○			○		andesite porphyry	1240		○		N	◎	○	○	

◎ much ○ : common × : little

Point Sample No.	Date		Nos. of Days Exposed	Rn. Cup No.	Cup Recovered					Temperature (°C)		Sample Appearance												Geology	Topography						Vegeta-tion		
												Soil Colour					Humidity			Block			Grain size				Slope						
	measure-ment of 1m depth temp.	Rn. cup recovered			fine	disturbed	dirty	dewed	submerged	ambient	bottom (60cm-depth /1m-depth)	black	blackish brown	brown	reddish brown	yellowish brown	wet	intermediate	dried	many	few	none	sandy	clayey		elevation (m)	flat	moderate	steep	dipping	sunniness	forestal	grassy	naked rock
40	Oct. 10. 83 10:20	Nov. 4. 83	25	566378				○		24.1	24.6/24.6				○			○			○		○		andesite porphyry	1270		○		E	◎	○	○	
41	Oct. 10. 83 9:21	Nov. 4. 83	25	566375				○		23.6	23.3/23.3		○					○			○			○	andesite porphyry	1340			○	E	◎	○	○	
42	Oct. 18.83 9:25	Nov. 9. 83	22	566427	○					33.4	26.4/26.2		○					○			○			○	granodiorite	840			○	E	◎		○	
43	Oct. 6. 83 13:34	Nov. 2. 83	27	566372			○			32.8	26.4/26.2			○				○				○		○	andesite porphyry	920			○	N	◎	○	○	
44	Oct. 6. 83 13:19	Nov. 2. 83	27	566371			○			28.2	23.9/23.2					○		○			○			○	andesite porphyry	930			○	N	○	○	○	
45	Oct. 17. 83 10:30	Nov. 8. 83	22	566423	○					30.4	25.0/25.4			○					○			○	○		andesite porphyry	900			○	SE	◎		○	
46	Oct. 17. 83 11:30	Nov. 8. 83	22	566425			○			23.2	23.5/23.2			○				○			○			○	andesite porphyry	810			○	S	○	○	○	
47	Oct. 7. 83 12:00	Nov. 3. 83	27	566360			○			29.8	24.2/ –			○				○			○			○	granodiorite	860			○	SE	◎			○
48	Oct. 14. 83 13:51	Nov. 8. 83	25	566437	○					27.8	23.4/23.9		○					○			○			○	granodiorite	880			○	W	○	○		
49	Oct. 14. 83 13:05	Nov. 8. 83	25	566435			○		○	28.2	23.6/24.0		○					○			○			○	granodiorite	910			○	NE	○		○	
50	Oct. 14. 83 12:25	Nov. 8. 83	25	566433	○					30.4	23.0/23.3		○					○			○			○	granodiorite	910			○	N	○		○	
51	Oct. 14. 83 11:30	Nov. 8. 83	25	566432	○					28.8	23.7/23.8		○					○			○			○	andesite porphyry	950			○	W	○		○	
52	Oct. 24. 83 9:25	Nov. 17. 83	24	566467	○					26.1	23.2/23.9					○		○			○			○	andesite porphyry	1105	○			N	◎		○	
53	Oct. 14. 83 10:03	Nov. 8. 83	25	566399			○		○	28.8	22.6/23.0		○					○			○			○	andesite porphyry	1080			○	NE	◎		○	
54	Oct. 14. 83 9:30	Nov. 8. 83	25	566398	○					25.9	22.7/22.9			○				○			○			○	granodiorite	1110			○	N	◎		○	
55	Oct. 18. 83 9:47	Nov. 18. 83	22	566428	○					29.9	23.1/ –			○				○			○			○	diorite	780			○	NE	◎		○	
56	Oct. 6. 83 13:51	Nov. 2. 83	27	566373				○		27.0	22.9/23.4			○					○		○			○	granodiorite	900			○	NE	○	○	○	
57	Oct. 18. 83 11:51	Nov. 9. 83	22	566443	○					31.0	24.5/24.6		○					○			○			○	andesite porphyry	855			○	SE	◎		○	
58	Oct. 18. 83 12:11	Nov. 9. 18	22	566444	○					33.4	25.0/24.8			○				○			○			○	andesite porphyry	830			○	SE	◎	○	○	

◎ : much ○ : common × : little

Point Sample No.	Date		Nos. of Days Exposed	Rn. Cup No.	Cup Recovered					Temperature (°C)		Sample Appearance											Geology	Topography					Vegetation		
												Soil Colour					Humidity			Block			Grain size				Slope				
	measurement of 1m depth temp.	Rn. cup recovered			fine	disturbed	dirty	dewed	submerged	ambient	bottom (60cm-depth/1m-depth	black	blackish brown	brown	reddish brown	yellowish brown	wet	intermediate	dried	many	few	none	sandy	clayey		elevation (m)	flat	moderate	steep	dipping	sunniness	forestal	grassy	naked rock
59	Oct. 17. 83 10:47	Nov. 8. 83	22	566424				○		32.7	25.3/25.6			○					○	○			○		andesite porphyry	820			○	S	◎	○	○	
60	Oct. 12. 83 13:25	Nov. 12. 83	26	566410				○		27.0	26.0/26.4		○					○		○			○		granodiorite	960	○			N	◎		○	
61	Oct. 14. 83 13:35	Nov. 14. 83	25	566436	○					28.5	23.9/24.5			○				○		○			○		andesite porphyry	910			○	E	◎		○	
62	Oct. 14. 83 12:55	Nov. 14. 83	25	566434	○					29.3	23.4/23.6		○					○		○			○		granodiorite	920			○	W	◎		○	
63	Oct. 24. 83 8:55	Nov. 17. 83	24	566465	○					24.3	22.3/22.4			○				○		○				○	andesite porphyry	1190			○	E	◎		○	
64	Oct. 24. 83 9:15	Nov. 17. 83	24	566466				○		31.6	23.2/23.2			○				○			○			○	andesite porphyry	1100	○			E	◎	○	○	
65	Oct. 14. 83 10:45	Nov. 14. 83	25	566431	○					29.1	23.3/23.3			○				○		○			○		granodiorite	1000			○	E	◎	○		
66	Oct. 14. 83 10:25	Nov. 14. 83	25	566400	○					26.3	23.3/23.9			○				○		○			○		granodiorite	1030			○	N	○	○		
67	Oct. 19. 83 8:30	Nov. 9. 83	21	566445				○		26.7	25.6/27.4			○				○		○			○		quartz diorite	800			○	S	◎	○	○	
68	Oct. 18. 83 11:31	Nov. 9. 83	22	566442	○					27.7	23.6/23.7			○				○				○	○		granodiorite	880			○	N	○		○	
69	Oct. 18. 83 11:19	Nov. 9. 83	22	566441	○					28.7	24.3/24.7			○				○		○				○	granodiorite	870			○	E	○		○	
70	Oct. 12. 83 14:15	Nov. 7. 83	26	566412			○		○	25.0	23.6/24.6	○						○			○			○	granodiorite	850			○	N	○	○		
71	Oct. 12. 83 13:50	Nov. 7. 83	26	566411			○		○	24.2	24.3/25.1		○					○		○			○		granodiorite	900			○	N	◎	○	○	
72	Oct. 12. 83 13:05	Nov. 7. 83	26	566409				○		29.0	22.9/25.5			○				○		○			○		granodiorite	1010	○			N	◎		○	
73	Oct. 12.83 12:50	Nov. 7. 83	26	566408				○		22.9	22.9/23.1			○				○		○			○		andesite porphyry	1070			○	N	◎		○	
74	Oct. 12. 83 12:35	Nov. 7. 83	26	566407				○		24.0	23.1/23.4		○					○		○				○	andesite porphyry	1200		○		N	◎		○	
75	Oct. 12. 83 12:10	Nov. 7. 83	26	566405				○		25.3	22.8/22.9				○			○			○			○	andesite porphyry	1210		○		N	◎	○	○	
76	Oct. 12. 83 11:20	Nov. 7. 83	26	566404				○		22.9	22.3/22.7				○			○			○			○	andesite porphyry	1100			○	SW	◎	○	○	
77	Oct. 14. 83 9:10	Nov. 8. 83	25	566397	○					23.8	23.6/24.5			○				○		○			○		granodiorite	1040			○	SE	◎		○	

◎ : much ○ : common × : little

Point Sample No.	Date		Nos. of Days Exposed	Rn. Cup No.	Cup Recovered					Temperature (°C)		Sample Appearance											Geology	Topography					Vegetation		
												Soil Colour					Humidity			Block			Grain size				Slope				
	measurement of 1m depth temp.	Rn. cup recovered			fine	disturbed	dirty	deved	submerged	ambient	bottom (60cm-depth)/(1m-depth)	black	blackish brown	brown	reddish brown	yellowish brown	wet	intermediate	dried	many	few	none	sandy	clayey		elevation (m)	flat	moderate	steep	dipping	sunniness	forestal	grassy	naked rock
78	Oct. 18. 83 10:28	Nov. 8. 83	22	566429	○					32.2	24.6/25.6			○				○				○		○	andesite porphyry	805			○	SE	◎		○	
79	Oct. 18. 83 11:00	Nov. 9. 83	22	566430	○					27.9	24.4/24.3			○				○		○			○		granodiorite	840			○	S	○	○	○	
80	Oct. 28. 83 14:30	Nov. 21. 83	24.	566546	○					27.1	22.7/22.9		○					○				○		○	andesite porphyry	790			○	N	○	○	○	
81	Oct. 13. 83 13:30	Nov. 7. 83	25	566396	○					30.2	24.7/26.1			○				○		○			○		andesite porphyry	850			○	NE	◎		○	
82	Oct. 13. 83 13:05	Nov. 7. 83	25	566395				○		26.8	25.1/24.6					○		○		○			○		andesite porphyry	930		○		N	◎		○	
83	Oct. 13. 83 12:40	Nov. 7. 83	25	566394		○				26.1	24.8/25.0				○			○			○			○	granodiorite	1025			○	W	◎	○		
84	Oct. 12. 83 11:05	Nov. 7. 83	26	566403				○		20.7	24.0/24.2		○					○			○		○		diorite	1250	○			N	◎	○	○	
85	Oct. 12. 83 10:45	Nov. 7. 83	26	566402				○		21.2	23.0/23.5		○					○				○	○		diorite	1300			○	N	◎	○	○	
86	Oct. 12. 83 9:58	Nov. 7. 83	26	566389				○		21.7	23.0/23.4			○				○			○			○	granodiorite	1280		○		N	◎		○	
87	Oct. 20. 83 8:25	Nov. 7. 8	21	566456	○					28.6	26.9/26.8			○				○			○			○	tonalite	880			○	S	◎		○	
88	Oct. 20. 83 8:50	Nov. 9. 83	21	566446				○		31.5	26.5/26.8			○				○		○				○	tonalite	800			○	S	◎	○	○	
89	Oct. 19. 83 10:30	Nov. 9. 83	25	566450				○		25.7	23.8/24.1					○		○			○				andesite porphyry	770			○	NW	×	○	○	
90	Oct. 28. 83 14:50	Nov. 21. 83	21	566547			○			27.3	24.1/24.8	○						○			○				andesite porphyry	765			○	NW	◎		○	
91	Oct. 28. 83 14:00	Nov. 21. 83	21	566545	○					27.7	23.9/25.5					○		○				○			andesite porphyry	835			○	W	◎		○	
92	Oct. 28. 83 13:40	Nov. 21. 83	21	566544			○			27.6	23.3/24.0		○					○				○			granodiorite	910			○	NW	○	○		
93	Oct. 13. 83 11:15	Nov. 7. 83	21	566391				○		24.9	22.7/22.8					○		○				○			diorite~gabbro	1200			○	NW	◎	○		
94	Oct. 13. 83 11:30	Nov. 7. 83	23	566392				○		24.4	23.0/23.4					○		○				○			diorite~gabbro	1125			○	NW	◎	○		
95	Oct. 13. 83 12:20	Nov. 7. 83	23	566393				○		29.1	23.9/23.7			○				○		○					diorite~gabbro	1120			○	SW	◎	○		
96	Oct. 12. 83 10:30	Nov. 7. 83	23	566401				○		21.0	22.6/22.6		○					○			○				andesite Pyroclasitic rock	1240		○		NE	◎	○	○	

◎ : much ○ : common × : little

Point Sample No.	Date		Nos. of Days Exposed	Rn. Cup No.	Cup Recovered					Temperature (°C)		Sample Appearance												Geology	Topography					Vegeta-tion		
												Soil Colour					Humidity			Block			Grain size			Slope							
	measure-ment of 1m depth temp.	Rn cup recovered			fine	disturbed	dirty	dewed	submerged	ambient	bottom (60cm-depth/1m-depth)	black	blackish brown	brown	reddish brown	yellowish brown	wet	intermediate	dried	many	few	none	sandy	clayey		elevation (m)	flat	moderate	steep	dipping	sunniness	forestal	grassy	naked rock
97	Oct. 12. 83 10:15	Nov. 7. 83	25	566390				○		27.8	24.0/24.4			○				○			○				granodiorite	1250			○	SE	◎	○	○	
98	Oct. 12. 83 9:40	Nov. 7. 83	25	566388				○		19.9	22.2/22.6			○				○			○				granodiorite	1325			○	N	◎	○	○	
99	Oct. 20. 83 8:55	Nov. 10. 83	23	566457		○				30.8	25.8/25.7					○		○				○			andesite, porphyry	890	○			SE	◎		○	
100	Oct. 19. 83 9:05	Nov. 9. 83	25	566447	○					30.5	24.7/25.1		○					○			○				andesite porphyry	800			○	S	◎	○	○	
101	Oct. 19. 83 10:10	Nov. 9. 83	21	566449				○		27.5	21.9/22.1			○				○			○				andesite porphyry	790			○	E	×	○	○	
102	Oct. 28. 83 11:23	Nov. 21. 83	21	566542	○					24.6	25.0/25.2			○				○			○				andesite porphyry	950		○		N	◎		○	
103	Oct. 28. 83 11:05	Nov. 21. 83	21	566541		○		○		24.9	23.9/24.1					○		○				○			diorite ~ gabbro	950			○	N	◎		○	
104	Oct. 28. 83 10:50	Nov. 21. 83	23	566480	○					24.5	23.5/23.9			○				○			○				diorite ~ gabbro	990			○	NE	◎		○	
105	Oct. 28. 83 10:35	Nov. 21. 83	23	566479	○					26.4	22.5/22.5			○				○		○					diorite ~ gabbro	1040			○	N	◎		○	
106	Oct. 28. 83 10:15	Nov. 21. 83	23	566478	○					24.6	22.8/24.1				○			○			○				diorite ~ gabbro	1150		○		N	◎		○	
107	Oct. 13. 83 10:44	Nov. 7. 83	23	566420	○					23.3	24.0/24.6				○			○		○					granodiorite	1250		○		NW	◎		○	
108	Oct. 13. 83 9:56	Nov. 7. 83	23	566417				○		21.6	24.0/24.4				○			○			○				granodiorite	1240			○	E	◎	○	○	
109	Oct. 13. 83 9:45	Nov. 7. 83	23	566416				○		21.5	22 /22.6			○				○		○					granodiorite	1260		○		NE	◎	○	○	
110	Oct. 13. 83 9:15	Nov. 7. 83	23	566414				○		22.4	22.0/22.5				○			○				○			granodiorite	1335		○		NE	◎	○	○	
111	Oct. 13. 83 9:20	Nov. 7. 83	25	566413	○					22.2	23.6/24.2				○			○				○		○	granodiorite	1350		○		NE	◎	○	○	
112	Oct. 20. 83 9:10	Nov. 10. 83	21	566458		○				23.5	27.2/24.2		○					○				○	○		andesite porphyry	895	○			SE	×	○	○	
113	Oct. 19. 83 9:30	Nov. 9. 83	21	566448	○					27.4	24.2/ –					○			○		○		○		andesite porphyry	800			○	SW	○	○	○	
114	Oct. 19. 83 11:55	Nov. 9. 83	21	566451	○					27.6	22.9/23.1			○				○				○	○		andesite porphyry	780			○	NE	○	○	○	
115	Oct. 19. 83 12:20	Nov. 9. 83	21	566452				○		28.9	25.4/24.3					○		○				○	○		andesite porphyry	770			○	NE	○	○	○	

◎ : much ○ : common × : little

Point Sample No.	Date		Nos. of Days Exposed	Rn. Cup No.	Cup Recovered					Temperature (°C)		Sample Appearance												Geology	Topography					Vegeta-tion		
												Soil Colour					Humidity			Block			Grain size				Slope						
	measure-ment of 1m depth temp.	Rn. cup recovered			fine	disturbed	dirty	dewed	submerged	ambient	bottom (60cm-depth /1m-depth)	black	blackish brown	brown	reddish brown	yellowish brown	wet	intermediate	dried	many	few	none	sandy	clayey		elevation (m)	flat	moderate	steep	dipping	sunniness	forestal	grassy	naked rock
116	Oct. 25. 83 12:15	Nov. 17. 83	23	566497	○					28.2	23.0/24.0			○				○		○					andesite porphyry	770			○	SE	×		○	
117	Oct. 25. 83 11:55	Nov. 17. 83	23	566496		○				28.0	23.8/24.2			○				○		○				○	diorite～gabbro	810			○	NE	○		○	
118	Oct. 25. 83 11:30	Nov. 17. 83	23	566495	○					31.1	23.1/24.2			○				○		○				○	diorite～gabbro	840			○	NE	○		○	
119	Oct. 13. 83 10:30	Nov. 7. 83	25	566419				○		22.2	24.5/25.0		○					○		○			○		diorite～gabbro	1220			○	E	◎		○	
120	Oct. 13. 83 10:10	Nov. 7. 83	25	566418				○		24.5	24.3/24.7				○			○			○			○	andesite rock	1260	○			S	◎		○	
121	Oct. 25. 83 9:35	Nov. 17. 83	23	566488	○					29.4	23.6/25.1		○					○			○			○	diorite～gabbro	1080			○	SE	◎		○	
122	Oct. 13. 83 9:30	Nov. 7. 83	25	566415				○		22.1	24.1/24.8				○			○		○				○	diorite～gabbro	1270			○	E	◎	○	○	
123	Oct. 20. 83 9:45	Nov. 10. 83	21	566460		○				31.4	25.7/25.9			○				○			○		○		andesite porphyry	860	○			SE	◎		○	
124	Oct. 20. 83 9:25	Nov. 10. 83	21	566458	○					27.8	25.4/25.8					○		○				○		○	andesite porphyry	875		○		SE	◎		○	
125	Oct. 19. 83 12:40	Nov. 9. 83	21	566453	○					31.1	26.3/27.7			○				○			○		○		andesite porphyry	750		○		E	◎		○	
126	Oct. 25. 83 12:40	Nov. 17. 83	23	566499	○					30.3	23.1/23.9			○				○				○		○	andesite porphyry	720			○	E	×		○	
127	Oct. 25. 83 12:30	Nov. 17. 83	23	566498	○					30.1	23.8/24.2			○				○		○				○	andesite porphyry	750			○	SW	◎		○	
128	Oct. 25. 83 11:20	Nov. 17. 83	23	566494			○			27.6	24.2/24.5			○				○		○				○	quartz-diorite	870	○			NE	◎		○	
129	Oct. 25. 83 11:00	Nov. 17. 83	23	566493			○			27.8	22.2/22.7			○				○			○			○	diorite～gabbro	920			○	NE	◎	○	○	
130	Oct. 25. 83 10:25	Nov. 17. 83	23	566491			○			28.8	23.5/24.5			○				○		○				○	diorite～gabbro	990			○	E	○		○	
131	Oct. 25. 83 9:50	Nov. 17. 83	23	566489			○			31.9	23.9/23.6			○				○			○			○	diorite～gabbro	1030			○	S	◎	○	○	
132	Oct. 25. 83 9:20	Nov. 17. 83	23	566487	○					33.3	23.6/24.4		○					○		○				○	diorite～gabbro	1060			○	E	◎	○	○	
133	Oct. 25. 83 9:00	Nov. 17. 83	23	566486	○					26.5	22.1/22.9			○				○			○		○		diorite～gabbro	1080			○	E	◎	○	○	
134	Oct. 20. 83 10:00	Nov. 10. 83	21	566461	○					30.3	26.1/25.9			○				○		○			○		tonalite	845			○	S	◎		○	

◎ : much　　○ : common　　× : little

Point Sample No.	Date: measurement of 1m depth temp.	Date: Rn. cup recovered	Nos. of Days Exposed	Rn. Cup No.	Cup Recovered: fine	disturbed	dirty	dewed	submerged	Temperature (°C): ambient	bottom (60cm-depth /1m-depth)	Sample Appearance: Soil Colour: black	blackish brown	brown	reddish brown	yellowish brown	Humidity: wet	intermediate	dried	Block: many	few	none	Grain size: sandy	clayey	Geology	Topography: elevation (m)	Slope: flat	moderate	steep	dipping	sunniness	Vegetation: forestal	grassy	naked rock
135	Oct. 20. 83 10:25	Nov. 10. 83	21	566462	○					29.0	27.9/27.7					○		○		○			○		tonalite	810			○	SE	◎		○	
136	Oct. 20. 83 10:46	Nov. 10. 83	21	566463	○					29.8	27.2/27.2			○				○		○			○		dacite	830			○	E	◎		○	
137	Oct. 19. 83 13:10	Nov. 9. 83	21	566455	○					29.7	25.0/25.4					○		○		○			○		tonalite	690			○	S	○		○	
138	Oct. 26. 83 10:55	Nov. 18. 83	23	566508				○		31.3	23.6/25.3	○						○		○				○	tonalite	780			○	NW	◎	○	○	
139	Oct. 26. 83 8:33	Nov. 18. 83	23	566500				○		27.5	22.7/22.7			○			○			○				○	quartz diorite	875			○	NE	◎	○	○	
140	Oct. 26. 83 8:43	Nov. 18. 83	23	566501	○					23.6	23.8/24.1			○				○		○				○	tonalite	850			○	E	◎		○	
141	Oct. 27. 83 8:35	Nov. 18. 83	22	566510	○					24.1	23.6/23.2			○				○			○		○		diorite-gabbro	935			○	NE	◎		○	
142	Oct. 27. 83 9:00	Nov. 18. 83	22	566471			○			24.6	22.9/23.7			○				○		○			○		diorite-gabbro	950			○	NE	◎	○	○	
143	Oct. 20. 83 11:35	Nov. 10. 83	21	566464	○					31.2	26.8/26.6			○					○		○		○		tonalite	710			○	SE	◎		○	
144	Oct. 26. 83 10:35	Nov. 18. 83	23	566507	○					31.4	24.2/24.9			○				○			○			○	toanlite	870			○	NW	◎		○	
145	Oct. 26. 83 10:15	Nov. 18. 83	23	566506	○					28.0	24.8/25.1			○				○			○			○	tonalite	915	○			NW	◎		○	
146	Oct. 26. 83 9:45	Nov. 18. 83	23	566504	○					26.0	22.3/23.3			○			○			○			○		tonalite	870			○	NW	◎		○	
147	Oct. 26. 83 9:25	Nov. 18. 83	23	566503	○					23.4	23.1/23.4		○					○		○			○		tonalite	840			○	W	◎		○	
148	Oct. 26. 83 10:10	Nov. 18. 83	23	566505	○					27.8	24.0/24.0			○				○		○			○		tonalite	900			○	W	◎		○	
149	Oct. 27. 83 11:00	Nov. 18. 83	22	566477	○					32.2	26.7/25.8			○				○				○	○		tonalite	1000		○		NE	◎		○	
150	Oct. 27. 83 10:50	Nov. 18. 83	22	566476	○					29.1	23.7/23.9		○					○				○		○	tonalite	1050		○		N	◎		○	
151	Oct. 10. 83 12:57	Nov. 4. 83	25	566384				○		27.8	25.7/25.8			○				○			○		○		granodiorite	1075			○	NE	◎		○	
152	Oct. 10. 83 13:40	Nov. 4. 83	25	566387			○		○	28.0	23.9/24.0		○					○		○			○		granodiorite	925			○	NE	○		○	
153	Oct. 12. 83 12:20	Nov. 7. 83	26	566406				○		25.7	23.4/23.8		○					○			○			○	andesite porphyry	1150		○		N	◎		○	

◎ : much　○ : common　× : little

Point Sample No.	Date		Nos. of Days Exposed	Rn. Cup No.	Cup Recovered					Temperature (°C)		Sample Appearance											Geology	Topography					Vegetation		
												Soil Colour					Humidity		Block			Grain size			Slope						
	measurement of 1m depth temp.	Rn. cup recovered			fine	disturbed	dirty	dewed	submerged	ambient	bottom (60cm-depth)/1m-depth	black	blackish brown	brown	reddish brown	yellowish brown	wet	intermediate	dried	many	few	none	sandy	clayey		elevation (m)	flat	moderate	steep	dipping	sunniness	forestal	grassy	naked rock
154	Oct. 19. 83 12:52	Nov. 9. 83	21	566454	○					32.3	25.9/27.1			○				○		○			○		andesite pyro-clasitic rock	710			○	E	◎		○	
155	Oct. 24. 83 9:55	Nov. 17. 83	24	566468	○					31.2	24.6/ –			○				○		○					andesite porphyry	1030			○	N	◎		○	
156	Oct. 24. 83 10:20	Nov. 17. 83	24	566469				○		32.4	23.5/23.7		○					○		○			○		granodiorite	1000			○	NE	◎		○	
157	Oct. 24. 83 10:45	Nov. 17. 83	24	566470	○					31.5	22.7/23.4			○				○			○		○		andesite porphyry	950			○	NE	◎		○	
158	Oct. 24. 83 12:35	Nov. 17. 83	24	566483			○			28.3	22.7/22.8			○				○		○			○		andesite rock	920			○	W	◎	○	○	
159	Oct. 25. 83 10:05	Nov. 17. 83	23	566490	○					31.3	23.2/23.8					○		○		○			○		diorite-gabbro	1020			○	S	○	○	○	
160	Oct. 25. 83 10:45	Nov. 17. 83	23	566492	○					32.4	22.6/23.5		○					○		○				○	diorite-gabbro	960			○	E	○	○	○	
161	Oct. 26. 83 9:05	Nov. 18. 83	23	566502	○					31.0	24.3/24.6		○					○			○		○		tonalite	840			○	SE		○	○	
162	Oct. 26. 83 11:10	Nov. 18. 83	23	566509				○		28.5	23.7/25.4	○						○				○	○		tonalite	700		○		N	◎		○	
163	Oct. 27. 83 9:10	Nov. 18. 83	22	566472	○					23.0	22.4/23.4	○						○		○			○		tonalite	925			○	NE	○		○	
164	Oct. 27. 83 9:35	Nov. 18. 83	22	566473	○					27.0	23.8/24.5			○				○			○		○		tonalite	1000			○	NE	◎		○	
165	Oct. 27. 83 10:05	Nov. 18. 83	22	566474	○					26.3	22.6/23.1			○				○			○		○		tonalite	1090		○		W	◎		○	
166	Oct. 27. 83 10:25	Nov. 18. 83	22	566475	○					27.6	22.7/23.4			○				○				○		○	tonalite	1150		○		NW	◎		○	
167	Oct. 28. 83 11:35	Nov. 21. 83	24	566543	○					24.3	22.3/22.7		○					○				○		○	diorite-gabbro	960			○	N	◎		○	
168	Oct. 31. 83 10:24	Nov. 19. 83	19	566521	○					29.3	25.8/26.2			○				○			○			○	quartz diorite	1065		○		SE	◎		○	
169	Oct. 31. 83 10:38	Nov. 19. 83	19	566522	○					28.8	26.4/26.4				○			○				○		○	quartz diorite	1020		○		S	○		○	
170	Oct. 31. 83 10:35	Nov. 19. 83	19	566548			○			32.2	24.8/21.9			○				○			○			○	quartz diorite	960			○	SW	○	○	○	
171	Oct. 31. 83 10:55	Nov. 19. 83	19	566549	○					27.9	23.9/24.4			○				○				○		○	quartz diorite	910			○	NE	◎		○	
172	Oct. 31. 83 11:05	Nov. 19. 83	19	566550				○		31.7	26.3/26.0			○				○				○		○	tonalite	900		○		SW	◎		○	

◎ : much ○ : common × : little

Point Sample No.	Date		Nos. of Days Exposed	Rn. Cup No.	Cup Recovered					Temperature (°C)		Sample Appearance											Geology	Topography						Vegetation		
												Soil Colour					Humidity			Block			Grain size				Slope					
	measurement of 1m depth temp.	Rn. cup recovered			fine	disturbed	dirty	dewed	submerged	ambient	bottom (60cm-depth /1m-depth)	black	blackish brown	brown	reddish brown	yellowish brown	wet	intermediate	dried	many	few	none	sandy	clayey		elevation (m)	flat	moderate	steep	dipping	sunniness	forestal	grassy	naked rock
173	Oct. 31. 83 11:35	Nov. 19. 83	19	566531	○					35.7	25.2/25.4			○				○			○			○	tonalite	900			○	S	◎	○	○	
174	Oct. 31. 83 11:45	Nov. 19. 83	19	566532				○		31.3	27.1/27.1			○				○				○		○	tonalite	870			○	S	◎		○	
175	Oct. 31. 83 12:00	Nov. 19. 83	19	566533				○		33.4	27.1/27.4			○				○			○		○		tonalite	820			○	SE	◎		○	
176	Oct. 31. 83 12:10	Nov. 19. 83	19	566534				○		31.4	27.9/27.7			○					○	○				○	tonalite	765			○	S	◎		○	
177	Oct. 31. 83 12:35	Nov. 19. 83	19	566535	○					29.5	26.4/26.4			○				○		○			○		tonalite	700			○	S	◎		○	
178	Oct. 31. 83 10:50	Nov. 19. 83	19	566523	○					28.8	24.8/25.5				○			○				○	○		quartz diorite	1000		○		E	○		○	
179	Oct. 31. 83 11:35	Nov. 19. 83	19	566524	○					34.0	26.8/26.8			○				○			○			○	quartz diorite	985			○	S	○		○	
180	Oct. 31. 83 12:50	Nov. 19. 83	19	566525	○					31.1	25.0/25.0			○				○		○			○		quartz diorite	880			○	SE	◎	○		
181	Oct. 31. 83 13:00	Nov. 19. 83	19	566526		○				28.3	25.5/25.8			○				○		○			○		quartz diorite	780			○	S	◎	○		
182	Oct. 31. 83 13:27	Nov. 19. 83	19	566527	○					33.1	25.1/25.6			○				○		○			○		quartz diorite	715		○		E	◎		○	
183	Oct. 31. 83 13:40	Nov. 19. 83	19	566528	○					30.5	27.3/27.9			○				○				○	○		tonalite	710		○		E	○		○	
184	Nov. 3. 83 8:30	Nov. 21. 83	18	566529	○					24.0	22.0/22.4			○				○		○				○	conglo, Pyroclasitic rock	985			○	NE	◎		○	
185	Nov. 3. 83 8:45	Nov. 21. 83	18	566530	○					26.6	25.5/25.3				○			○			○			○	conglo, Pyroclastic rock	955		○		E	◎		○	
186	Nov. 3. 83 8:55	Nov. 21. 83	18	566536	○					27.8	26.4/26.3			○				○			○		○		conglo, Pyroclastic rock	920		○		E	◎		○	
187	Nov. 3. 83 9:40	Nov. 21. 83	18	566538	○					26.6	22.8/23.0			○				○			○		○		andesite porphyry	980	○			W	◎		○	
188	Nov. 3. 83 10:00	Nov. 21. 83	18	566539	○					27.7	22.9/23.1			○				○			○		○		andesite porphyry	990	○			E	◎		○	
189	Nov. 3. 83 10:10	Nov. 21. 83	18	566540	○					27.3	23.6/23.8				○			○			○		○		andesite porphyry	975	○			E	◎	○	○	
190	Nov. 3. 83 9:20	Nov. 21. 83	18	566537	○					26.1	25.2/25.1				○			○			○		○		conglo, Pyroclasitic rock	1020	○			N	◎		○	
191	Nov. 3. 83 10:30	Nov. 21. 83	18	566511	○					26.7	24.7/25.1				○			○			○		○		andesite porphyry	1000			○	NE	◎		○	

◎ : much ○ : common × : little

Point Sample No.	Date: measurement of 1m depth temp.	Date: Rn. cup recovered	Nos. of Days Exposed	Rn. Cup No.	Cup Recovered: fine	disturbed	dirty	dewed	submerged	Temperature (°C): ambient	bottom (60cm-depth)/(1m-depth)	Sample Appearance: Soil Colour: black	blackish brown	brown	reddish brown	yellowish brown	Humidity: wet	intermediate	dried	Block: many	few	none	Grain size: sandy	clayey	Geology	Topography: elevation (m)	Slope: flat	moderate	steep	dipping	sunniness	Vegetation: forestal	grassy	naked rock
192	Nov. 3. 83 10:40	Nov. 21. 83	18	566512	○					28.7	23.3/23.5			○				○				○		○	conglo, Pyro-clasitic rock	1000		○		NE	◎	○	○	
193	Nov. 4. 83 8:23	Nov. 21. 83	17	566513	○					24.8	26.4/25.9				○			○		○			○		tonalite	910		○		SE	◎		○	
194	Nov. 4. 83 8:40	Nov. 21. 83	17	566514	○					22.9	25.6/25.7				○			○				○		○	andesite porphyry	930			○	SE	◎		○	
195	Nov. 4. 83 9:00	Nov. 21. 83	17	566515	○					28.3	24.4/24.7			○				○				○		○	andesite porphyry	950			○	SE	◎		○	
196	Nov. 4. 83 9:10	Nov. 21. 83	17	566516				○		27.0	24.6/24.6				○			○			○			○	andesite porphyry	985	○			SE	◎	○	○	
197	Nov. 4. 83 9:25	Nov. 21. 83	17	566517		○		○		25.0	26.0/25.7			○				○			○			○	andesite porphyry	960	○			SW	◎		○	
198	Nov. 4. 83 9:35	Nov. 21. 83	17	566518	○					27.3	25.4/25.7			○				○				○		○	andesite porphyry	900			○	SW	◎		○	
199	Nov. 4. 83 9:50	Nov. 21. 83	17	566519				○		27.6	24.2/24.3			○				○				○		○	andesite porphyry	850			○	SE	◎	○	○	
200	Nov. 4. 83 10:05	Nov. 21. 83	17	566520				○		28.3	25.3/25.2					○		○				○	○		andesite porphyry	790			○	SW	◎	○	○	

◎ : much　○ : common　× : little

visible signs or labels were placed to mark the spots in order to facilitate subsequent recovery of the Radon cups. The cup number, date of emplacement and retrieval, and description of the cup when recovered were noted. After three weeks, the radon cups were noted. After three weeks, the radon cups were collected and these were sent to Terradex Corporation for radon track-etch analysis.

2.2.2 O/H Isotope Investigation of Hot Spring Water

A total of fifteen (15) samples were collected from the surface and underground tunnels in the survey area for isotope analysis. 500-ml. bottles were used as sample containers. The bottle was cleaned 2–3 times with the water sample, then filled with the water sample and sealed. The samples were brought back to Japan for O/H isotope analysis at the Central Research Laboratory of Mitsubishi Metal Corporation.

(a) Occurrence of Hot Spring Water: Sampling locations are shown in Fig. III–2–3 and occurrences of discharge are indicated in Table III–2–2. Details of sampling are given below:

(i) No. 1 (Gradient hole AGH-1): The hot water coming from gradient AGH-1 was sampled. The rate of discharge is about 2.5 lit/min., the temperature 66.2°C and pH 7.0. The gradient hole was drilled in andesitic tuff breccia and andesite lava.

(ii) No. 2 (Ambalanga River): The site is located about 300 meters upstream of AGH-1 hole. The geology is composed of light green-colored andesitic tuff breccia cut by andesite dikes. Hot spring water discharges along joint planes. The water flow rate is about 3 lit/min., the temperature 73.8°C and pH 7.0. The host rock is altered and is light green in color. Many calcite veinlets occur.

(iii) Nos. 3, 4 and 5 (2,900 level, Acupan mine): Discharge of hot water is widespread inside the mine workings occurring particularly along the joint planes in Virac granodiorite. The samples were collected on the spots of comparatively

large discharge volume. Three samples have discharge rate of 100 lit/min., 50 lit/min. and 100–150 lit/min., respectively, at corresponding temperatures of 35.9°C, 43.5°C and 41.7°C, and identical pH of 7.0. The host rock is altered and is pale greenish gray in color. Precipitation of calcium sulfate and ferrous iron sulfate is observed.

(iv) No. 6 (3,150 level of Acupan mine): The hot spring water running on the tunnel floor was smapled. It has a flow rate of 5 lit/min., a temperature of 65°C and pH of 7.5. The surrounding rocks are composed of light green andesitic tuff breccia of the old Balatoc plug partially cut by andesite dikes.

(v) No. 7 (3,150 level of Acupan mine): There was difficulty in approaching the exact point of discharge due to extremely heated air. Consequently, the hot water flowing on the tunnel floor was sampled. It has a flow rate of 10 lit/min., a temperature of 90°C and pH of 7.5. The exposed lithology is of dacite volcanic breccia of light green color and tuff breccia. Pervasive pyrite dissemination, silicification and occurrence of calcite veinlets are noted.

(vi) No. 8 (3,150 level of Acupan mine): The sample collected was flowing on the tunnel floor from an area blocked-off from hot air fluid. It has a flow rate of 2 lit/min., a temperature of 65°C and pH of 7.0. Young plugs of pale green dacitic volcanic breccia-tuff breccia comprise of the host rock.

(vii) No. 9 (3,150 level of Acupan mine): Hot water with steam springs out of the D/D drill hole and joint planes and flows down the tunnel floor where it was sampled. It has a flow rate of about 70 lit/min., a temperature of 75°C and pH of 7.5. The host rock is pale greenish gray andesitic tuff breccia representing the boundary of the old and young plugs.

(viii) Nos. 10 and 11 (3,150 level of Acupan mine): The sample collected was hot water flowing down the tunnel floor from the joints of the roof and wall of the tunnel. It has a flow rate of 50–60 lit/min., a temperature of 80°C and pH of 7.0–7.5. The nearby host rock is granodiorite of whitish gray-white in color. Intense silicification is observed. No. 10 site comprises of andesite intrusive of green-dark green color.

(ix) Nos. 12 and 13 (3,300 level of Acupan mine): Inside the tunnel, the temperature was a high as 65°C. Steam and thermal fluid gushes out from the drill hole. The tunnel is blocked immediately before the site of the spring in order to prevent the circulation of hot air. The sample collected was thermal fluid running in the drain. The flow rates of the two samples are 25–30 lit/min., the temperatures are 57.1°C and 85.8°C, and pH 7.0 and 7.5 for No. 12 and 13, respectively.

The nearby host rock is composed of pale green andesitic tuff breccia and is cut by andesite dikes. Amphibole is altered to chlorite. Strong pyrite dissemination and silicification are observed. Abundant white calcium sulfate deposits occur on the vent pipes installed adjacent to the rocks.

(x) No. 14 (2,300 level of Acupan mine): The sample collected was thermal fluid flowing down the floor tunnel from the tunnel wall. It has a flow rate of 50–100 lit/min., a temperature of 32.8°C and pH of 7.0. The host rock is composed of pale green dacitic volcanic tuff breccia.

(xi) No. 15 (700 meter above sea level, Acupan mine): A drain tunnel was constructed at a site about 100 meters northwest from the AGH-1 drill hole. The hot spring water was sampled from the tunnel wall, and has a discharge rate of about 5 lit/min., a temperature of 73.1°C and pH of 7.5. The lithology of the host rock is geen-colored andesitic breccia.

(b) O/H Isotope Analysis: For hydrogen and oxygen, the isotopic ratio may be expressed as deviation in per mil (part per thousand) to a reference material as given below.

$$\delta X = \left[\frac{\text{R. sample}}{\text{R. standard}} - 1 \right] \times 1{,}000$$

where X denotes D, ^{18}O; R. sample and R. standard represent, respectively, the D/H and $^{18}O/^{16}O$ of the sample and the standard material. SMOW (Standard Mean Ocean Water) is used as standard material for hydrogen and oxygen.

Hydrogen is generated by allowing the sample water to react with metallic uranium which is heated to about 800° C in a vacuum unit. The dissolved hydrogen is collected by means of Teopler pump and D/H ratio is determined using isotope analyzer (RMS-HB) of Hitachi Ltd. after measurement of rate recovery. In the case of oxygen, the sample waters and carbon dioxide are set in vacuum container, which is kept shaking in a water tank at a constant temperature of 25° C for one day and overnight. In this way, water and carbon dioxide reach the isotopic exchange equilibrium for $^{18}O/^{16}O$, and the isotopic ratio of water is measured in comparison with $^{18}O/^{16}O$ ratio of carbon dioxide. The measuring instrument is the mass spectrometer, Micromass 903 of VG Isotope, Ltd.

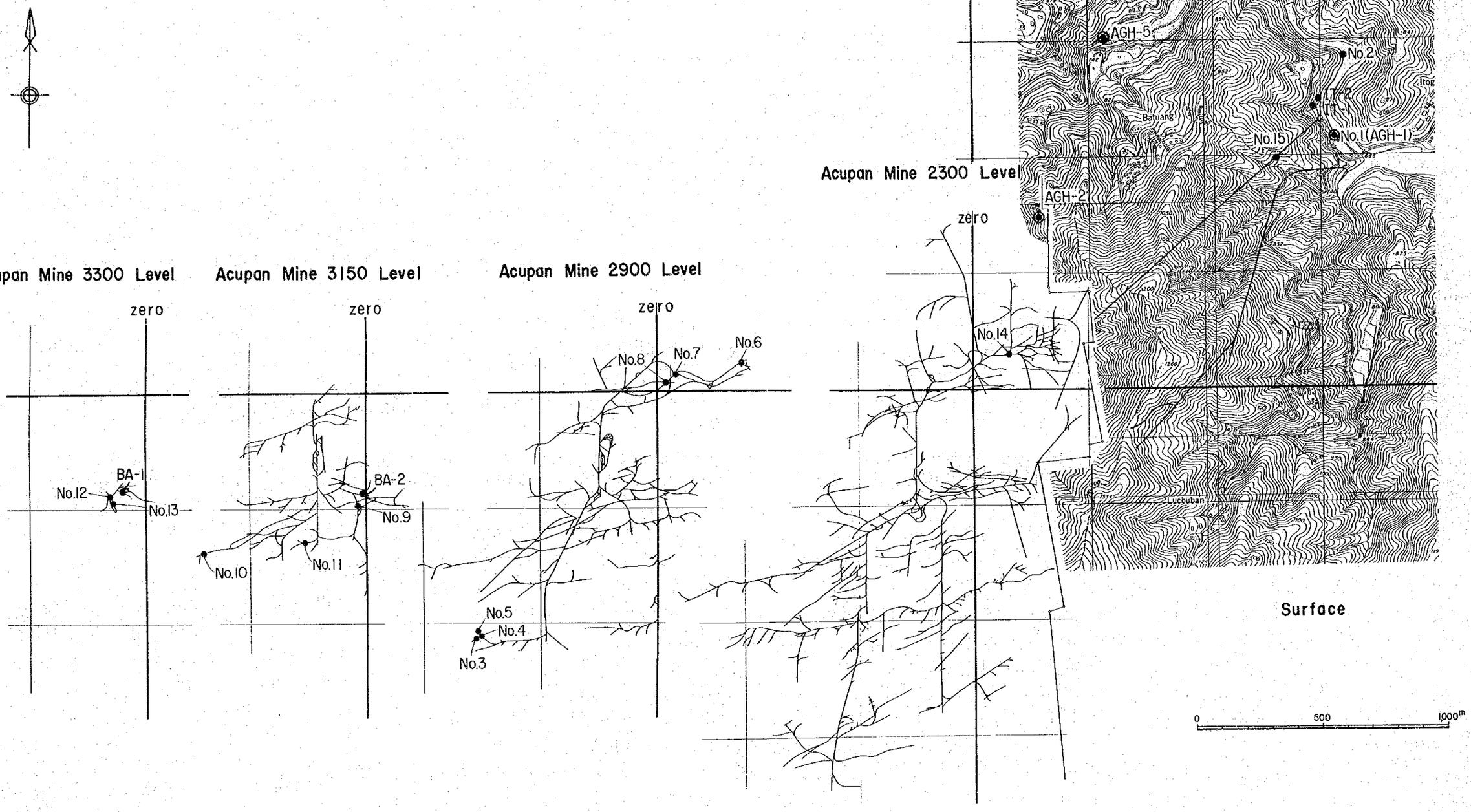

Fig. Ⅲ-2-3 Location Map of Water Spring