SOME GEOPHYSICAL MEASUREMENTS AND OBSERVATIONS IN SURTSEY 1963-1964.

by

Thorbjörn Sigurgeirsson
University of Iceland, Physical Laboratory

1. Time-lapse photographs of volcanic cloud.

During the early stages of the eruption, photographs were taken of the upper part of the volcanic cloud at 10 sec. intervals from the Physical Laboratory in Reykjavik, 114 km from the volcano. The photographs were taken on an 8 mm movie camera. The periods covered by these photographs are:

1963	Nov.	16,	7:30 - 16:05	Icel.	Mean	Time
"	"	17,	7:30 - 12:55	"	"	"
"	"	18,	11:20 - 15:35	"	"	"
"	"	22,	8:45 - 14:30	"	"	"
"	"	23,	9:50 - 16:05	"	"	"
"	Dec.	1,	9:35 - 15:45	"	"	"

From these photographs it is possible to follow the height of the cloud. These measurements have not yet been completed, but the maximum height shown on these photographs occurred on Nov. 23rd at 10:10 o'clock. Between 7 and 9 km height the top of this cloud rose at a speed of 12 m/sec. Fig. 1 shows samples of how the height of the volcanic cloud varies with time.

2. Geomagnetic field measurements.

On Aug. 19th field intensity measurements were carried out with a proton precession magnetometer in collaboration with Mr. Gudmundur Gudmundsson. Measurements were made on profiles totalling 5 km as shown on the map in fig. 2. The results have been reduced to mean field intensity at Leirvogur Magnetic Observatory, and profiles A and B are shown on fig. 3.

Profile A reaches from the east coast of the island up a steep slope to the 155 m peak and from there along the ridge to the 173 m high top close to the west coast.

The magnetic profile shows a clear correlation to the landscape. All peaks give increased field intensity, but the variations in intensity are remarkably small. Along the entire length of profile A the island is made of volcanic ashes or sand, formed during the first phase of the eruption. The results show that this formation is only weakly magnetized.

Profile B runs from the end of the lava field in the southeast part of the island along the sandy beaches in east and north and ends at the end of the lava field in northwest.

A strong magnetic disturbance from the lava shows up at both ends of the profile. Otherwise the magnetic field is homogeneous. The two small maxima in the magnetic profile might indicate the location of craters which were active during the early stages of the eruption.

On Sept. 12th complete field determinations were made at two points on the island (marked by I and II in fig. 2). The D and H components were measured with a QHM-magnetometer and the total field F with a proton precession magnetometer. Reduced to mean field values at Leirvogur the results were:

Surtsey I (20°36'30"W, 63°18'22"N):
D = 336°18' H = 12800 γ F = 51455 γ

Surtsey II (20°36'30"W, 63°18'32"N):
D = 336°44' H = 12847 γ F = 51456 γ

3. Temperature measurements.

On September 15th, 1964, an attempt was made to measure the temperature in flowing lava at its advancing edge close to the shore in the southeast part of the island.

The thermometer was a 2 m long iron-constantan thermocouple enclosed in a steel pipe 0,5" in diameter. The electromotive force is measured with a microammeter having an internal resistance of 2500 Ω and a full scale deflection of 50 μA.

Temperature measurements in two different places gave the following results:

Emf	Cold junction temperature
64,5mV	25°C
63,0mV	30°C

Standard tables of Emf for iron-constantan thermocouples only extend to 1000°C, but a linear extrapolation would give as a result of the two temperature measurements 1130°C and 1110°C respectively. For such high temperatures an iron-constantan thermocouple is, however, not a reliable thermometer.

Subsequently an attempt was made to measure the temperature in a flame of gas emerging from a small opening in the top of a lava cone about 100 m from the crater. The opening was only about 10 cm long and 1 cm wide, but the gas emerged from it with a great force, apparently with supersonic speed, creating a loud whistling sound. Samples of this gas were collected by Gudmundur Sigvaldason and Gunnlaugur Elísson for chemical and isotopic analysis.

When the thermometer was inserted in the flame, the steel pipe melted or burned, and the thermocouple was destroyed. A tube of stainless steel used for collecting gas samples was, however, not affected by the flame.

On November 25th, 1964, temperature measurements were made with a 10 m long Chromel-Alumel thermocouple enclosed in a chromium-nickel steel tube, 0.25" in diameter. The resistance of the thermocouple is 5 Ω. The Emf was measured with the same instrument as previously. Measurements in an advancing lava front at the coast due south of the crater gave the following results:

	Emf	Cold junction temperature	T
Location 1	47,9mV	~15°C	1193°C
" 2	47,9mV	~15°C	1193°C

The thermometer intended for measuring the temperature of the cold junction was broken so these temperatures are only estimated.

Near to the crater the thermometer was sunk about 5 m into a large opening in a lava tunnel. A temperature of about 1140°C was reached, but the thermometer did not reach the fluid lava. This same opening was being used for gas sampling by Gudmundur Sigvaldason, Gunnlaugur Elísson and Bragi Árnason.

In another opening at the edge of the crater a temperature of about 1170°C was measured, but also here the thermometer does not appear to have reached the fluid lava, (visual observation was made impossible by the heat).

On January 18th, 1965, an attempt was made to measure the temperature in the crater itself. The thermometer was hanging about 8 m vertically down from a cliff forming the bank of the crater lake, the cold junction was only 2 m from the edge. A visual observation of the thermometer was not possible and apparently it did not reach to the surface of the lava lake as the temperature only rose to between 1000 and 1100°C. When the thermometer was pulled out, about 50 kg of solidified lava was sticking to its end. Most likely this came from lumps of partly solidified lava which were thrown up from the surface of the lava lake. In an attempt to free the end of the thermometer from the solidified lava, the thermometer was broken and had to be brought home for repair.

On January 31st, the temperature was measured in lava about 800 m SSW of the crater and 100 m from the sea. The lava came welling up through cracks in the consolidated lava field and had formed a low dome-shaped hill. At the edges of this hill the molten lava emerged through small openings (20-40 cm in diam.) in the partly solidified crust. Frequently the flow

through one opening stopped and was covered by a solid crust in a few minutes, but new outlets were formed elsewhere.

The end of the thermometer was pushed to a depth of 10-20 cm into the lava and allowed to follow its flow for about half a meter. This takes a few minutes and meanwhile a solid crust starts to form on the surface, so that the thermometer has to be pulled out to avoid its freezing in.

Both a potentiometer and the previously mentioned microammeter (AVO-Meter) were used to measure the Emf of the thermocouple, which had been repaired by welding together the ends of the wires and the shield tube with stainless steel.

The microammeter was calibrated against the potentiometer on November 26, 1964, and again on February 2md, 1965, with the same result.

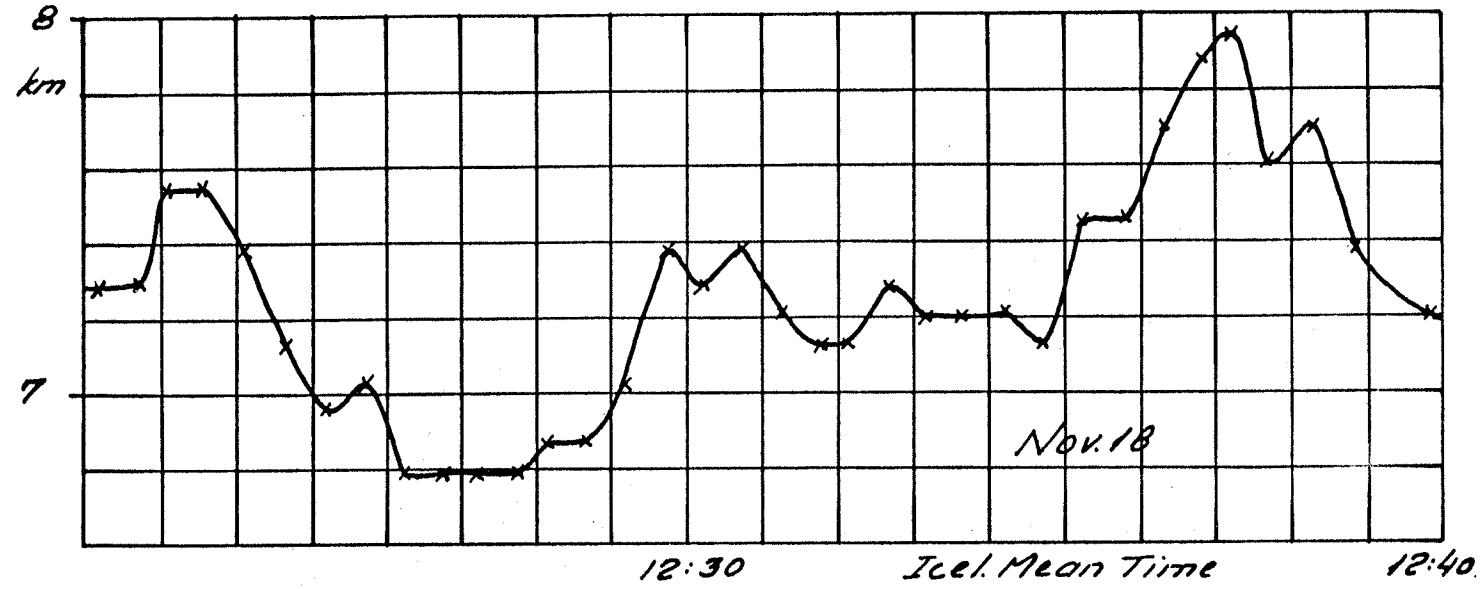
The following 9 temperature determinations were made:

Meter	Emf mV	C.j.temp. °C	T °C
AVO	47,4	21	1182
Pot.	45,21	22	1125
AVO	46,5	24	1164
"	44,8	44	1138
"	46,0	21	1144
Pot.	45,77	20	1138
"	45,81	20	1139
"	45,85	20	1140
"	45,81	19	1138

The results show that the temperature varies a great deal from place to place, and most likely the entire mass of lava welling up in this place has been cooled down to some extent. The four last measurements are made in two openings only a few meters apart, and give consistent results.

FIG 1.

Height of volcanic Cloud.



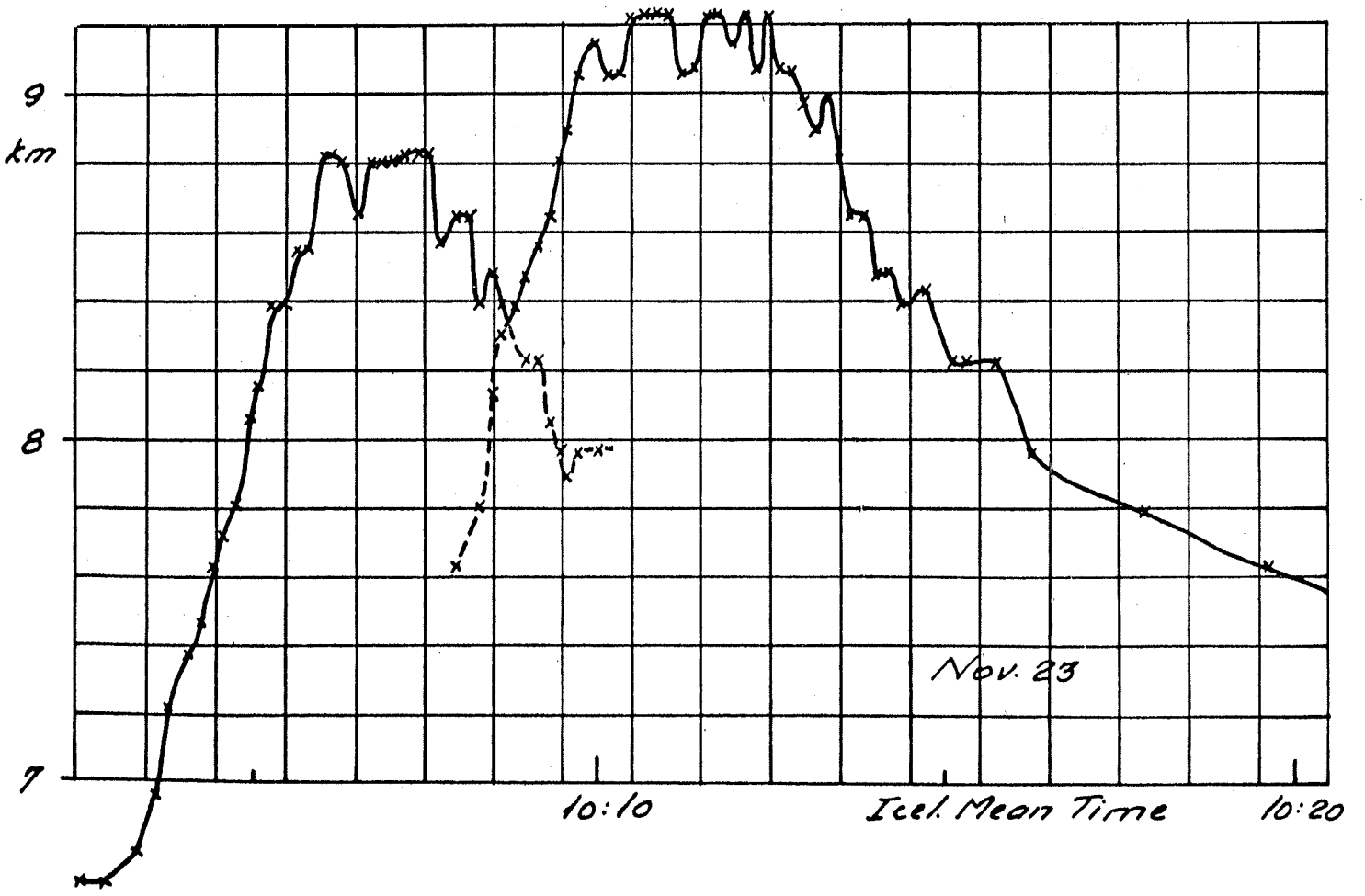


FIG 2.

SURTSEY

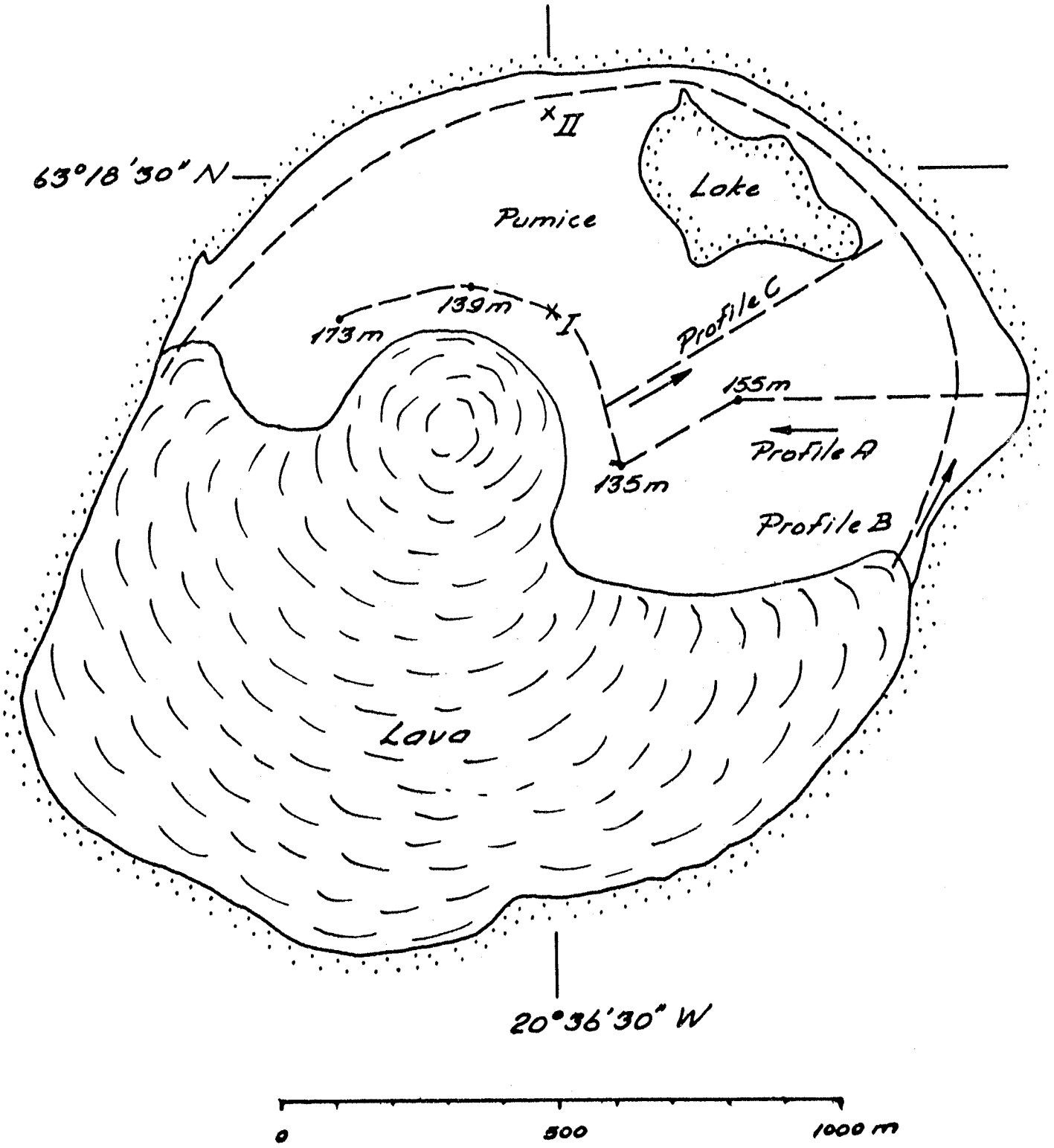


FIG 3

Magnetic Field Intensity