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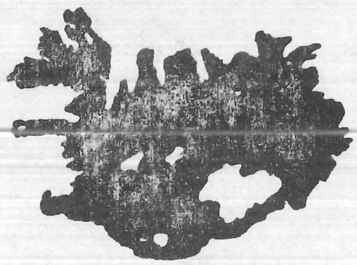
Thorpe St.Andrew School

Iceland



Expedition 1978

Thorpe St. Andrew School

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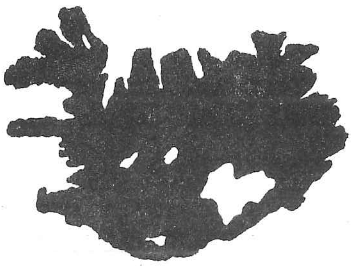

Expedition 1978

Foreword

Expeditions are of immense value in the personal development of young people. The experience of four weeks under canvas in all types of weather gives a person a very different view of life and an opportunity to find out about themselves. The tougher the conditions the greater the value and generally the more enjoyable (in retrospect that is).

It is difficult, however, for those not involved in an expedition to see all the benefits of such a venture. I hope that those who read this report will realise that it was not just a holiday and that we did work hard to produce our results.

I hope that the success of this expedition will encourage more young people from Norfolk to undertake ventures of this kind.

Owen J. Hunt

Owen J. Hunt

Leader

Norwich Sept. 16th 1978

Members of the Expedition

Members of the Expedition

Owen Hunt	(Leader) Geography. Churchill Fellow 1978 Led expedition to the same area 1970. Led expedition to Arctic Norway 1972.
Guy Hawkins	Member of Iceland Expedition 1970. Mountain Leadership Certificate.
Chris Race	Organized school parties abroad. Mountain Leadership Certificate.
Imelda Race	Member of Keswick Hall Expedition to Iceland 1974.

Marcus Charig
Guy Coulson
Mark Godden
Stephen Goulder
Mark Hill
Robin Hubbard
Nick Kendle
Graham King
Kate Manning
Andrew Pinnock
Kate Potter
Peter Rowe

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Sketches.

Cross-sections.

Part 1.

1. Introduction

1. Introduction

Iceland lies between 63°24' and 66°33' north latitude nd between I3°30' and 24°32' west longitude. It is 490 kms. rom east to west and 3I2 kms. north to south. Its nearest eighbours are Greenland (300 kms.), Scotland (800 kms.), and orway (970 kms.).

Floki Vilgerdarson gave the country its name in 866 A.D. fter seeing a fjord full of pack ice.

Geologically Iceland is still a young country and the rocess of its formation is still going on. Iceland is in arge part a table land broken up by tectonic forces. Its nterior consists entirely of mountains and high plateaus devoid f human habitation. There are numerous fissures running in a -S direction in the north, and in a N.E.-S.W. direction in the outh. This area is a continuation of the Mid Atlantic Ridge stride which Iceland sits, and contains numerous active Volcanoes. lap 1,P.12.).

Iceland is the home of glaciers and ice sheets. Some 11% the country is covered by ice, the largest single area being tnajokull.

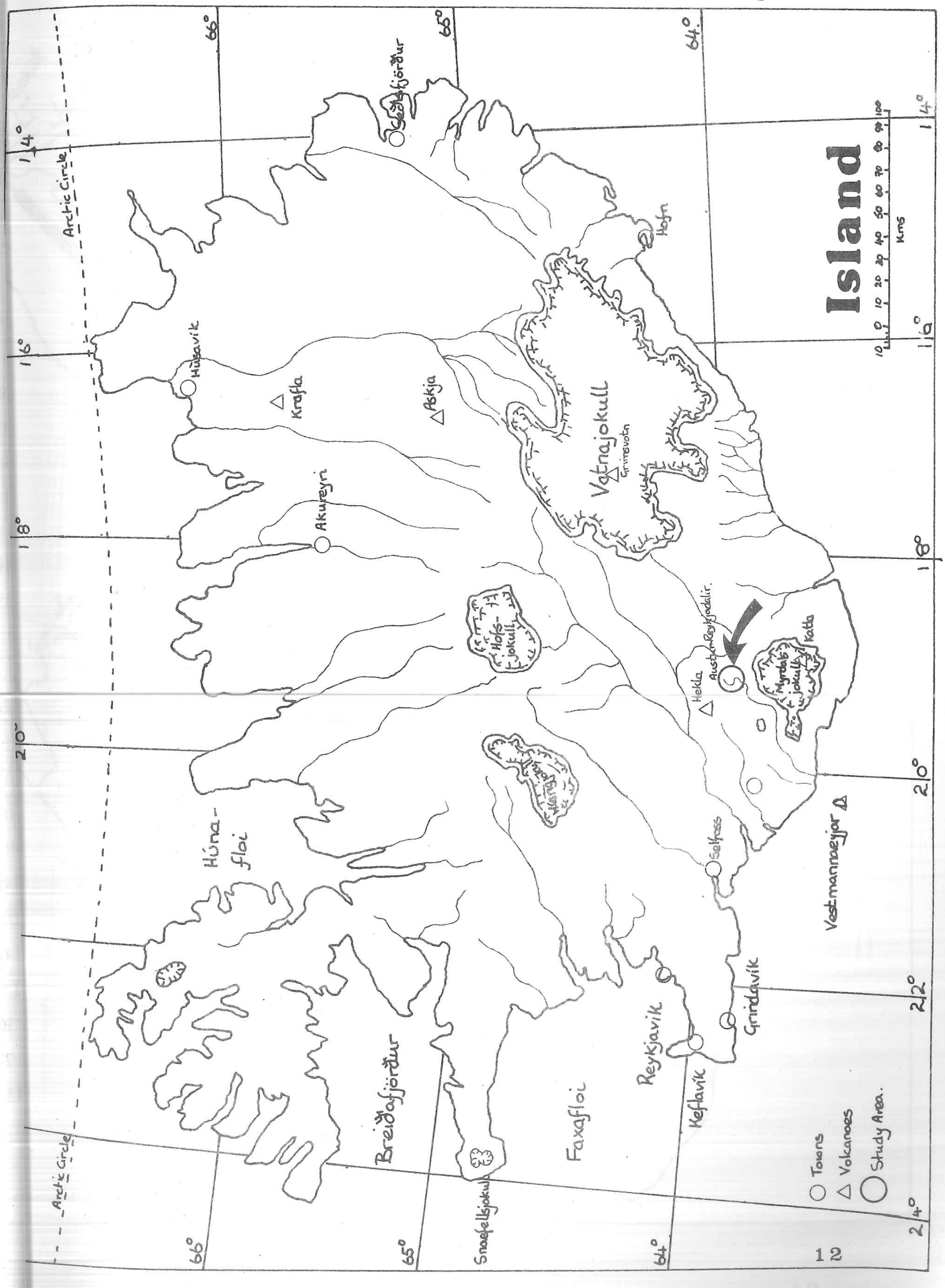
The area of Austur Reykjadalir lies in the volcanic zone south central Iceland to the south-east of Hekla and to the rth-west of Torfajokull. It is the most hydrothermally active ea in Iceland and contains upwards of I00 hot springs of rious sizes.

Geologically the area is composed of acid lavas including yolite, Obsidian and Pumice.

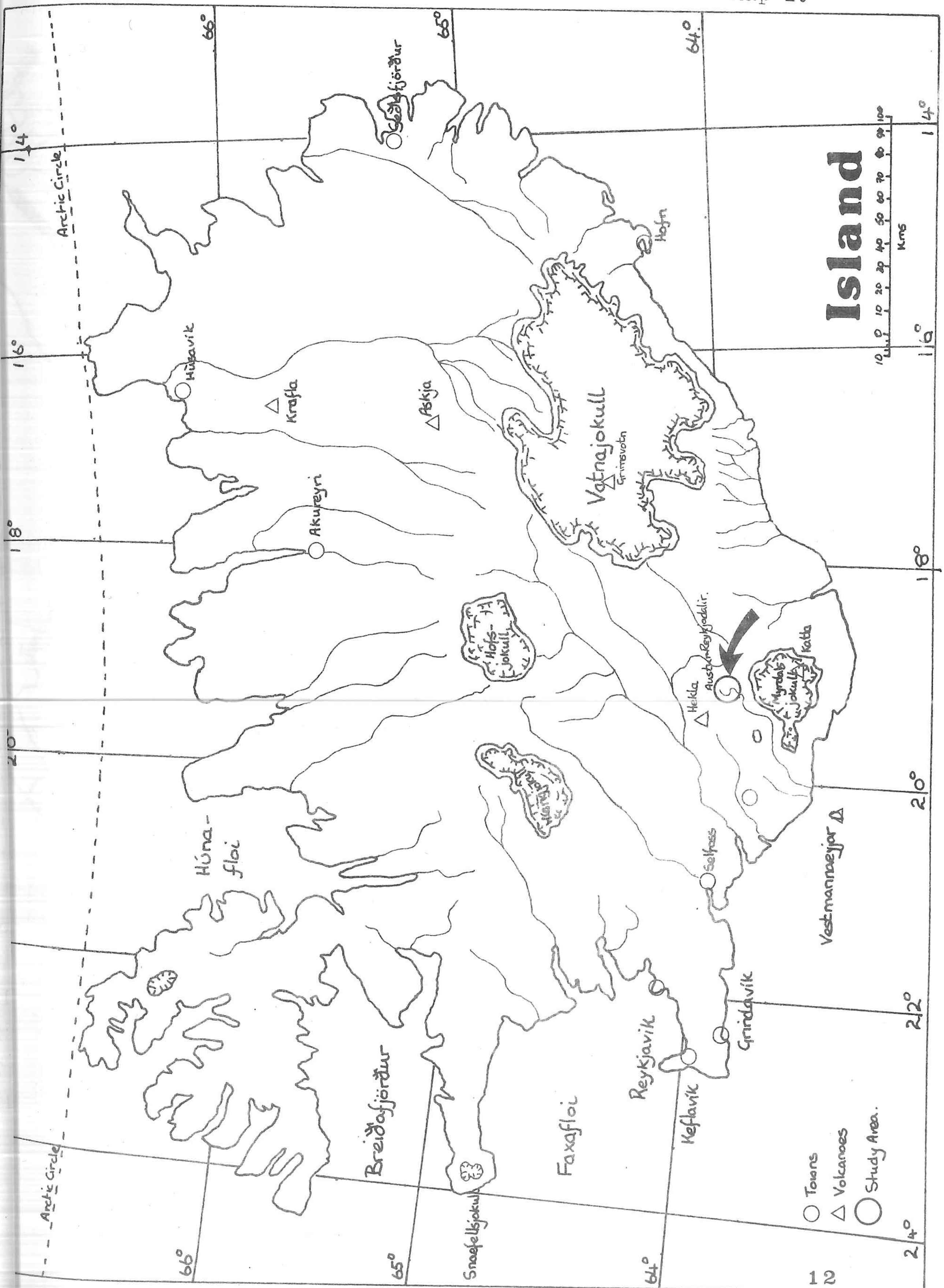
Hella is some 60 kms. to the west along an ash track.

This, then, is tha setting for the Thorpe St. Andrew School pedition to the Land of Ice and Fire.

Map 1.



Island
Kms
Arctic Circle
Húsavik
Krafla
Askja
Akureyri
Vatnajokull
Grimsvotn
Hofn
Höfs-jokull
Hekla
Austur-Reykjadalir.
Myrdals-jokull
Katla
Vestmannaeyjar
Selfoss
Grindavik
Reykjavik
Keflavik
Faxafloi
Breiðafjörður
Snaefellsjokull
Húna-floi
Towns
Volcanoes
Study Area.


Island
Kms
Arctic Circle
66°
65°
64°
14°
16°
18°
20°
22°
24°
Húsavik
Krafla
Askja
Akureyri
Hofn
Vatnajokull
Grimsvotn
Hofs-jokull
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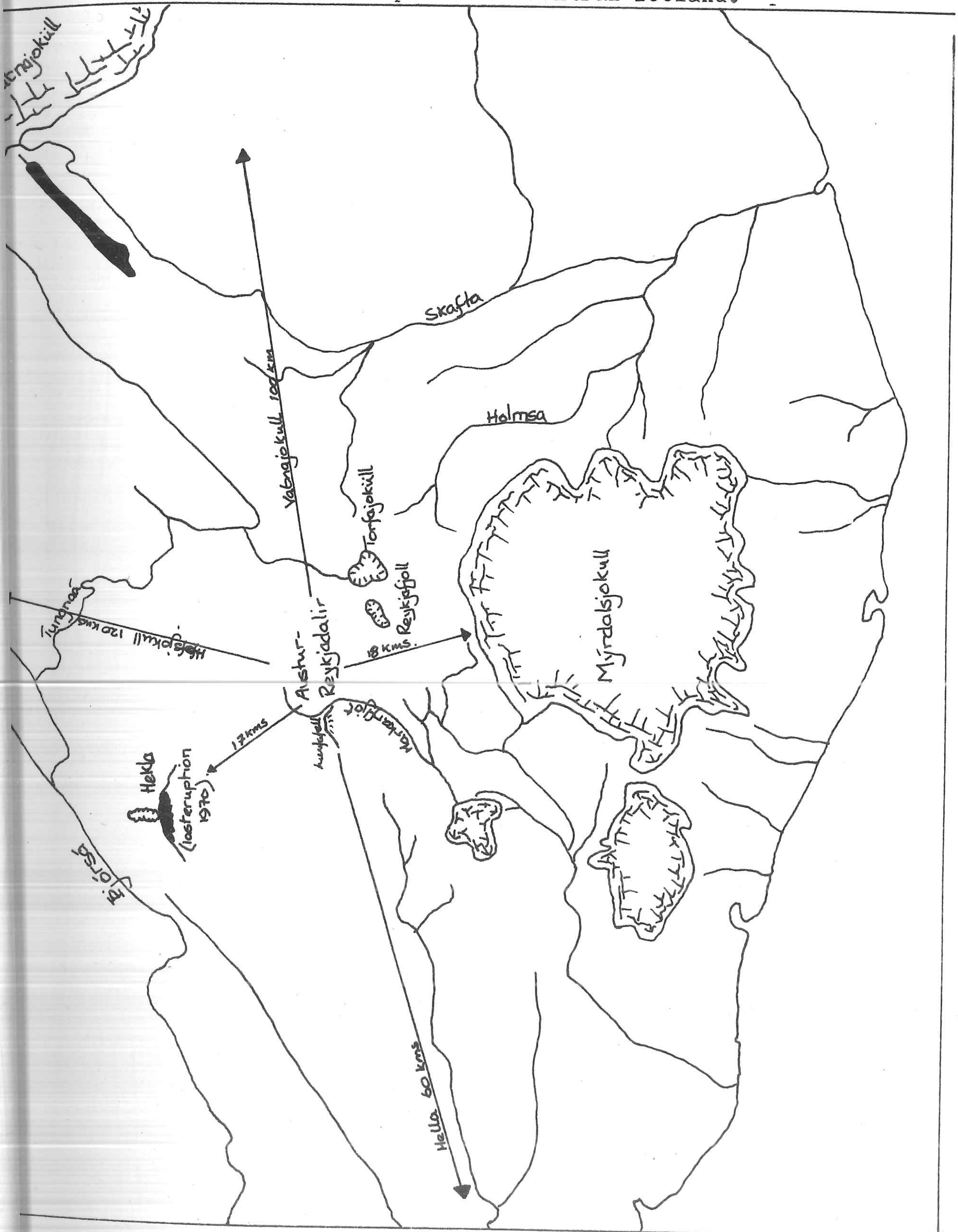
Keflavik
Faxafloi
Breiðafjörður
Húna-floi
Snaefellsjokull
Towns
Volcanoes
Study Area.

Map 2 South Central Iceland.



2.Aims

2. Aims of the Expedition

The aims of the expedition were threefold. Firstly, it's main aim was to see whether an expedition of this nature from a Norfolk school would work. It was in fact the first Norfolk state school expedition. It was hoped that its sucess would lead to the formation of a Norfolk School'S Exploring Society, which would give young people the opportunity to participate in ventures such as this.

The difficulty of surviving in such a harsh climate and living in close proximity with others is an adventure in itself. It can bring out the best qualities in the individual. We hoped in this strange environment to enable the group to find out more about themselves, their limitations and their abilities.

Our final aim was to put classroom theory into practise in the fields of geography, geology and biology through personal observation and study in the field.

The scientific programme was divided into three parts as follows.

1) Mapping

The I:50,000 map of the area made in 1948 had some features missing. The object of this survey was to make corrections to this map and mark in missing features. e.g. roads, hot springs, rivers. It was also intended to map the crater of Hrafntinnahraun.

2) Geographical Survey

a) Hot springs-measurements were to be made of the following:

i) Hourly change in temp.
ii) Heat output per hour.
iii) Volume of water discharged per day.
iv) Area of deposits.
v) Type of deposits.
vi) Type of hot spring

The results of this survey were to be correlated with the results of the biological survey to see if there was any relationship between temperature, vegetation and chemical deposits.

b) Volcanoes

This survey involved a study of the volcanic crater and lava flow of Hrafntinnahraun. Its area and the thickness of the lava was to be measured.

c) Geology

A study of the area was to be made with respect to its geology and the effect of rock type on erosional feature.

d) Slopes

A study was to be made of slopes and mass wastage in this Tundra region. The following was to be looked at:

i) Slow flowage types of mass wastage.
   a) creep, b) soil creep, c) talus creep, d) rock creep, e) rock glacier creep, f) solifluction.

ii) Rapid flow features of mass wastage:
   a) earthflow, b) mudflow.

iii) Debris avalanches.

iv) Landslides
   a) slump, b) debris slide, c) debris fall, d) rock slide, e) rock fall.

It was intended to use the following methods for this study:

i) Measurement of surface wash.
ii) Slope profile survey and analysis.
iii) Angle frequency.
iv) Sketch profile survey.
v) Morphological mapping.
vi) Soil expansion and contraction on wetting.

e) Weather

Daily measurements of the following were to be made each day:

i) Max. and min. temp.
ii) Wind speed and direction.
iii) Cloud cover and type.
iv) Precipitation.

f) Rivers

A study of the Markarfljot was to be made recording rate of flow and its hourly change in height throughout 24 hours.

3) Biological Survey

There will be two main areas of study:

a) Study of flora

This was to require detailed identification of plants leading to a species list being made. Environmental factors possibly accounting for distribution of species were to be examined and statistical tests for correlation carried out.

Other plant studies were to include comparing and contrasting the morphological characteristics of selected plant species found in both Britain and Iceland.

b) Vegetation of the hot springs.

The dominant species found in this habitat are the blue-green algae. The temperature tolerance of these algae was to be the focus for study.

Specimens of Bryophytes and Lichens were to be collected for the Natural History Museum in London.

We did not in fact manage to complete all the scientific programme but, as will be seen from the report, we did do a great deal of work.

3. Geographical Surveys:

a) Mapping

b) Hot Springs

c) Gèology

d) Volcanoes

e) Snow and Ice

f) Slopes and Surfaces

g) Rivers

h) Weather

a) Mapping.

One thing was really brought home to those in the map-making part of the expedition - the immense practical difficulty of producing accurate maps of a remote, rugged area with little previous experience of cartography and less than ideal equipment.

Our intentions were fairly ambitious; we were to make corrections to the existing 1:50,000 map of the area - a venerable document produced by the US Army shortly after the last war. We also aimed to make detailed maps of such features as the hot springs of Austur-Reykjadalir, the ice hole on Hrafntinnusker and the volcano and lava flow of Hrafntinnahraun.

Problems started to occur even before we left England. The ceiling of the departure lounge at Heathrow was so low that it was in imminent danger of being impaled on the tripod which was strapped to the back of a rucksack. But, seriously, we did have a few difficulties with the equipment.

On the fourth day in the field we set about our first survey - that of the small hot spring near base camp. The first thing to do was to find the index error on the vertical scale of the theodolite. This is particularly important since the terrain is so mountainous that much of our work would involve large vertical angles. The instrument we were using was of rather basic design consisting merely of a tube with a pin-hole in one end and cross-hairs in the other, mounted on horizontal and vertical protractors fitted with verniers - not a lens or micrometer-screw in sight. The calibration of the vertical protractor should , therefore, have posed no problem. It simply involved taking three sights from two ranging poles and then adjusting the vernier. In attempting this, we found that the theodolite could not be levelled properly. Levelling in one direction just threw it out of truein the other. This problem had developed since shipment from England, so we concluded that the small circular spirit level had been knocked out of true in transit.

We made the best compromise we could and then started work.

After about half an hour we discovered that the instrument was giving conflicting readings depending on which way round it was being used. We reluctantly concluded that our theodolite was bent! Then we stripped the thread on the adjusting screw. 'Most displeasing!' We made a repair with elastoplast and glue and set to work

The hot spring in question was situated in the floor of a small valley which ran east-west. It was clearly visible only from the south side of the valley, which was steep and the slope topped with a small cornice. We set our base line on top of the snow since the ash was too steep and loose to support the tripod. As it turned out, the snow was not much better. The theodolite had no refinements and was adjusted by brute force which thrust the tripod legs further into the snow.

Nevertheless we persevered with drizzle in our eyes, blowing water out of the instrument before each reading, waiting for the steam to clear and make the ranging poles visible again, and every now and again pausing to go down and thaw our feet in the hot ash below.

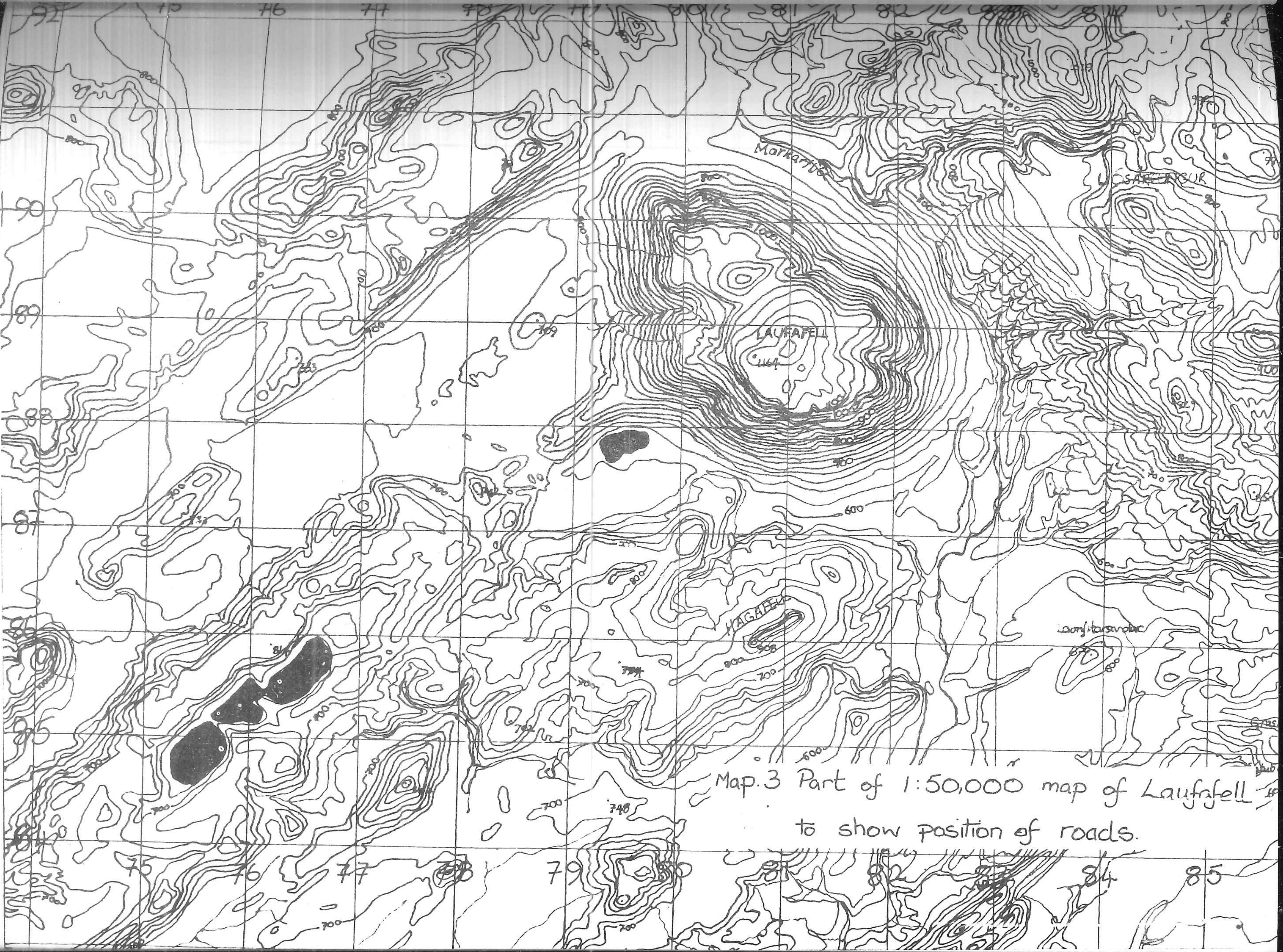
From two days work at this site we obtained enough readings to produce a map of somewhat dubious accuracy and unknown scale, since all the tape measures had inadvertantly been left in England. This problem was solved by including an object of known size in the map. The largest ice-axe was employed for this purpose. We also took the precaution of taking a number of photos from the top of the ridge, hoping to treat these trigonometrically to produce a more accurate map.

By the time the group of rather dispirited failed cartographers had reached Camp 1V we had decided that the theodolite was not going to be of much use, so for our next survey we adopted a different technique. At camp 1V we spent some considerable time mapping the locations of the hot springs, steam vents and mud holes of the main geothermal area using compass bearings. With this method, we took bearings from at least two prominent landscape features which we later located on the 1:50,000 map

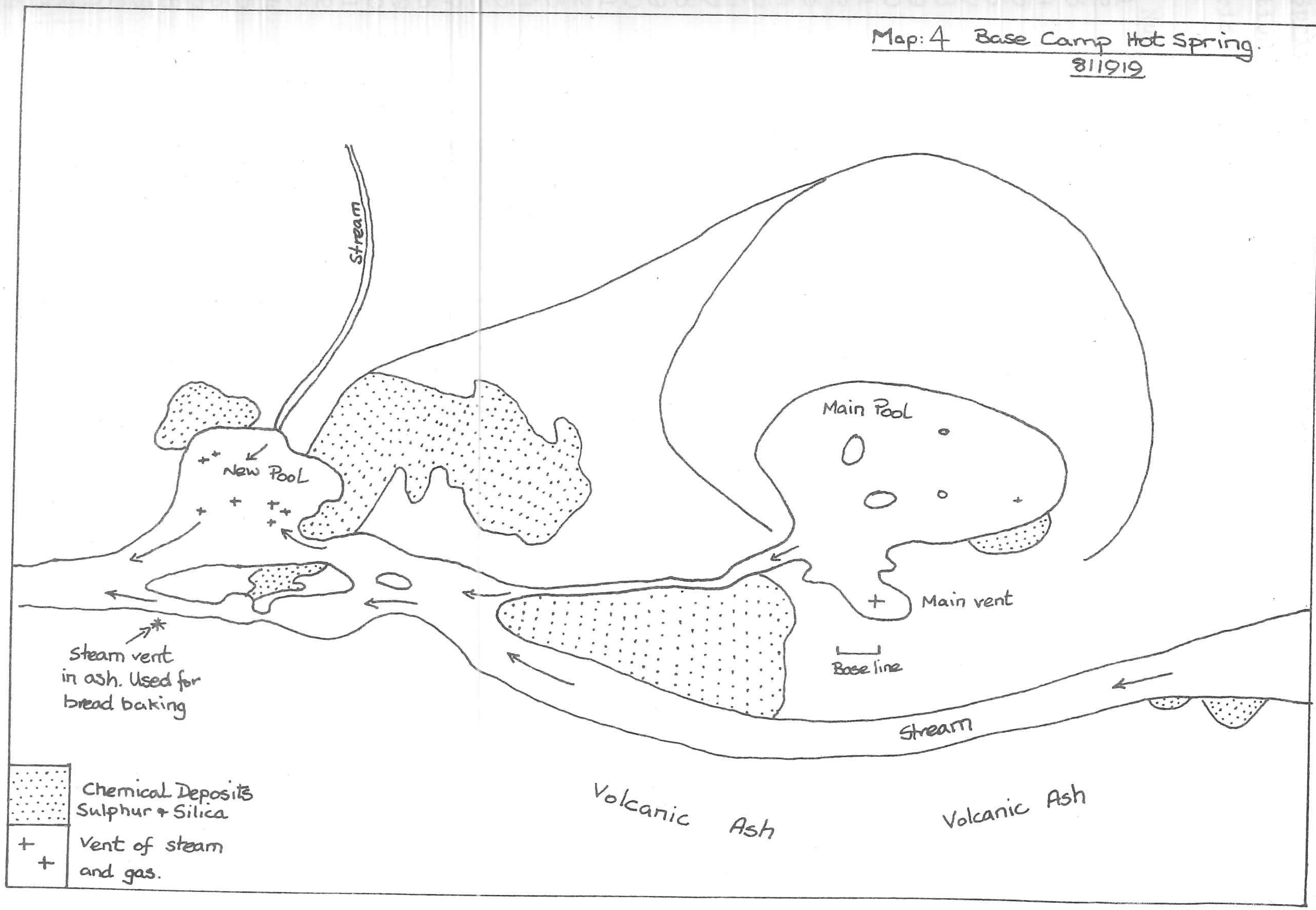
On plotting these bearings and taking back bearings we were able to plot the positions of the springs. So much for the theory... In Iceland a number of factors operate to confound the aspiring cartographer, the most troublesome of which is compass deviation. This is distinct from magnetic variation which is a product of the non alignment of the Earth's rotational and magnetic axes, has a known value and can therefore be allowed for, compass deviation is a deflection of the compass needle caused by local effects of unknown magnitude. In our survey deviation was probably caused by ferromagnetism in the igneous rocks and possibly on a less localised scale, by the magma convection cell beneath the North Atlantic ridge. The problem may well have been compounded by our northerly latitude.

The effect was that one could take a few steps in any direction and observe one's compass needle to swing through a considerable angle, in the worst places up to 20°. The map we produced,however, bears a close resemblance to what we saw on the ground.

For the other surveys of the volcanic cone and lava flow of Hrafntinnahraun, the ice hole and plans directly related to slope surveys and the wanderings of biologists, we constrained by time and terrain to rely largely on photographs, sketches and paced out measurements from which, however, we have gained a great deal of knowledge and the intimate appreciation of the volcanic land forms of the area.



Map.3 Part of 1:50,000 map of Laufafell to show position of roads.

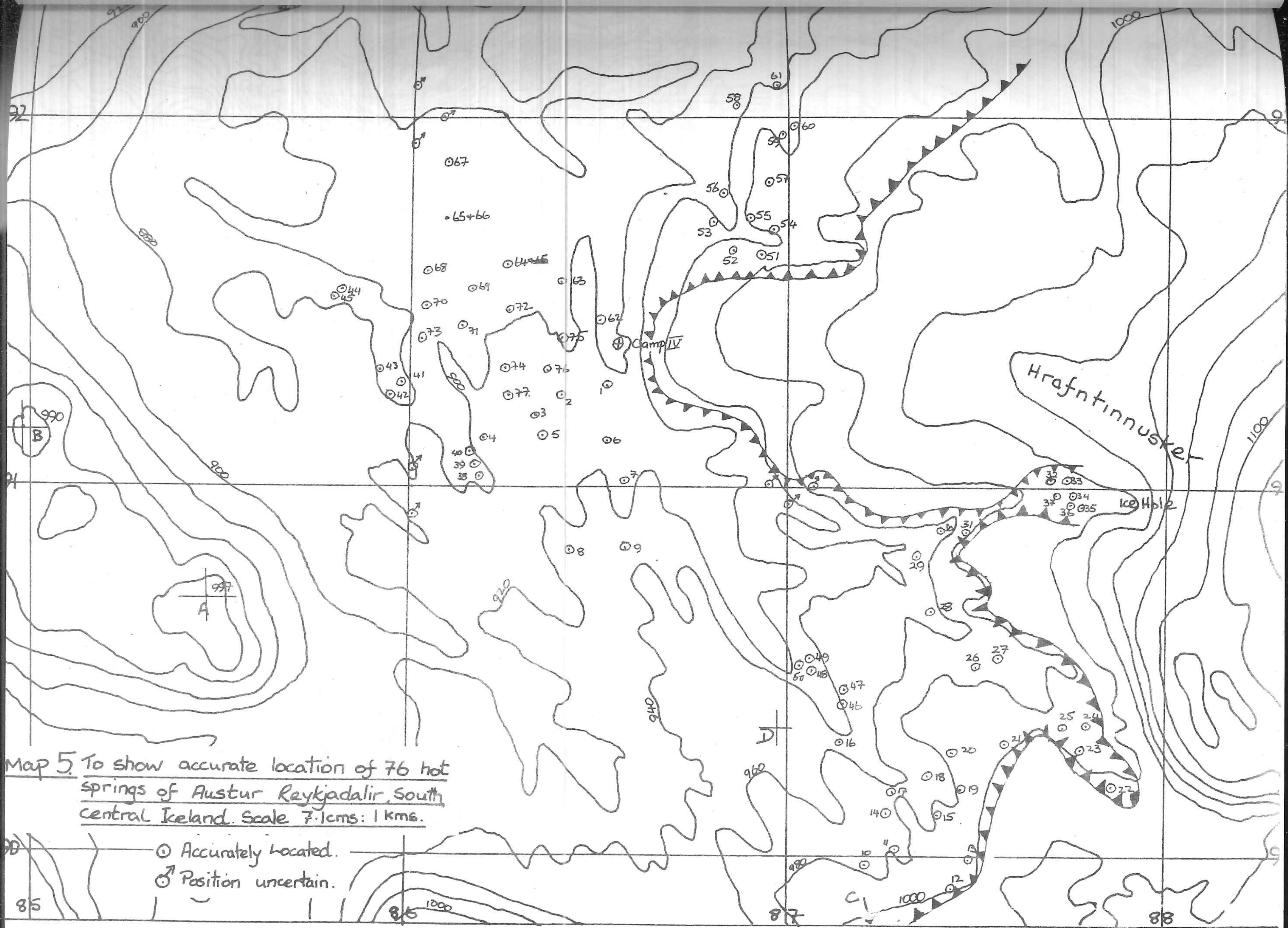

Map: 4 Base Camp Hot Spring
8/1/919
Stream
New Pool
Main Pool
Main vent
Base line
Stream
Steam vent in ash. Used for bread baking
Chemical Deposits Sulphur + Silica
Vent of steam and gas.
Volcanic Ash
Volcanic Ash

Hot Spring Survey. Austur Reykjadalir.

Location of sites by bearings. Bearings converted from magnetic to grid and allowance made for magnetic variation of 19.3°West.

Site Number.	Bearings of springs			
	A	B	C	D
1	60.5			333
2	58.5			326
3	59			322
4	59			314
5	62			321
6	66			329
7	73.5			328
8	81			310
9	82			319
10			340	151
11			1	140
12			42	136
13			39	128
14			359	132
15			20	122
16			346	110
17			0	121
18			10	113
19			22	113
20			18	100
21			28	96
22			54	102
23			42	96
24			40	91
25			37	92
26	95		17	
27	94		22.5	
28	91		7	
29	86		4	
30	85		8	
31	84		11	
32	81		18	
33	82		21	
34	84		12	
35	85		24	
36	85		22	
37	84		20	
38	66	97		
39	64	96		
40	61	95		
41	41	84		
42	42	86		
43	36	82		
44	22	68		
45	22.5	66		
46	100	76		
47	99	60		

Site Number	Bearings of springs			
	A	B	C	D
48	97.5	29		
49	96.5			24
50	98			13
51	57.5	76		
52	56	75		
53	53	73		
54	56	75		
55	55	74		
56	52	71		
57	53	71		
58	48	67		
59	51	69		
60	52	69		
61	48	66		
62	53	78		
63	46.5	72.5		
64	40	70		
65	30.5	61.5		
66	30.5	61.5		
67	27	56		
68	32	62		
69	38	71		
70	35	71		
71	41	75		
72	44	74		
73	38	76		
74	52	79		
75	51	81		
76	55	82		
77	55	85		



Map 5. To show accurate location of 76 hot springs of Austur Reykjadalir, South central Iceland. Scale 7·1cms: 1 kms.

⊙ Accurately Located.

Position uncertain.

Map. 6. Part of 1:50,000 map to show hot spring survey sites and route to Landmannalaugar from Camp IV and back.

b) Hot Springs

1. Base Camp

This hot spring was located at grid reference 811919, very near the base camp. Since 1970 the pool has changed a great deal. It is more active than in 1970 and new vents have been formed, including two new pools.

We carried out a detailed study of this pool and made a map to compare with a map made in 1970. We took measurements of temperature in the pools and the surrounding ground.

Base Camp Hot Spring Survey One.

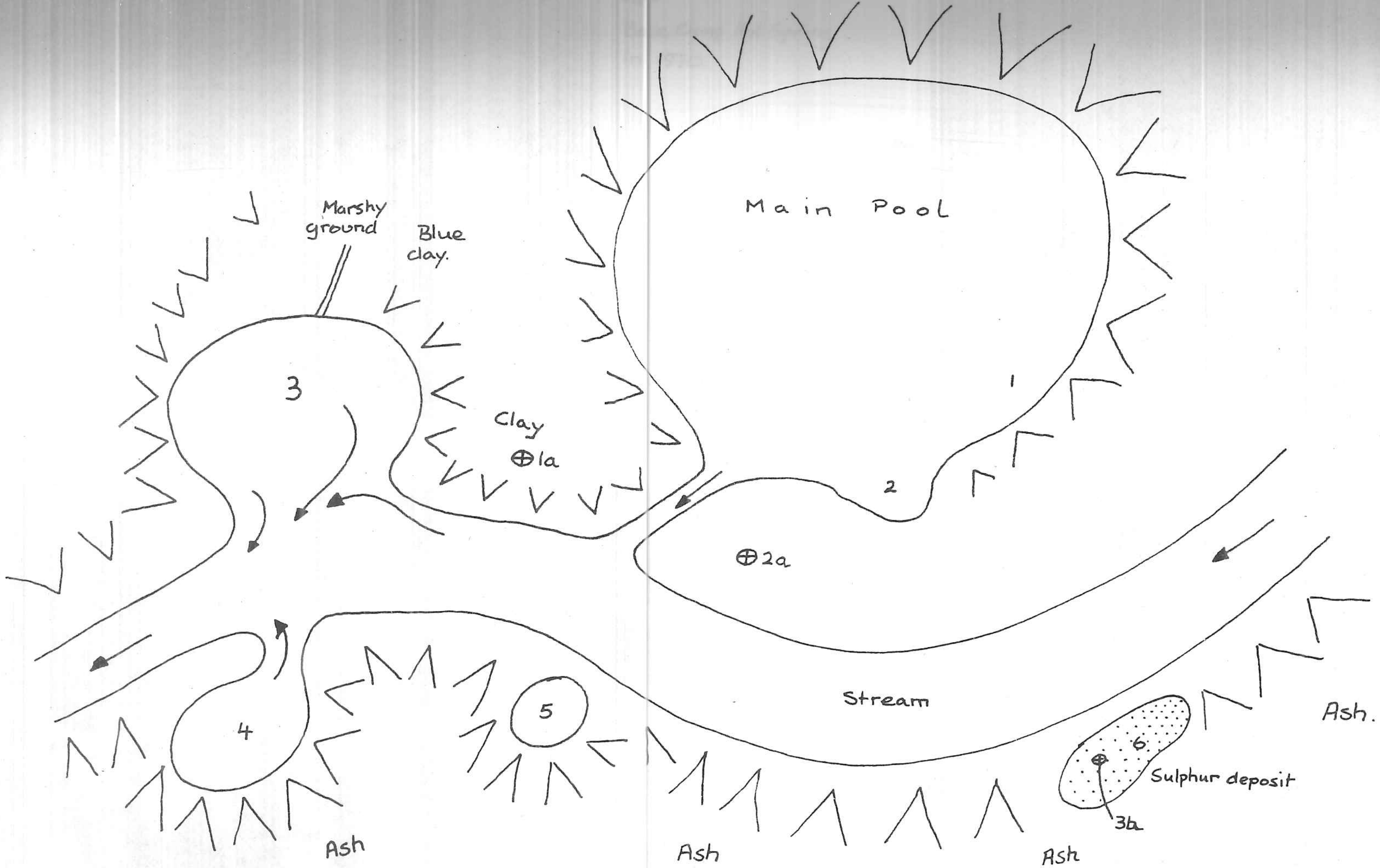
Measurement of Pool and Vent Temperatures.
(see sketch map for location of sites p.28.).

a) Description of sites.
Site 1. Main pool. Surrounded by steep slopes (2m) to north, west and east. Size 2.5x3m. Clear, faint blue colouration due to colloidal silica. Depth 15m+.

Site 2. Main vent. Permanently gushing steam vent. 0.8m. across. Small output. 2 litres per minute feeding into main pool.

Site 3. Secondary pool. Inlet of water from marshy area above pool. Steep slope on west side of pool, shallow slope on east side. Pool water mixes with stream water. Size 3.2mx3.4m. Clear, bubbling.

Site 4. Secondary pool. Small pool recessed into a steep ash bank. Cold water from stream flushes pool. Size 0.8mx1m. Clear, bubbling.



Sketch.1.

Sketch of base camp hot spring showing survey sites. (see text).

Photo.1. ← Base Camp Hot Spring in 1970.

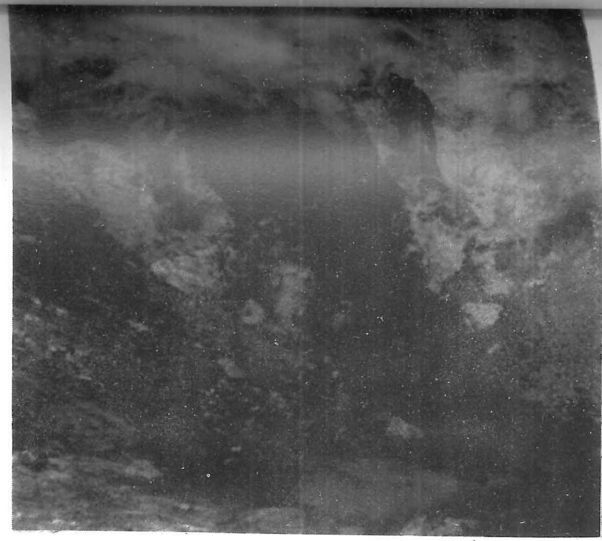


Photo.3. → Intermittent hot spring 1970. Note the pool at the base of the spring.

Photo 2 ↓ Base camp hot spring 1978

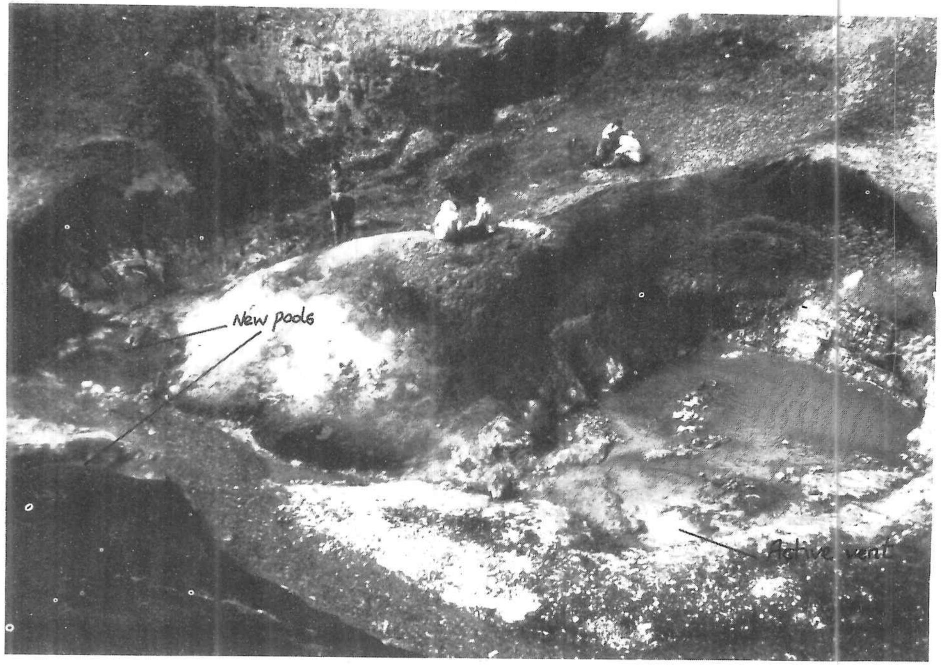


Photo.4. → Intermittent hot spring 1978. Pool now filled in with chemical deposits.

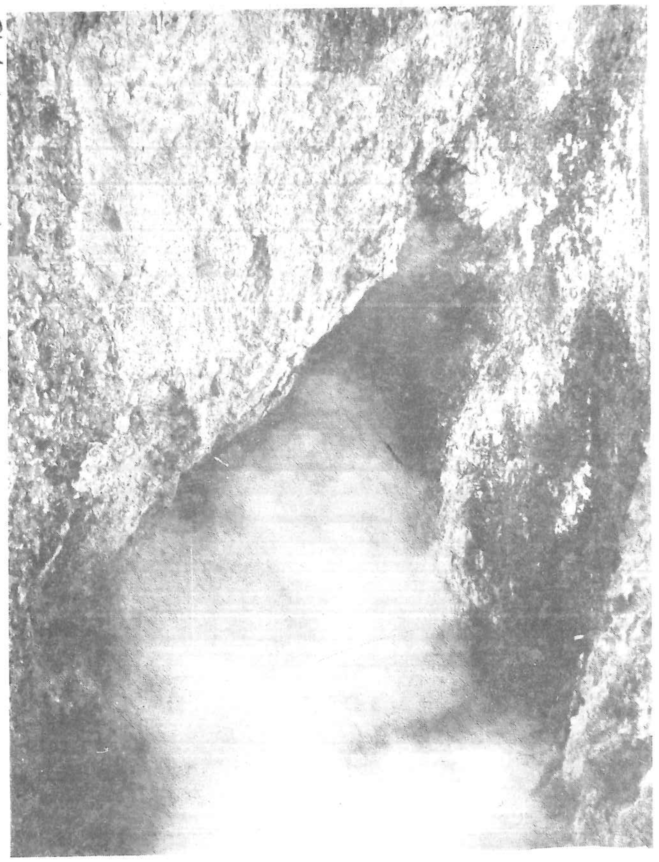


Photo.6. Large Steam vent.

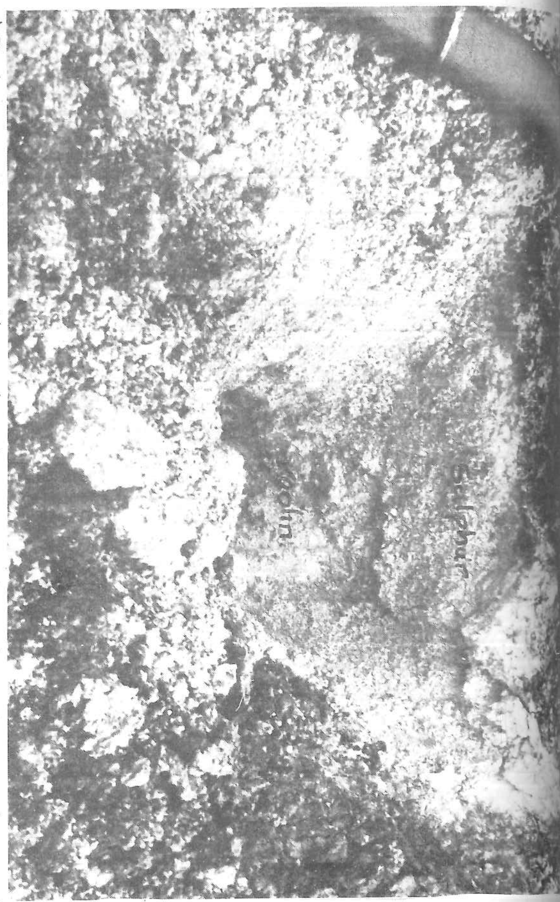


Photo.5 Sulphur deposits just below the surface. Rhombic + monoclinic crystals

Photo.8. Blue mud pool. Very active.

Photo.7. One of the largest hot areas.

Site 5. Small Mud Hole. Recessed into ash slope. Small outflow of muddy brown water.

Site 6. Sulphur deposits on lower slopes. Rhombic and monoclinic sulphur crystals present on ash particles.

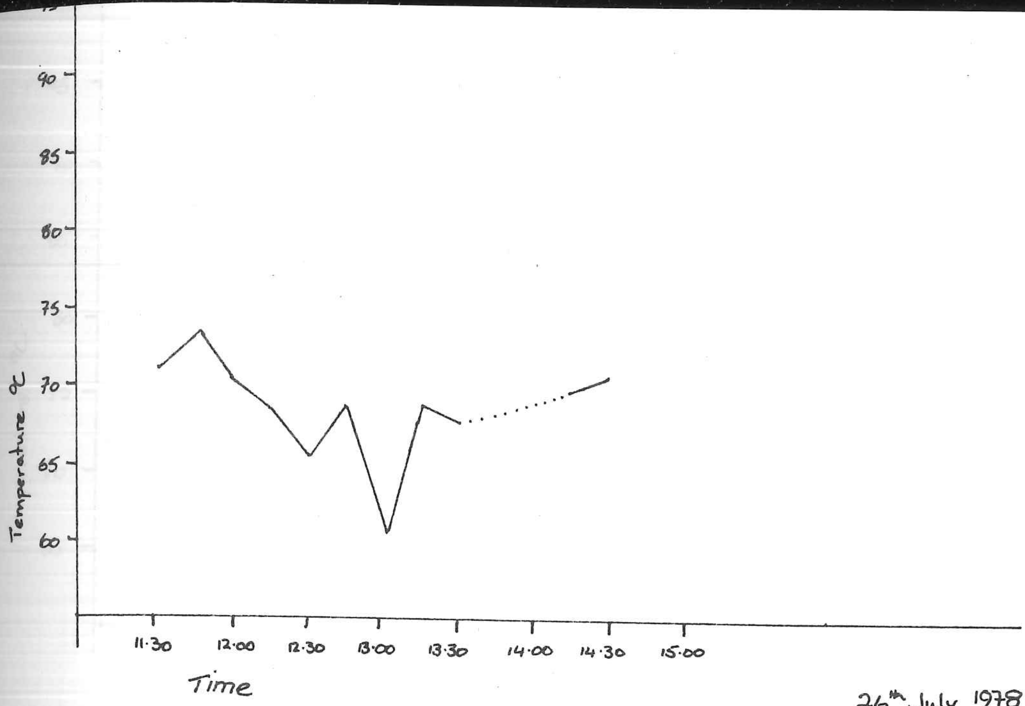
Results of Survey One.

Wednesday 26th. July.

Time \ Site	1	2	3	4	5	6
11.30	71	78	90	34	84	94
11.45	73	76	90	35	85	91
12.00	70	84	88	32	86	95
12.15	68	83	89	30	86	94
12.30	65	85	91	34	85	95
12.45	68	85	90	36	85	93
13.00	61	92	91	33	85	95
13.15	68	95	91	32	87	95
13.30	67	84	92	33	86	95
13.45	-	-	-	-	-	95
14.00	-	-	-	32	90	95
14.15	69	86	91	31	92	95
14.30	70	85	90	29	95	95

Thursday 27th July.

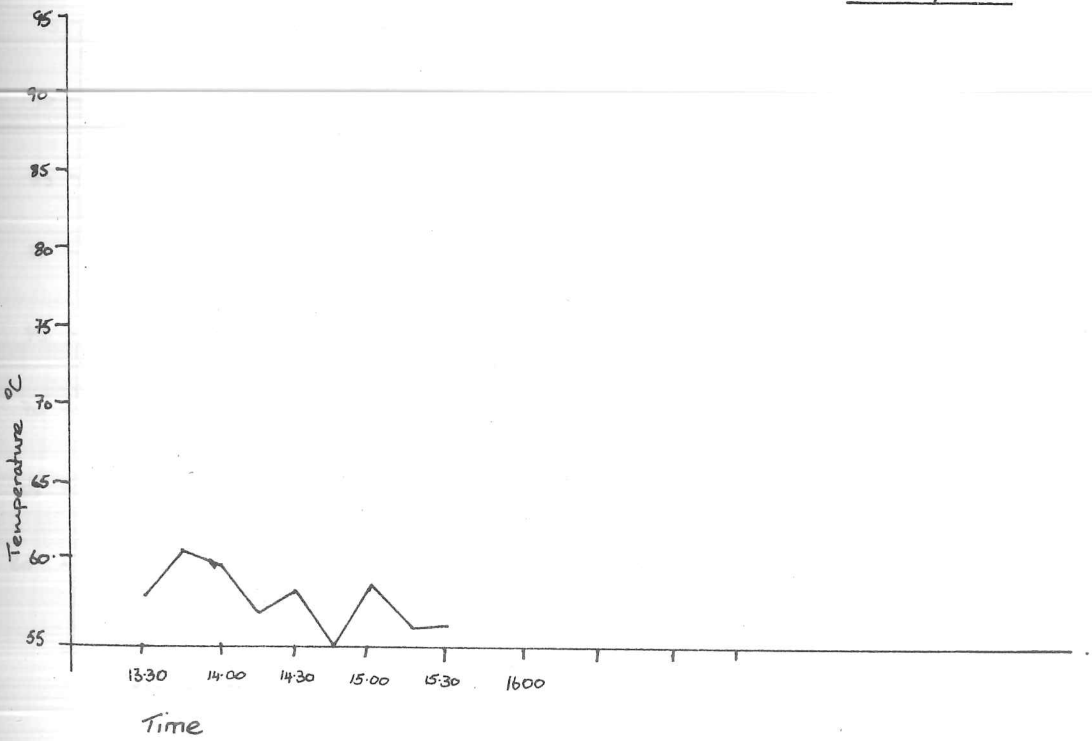
Time \ Site	1	2	3	4	5	6
13.30	58	85	80	25	90	96
13.45	61	83	82	28	90	96
14.00	60	84	80	24	90	96
14.15	57	86	80	22	89	96
14.30	58	85	78	24	88	96
14.45	55	88	79	27	89	96
15.00	58	85	79	26	89	96
15.15	56	85	78	29	89	95

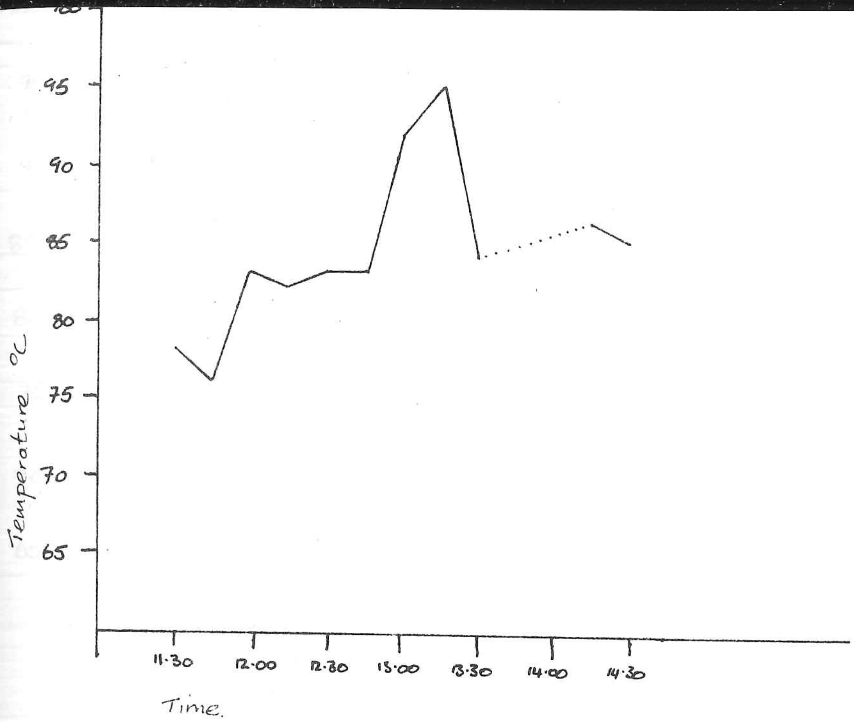


26th July 1978

Hot Spring Survey Site 1

27th July 1978

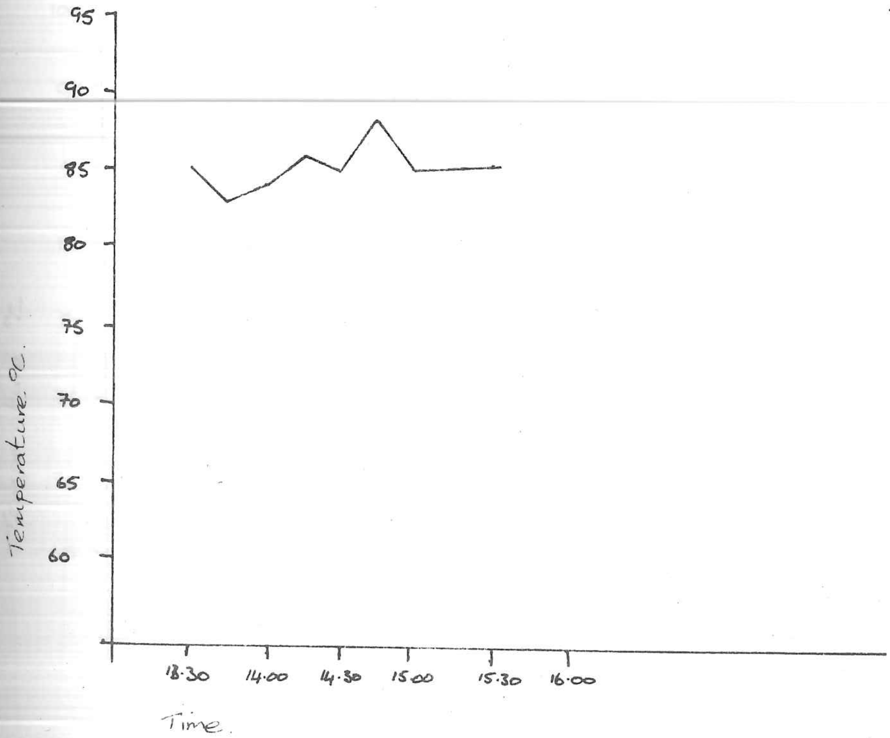


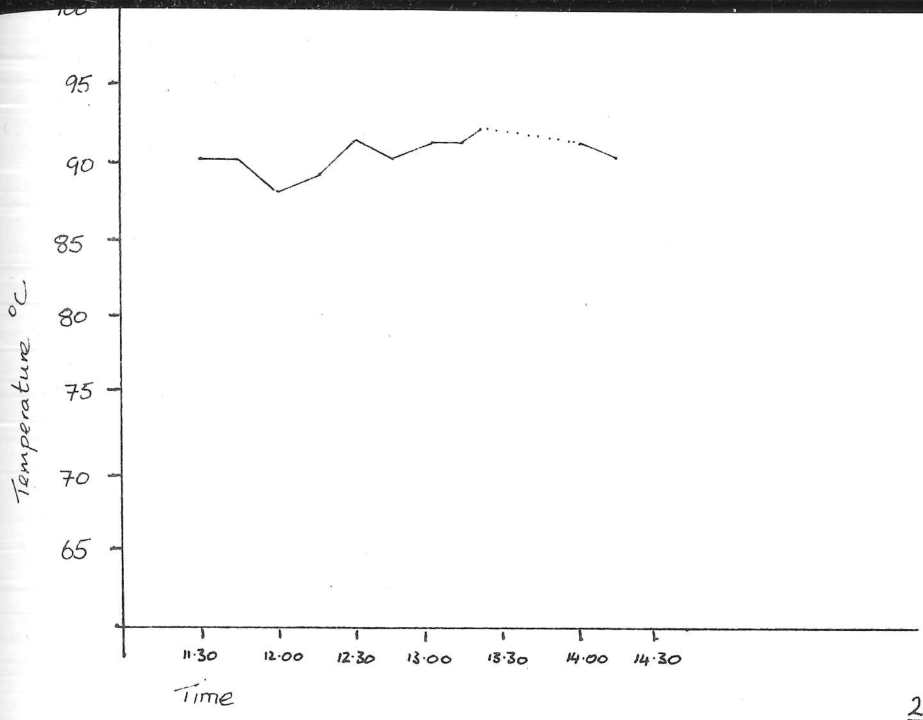


26th July 1978.

Hot Spring Survey Site 2

27th July 1978.

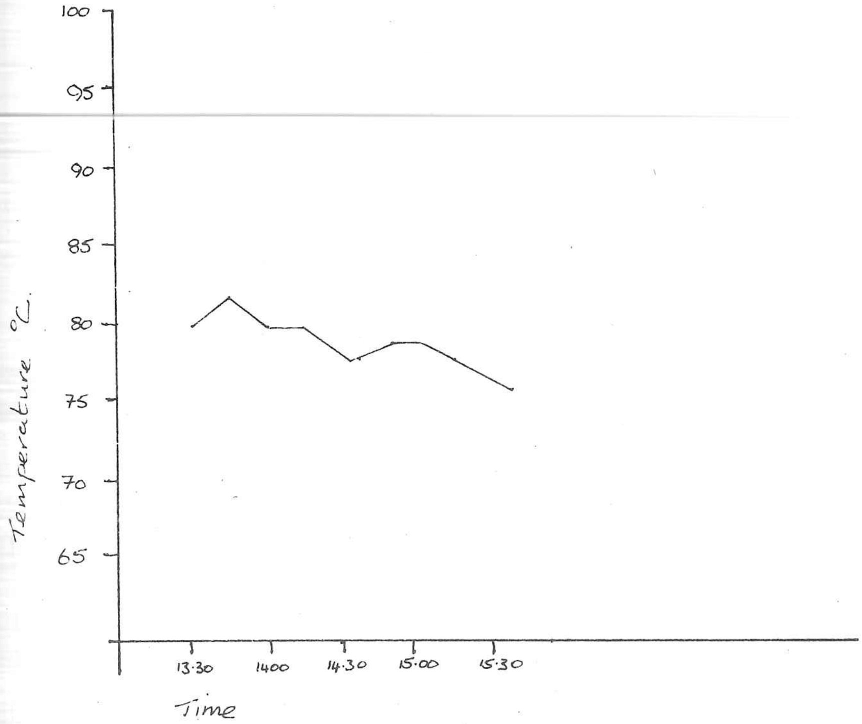


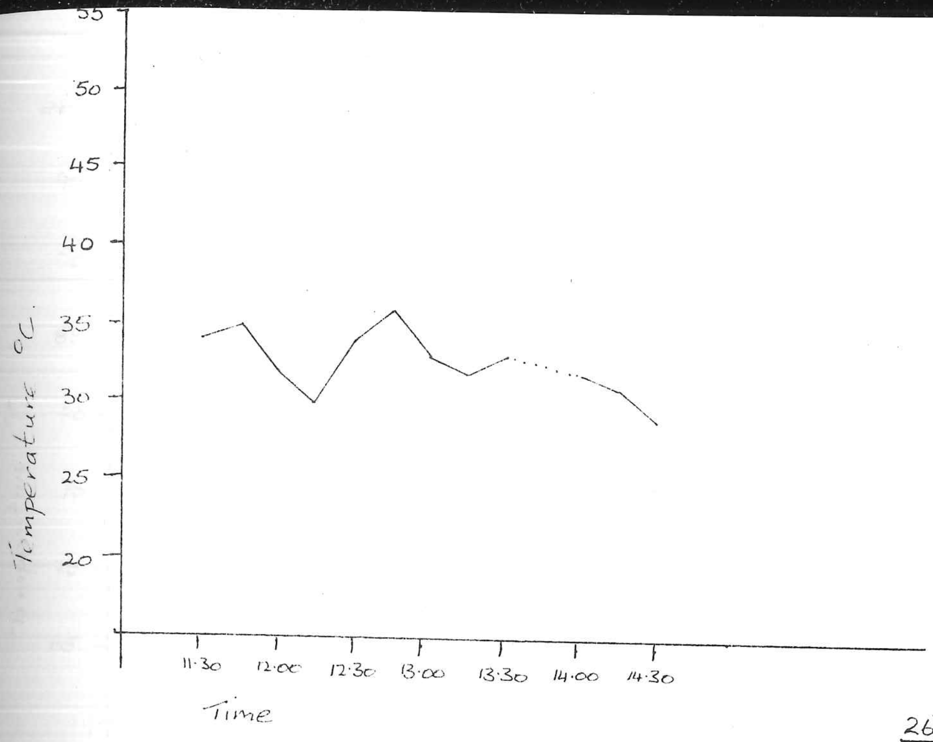


26th July 1978

Hot Spring Survey Site 3

27 July 1978

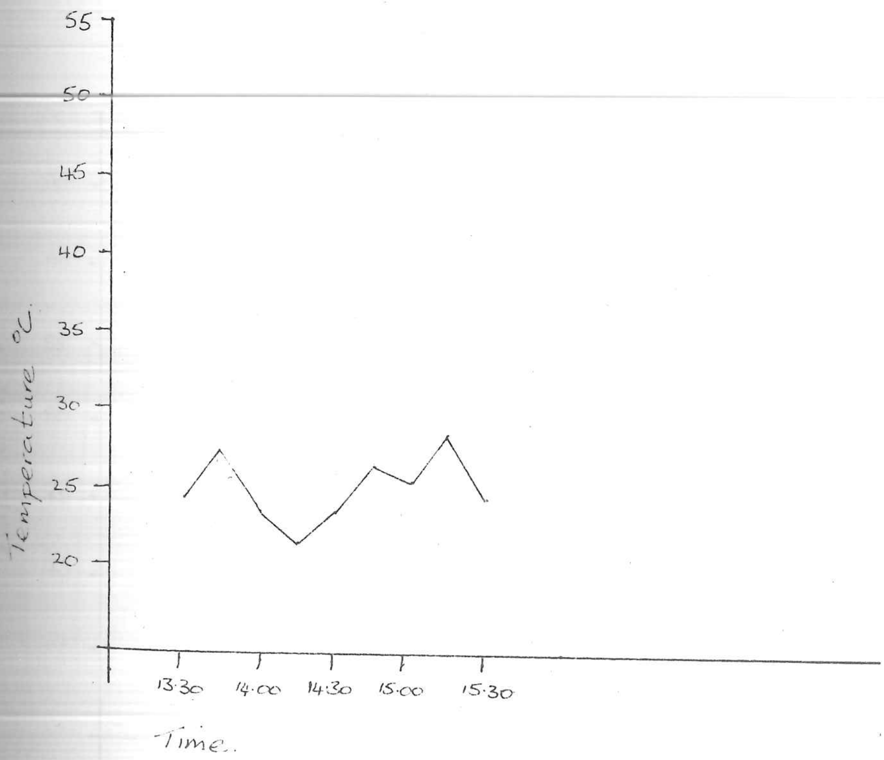


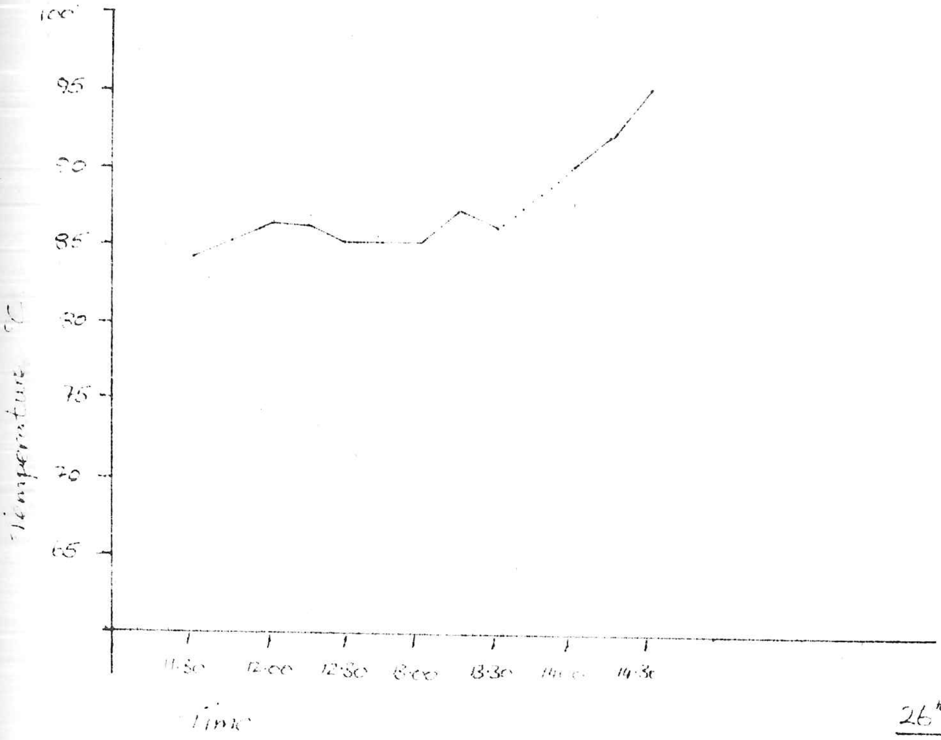


26th July 1978

Hot Spring Survey Site 4

27th July 1978

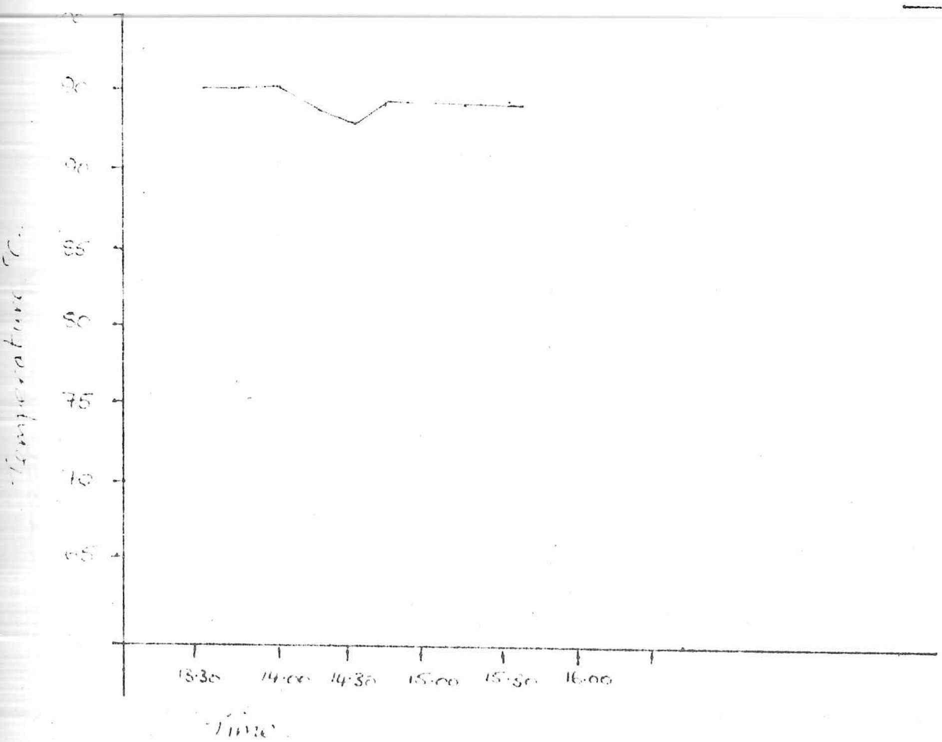


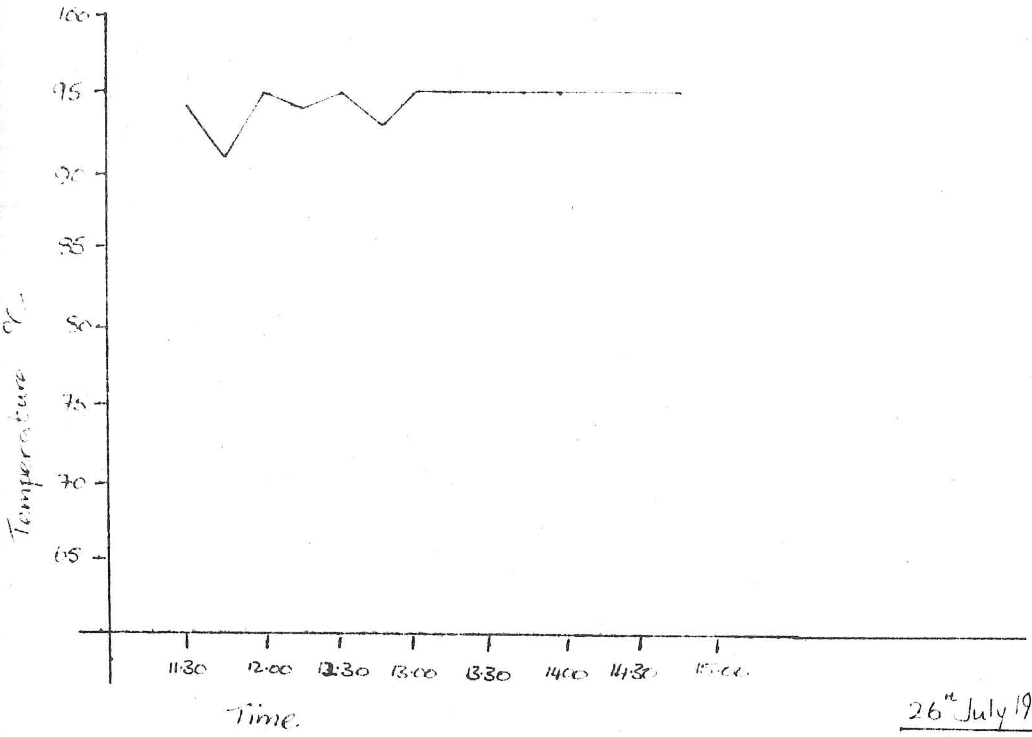


26th July 1978

Hot Spring Survey Site 5

27th July 1978

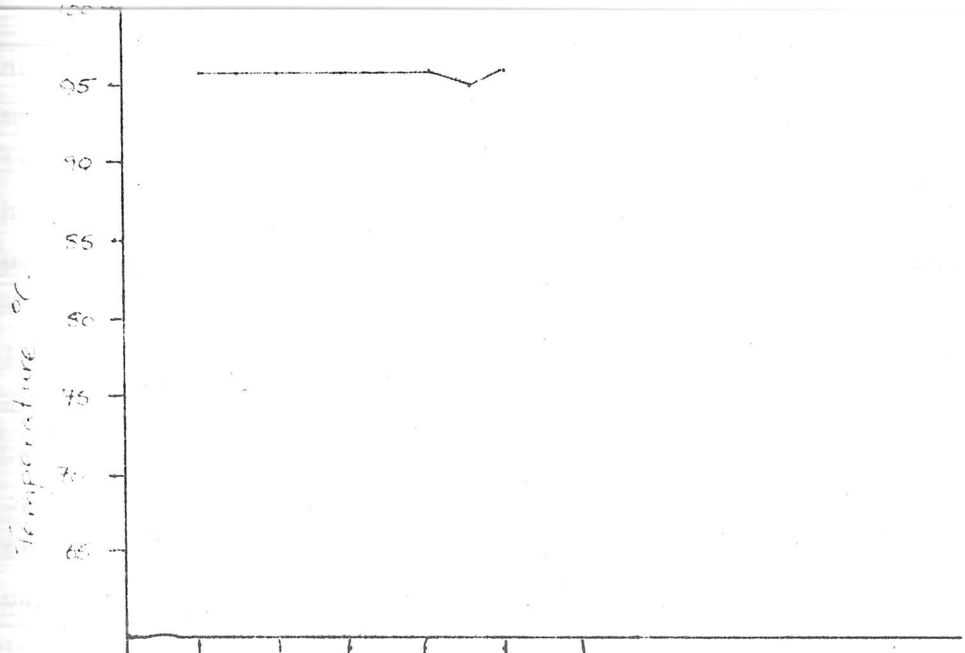




26th July 1978

Hot Spring Survey Site 6.

27th July 1978



Results of Survey Two.

Temperature variation with depth.

Depth cms. \ Site	1a	2a (temp. °C)	3a
0	39	81	79
3	56	89	95.5
6	69	90	96
9	81	98	96
12	91	98	96
15	95	99	96
18	90	96	94
21	97	95	85
24	90	96	85
27	-	-	85

Conclusion

All three graphs have something in common. The temperature rises fairly quickly to begin with and then the rate of increase falls off. The highest temperatures are around the 12cm. mark.

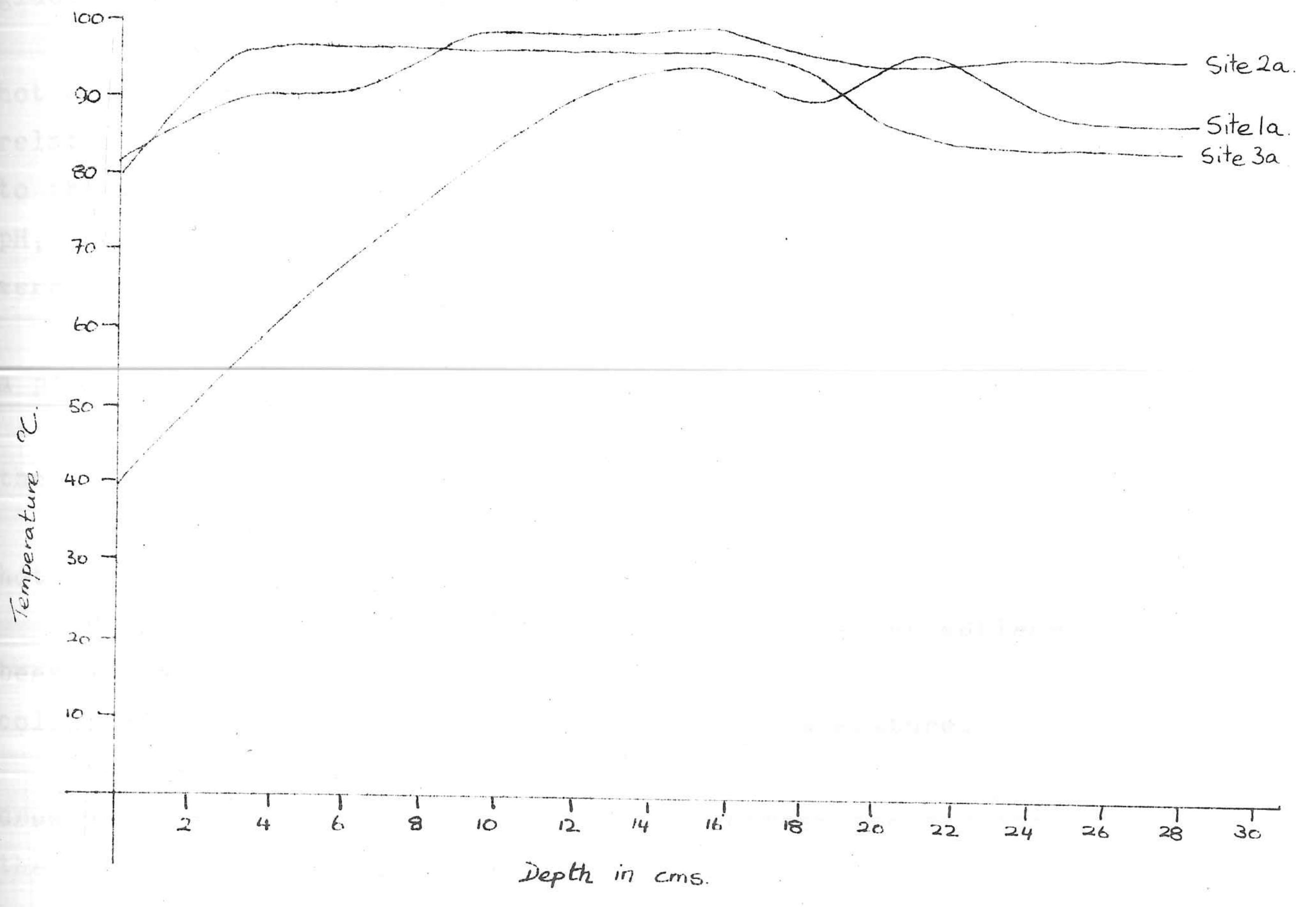
No definite conclusions can be made from these results and further measurements with an instrument capable of measuring the temperature of rocks at depth would be extremely interesting. However the surveys were interesting as these hot springs were the first seen by the majority of the members of the expedition and therefore the study was worthwhile.

The deposits of sulphur and silica collect rapidly. In a cleared area deposits were noticed coating the volcanic ash after three days.

The changes in the pool in eight years have been quite dramatic. The large pool has not altered in size although the water level has dropped 10cms. due to downcutting of the outflow channel. The second pool is completely new and has formed where ther were gas outlets in the stream bed.

Hot Spring Survey 2.

Variation in temperature with depth



Decomposition of the rock has taken place and the pool is now quite large. Opposite this pool is the other new one formed in the steep ash slope and upstream a small vent.

In all there has been a noticeable increase in activity over the past eight years.

2. Austur Reykjadalir

This survey was carried out on the hot springs of Austur Reykjadalir to the north and north-west of Hrafntinnusker.

The area was divided into two sections, one to the south of Camp IV and the other to the north. (see map p.26).

To the south the area was much higher and nearer to the glass lava flow capping Hrafntinnusker.

The purpose of the survey was to fix the position of each hot spring and so determine whether their position bore any relation to the geological structure of the area. In addition to this, each site was sketched and recordings of temperature, pH, slope direction, vegetation and type and extent of deposits; were made.

The data was then collated back at camp and put onto a photographically enlarged map of the area.

In the whole area no temperature was found above 98 ^{o}C and the clay surrounding the pools was generally lower than this.

The springs to the south of the area were found to be hotter than those to the north in general.

The soil temperatures, measured 5cms. below the surface, bear no relation to the temperature of the hot pool, and the colour of the clay is no indication of the temperature.

The light brown areas around some springs were usually crusty, with a thin layer of dried clay between the air and the hot clay beneath which was usually blue in colour.

A number of dead vents were found in places where eight years before there was activity. Some had been filled in by wind blown material and rings of moss have grown over the areas.

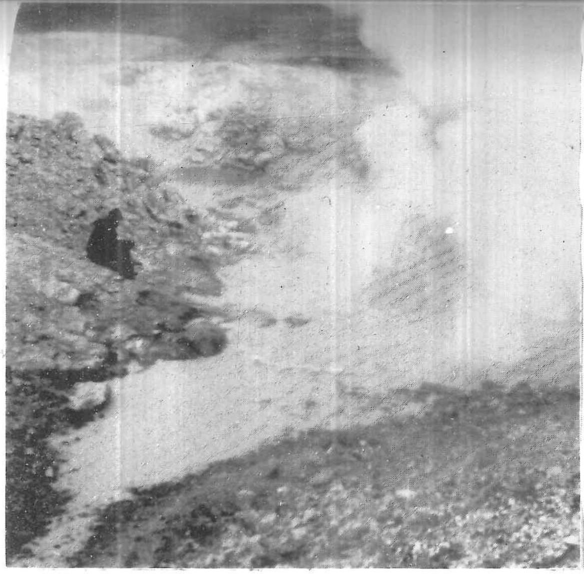
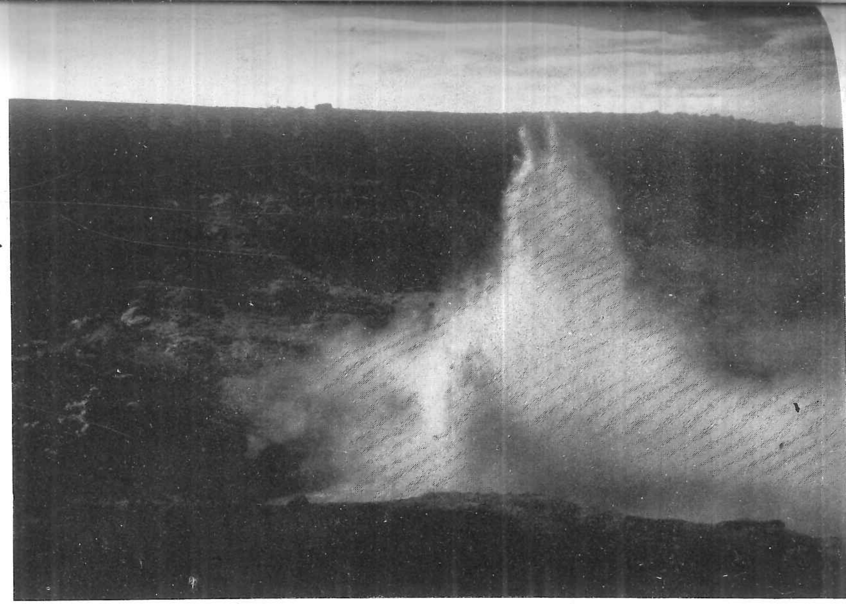


Photo. 9.
←
Larget hotspring observed in 1970. Column of water 1·5 m high.

Photo. 10.
→
Largest pool as in photo 9. Now a geyser erupting every 30 seconds 5+ metres.



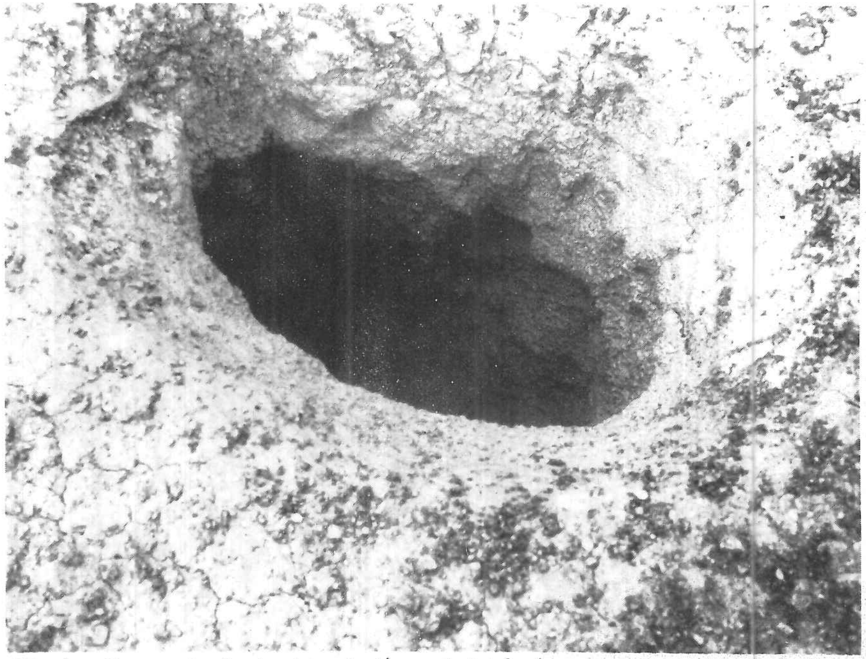


Photo 11. ↑ Mud hole. Active. Light brown in colour

↑ Photo. 12. Blue Mud Pool.

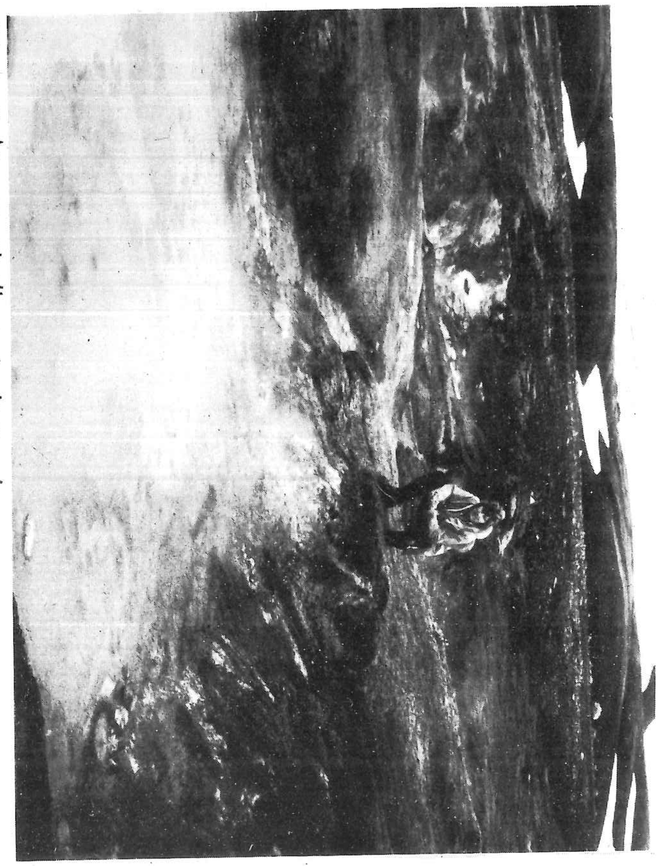


Photo 14. Large shallow hot pool.

Photo 13. Sulphur deposits around an active vent.

Photo 16. Small blue watery mud hole.

Photo 15. Small clear active hot pool.

It appears that some vents are dependant upon the height of the water table for their activity. During a dry period the water table falls and the vent becomes inactive (issueing only a small quantity of gas in some cases). As the water table rises during a period of rain the vent becomes active. In most cases however, the amount of water discharged was very small, 2-5 litres per hour. At Landmannalaugar the rate of discharge was considerably greater (see p.66).

In one area we located a spring which discharged water at an estimated rate of 5 litres per second and it's temperature was 42°C. This was a spring emerging from beneath the glass lava flow of Hrafntinnusker at grid ref. 875906.

Conclusion

Although no relationship was found in this area between the position and temperature of hot springs it was discovered that violence or activity increased from the north to the south. The source of heat for this activity is coming from beneath the glass lava flow. The flow is acting as a cap and heat only escapes around the edges.

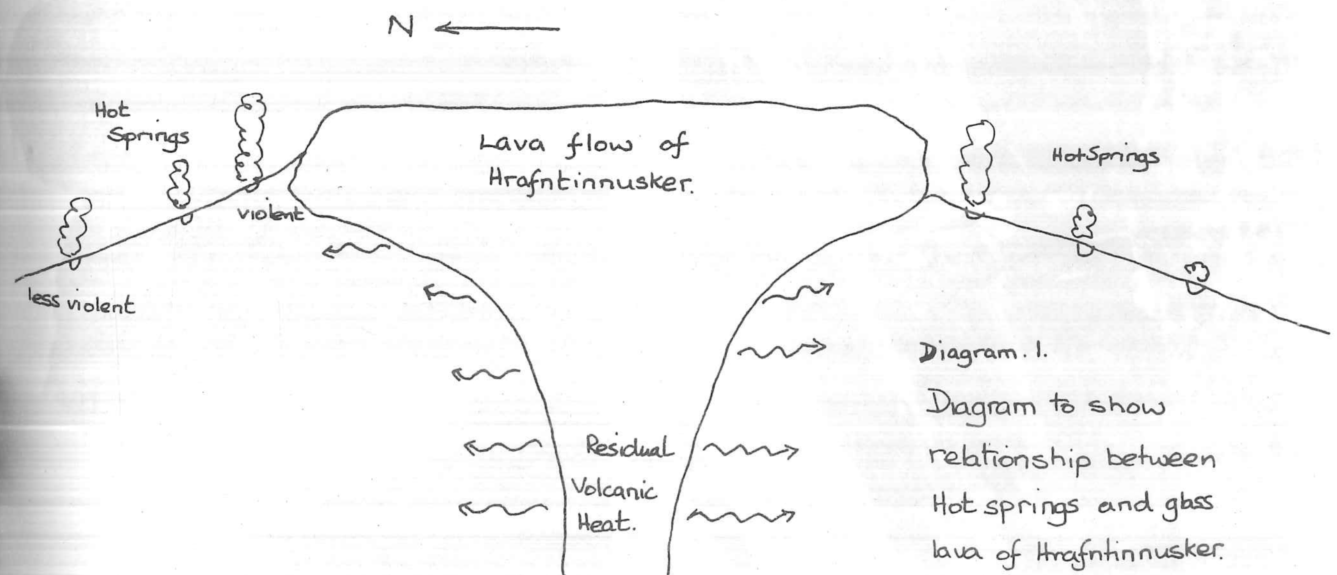
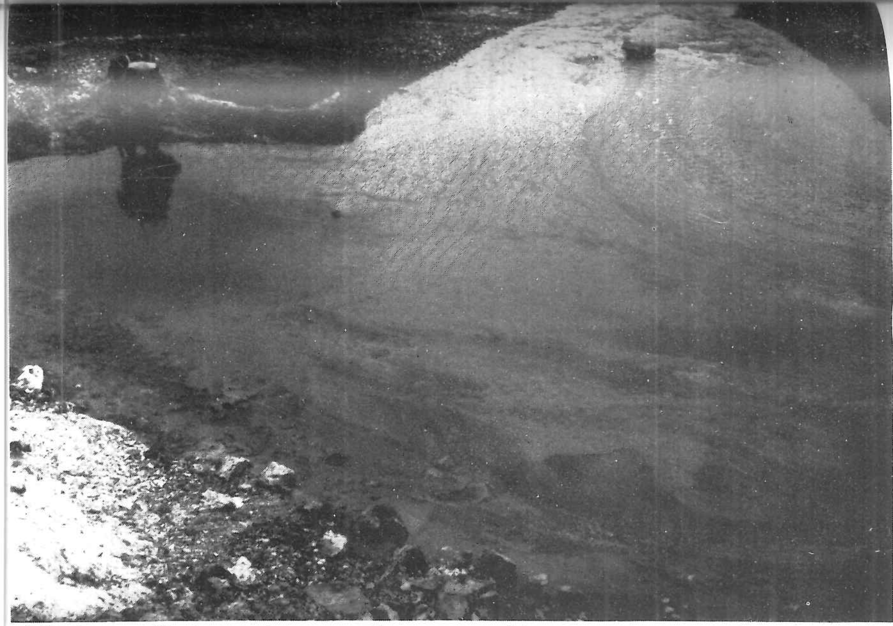


Diagram. 1.
Diagram to show relationship between Hot springs and glass lava of Hrafntinnusker.

Photo. 17. ↑ Steam vent below glass lava of Hrafntinnusker.



↑ Photo. 19. Pools in stream bed. Downward current observed in left hand pool.

Photo. 18. ↑ Travertine terraces. The only terraces observed.

Photo. 20. Large, deep hot pools. ↑

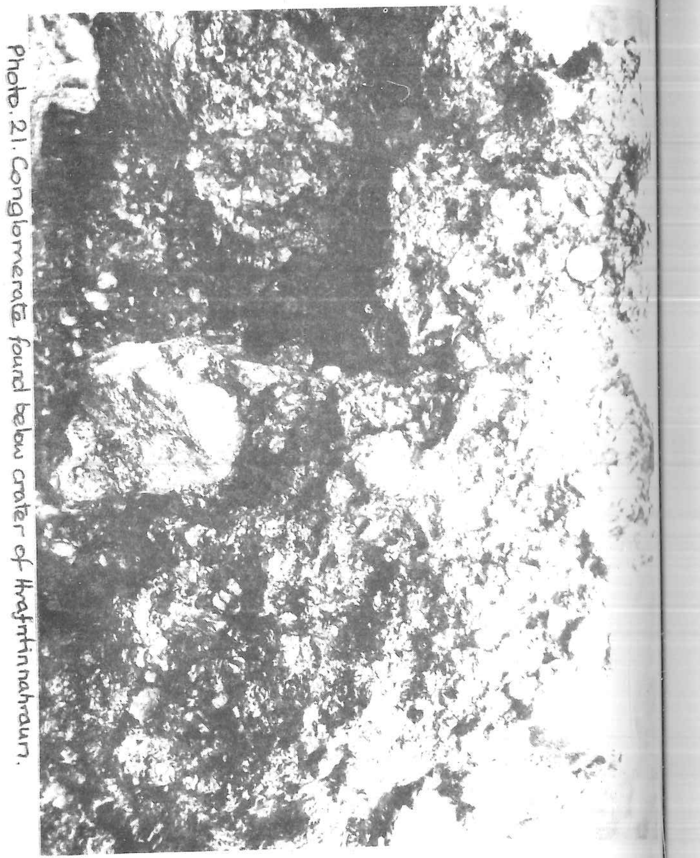


Photo. 21. Conglomerate found below crater of Hrafntinnuhraun.

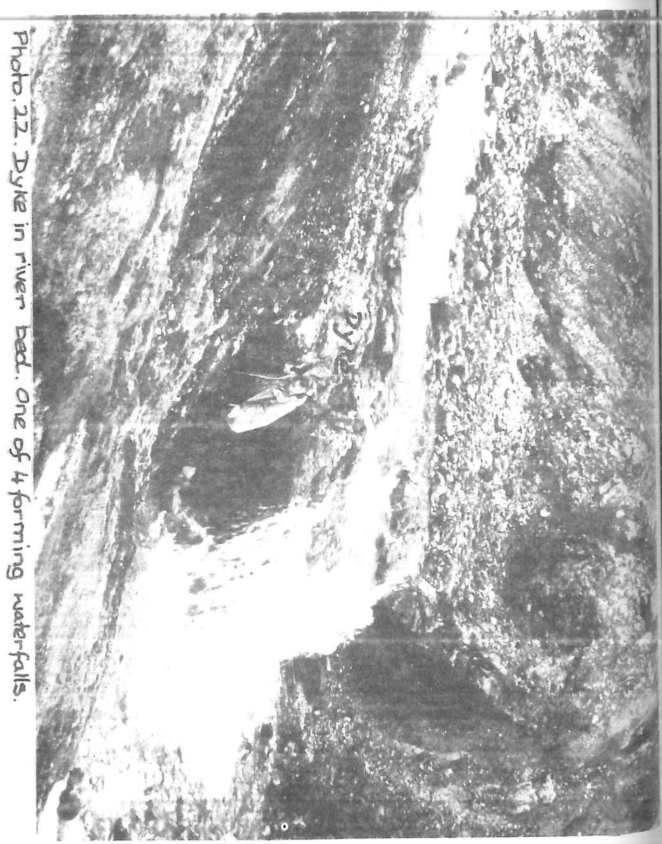


Photo. 22. Dyke in river bed. One of 4 forming waterfalls.

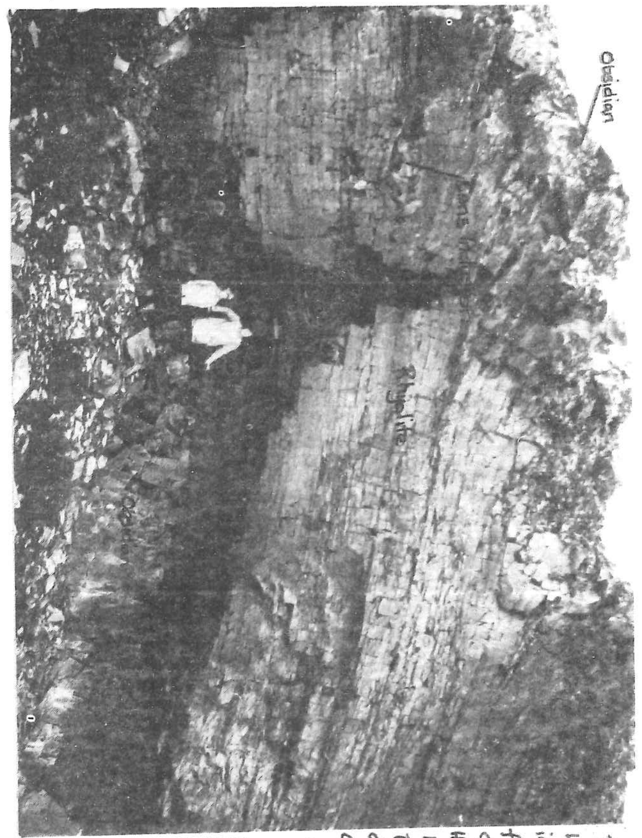


Photo. 23. Lens inclusion in large lava flow in the crater of Hrafntinna-hraun. Block jointing due to cooling.

Photo. 24. Lens inclusions in same crater

The nearer to the source of heat the more intense the activity. The further away (to the north), the less intense the activity becomes. Overall, activity in the area has increased substantially since 1970.

Austur Reykjadalir Hot Spring Survey

Description of sites.

Site 1. Vegetation absent in vicinity of vents. Three inactive vents which have dried up and issue no steam although ground is still warm. Mud at 88°C but surrounding ground 35°C.

Site 2. S.E. facing slope. No central vents. Mud coloured red, yellow and brown. One small bubbling pool with temperature at 96°C. Vegetation growing around water outlet (51°C). Algae closest grading into moss.

Site 3. Some small steam vents. Deposits very pale blue and brown, not extensive. Vegetation not extensive.

Site 4. Main pool turbid with blue colloidal silica. Extensive deposits downslope at 92°C. Spring 2 metres deep on one side. South facing slope.

Site 5. Large area of hot mud pools. One steam vent.

Site 6. North facing slope with blue clay deposits. Colour of soil bore no relation to temperature.

Site 7. Area of clay and sulphur deposits. No main vents but whole area steaming. East facing slope 96°C.

Site 8. Active area but with no central vent. Split by E-W ridge. Concentric rings of dead plants on old, filled in vents.

Site 9. Large area-50 square metres of gullied ground, mostly light brown. Large numbers of blue clay areas with temperatures of 96°C. Violent steam vent in top left of diagram. (see,p. 53).

Site 10. Large area. Difficult to sketch due to steam. One large pool of watery mud. Temperature of water 90°C.

Site 11. No extensive deposits. Large pool 48°C.

Site 62. Inactive area apart from 2-3 steam vents. Blue colour around vents. Clay 90°C. Steam 96°C.

Site 63. Large area of steam vents in depressions, yellow colour. Larger hole had pool of grey-blue water.

Site 64. Inactive area apart from one steam vent at 85°C.

Site 66. Green algae growing at temperature of 41°C. Stream was a dark grey colour at 63°C.

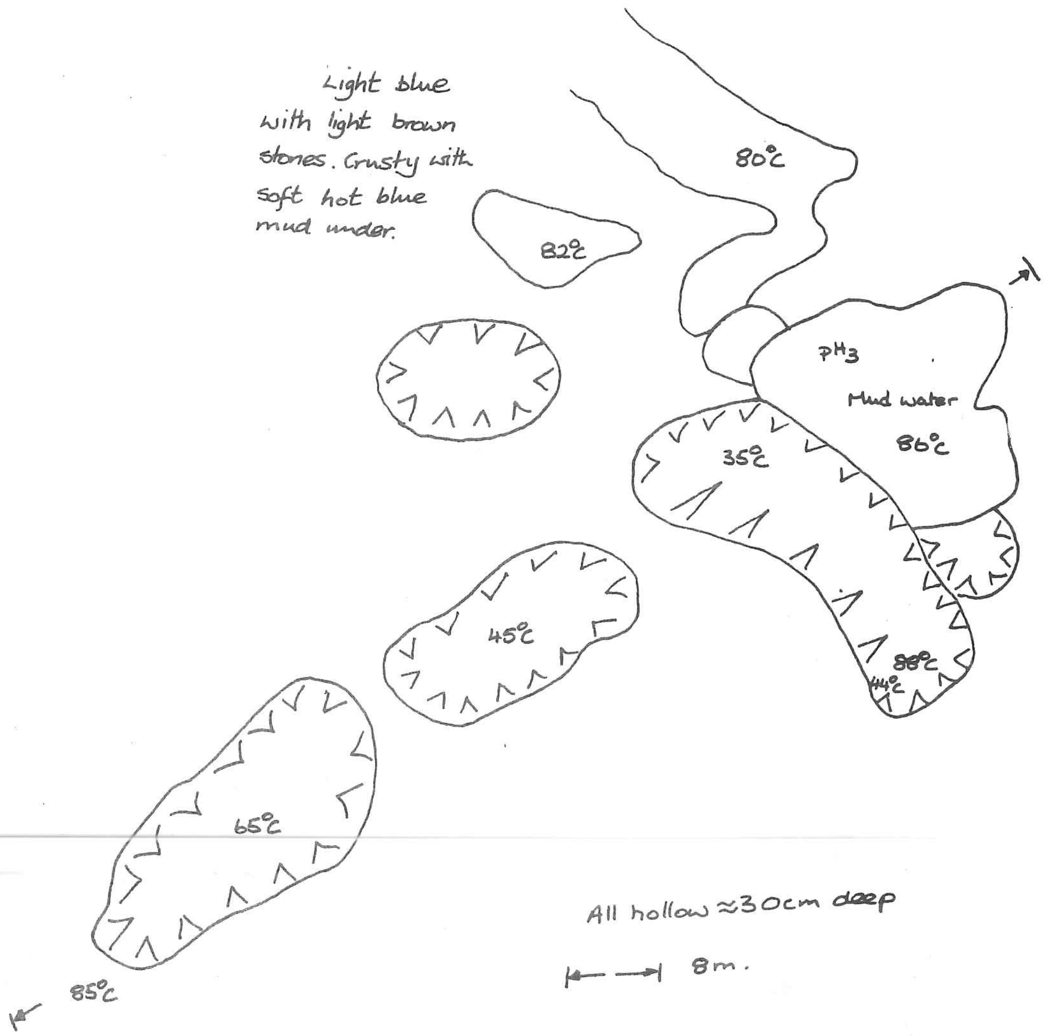
Site 68. A curved bank. Layers of colour along the bank. Red on top, then blue, then yellow. No vegetation.

Site 69. Two active areas with a dead area in between.

Site 70. Area of activity centralized on a pool of blue water. Red colouration in many areas. 12 metres across.

Site 71. Fairly large area. No central pool but ground had a large number of vents.

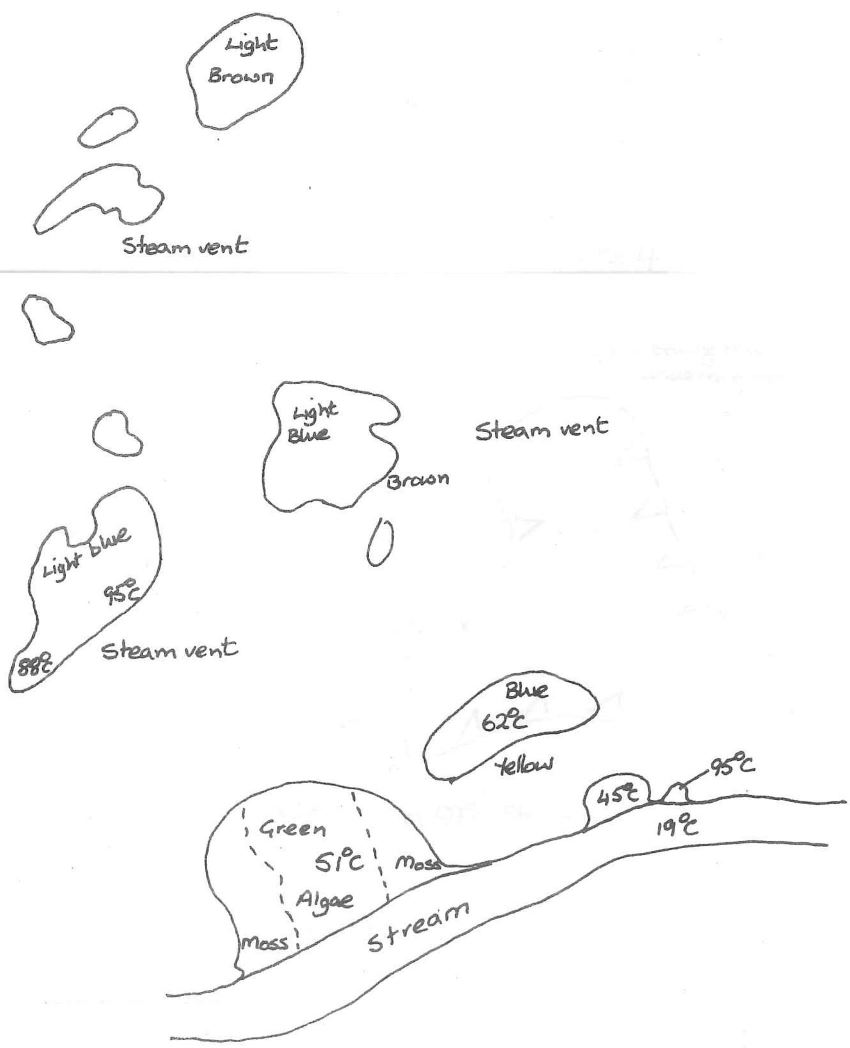
Site 1.



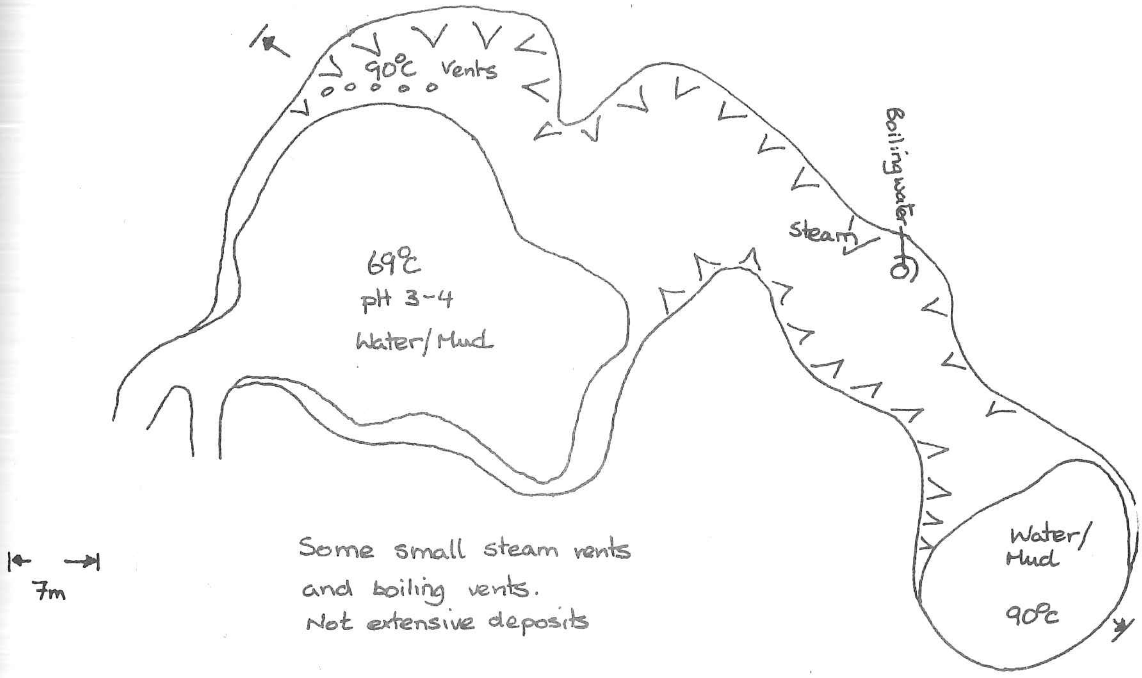
Light blue with light brown stones. Crusty with soft hot blue mud under.
80°C
82°C
pH3
Mud water
86°C
35°C
45°C
88°C
44°C
65°C
85°C
All hollow ≈30cm deep
8m.

Site 2.

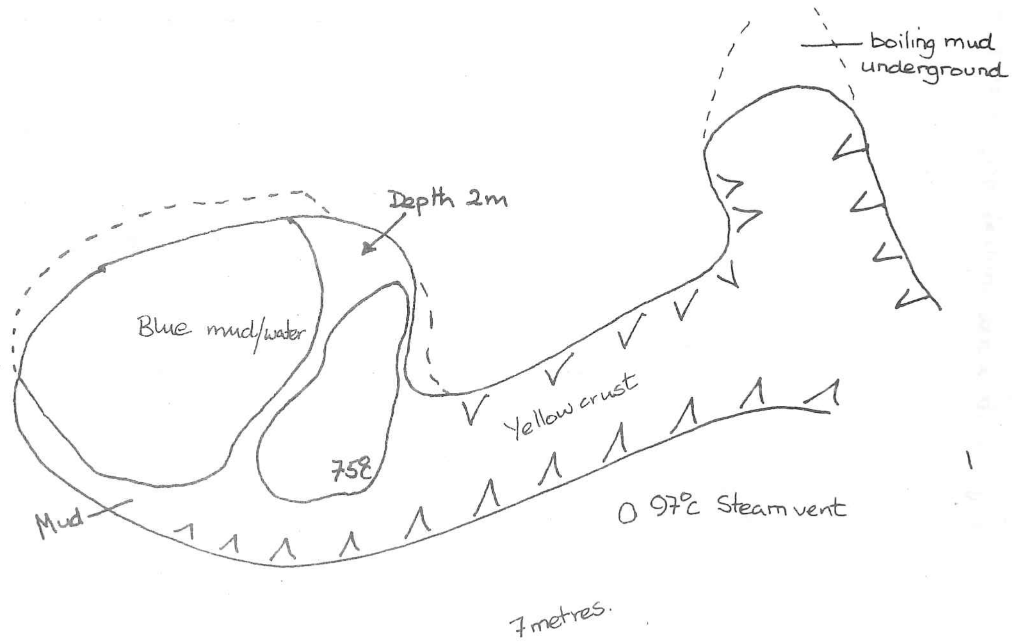
Steam drifts off surface.
No violent activity
SE. facing slope



Site 3

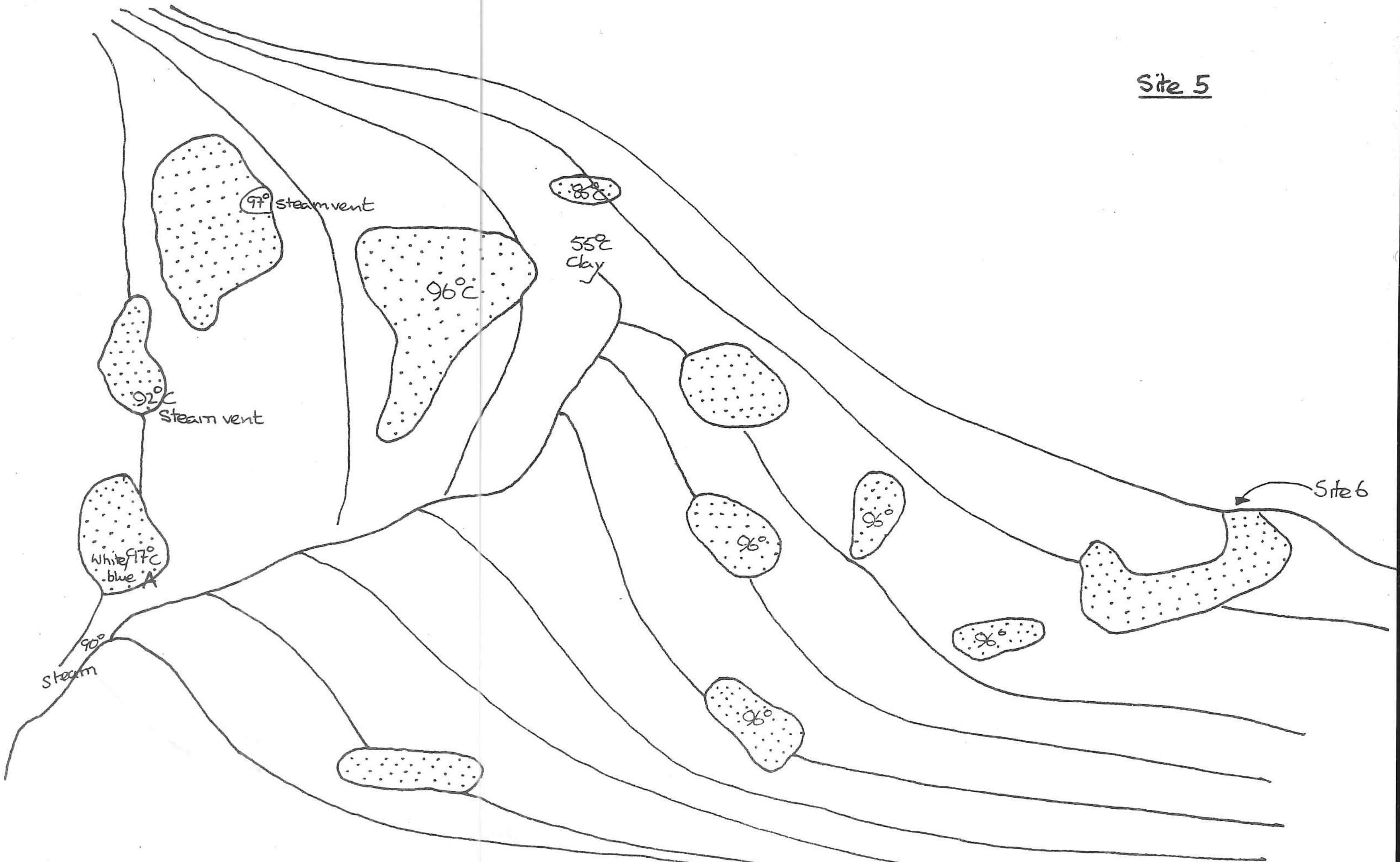


Site 4



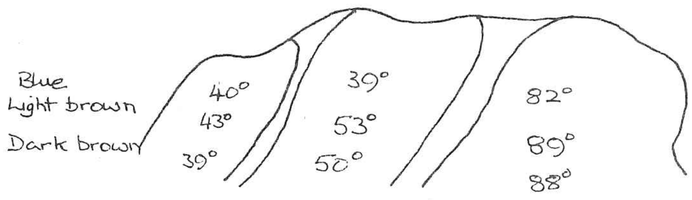
Extensive deposits to SE. downslope. All deposits at about 92°C.

Site 5

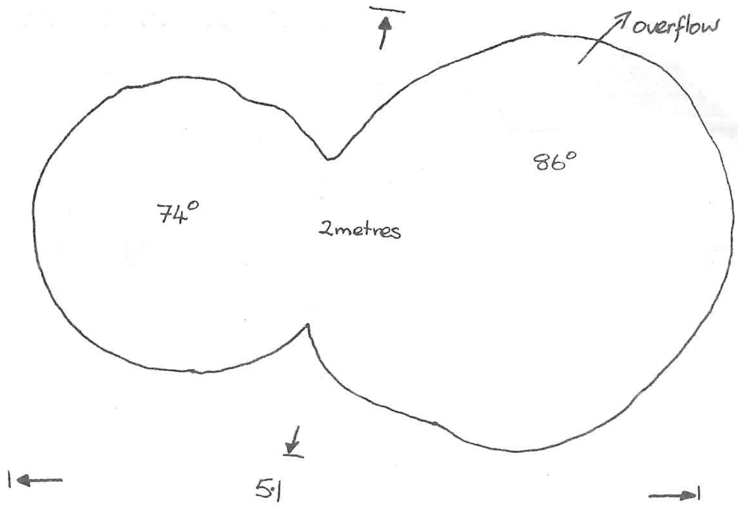


At 'A' temperature drop of 40°C over 10cms
All blue, white and yellow. No pressure.

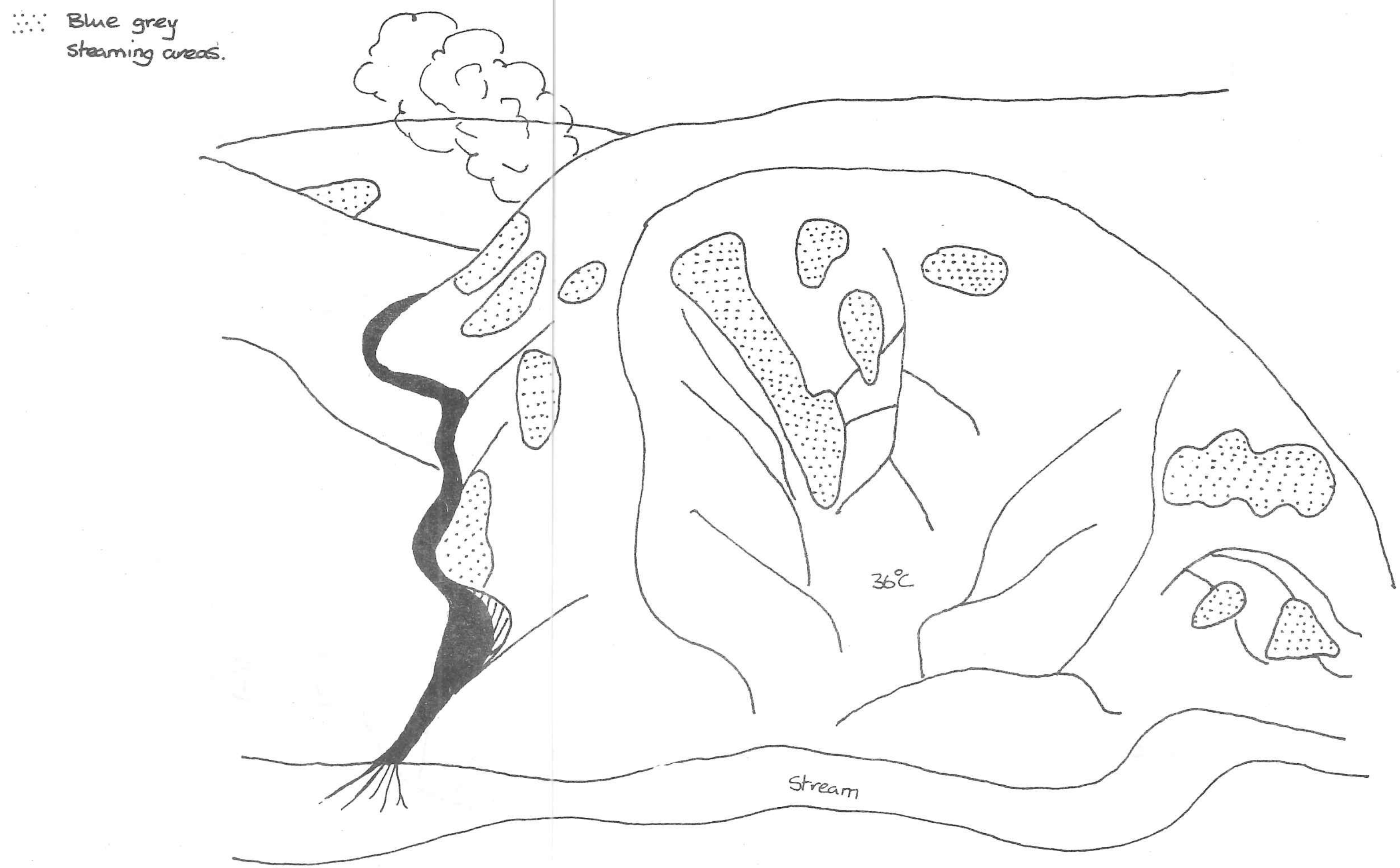
Site 6


Blue
Light brown
Dark brown
40°
43°
39°
39°
53°
50°
82°
89°
88°

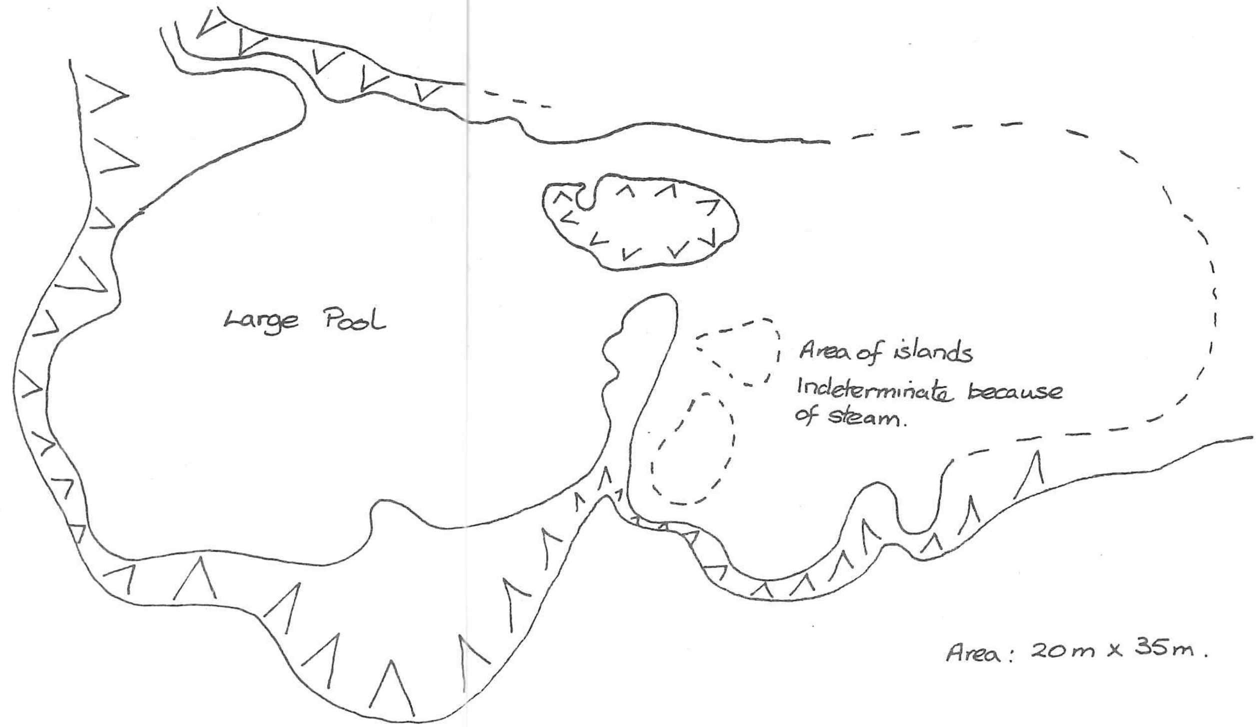
Site 8


overflow
86°
74°
2metres
51

Site 9



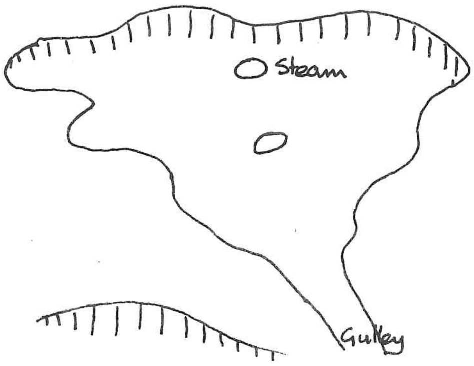
Site 10



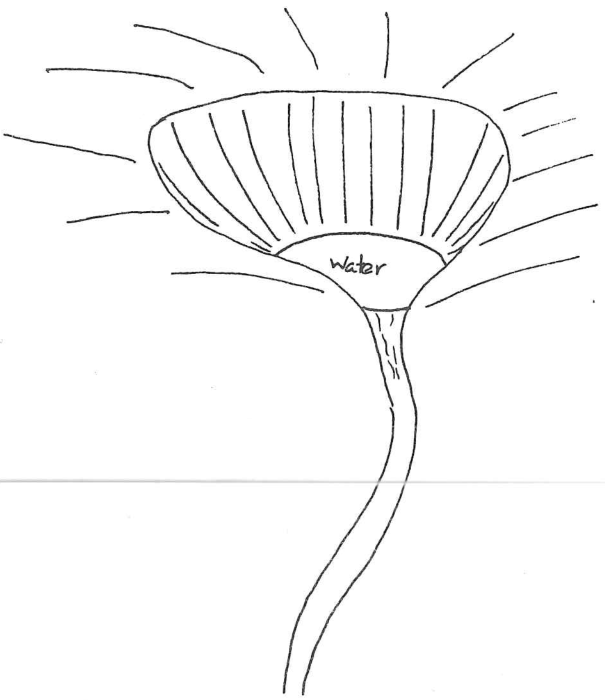
Area: 20m x 35m.

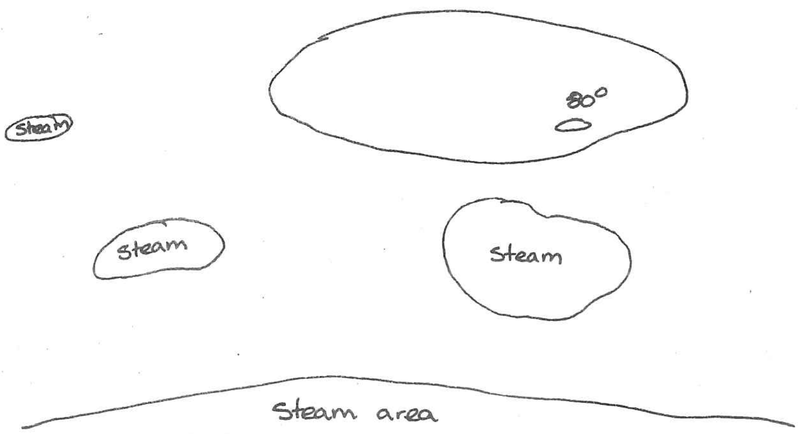
Site 11

Site 62.

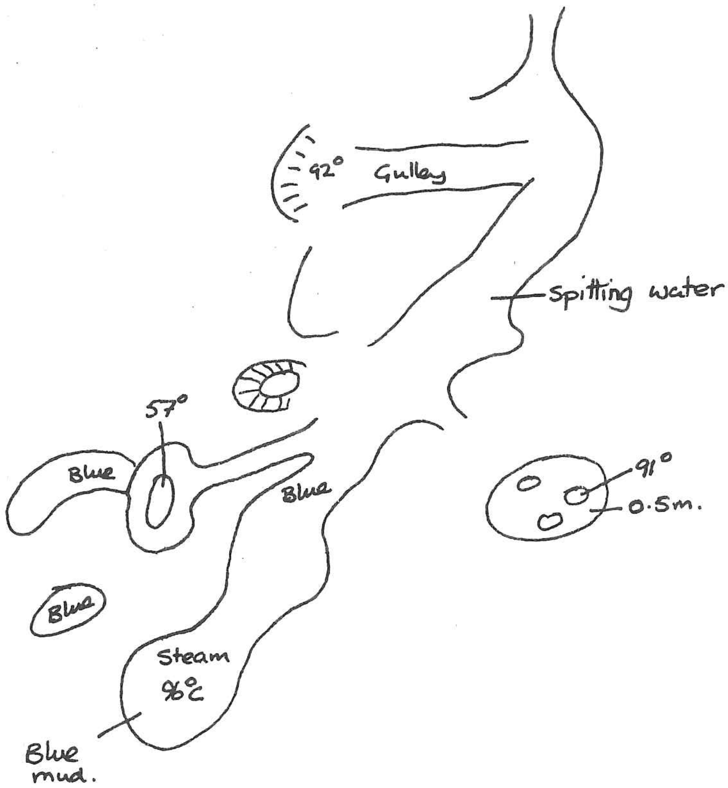


Site 63

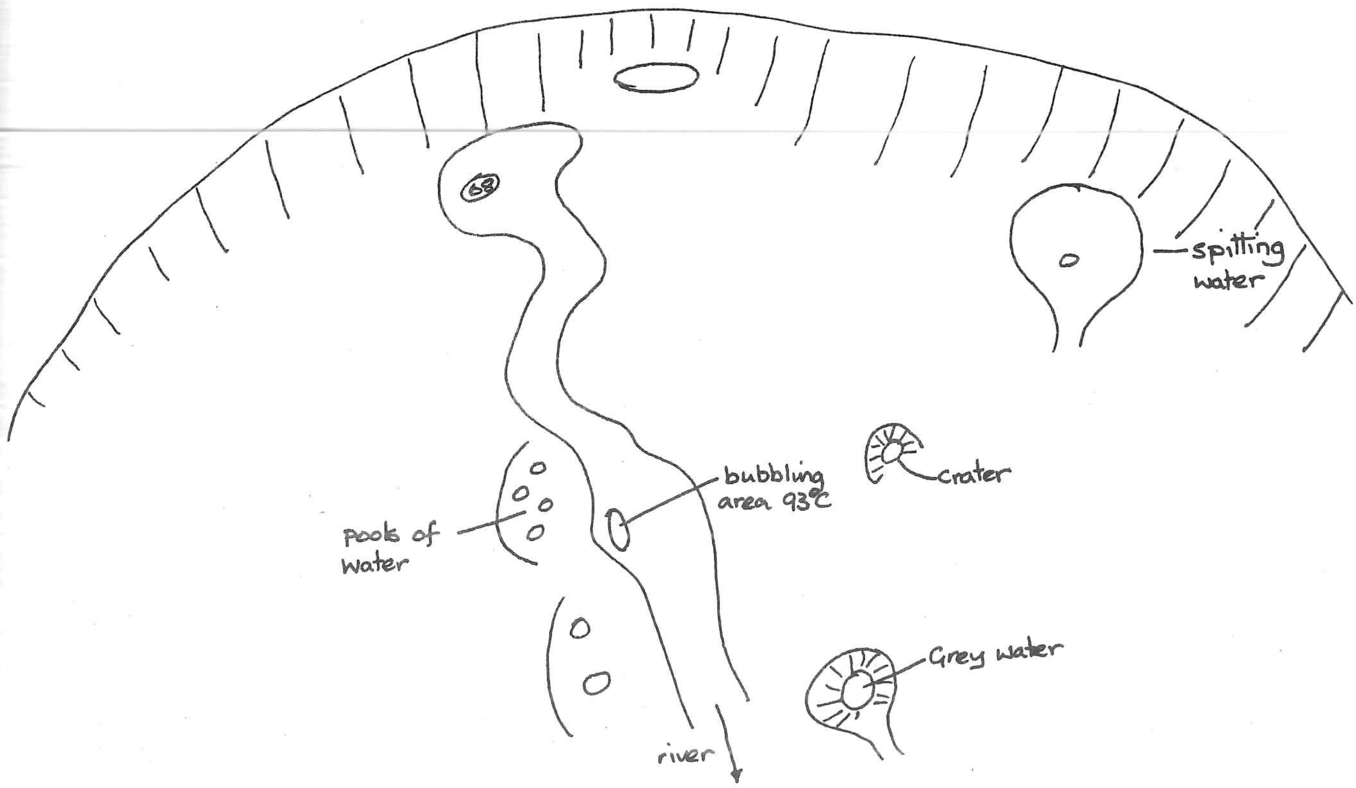




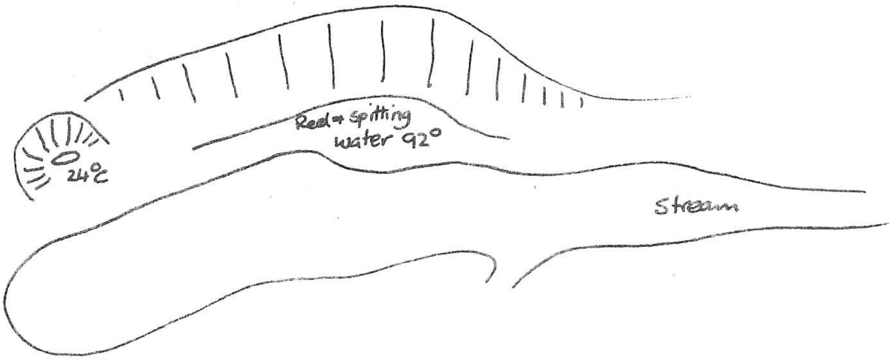
Site 65



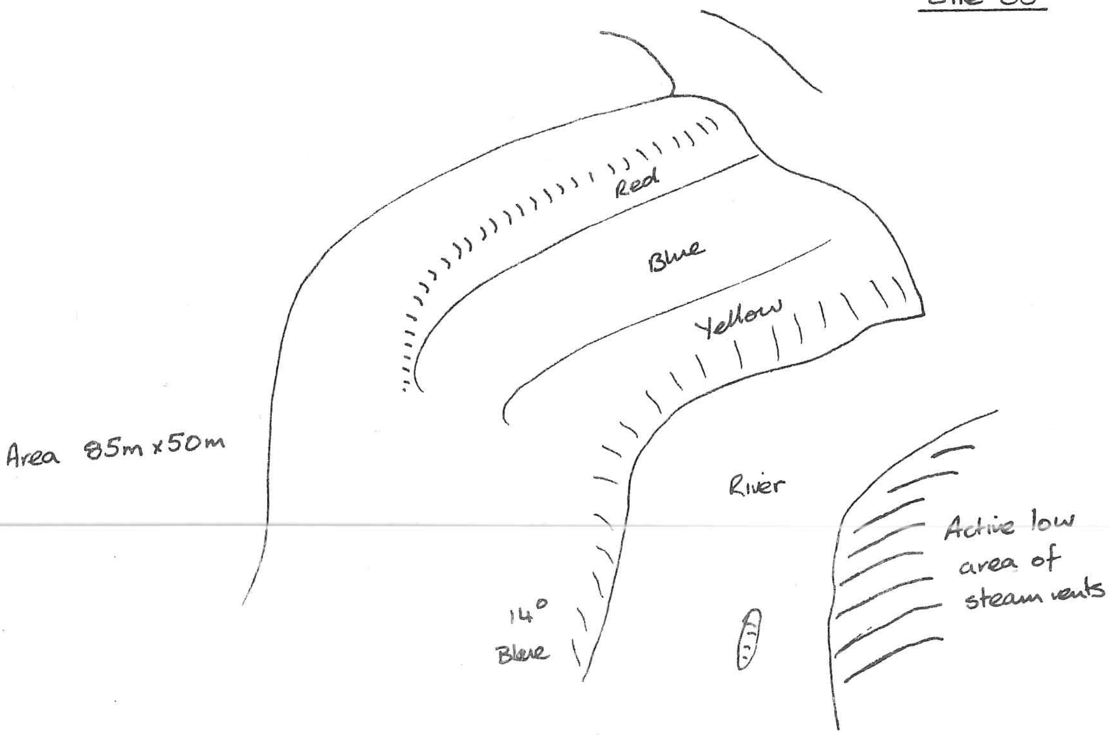
Site 66



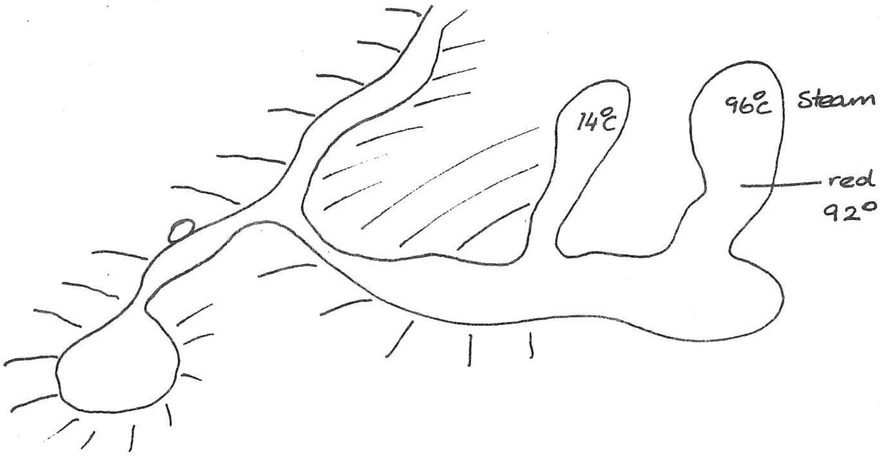
Site 67



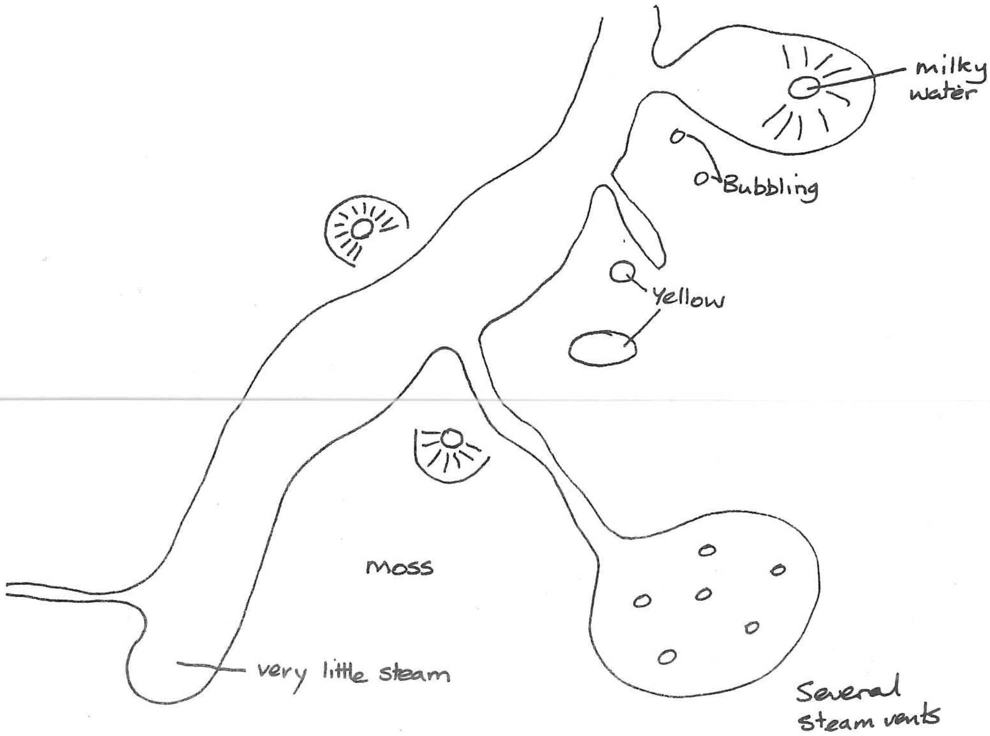
Site 68



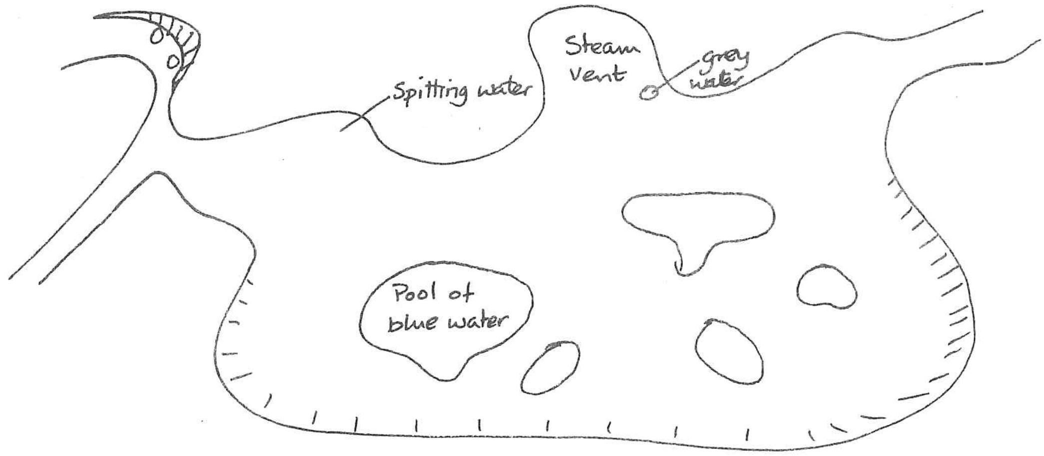
Site 69



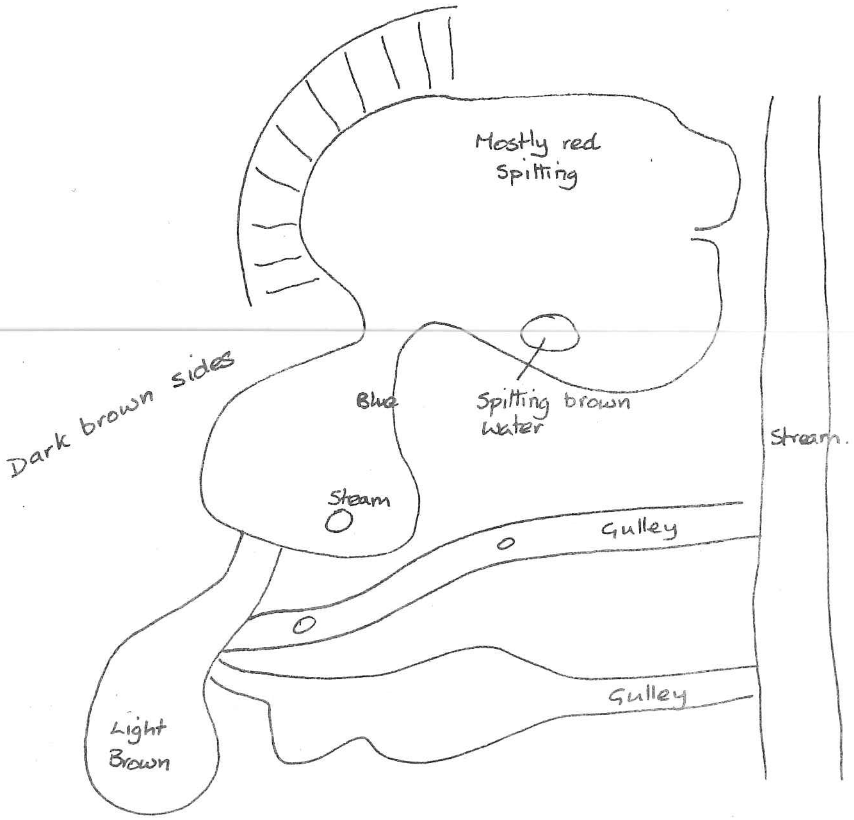
Site 70



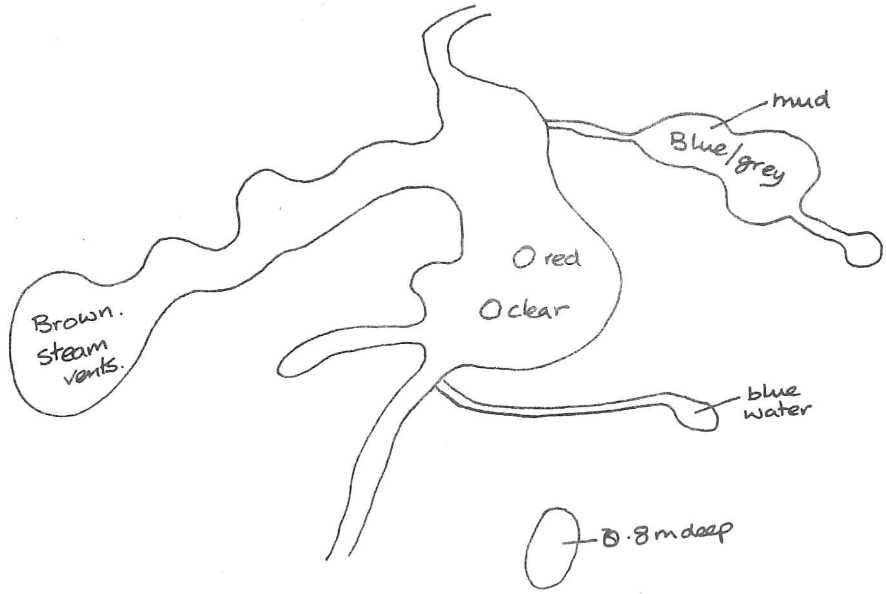
Site 71



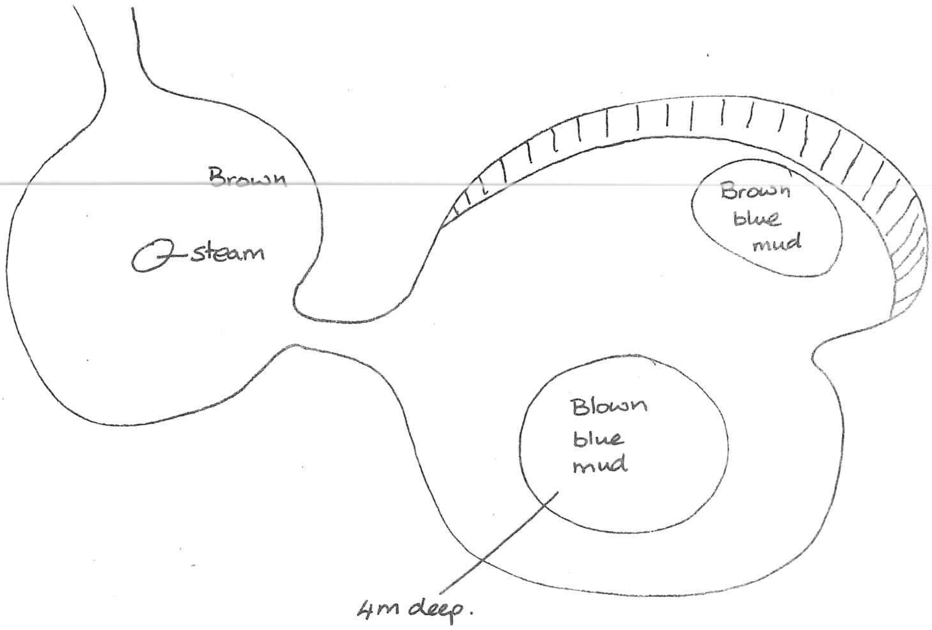
Site 72.



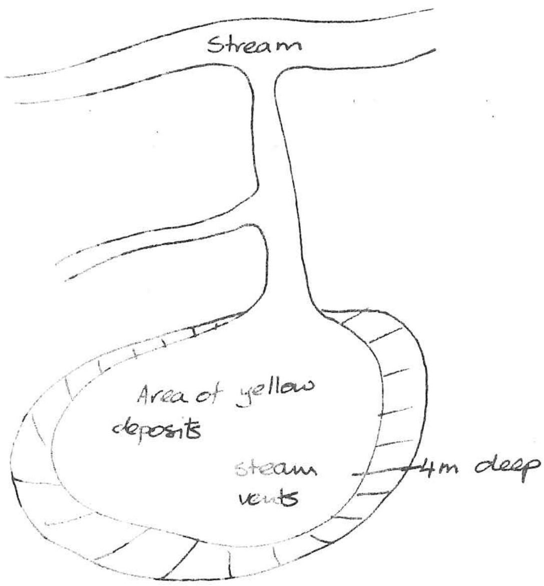
Site 73



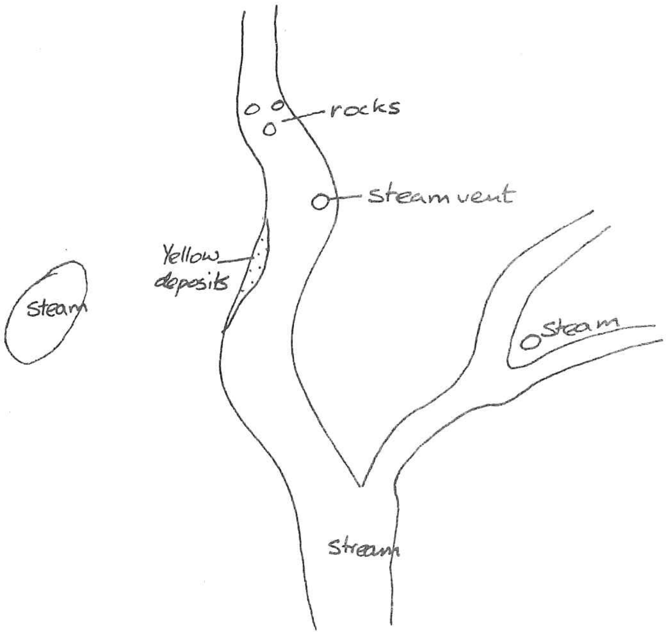
Site 74



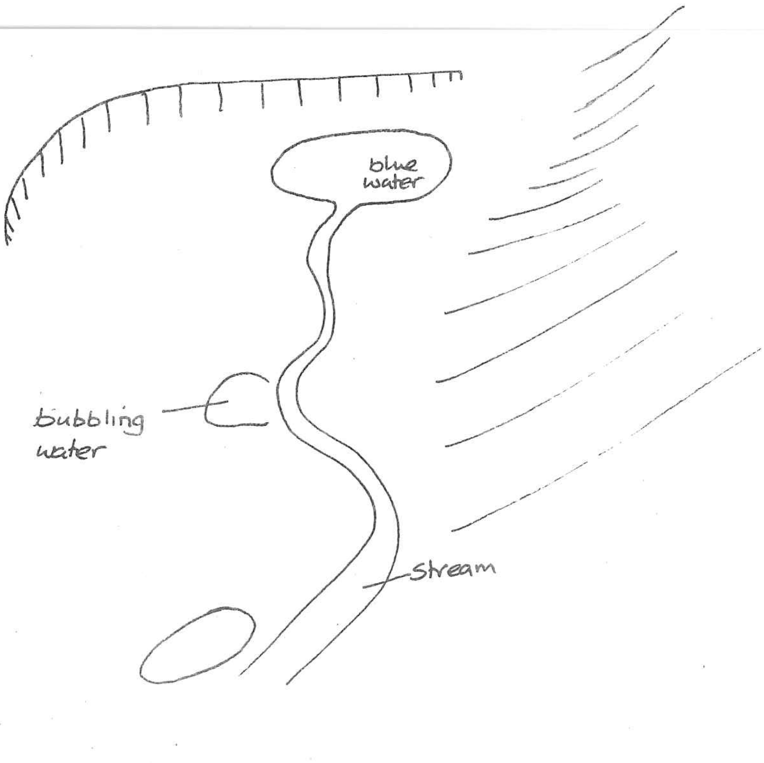
Site 75



Site 78



Site 77.



Site 72. All of this area was active with many gullies of spitting water and yellow and red deposits. 10m.x 14m.x 12m.

Site 73. Two large pools. Circumference 17m. and 18m. Brown and blue mud.

Site 74. Yellow and brown deposits. Sides of pool 4 metres high.

Site 75. Steam vents in stream. Yellow deposits on bank.

Site 76. Coloured deposits, (yellow and white) covering large area. A few steam vents present.

Difficulties involved during this study were considerable. In sketching the hot areas the quantity of steam tended to obscure the hot pools. Measuring the temperature with a hand held thermometer proved dangerous as the possibility of being scalded was high. Great care had to be taken on the ground around the pools as this was sometimes soft and dangerous. The gases caused headaches and tiredness and the sulphurous water caused two people to come up with large blisters on the hands and an irritating rash.

In locating the springs using compass bearings a substantial error was noted due to very localised magnetic fluctuations.

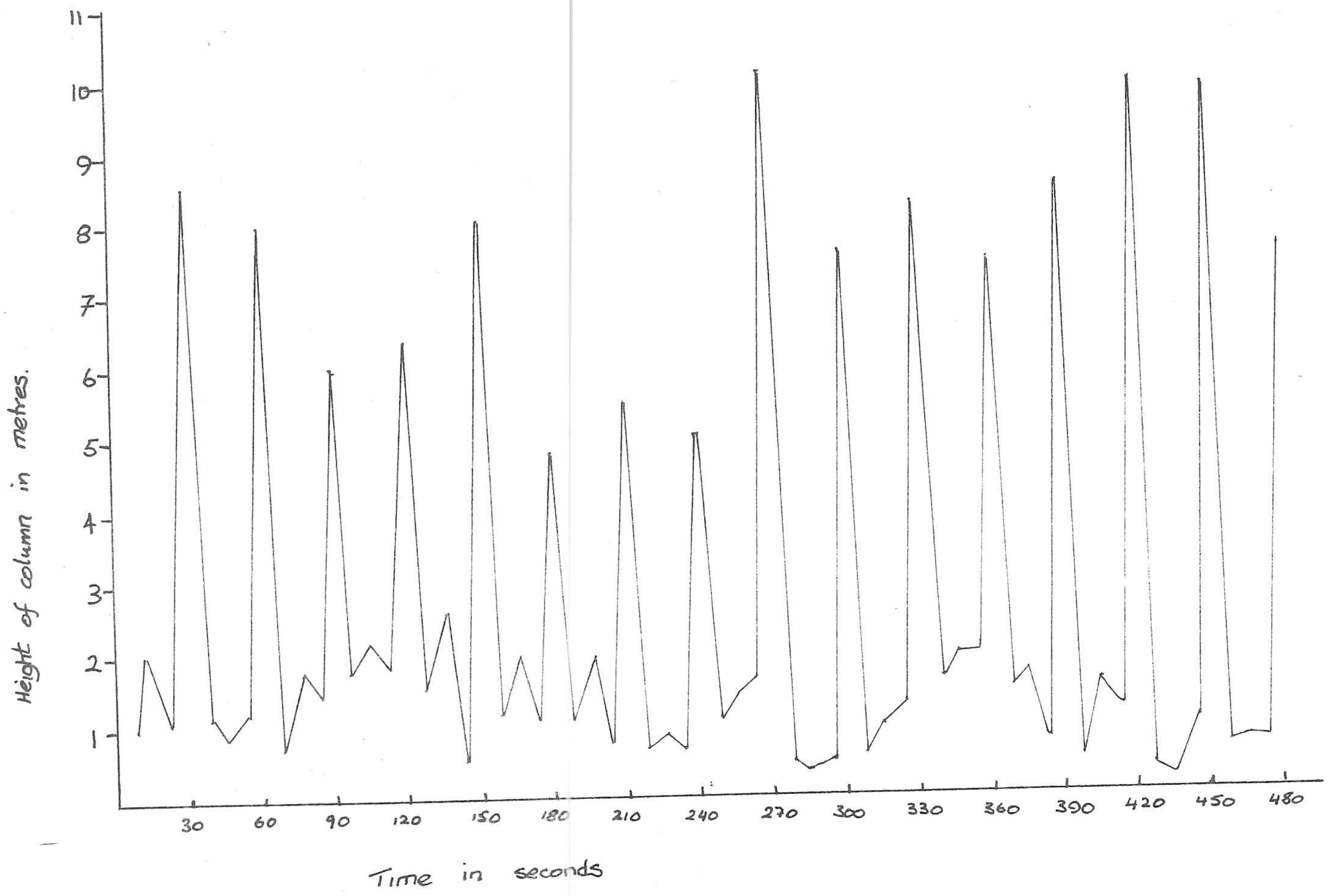
The use of a maximum thermometer on a long pole to measure pool temperatures would simplify the exercise, decrease the dangers and be a thorough improvement on our technique.

3) The Geyser

When the area was visited eight years ago a large pool was found at grid reference 870919. This pool was the most active seen in 1970, when it sent up a dome of water one metre high continually.

This year, this same pool contains a geyser throwing

Graph to show eruption height against time for the Geyser. GR:



water up 10-15 metres every 60 seconds or so.

Area of pool 10m.x12m. Outflow very small, 1.5 litres per minute, most of this caused by the waves formed by an eruption.

4) Landmannalaugar

The hot springs at Landmannalaugar are of a different type from those at Austur Reykjadalir. They are situated at the edge of a block lava flow which has a height of 15-18 metres on average. (Namshraun) This lava flow issued from a vent to the west of Landmannalaugar and a volcanic plug is all that remains of the vent grid reference 931965.

There is a marked path through the flow which should be kept to. The springs issue from beneath the leading edge of the flow between grid reference 945970 and 943978 and large pools have formed in which it is possible to swim. Some steam vents were found near the western edge of the lava flow but no pools had formed.

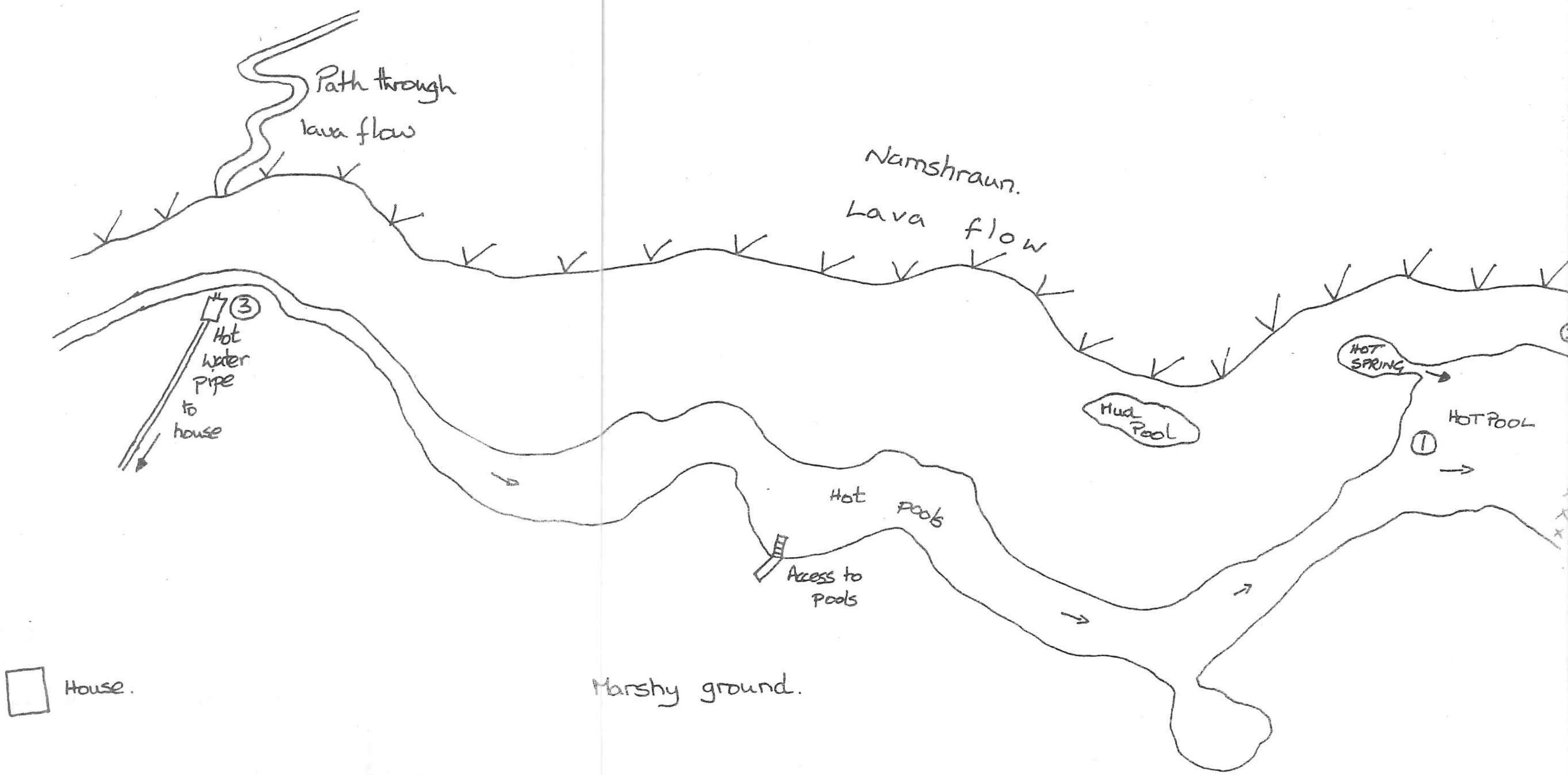
Analysis of hot pool water. (see sketch p.68.)

	1	2	3
pH.	8.0	7.0	7.0
SiO_2	200ppm	240ppm	32ppm
K	3.0ppm	-	1.2ppm
Na	300ppm	-	23ppm
Fe	0	0	-
Ca	28ppm	20ppm	14ppm
Mg	2.4ppm	2.4ppm	2.4ppm
Cl	335ppm	295.5ppm	35.5ppm
SO_4	100ppm	80ppm	24ppm
F	5.6ppm	5.6ppm	1.1ppm

Conclusion

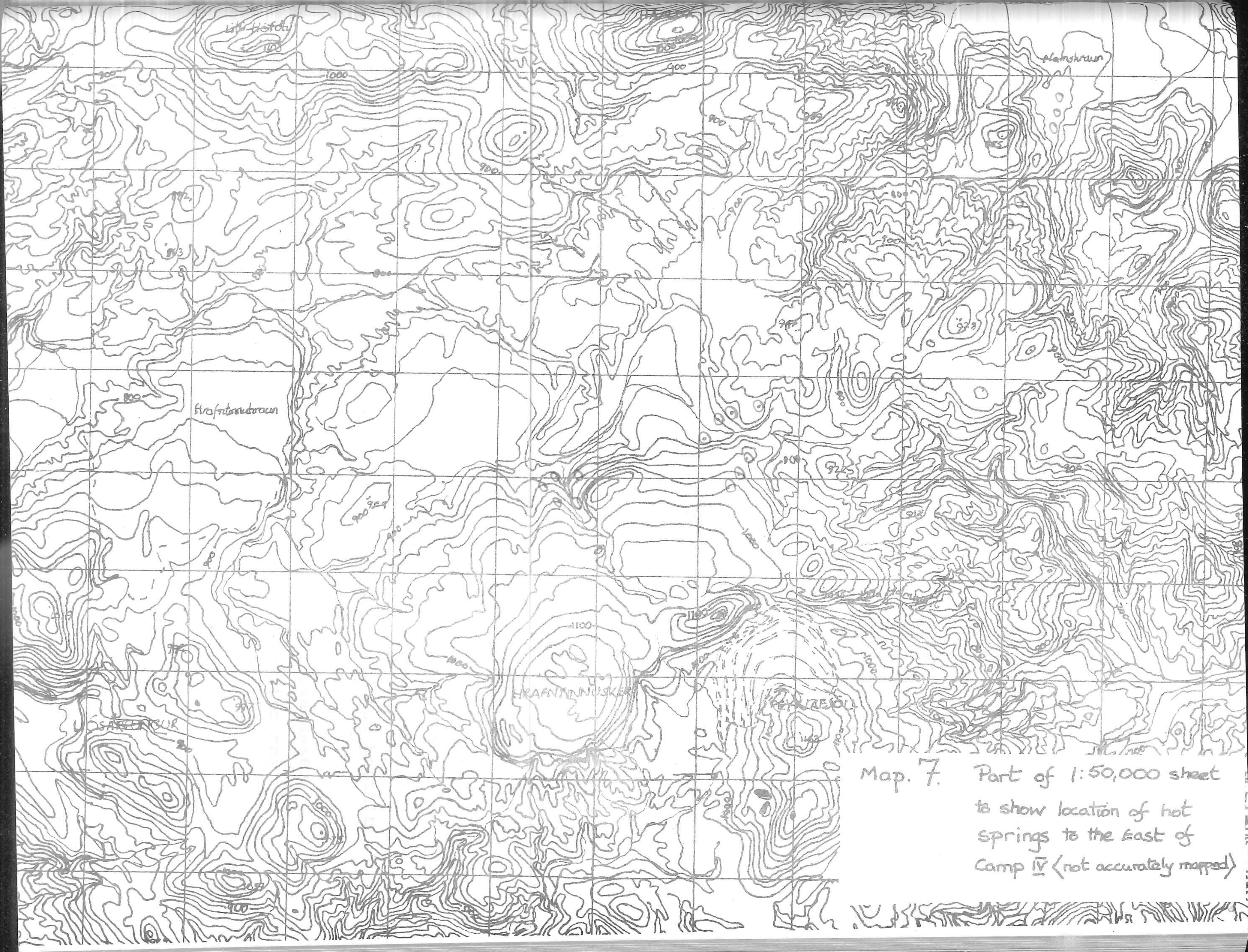
Although most of the work we did on this survey was by no means original (except for the mapping) the hot springs make a fascinating study. The variety in colour, size, shape and sounds is remarkable.

One general conclusion can be made. The area of Austur Reykjadalir has become far more active in the last eight years. This could be a significant factor since activity in the north-east of Iceland has also been increasing.



Sketch.3.

Sketch map of the pools at Landmannalaugar



Map. 7. Part of 1:50,000 sheet to show location of hot springs to the East of Camp IV (not accurately mapped)

c). Geology.

Introduction.

Although the origin of the Earth is still open to question it is now generally accepted that it was formed from a solar cloud of gas - mainly hydrogen - which shrank and condensed under the influence of its own gravity to form planets orbiting about the sun.

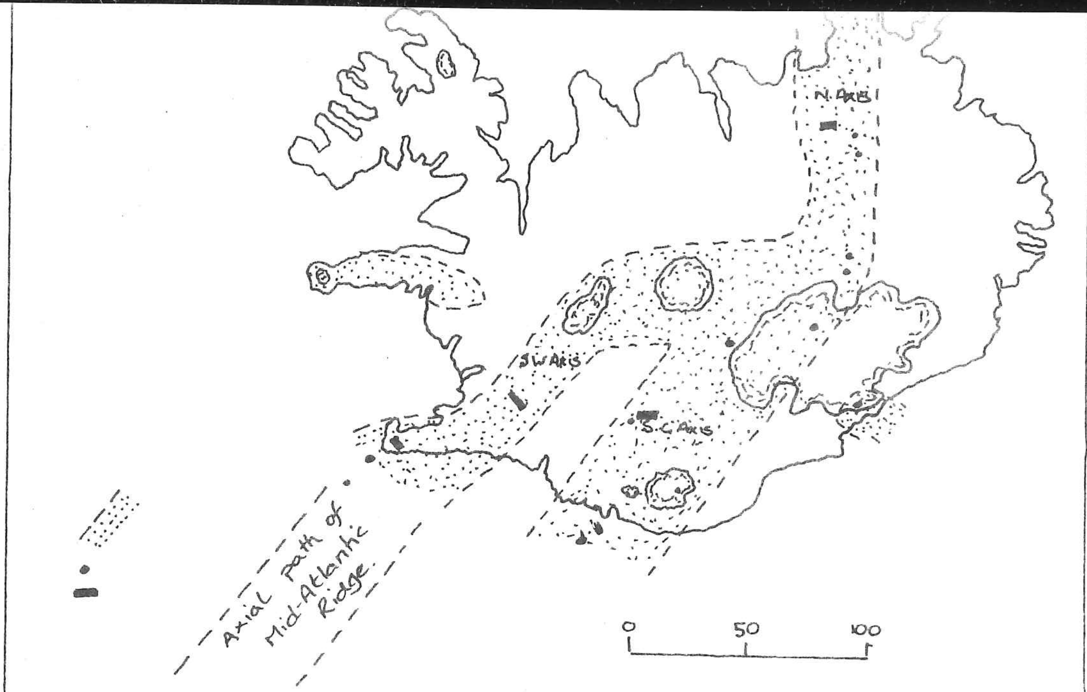
Lighter minerals rose to the surface where they cooled and solidified to form the Earth's crust. Deeper material remains hot and fluid to this day: at least 3.5×10^9 years after the first rocks were formed.

Until 1858 it was generally believed that the crust had remained more or less the same since time began. In that year Antonio Snider first developed the idea of continental drift. It was not until 1915 when Alfred Wegener published geological, biological and climatalogical evidence in its support, that the idea was taken seriously. The conclusions drawn by Wegener were very similar to those drawn from current research. Only his ideas of the speed with which the break up occured were widely inaccurate. He did not have the benefit of more recent palaeomagnetic information.

Modern theory has evolved to the present ideas of plate tectonics. The theory proposes a surface structure of rigid plates floating on the hotter, fluid, mantle layer beneath. These plates are free to move and the motive source is thought to be provided by deep seated convection currents in the Earth's interior.

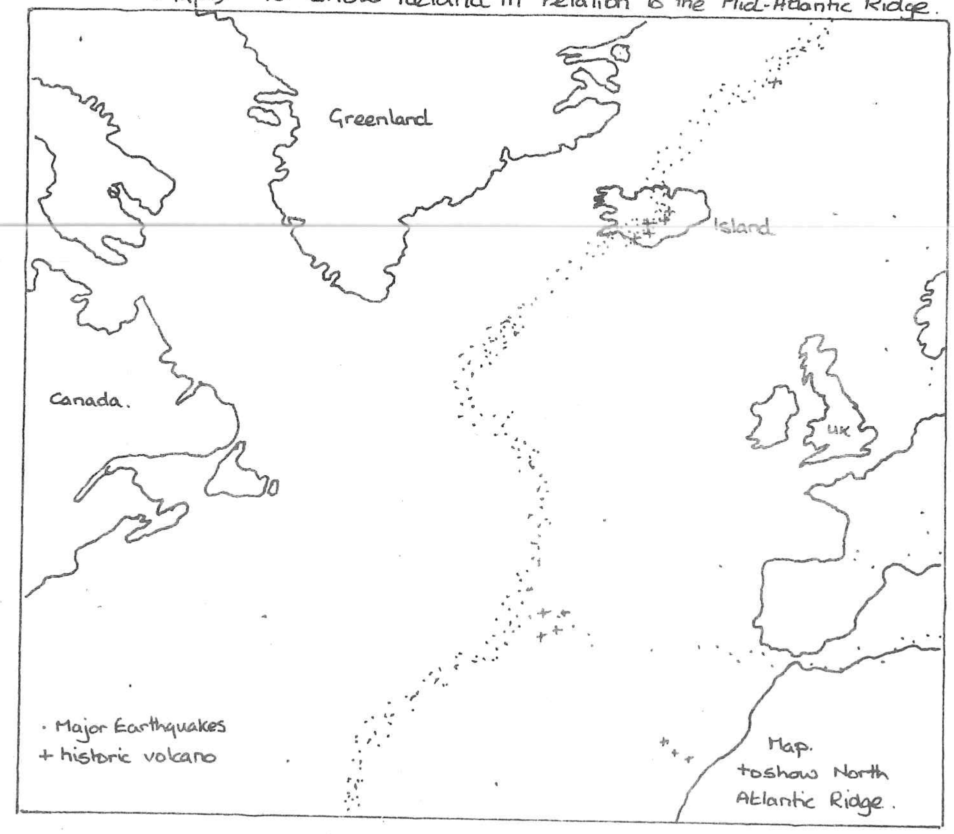
Plate movements result in margins marked by earthquakes, volcanoes and allied seismic activity. Adjacent plates may converge, diverge or slide past each other.

Where plates converge, trenches form as oceanic plates sink below lighter continental rocks. As the oceanic plate sinks some of its surface sediments are scraped off and pile up on the landward side later being incorporated into the



Map.8 Iceland showing volcanic zones in relation to mid ocean ridge.

Map.9 to show Iceland in relation to the Mid-Atlantic Ridge.



fold mountain range which is often to be found along the edge of a continent. e.g. the Rockies, the Andes.

When continental plates converge, sediments are again forced up into the new mountain ranges. e.g. the Himalayas.

When plates diverge, tension cracks occur and magma is extruded forcing the plates apart at a rate estimated to be 20 mm. per year. These are called construction margins or ridge boundaries. Ocean rises or crests are made up of basaltic lavas which rose instantly in a molten state to fill the incipient rift and formed a ridge. Ridges of this type form lines almost exactly in the centres of the major oceans. Such a ridge runs through the centre of the North and South Atlantic Oceans surfacing in Iceland, the Azores and Tristan da Cunha. (see map 8 p71).

Throughout history there have been reversals of the Earth's magnetic field. As new lavas are extruded along the ocean ridges they cool and solidify. Particles in the molten lava become aligned with the Earth's magnetic field and are locked in position as the lave solidifies. By mapping the magnetic alignment on either side of the ridge a symmetrical pattern of parallel alternating fields can be observed (see diag. 3 p.73). Minerals in the same rocks can be dated and so the rate of spreading can be calculated.

This movement explains why the oldest sediments in the present oceans are no more than 150 million years old although it is presumed that the oceans are very much older.

In 1967 two projects aimed at direct measurement of sea floor spreading began in Iceland. Both used electromagnetic distance measuring instruments. One based on Columbia University used a Geodimeter Mk. 6; the other based on Imperial College, London used a prototype of the National Physical Laboratory's Mekometer III. This instrument, using phase modulation, was capable of great accuracy; of the order of two parts per million.

Iceland is divided into three parts by axes of present

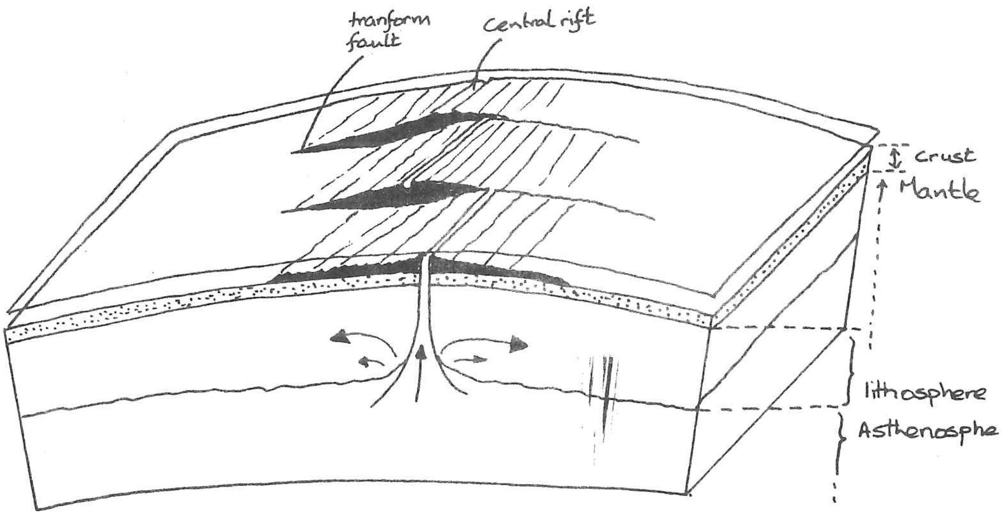
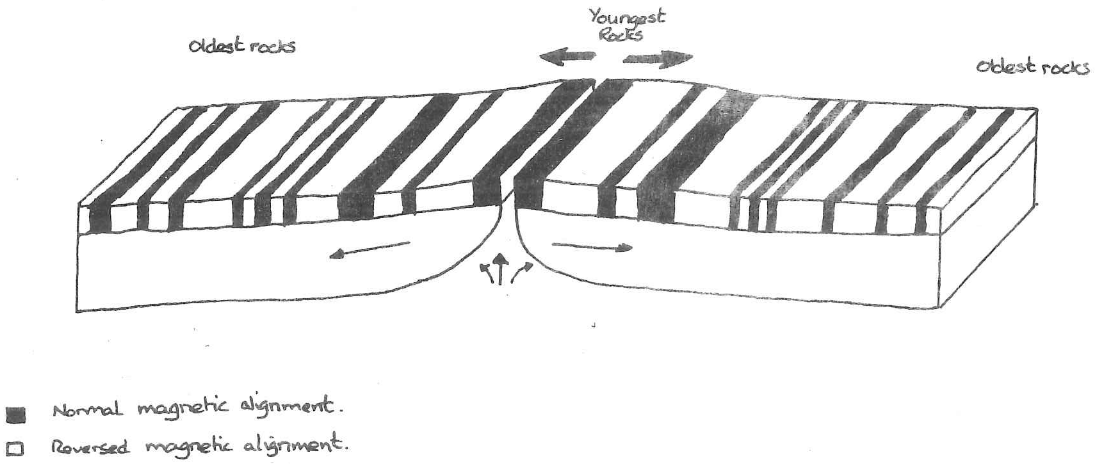
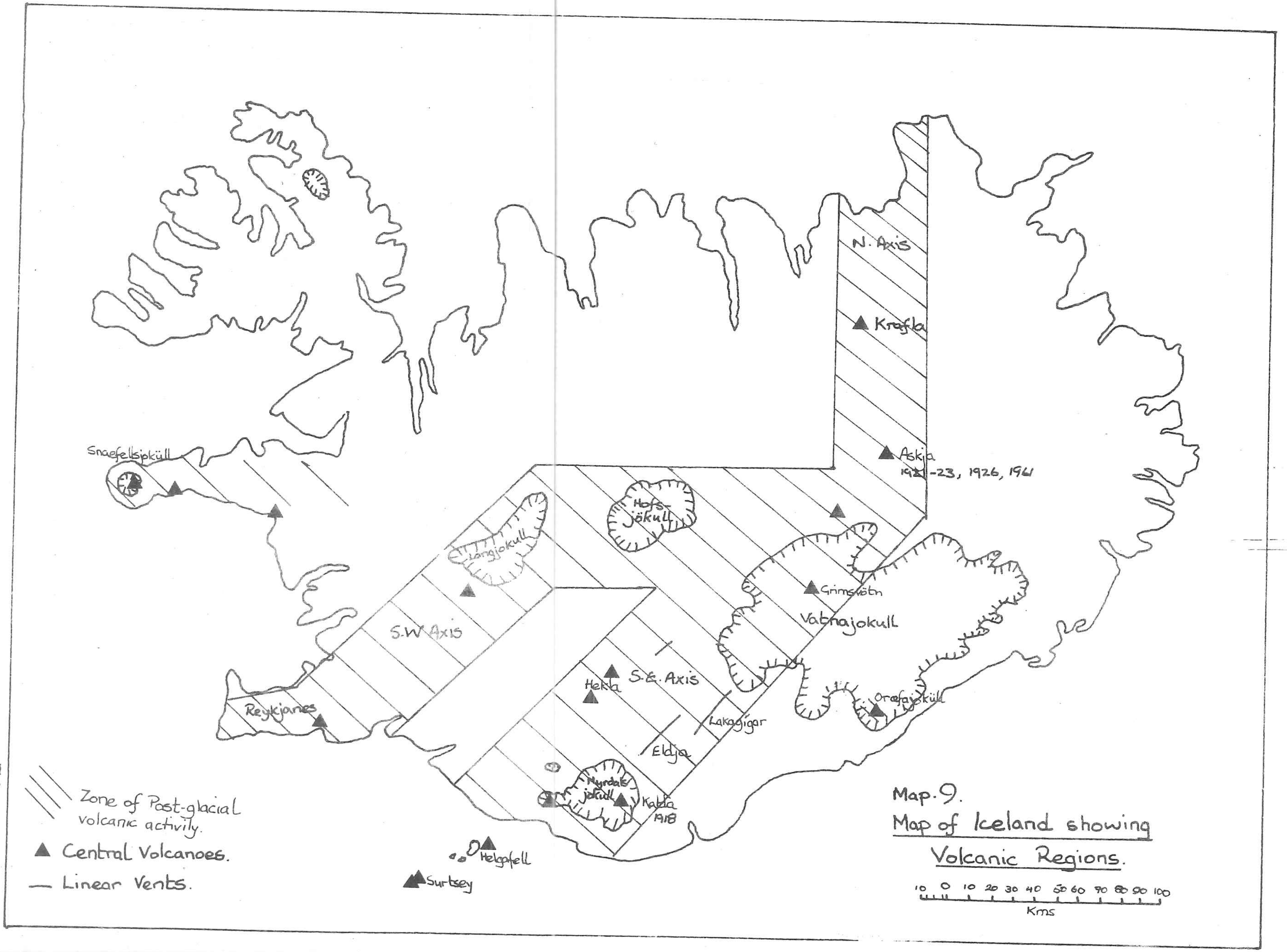


Diagram 2.
Diagram of spreading ridge

Diagram 3. to show magnetic anomaly pattern along the N. Atlantic spreading ridge.





Map. 9.
Map of Iceland showing Volcanic Regions.

day Earth movements. Two axes, one in the south-west and one in the south-central regions may or may not be connected. The third axis is in the north. (see maps 8 and 10 p.71,74). All three axes lie in the neovolcanic zones to which volcanic eruptions of the last million years have been almost exclusively confined.

The American project consisted of measuring distance markers along the road from Reykjavik to Hekla crossing all the south west axis and about half the south-central axis. They reported the first signs of crustal extension when they found increases of 63 $\pm$ 31 mm. on the south-central active zone between 1967 and 1970. This included the most recent eruption of Hekla (June 1970) and since all the changes were measured in its vicinity it seems likely that they were associated with it. This suggested an annual rate of about 20 mm. an exact agreement with the paleomagnetic estimate for the nearby North Atlantic Ridge. More recent surveys show no further movement so the average is considerably lower.

The London group established areal networks in tectonically interesting areas. In the south-west at Reykjanes and Thingvellir; in the south-central zone near Mount Hekla and in the north at Myvatn. These sites showed considerable recent activity, open tensional fissures, historic fissure eruption lines, normal faults and faulted valleys or Grabens. The Reykjanes network is situated just where the axial magnetic anomaly of the Mid-Atlantic ridge reaches the mainland. It is also associated with Myvatn a geothermal field.

The Reykjanes area showed the most interesting results with a total ridge movement of 36 $\pm$ 6 mm. in four years in a direction N143°E. This direction is perpendicular to the general trend of the Mid-Atlantic ridge in the North Atlantic (N45°E). The rate, 10 mm. per year is low compared with the magnetically inferred value from the ridge.

Structural investigations of the Heimaey (1973) and Surtsey (1963-7) eruptions also revealed extensional axes whose directions were N135°E. Here again was evidence of extension perpendicular to the general strike of the Mid-Atlantic ridge in the North Atlantic, though as at Reykjanes it was more complicated than expected.

Iceland is undoubtedly an anomolous part of the Mid-Atlantic Ridge or it would not be there at all. Nonetheless the results agree that there is extension at right-angles to the general trend just as is required by the spreading ridge hypothesis.

Austur-Reykjadalir.

General Survey.

The specific area studied by the expedition was the western part of a Rhyolite massive in the south-central volcanic zone near Hekla. This area is part of the largest and most intensive hydrothermal area in the country.

There have been at least three periods of igneous activity; Pre-glacial, glacial and post glacial lava flows. Each period is typified by distinct types of rock. Rhyolites, Hyaloclastites and Obsidian respectively.

Rhyolites.

The pre-glacial rhyolites form a massive which rises steeply as much as 450 m. above the surrounding country. It consists of a uneven plateau surmounted with domes and conical hills rising 200m. above it. Valley glaciation has isolated a large block in the south west called Laufafell. The glaciated cross-section of the valley has been largely destroyed by river erosion. The river at present is cutting back through a post-glacial basaltic flow overlapping the edge of the massive. This has led to the formation of a 10m. waterfall and incised meanders with interlocking spurs below it.

The rhyolites come from several sources issuing several different flows and some domes and breccias. (see map 12 p.85). They are mainly light coloured greyish rocks with yellow and pink tints. The colour is often masked by the brown iron staining resulting from the oxidation of the included pyrite.

Dark colours predominate in Iceland due largely to the prescence of dark basalts both in the form of mountains and in the form of dark sands washed down by rivers into the low lying districts.

Hyaloclastites.

The rhyolite massive is bounded by hyaloclastites to the north. These take the form of low NE-SW ridges 90-120m. produced by sub-glacial fissure eruptions. The general strike is common to the Mid-Atlantic Ridge axis and must be considered as a surface expression of that feature. These rocks are dark brown or black finely grained basaltic lavas often with yellowish or greenish tints.

Post-glacial Lava Flows.

At least eleven post-glacial flows were observed. Two were studied in some detail and a map produced to show the direction of flow. (see map 11 p.82).

The composition of the lavas varied greatly from basaltic -north of Laufafell to rhyolitic at Hrafntinnahraun and Hrafntinnusker. Between these two extremes were several intermediate grades.

The composition of the lava depends upon the silica content. Where it is high the lavas are most viscous and acid. This type gave rise to steep sided, very rough black lava flows up to 50m. thick. The texture was glassy near the surface where the lava had cooled rapidly. Many flow features and lens inclusions were observed. (photos. 23 and 24 p. 45). These features were particularly impressive especially when etched by gas from the hot springs. Lens inclusions are formed when molten lava picks up blocks of country rock from the ground over which it is flowing. The lava fails to melt the block and it is therefore included in the lava flow.

When it solidifies very rapidly the rock is a brilliant pitch black glassy substance exhibiting conchoidal fracture called obsidian. On Hrafntinnusker the obsidian was pure black and in some cases showed no colour variation which is rather unusual. The word used for it in Iceland is Hrafntinna meaning literally 'Raven-stone'.

In contrast to the black rhyolites and obsidian are the low silica, basic basaltic lavas. These were more fluid when molten and have given rise to lavas of smooth profile. These were not studied in any great detail since they were on the north side of Markarfljot.

Tephra.

Tephra or pyroclastic material (volcanic ash, lapillae and bombs) were most abundant. The deposits varied in thickness from individual layers a few centimetres thick to many metres thick.

The very fine ash produced by volcanic eruptions was ever present and easily blown by the strong winds we experienced. The ash was fine and very abrasive.

Larger particles or lapillae covered very large areas and these varied in size from a few millimetres to 2 cms.

Volcanic bombs were abundant. Some were very large (1.5 metre) and had flanges around its edge. It weighed an estimated 65 kilos. Another example was a spheroidal bomb with a glassy exterior and vesicular interior. These bombs were found around the crater of Hrafntinnahraun.

Spindle or fusiform bombs were found to the north-west of base camp and had a distinct red colour.

Intrusions.

Four dykes were observed in the bed of Markarfljot near its source. These dykes were approximately 1 m. thick and ran in a NE-SW direction giving rise to a series of waterfalls. (photo. 22 p. 45).

Hydrothermal Activity.

Hot springs have been studied in some detail but it is appropriate to mention their probable origins. The largest numbers of fumaroles and solfataras are found on the surface of rhyolitic areas. Most frequently they are found around the edges of the glassy flows which presumably are acting as a cap and are not so readily disintigrated by the hot emmisions. The presence of the fumaroles and solfataras on the surface is due to the slow solidification of rhyolitic magma at great depths accompanied by the emmision of hot gas. The hot vapours cause an intense disintigration of the rhyolite which leaves clayey material which is bright yellow or reddish brown. These colours are brilliantly displayed at Landmannalaugar to the east of the area. The solfataras are even more brilliant due to the local deposition of yellow sulphur crystals and whilte selenite crystals and salicilic acid. The red colour frequently found is due to iron III compounds.

Conclusion.

The area is an unusual one for Iceland. It is generally an acid lava area almost totally surrounded by basic basaltic magma. This is probably due to the following reason.

When a volcano ceases to erupt the still liquid magma deep below the surface begins to cool. The lighter, silicon rich magma rises to the top of the magma chamber. At the next eruption acid lava will be emitted first. The longer the interval between eruption the more likely an acid lava will be produced. If a short time exists between eruptions then the lava will probably be basic. Hence the fact that some Icelandic volcanoes emit both acid and basic lavas.

This area is extremely interesting geologically. The variety of lava types and scenary produced is remarkable and a detailed study would be worthwhile.

d) Volcanoes.

A study of the volcanic crater of Hraftinnahraun was carried out over a period of three days. We located the centre of this crater and observed where the lava had flowed vertically up from the earth.

From this crater a large thick (up to 50 metres) lava flow had issued to the north and east of the vent. The flow consisted of acid black lava and was post glacial. The flow was 1.75 kms at its greatest length. A smaller flow appeared to have flowed out of the crater to the south and west. The map on page 82 shows the crater and its lava flows as mapped in 1970 by Guy Hawkins.

The crater appears to have collapsed. This probably occured during the final stages of the eruption with its more slowly cooling central area showing a marked gradation in both texture and structure.

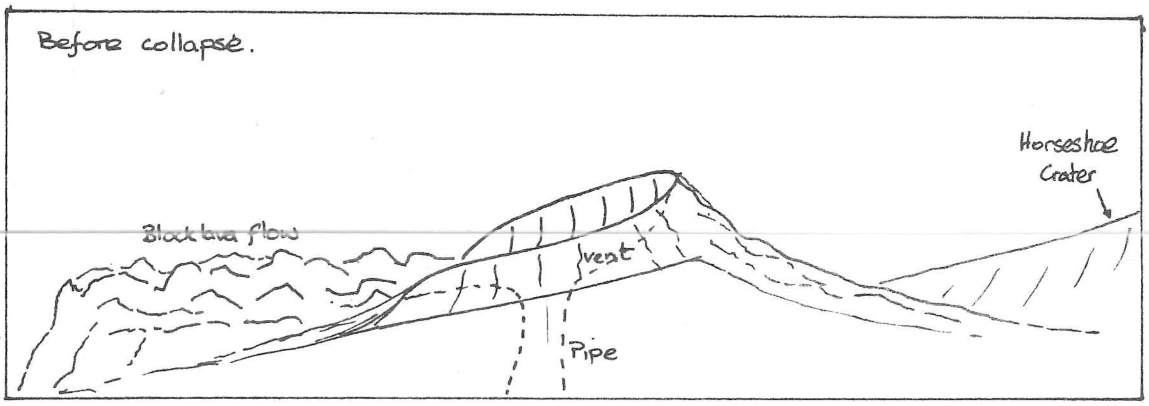
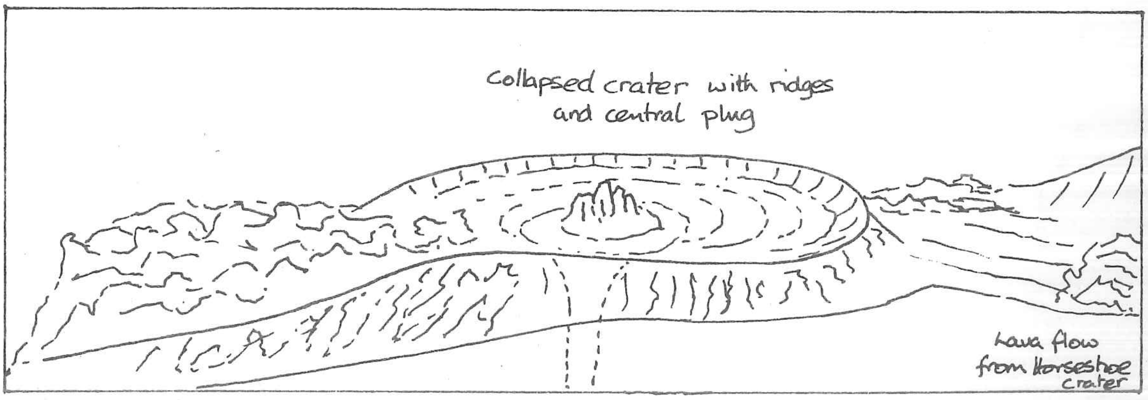


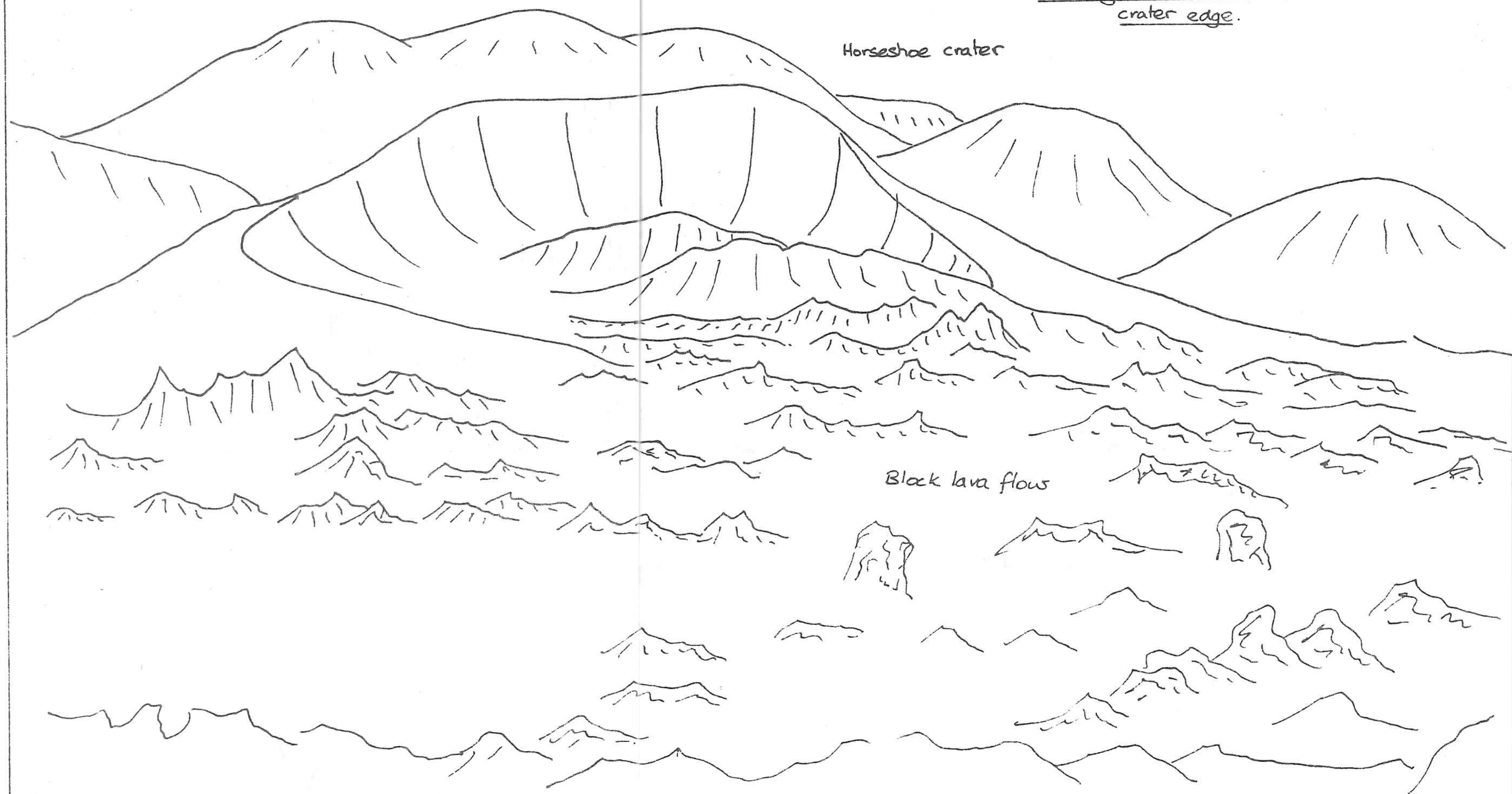
Diagram. 4.

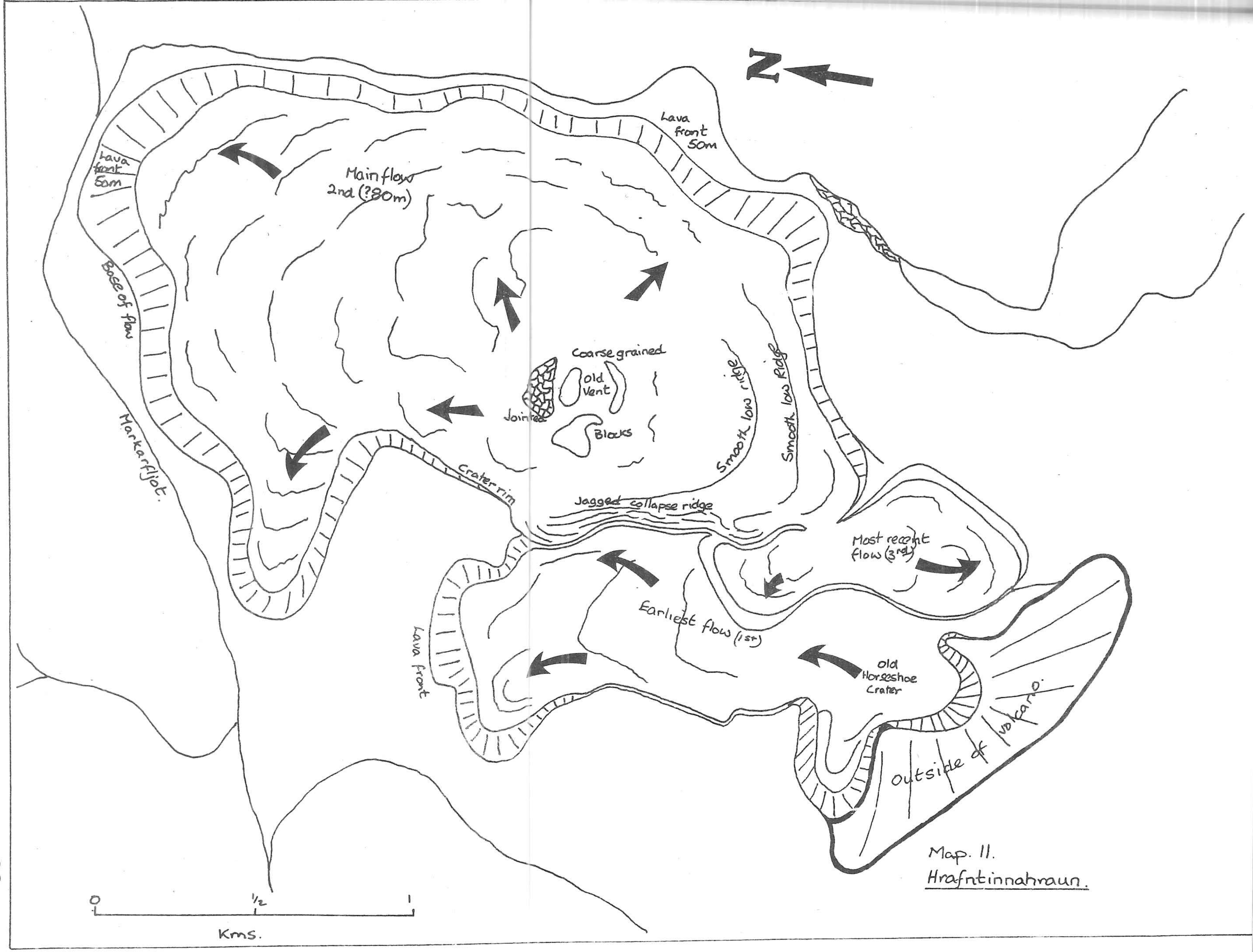


Diagrams to explain the possible shape of Hrafntinnahraun

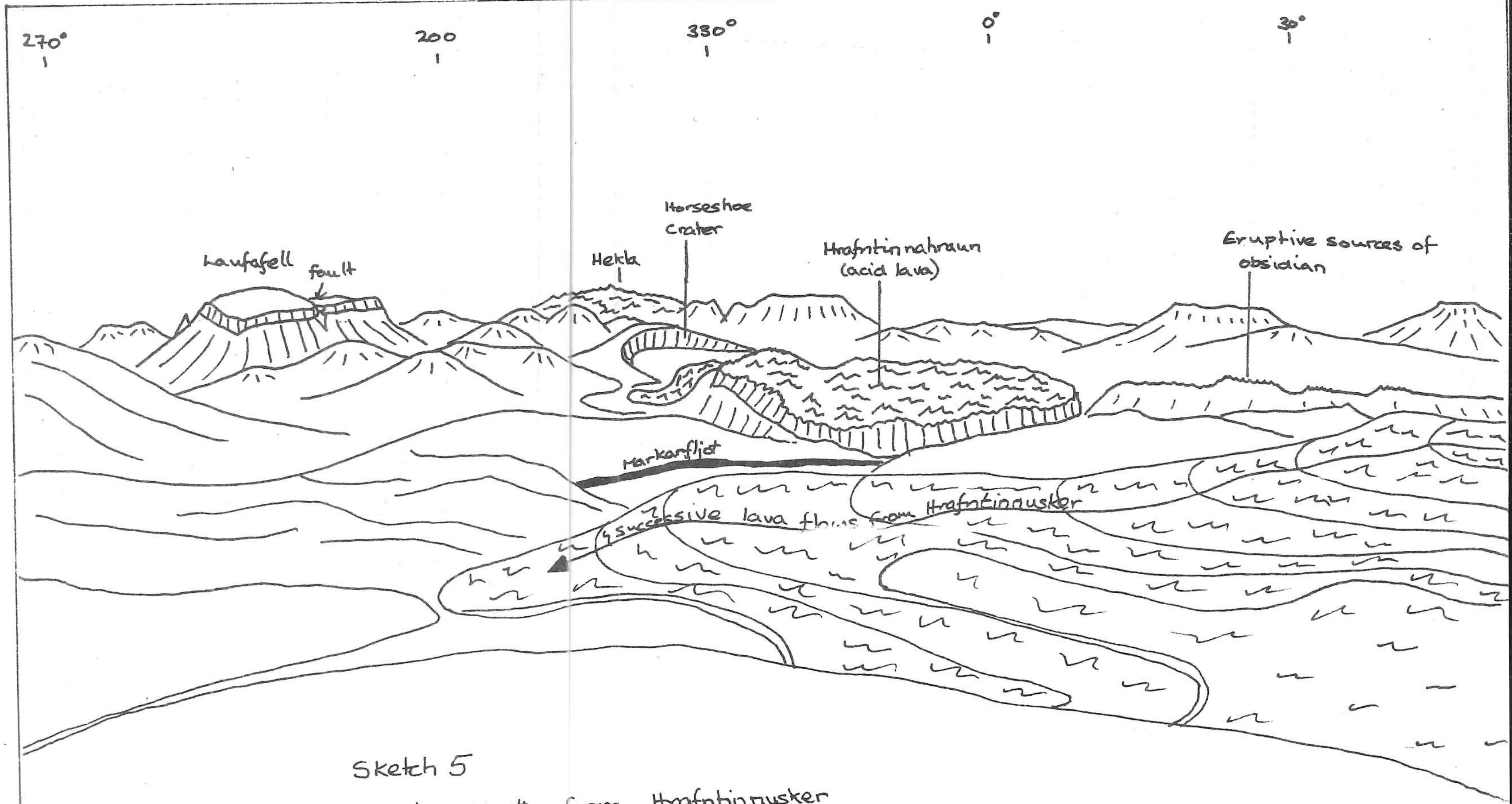
Sketch 4.

The Crater + Lava flow of Hrafntinnahraun Looking west from the collapsed crater edge.





Map. 11.
Hrafntinnahraun.



Sketch 5

Looking North from Hrafntinnusker over the Hydrothermal area.

The surface of the lava flow was extremely rough with many gaps between blocks, some of which went down considerable distances (10 metres +). In between the blocks and covering most of the floor of the crater was pyroclastic material from this and other nearby eruptions.

Around the edge of the crater many bombs were found. The shape of these bombs was mainly spherical the largest collected measuring $\frac{1}{4}$ metre in diameter. The outside of the bomb was glassy in texture but where the skin had broken the inside appeared vesicular. One large bomb weighed an estimated 57 kilos. and had flanges on either side.

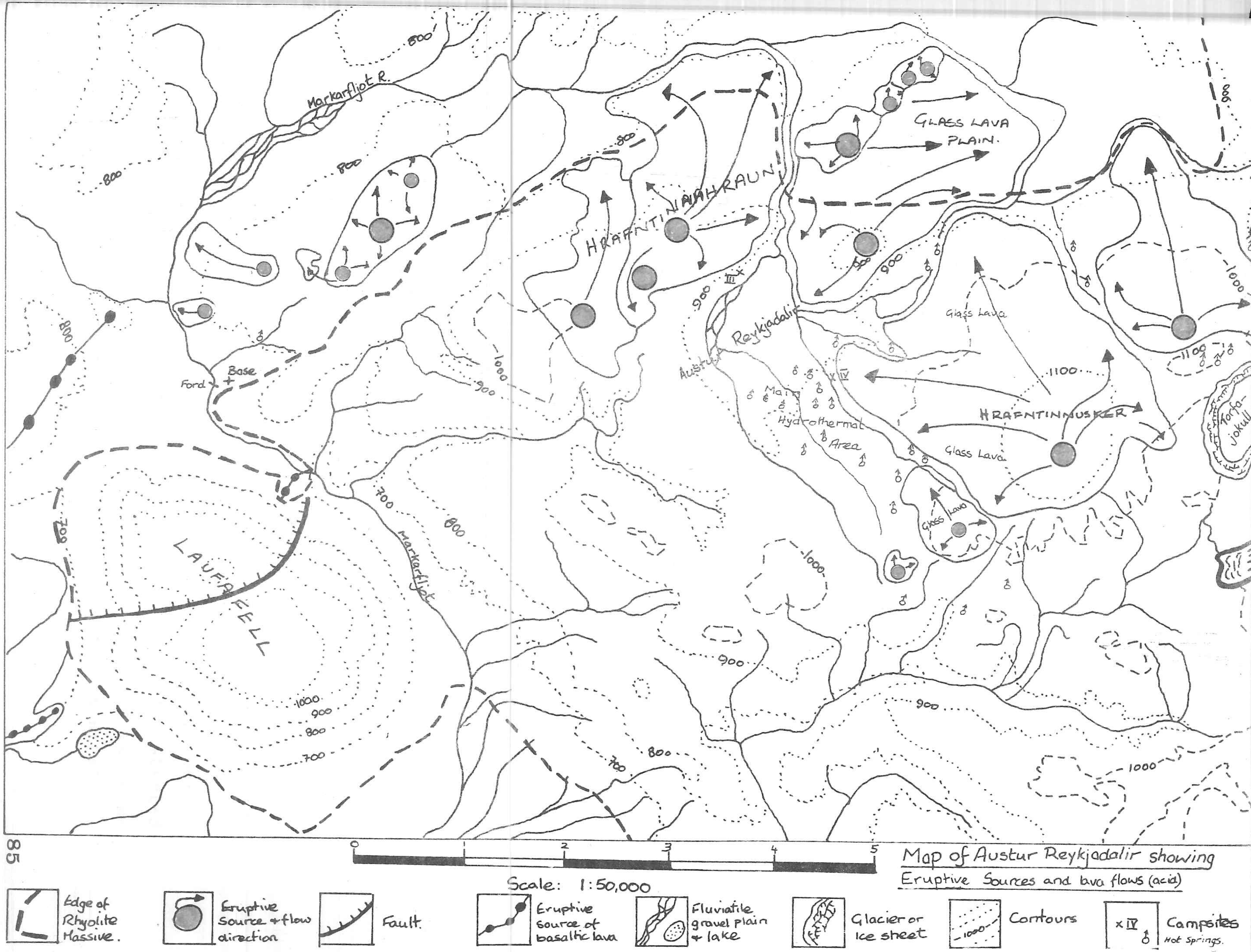
In one area a volcanic conglomerate was found, where the molten lava had picked up solid bits of rock and welded them together into a rock. Related to this were the lens inclusions which were found in the crater. These were formed when the molten rock picked up a piece of material from the ground and included it in the flow but did not melt it. (see photos. 21, 23 and 24.p.45).

To the west of Hrafntinnahraun was an ash cone with only half the crater remaining. The lava flow issued from the north-east side of the crater.

A third crater was observed to the north of Laufafell. The side of this crater had also been destroyed on the north-east side. This volcano appears to have been an explosive vent sonce no lava flows were visible and numerous bombs (spindle shaped) were found together with vast quantities of tephra.

To the east of Hrafntinnahraun an eruptive source was found which had produced coarse scoriaceous material, red or pink in colour.

By far the most extensive area of acid lava was on and around Hrafntinnusker. This lava flow consisted almost entirely of obsidian or glass lava. This lava showed excellent examples of flow banding and etching where there were hot springs. (photo. 25 p. 88).



Map of Austur Reykjadalir showing

Eruptive Sources and lava flows (acid)

Scale: 1:50,000

e) Snow and Ice.

In general the quantity of snow in the area was far less then that experienced in 1970. The snow cover diminished rapidly during the course of the expedition as can be seen by the ice retreat survey. Our proposed study of the firn on Hrafntinnusker had to be cut short due to thick mist and rain.

Hrafntinnusker

The layers of ash in this firn indicate snowfalls over past years - one layer of ash per year. Wind blows ash onto the snow during the summer (or during volcanic eruptions) and this ash is buried each winter. A rough estimate in 1970 indicated that the firn was 75 metres thick (Photo. 28 p. 88). A rough estimate of the age of the bottom layer of ash gave 140 years. It was hoped to carry out more detailed studies of this firn in 1978. However not only time and the weather were against us but also the hole itself. The hydrothermal activity beneath the firn which originally produced the hole had caused slumping to occur. This almost totally obliterated the ash bands (photo. 27. p. 88).

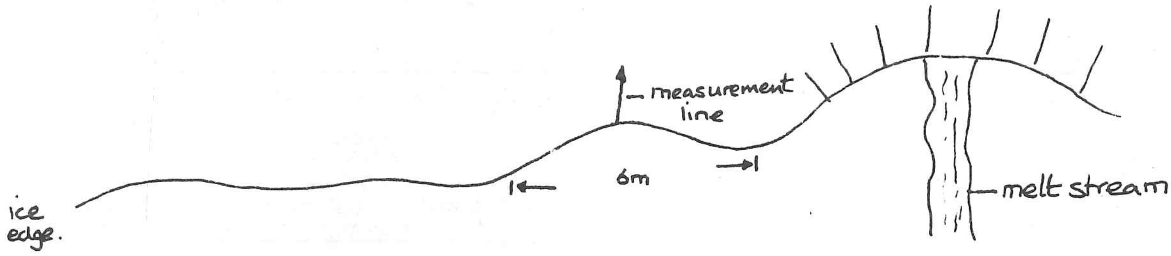
The volcanic ash in the area had other effects. Where ash had blown onto snow it sometimes protected the snow from the heat of the sun and thus slowed down the melting rate. This produced some very peculiar features. (photo. 26. p.88).

Evidence of frost shattering was very common especially on the higher peaks in the area. Initially frost action cannot take place if there are no cracks in the rock. Small cracks may be formed by alternate heating and cooling combined with chemical weathering. Once cracks have been started they can be enlarged by water freezing and expanding in these cracks. This will eventually cause the rock to disintigrate.

Ice Retreat Survey.

Three areas of ice and snow were studied for this survey. For each site regular measurements of ice retreat were recorded together with a sketch map and details of height, slope, direction of slope, type of ground surface and any other factors that could affect ice retreat.

Site 1. G.R. 868911 (camp 1V)
Height: 930m
Direction of slope: south-west
Slope: 25^{0}
Surface: volcanic ash.
Date: 3.8.78



Time of reading	Retreat since last reading	Notes
11.15		drizzle
12.15	4	
13.15	4	rain
14.15	2	rain
16.15	2	rain
17.15	5	rain
18.15	1	rain
19.15	0.5	
20.15	0.5	
21.15	0.5	
10.15	2.5	
11.15	3.5	
12.15	2	
13.15	6.5	
14.15	2.0	
15.15	1.5	
16.15	1.5	rain
17.15	0.5	
18.15	0.5	rain

measurements in cms.

Photo.25. Flow lines in obsidian (west of Hrafntinnusker)

Photo. 27. The Ice Hole on Hrafntinnusker. 1978. Person on right gives scale. Slumping has occured. Dark bands are ash.

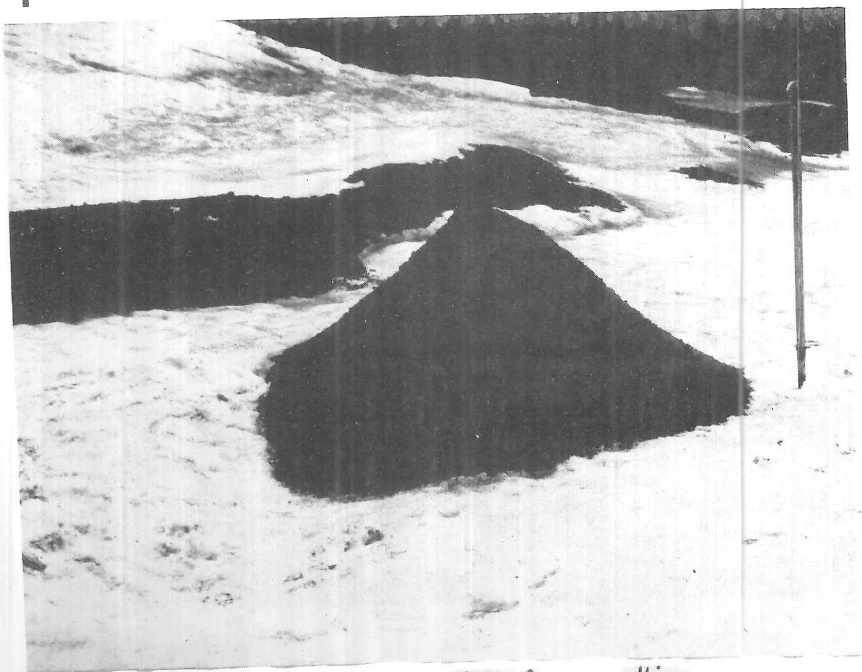


Photo. 26. Ash covered snow prevented from melting

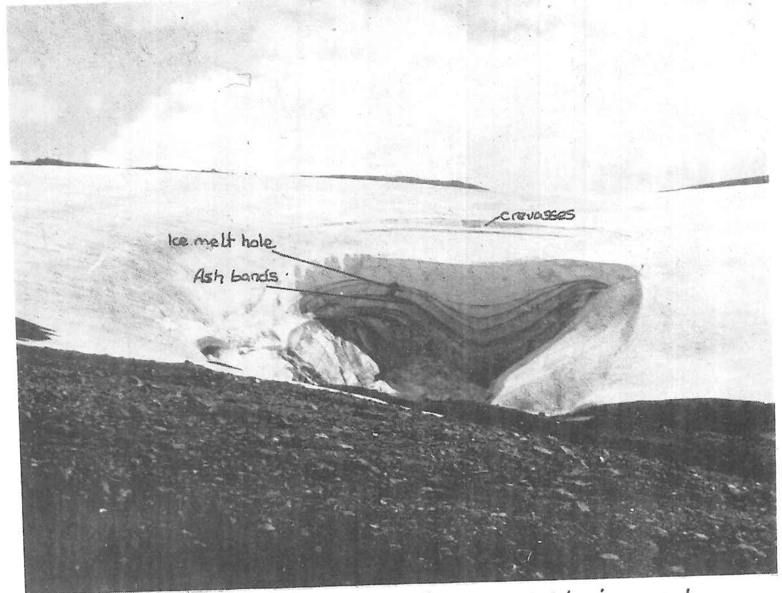


Photo.28. The Ice Hole 1970. Figure on right gives scale

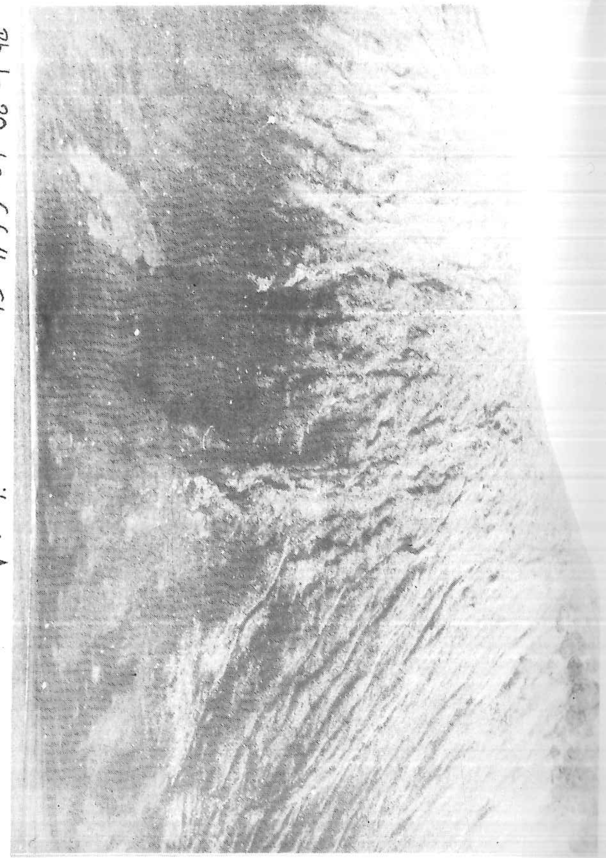


Photo 29. Laufafell. Slope survey site 4

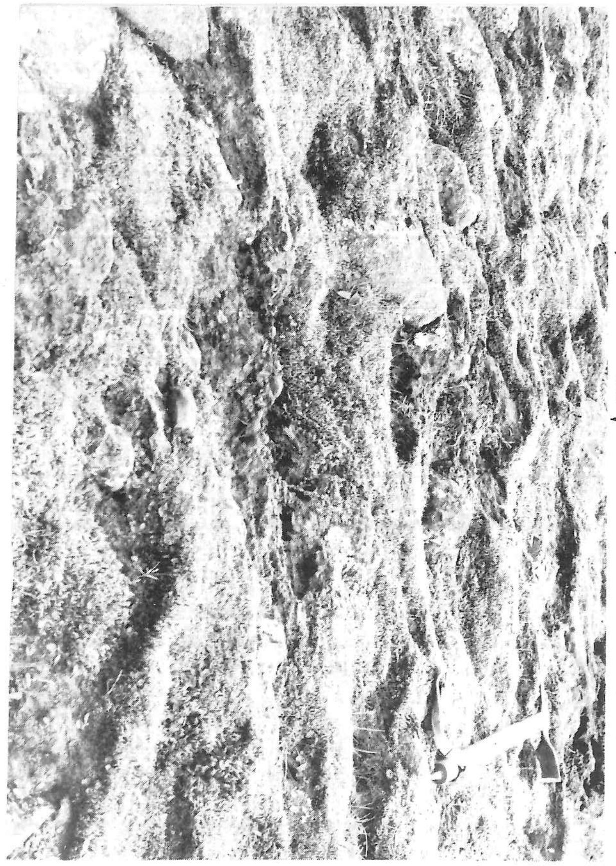


Photo 30. Soil creep terracettes

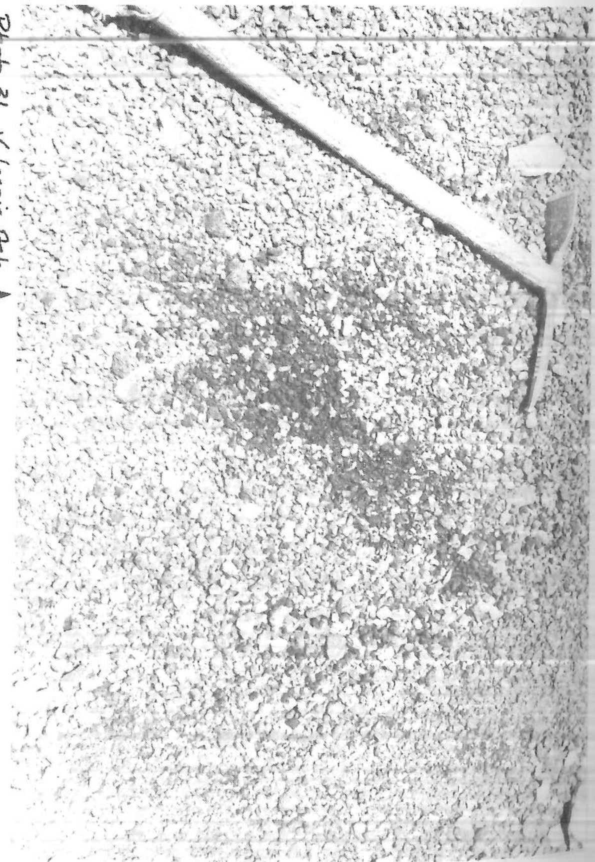


Photo 31 Volcanic Ash.

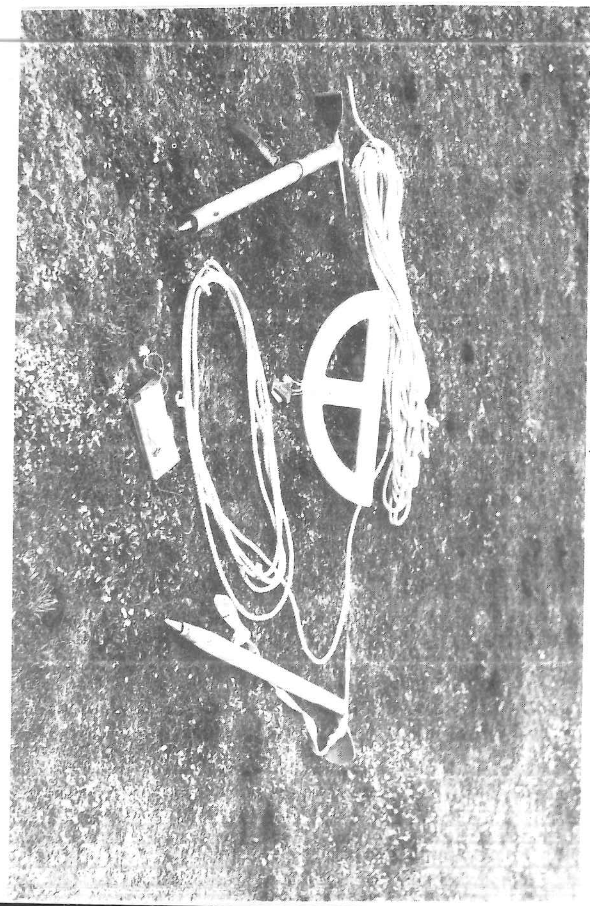
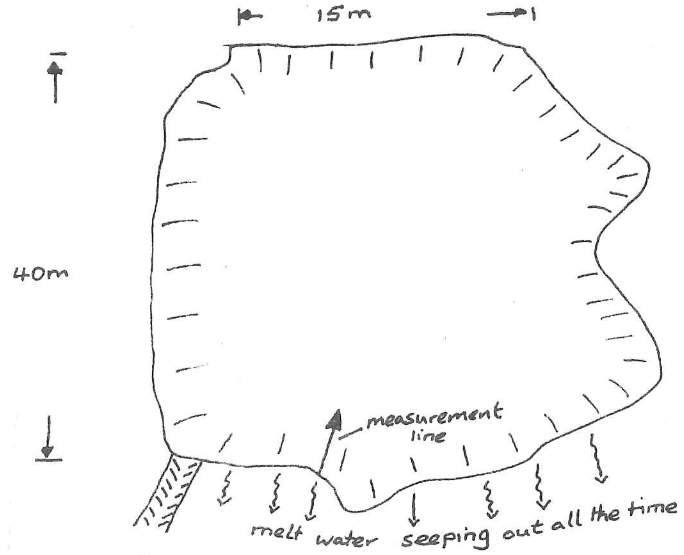


Photo 32. Slope survey equipment.

Site 2.

G.R. 8988 9
Height: 640m
Direction of slope: west
Slope: 15.5°
Surface: volcanic ash
Date: 8.8.78



Time of reading	Retreat since last reading	Notes
0900	3 cms.	21.00 last reading
11.00	2	sunny and hot
13.00	26	sunny
14.00	12	sunny
15.00	17	overcast
16.00	19	overcast
17.00	12	overcast
19.00	20	overcast
21.00	7	
09.00	36	stones at surface

<u>Site 3.</u> G.R. 299872

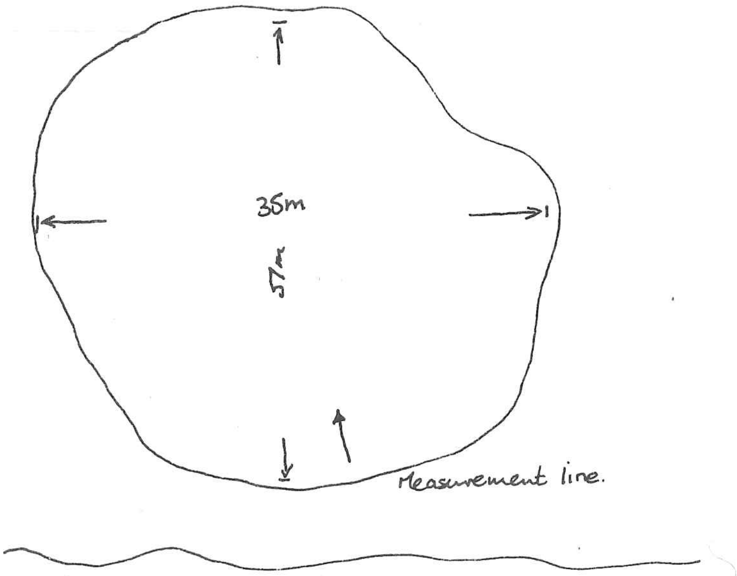
Height: 640m.

Direction of slope: north

Slope: 20°

Surface: volcanic ash with large stones.

Date: 8.8.78



Time of reading	Retreat since last reading	Notes
24.00		
09.00	5 cms.	sun but not on slopes
11.00	1.5	
13.00	5	
15.00	4.1	overcast
17.00	8	
19.00	6	
21.00	5	
09.00	13	

The results were then plotted on a graph (see pages 93 & 94).

All three graphs have certain common features, but the graph containing ice area samples (2 and 3) is perhaps best for comparitive purposes because the readings were taken at the same time on opposites sides of the valley; site 2 facing west and site 3 facing north, almost 1km. apart. Both have similar overnight readings, site 2 having an average rate of ice retreat of 0.2cm/hour and site 3 of 0.5cm/hour respectively.

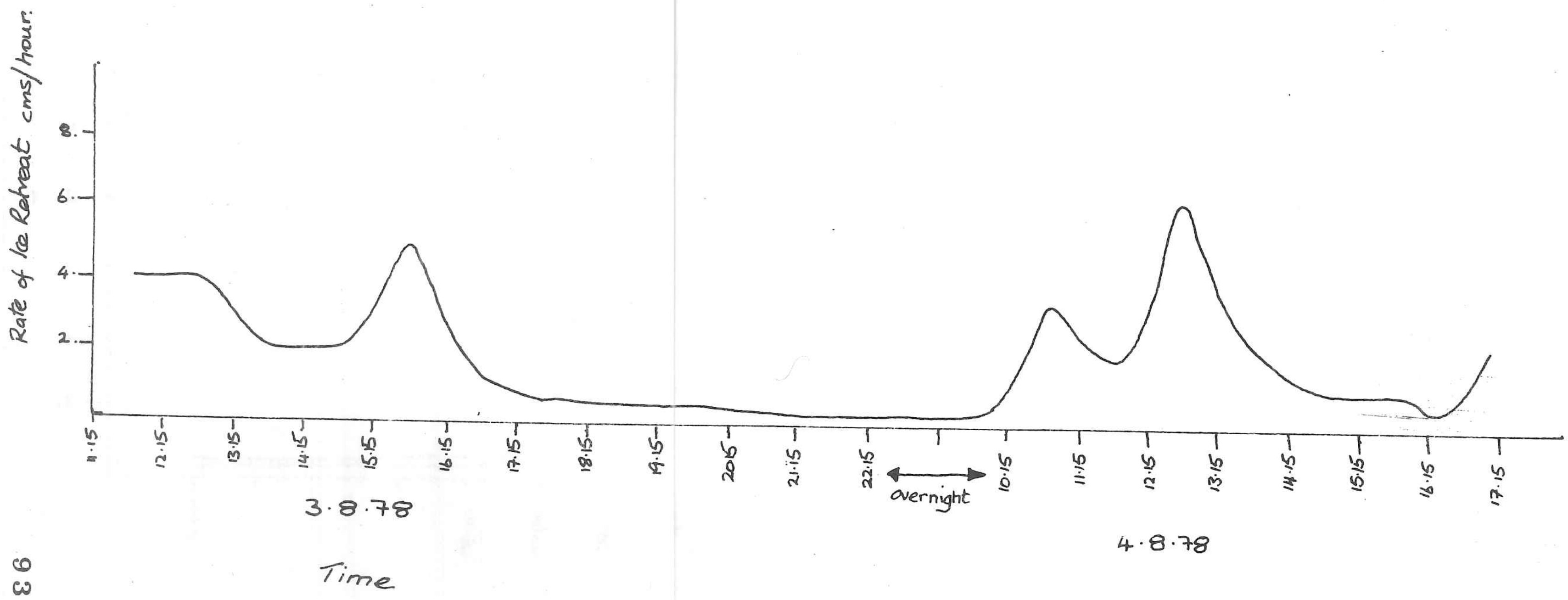
The significantly higher rate of retreat for the second night can be explained by the cloudy weather. This resulted in a warmer night than before when it was clear.

Unfortunately, the rate of ice retreat is easily affected by local factors. Thus the high peak in the graph of site 1 between 12.15 and 13.15 was clearly the result of stone in the ice. These heat up quickly in the sun and melt the surrounding ice by conduction.

The rate of ice retreat is also distorted by different thicknesses of ice as in the graph of site 1 at 14.15.

In general the greatest rate of retreat took place in the afternoon, when it was hottest. Site 3 reaching its peak quickly and then falling to a low rate of retreat. Site 2 showed a period of rapid retreat for a longer period of time. This is probably due to its position in facing west. Even in the evening the rate was 8cm/hour.

Graph for Site 1. (Snow Survey).



Graphs for Sites 2 + 3 (Snow Survey).