Tidal and leveling measurements on Surtsey July-August, 1979

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INTRODUCTION

During July and August, 1979, a 181 m deep hole was drilled on the eastern crater rim of the eastern vent on Surtsey (station SDH—1, Fig. 1). In order to establish the elevation of the top of the hole, a program of precise leveling and water-level measurements was undertaken. Leveling employed existing bench marks (Tryggvason, 1968, 1970, 1972), where practical, and utilized newly established bench marks where necessary. Water-level measurements were made in a pit east of the hut (station WP, Fig. 1), in the open ocean on the northeast coast, and within the drill hole.

WATER-LEVEL MEASUREMENTS

Water-level measurements were made in a newly dug pit (2 m deep, and about 2 m square) 100 m east of the hut at the northern base of the west vent. Measurements of the level of the brackish water within the pit were made relative to an arbitrary datum every hour for five 24-hour periods. The dates of record and 24-hour average water level above the datum are as follows: July 18 (64.43 cm), July 19 (64.32 cm), July 26 (55.48 cm), July 27 (54.34 cm), August 11 (67.26 cm. Fig. 2). The average of these averages which represents 120 measurements is 61.17 cm, and this is taken as the assumed average water level in the pit and the assumed *datum for the entire leveling survey*.

The tidal cycle is clearly shown in the water-level measurements and ranges in height 1.5 to 5 cm between adjacent high- and low-water (Fig. 2). The time of high water in the pit is clearly out of phase with that in the open ocean. It ranges from 5.1 to 6.5 (average 5.82) hours after the last preceding high tide in the Vestmannaeyjar (Westman Islands) as determined from tide tables.

The damping of the tidal flux and retardation of the tidal cycle is the result of limited permeability of the loose tephra, sand, and gravel which separates the dug pit from the open ocean which is 260 m distant at the closest point to the northwest and 340 m to the east. The determination of mean sea level in the open ocean cannot be accurately made without installation of a suitable tide gage on the island and maintaining it for a period of months or years. Hence only a rough approximation can be made of the elevation of the brackish water in the pit above mean sea level.

On July 27, 1979, a remarkably calm day, a tide staff was established on the beach on the northeast side of the northern cape and was tied in elevation to the dug pit by a level line. The staff was maintained from 1400 to 1900 (Icelandic standard time) during a period of rising tide which, unfortunately, did not include the trough of a low tide or crest of a high tide. During this period, the level of the ocean ranged from 126 cm below to 50 cm above the average level in the dug pit. Comparison with tide tables suggests that the average water level in the dug pit was 25 ± 15 cm above mean sea level in the open ocean. However, the day of measurement was one in which the pit water level was 6.8 cm below the assumed average. Hence the best approximation available is that the dug pit average water level is 32 ± 15 cm above mean sea level and all leveling measurements of bench marks would have to be increased by that amount to

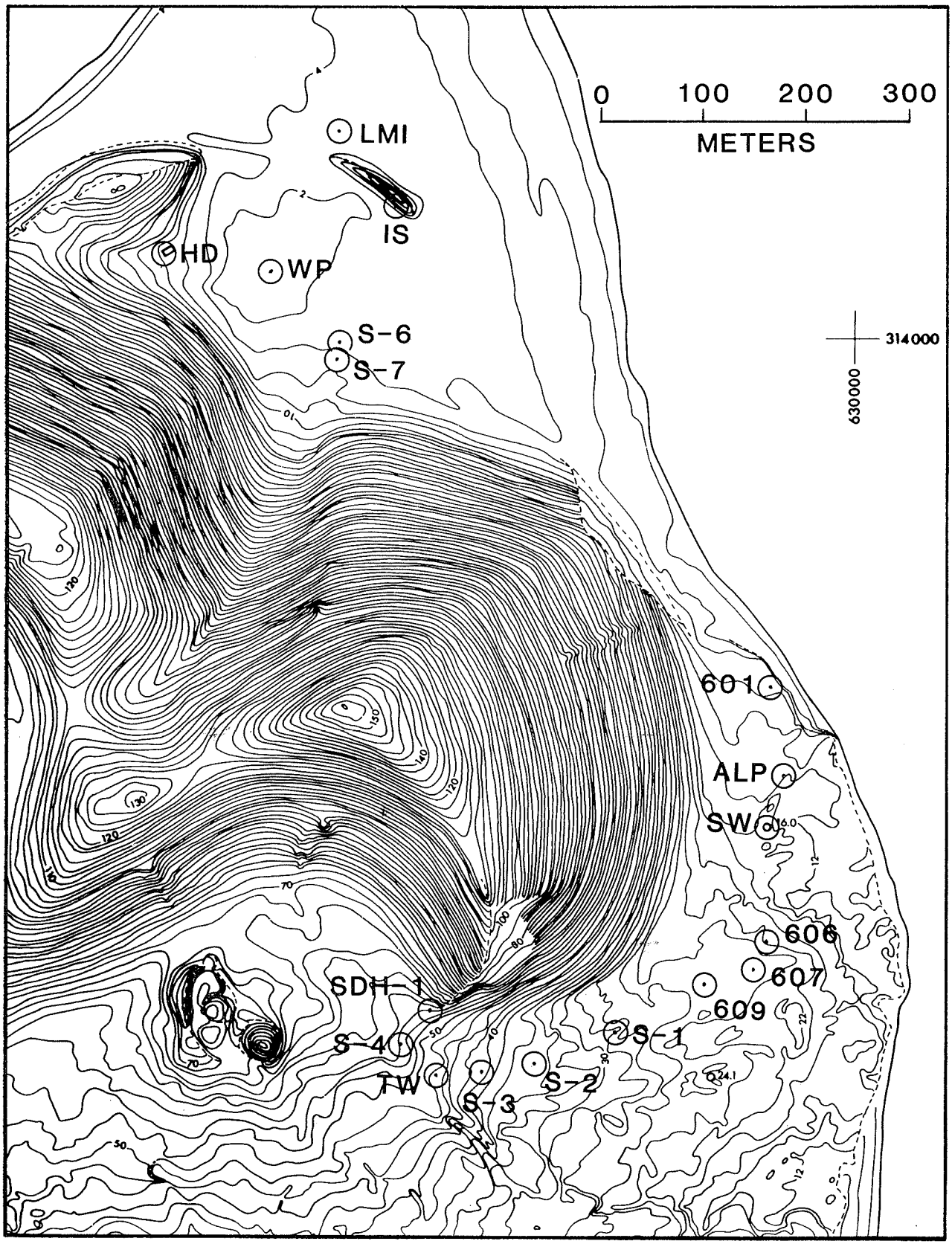

Fig. 1. Map of northeast Surtsey showing the location of bench marks occupied in the 1979 leveling survey. Drill hole is at station SDH—1. Map prepared by John Norrman from air photographs taken July 11, 1975. Contour intervals is 2 m.

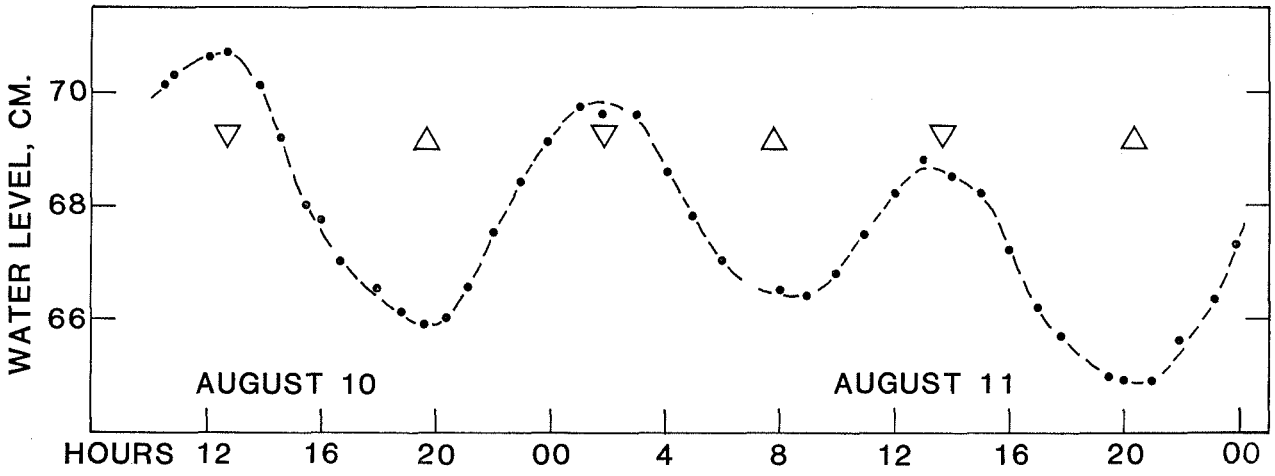

Fig. 2. Height of water level in dug pit August 10-11, 1979. Triangles show times of high tide, and inverted triangles, times of low tide at Westman Islands as determined from tide tables.

represent elevation above sea level. Also, of course, is the fact that water level in the dug pit is variable, and the five-day average may be a poor record of it considering variation due to rainfall, onshore wind, barometric pressure, and other local factors.

LEVELING

Precise leveling was carried out between the dug pit and the collar of the drill hole (Table I). Leveling was done with a Zeiss self-leveling level, and most of the lines were double-run and generally agreed within a few millimeters. Several new bench marks were established (Table I, Fig. 1) near the drill hole as well as on the northern cape of the island to serve as reference points for future water-level measurements near the dug pit. The elevation of all bench marks is shown relative to the five-day average water level in the dug pit which is arbitrarily assumed to be 0.00 m elevation (Table I).

The elevation of the drill hole collar (station SDH-1, Fig. 1, Table I) measured on the top of the outer casing (which is also the reference point for all depths measured within the hole) is 58.066 m above the average water level in the dug pit. The elevation of the drill hole collar above mean sea level in the open ocean is 58.39±0.15 m.

Measurements were made on the depth of water in the drill hole after it reached the depth of sea level on July 12, 1979. Measurements were made by lowering a weight on a monofilament fishline and listening for the splash or by lowering a float. The accuracy of both methods is reduced by stretch in the line, friction of the line on the walls of the casing, and the difficulty of

TABLE I

Elevation of stations above average water level in dug pit, July–August 1979

Station	Elev., M	Notes
SDH–1	58.066	Top of outer, large diameter steel casing of drill hole.
S–4	57.339	Concrete nail driven into lava flow with numbered aluminum tag.
TW	49.442	Center of white triangle painted on smooth lava.
S–3	41.183	Concrete nail driven into lava flow with numbered aluminum tag.
S–2	34.827	Concrete nail driven into lava flow with numbered aluminum tag.
S–1	27.157	Concrete nail driven into lava flow with numbered aluminum tag.
609	23.509	Brass bench mark (Tryggvason, 1972).
607	22.892	Brass bench mark (Tryggvason, 1972).
606	20.316	Brass bench mark (Tryggvason, 1972).
SW	15.905	White square with yellow, inner circle painted on smooth lava.
ALP	10.381	Base of bent aluminum peg.
601	8.295	Brass bench mark (Tryggvason, 1972) with last digit obscured.
LMI	3.387	Top of bent pipe north of small tuff hill (Tryggvason, 1970).
WP	0.00	Assumed datum. Five-day average of water level in dug pit (100 m east of hut) measured hourly.
HD	7.057	Threshold in doorway of hut.
IS	8.730	Top of iron stake on bench, southeast slope of small tuff hill, 3.75 m below summit of hill.
S–6	3.341	Concrete nail in lava flow about 200 m east-southeast of hut.
S–7	4.166	Concrete nail in lava flow about 200 m east-southeast of hut.

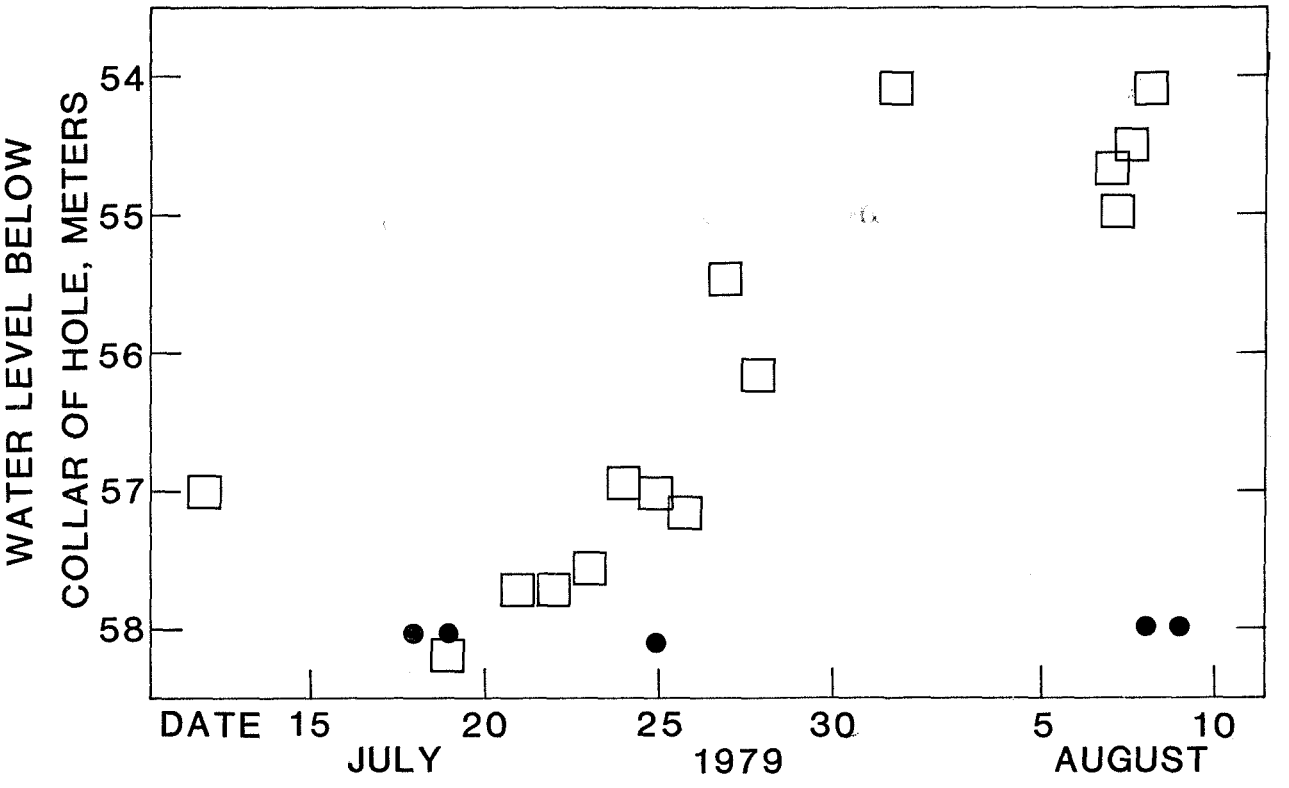

Fig. 3. Vertical distance of water level below collar of drill hole (station SDH—1) for water within drill hole (squares) and for water in dug pit (station WP, solid circles).

detecting the water level when the water is boiling. They show, however, that the lowest water level in the hole is close in elevation to that in the dug pit, and that as drilling progressed and large quantities of sea water were pumped down the hole, the water level steadily rose to about 4 m above that in the dug pit (Fig. 3). Presumably in time, the drilling-induced saturation of tephra around the drill hole will return to normal, and the water level will fall to its predrilling level. However, other factors no doubt affect the measured water level within the drill hole. Free convection of hot water within the hole may have elevated the average temperature of the water column causing it to rise. Also, tides no doubt affect the water level in the hole.

SUBSIDENCE OF DRILL HOLE SITE

Tryggvason (1972) has shown that BM 601 had subsided 30-40 cm between 1967 and 1970 relative to the water level in preexisting lakes and in dug pits on the north cape of the island. The rate of subsidence decreased by about a factor of 2 each year during this measurement period. We find an additional subsidence of about 20 cm making a total of 50-60 cm from 1967 to 1979. In addition, Tryggvason (1972) has shown that all bench marks in his line crossing the middle of the island have subsided varying amounts relative to BM 601. Benchmark 616 which is closest to the drill hole site, subsided (relative to BM 601) about 12 cm from 1967 to 1970. Hence the drill hole site has probably subsided about 70-80 cm since 1967.

The amount that the strata within the drill hole has subsided relative to sea level since the island grew above sea level November 14, 1963, or since activity at the eastern vent ceased January 31, 1964, is unknown. Extrapolating backwards using the same rate of decrease of subsidence suggests that the drill hole site subsided about 3 m prior to 1967 or a total of about 3.8 m from 1964 to the time of drilling in 1979. The amount of subsidence which occurred contemporaneous with volcanic construction of the eastern tephra cone is unknown but may have been considerable. In any event, the passage zone in the drill hole, separating submarine-deposited tephra from subaerially-deposited tephra, is probably deeper than 3.8 m below water level (61.9 m depth) and may be considerably deeper.

References

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