GEOLOGY

THE SURTSEY ERUPTION

COURSE OF EVENTS AND THE DEVELOPMENT OF THE NEW ISLAND

by

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Collecting of information.

From the very beginning of the Surtsey eruption my main contribution to the research work connected with this eruption has been to try to follow by all available means the course of events in order to facilitate the reconstruction of a more or less continuous and reliable picture of the eruption, and to time its different phases and changing habits.

This has been accomplished partly by own observations, partly by collecting information from eye witnesses such as pilots flying over Surtsey, visitors to the island, the staff of the Vestmann Islands Air Control Tower, who have Surtsey in view every clear day, passengers on ships passing Surtsey, a.s.o. I have also tried to collect everything written in newspapers about the eruption.

During the winter 1963/64 my observations from ships were supplemented mainly by Dr. Thorleifur Einarsson. We went out repeatedly on coast guard vessels together or by turns. The Director of the Coast Guard Service, Pétur Sigurdsson, and the crews on his vessels were most helpful to us.

Thanks to the helpfulness of Agnar Kofoed Hansen, Director General of Aviation, I have been able to do many more reconnoitring flights than otherwise would have been possible. Febr. 23, 1965, I made my 62nd reconnoitring flight over Surtsey. I had then visited the island 16 times by boat and landed there 11 times, thereof 4 times by air. My first landing was Dec. 16, 1963. I had taken about 2000 photographs of the island, whereof 1300 in colour. With the aid of these photos and verical photos

taken about every second month by the Geodetic Survey of Iceland, and with frequent measurements from coast guard vessels, it ought to be possible to reconstruct with tolerable exactness and continuity both the building up and the breaking down of Surtsey, as well as to illustrate most of the various phases of this spectacular eruption. Only two maps based on aerial photos have been worked out yet, and some of the areal figures given below are preliminary.

Mr. Ósvaldur Knudsen has taken a long 16 mm cinemafilm in colour of the Surtsey eruption, and I have tried to be of assistance to him in making the film documentary valuable.

Course of events.

The Surtsey eruption started visibly at 07 h 15 m Iceland mean time Nov. 14, 1963. This was witnessed by the crew of the fishing vessel Ísleifur II of the Vestmann Islands. The position of the volcanic activity was $63^{o}18'$N and $20^{o}36'.5$ W, three naut. miles WSW of Geirfuglasker, the southernmost island of Iceland. At 11 o'clock, when first seen by the writer, there were active eruptions in at least two separate places on a line running N 35^{o} E to S 35^{o} W, and the length of the fissure, about 500 m in length. The following night the island was born. In the morning of Nov. 15 it had reached a height of 10 m, and during the next few days it grew rapidly, as the eruption was more or less continuous. Nov. 19 the island was 60 m high and 600 m long. Then it was still an oblong ridge, split by a fissure which was flooded by the sea, and on this fissure two to four separate vents were erupting, shifting from one part of the fissure to another. Gradually the form of the island changed to hoof shape, which after Nov. 26 was usually open to the soutwest. Sometimes a reef blocked the opening, but it never lasted long until the reef was broken by the surf, or blown away by explosions. After the middle of December only one crater was active most of the time, and the island became nearly circular. In spite of the

very effective marine abrasion, which at times cut broad platforms into the outer walls of the volcanic cone, the island on the whole grew in area and height. Dec. 30, the height was 145 m and the diam. about 1100 m.

Towards the end of January the activity in the crater ceased altogether. The island has then reached a height of 174 m, or 300 m from the former sea floor. Its max. length was then 1300 m. Febr. 2 at 11 p.m. a new vent started at sea level on the NW flank of the cone, and the following day the new eruption increased rapidly. Between Febr. 2 and 7 two vents were usually playing at the new eruption site, the innermost erupting lava fountains as the outer one, which was tephra producing, barred the sea from access to it. After Febr. 7 only the outer vent, Surtur II, was active, behaving on the whole in similar way as Surtur I had done until its extinction at the end of February. The eruption was wholly explosive, either with intermittent "wet" explosions, when the sea flooded the vent, or with a more or less continuous uprush of tephra and vapour, when the access of water was blocked by a tephra reef. The explosive activity went on until April 4 at noon, when so thick a tephra wall blacked the gap in the crater wall that the sea had no longer access to the vent. Then the eruption changed to a wholly effusive one with lava in the crater, and so it has been since then.

When the explosive activity ceased the eruption had, roughly estimated, produced 400/500 million cub.meters of tephra, equivalent to an average production of 40 cub.m per second. The area of the island at the end of the explosive phase was about 1.05 km^2.

The effusive phase.

Since the effusive eruption started on April 4, 1964, a lava lake has nearly continuously boiled in the crater, and except for a lull in the lava production between the end of April and June 9, 1964, there has been no stop in the flow of lava from the crater. At times the lake rose so high that the lava welled over the rims

of the vent and flooded the slopes of the lava dome with speeds up to at least 10 m per second. More often, however, the lava found outlets through channels high in the lava dome flowing down the slopes in many rivulets. Gradually their routes were extended along closed tunnels, and during the winter 1964/65 these rivulets usually did not come to the surface until they had almost reached sea level. The lava has mainly flowed towards south and built up a semicircular lava dome with the result that Surtsey may now be regarded as a tablemountain, vix. a basalt shield volcano resting on a tephra socle. The height of the lava dome above sea level was about 95 m at the end of August, 1964; Oct. 23 it was 100 m, and has not changed much since then. The area of the new island, which was about 1.7 km^2 at the end of August, 1964, was 2.3 km^2 according to an aerial photogrammetric measurement of Feb. 23, 1965. Bathymetric maps are needed before the total amount of lava can be calculated, but it seems that the production of lava per month is about the same, calculated in weight, as that of tephra during the explosive phase of the eruption. The chemical composition of the lava is the same as that of the tephra. Thus the change from explosive to effusive activity was due entirely to change in the external conditions.

What happens, when the lava enters the sea.

From the very beginning of the lava eruption it has been striking, how much of the lava becomes fragmented when coming in contact with the sea water. Explosive pseudoeruptions on a small scale could frequently be observed. A great amount of coarse, more or less glassy sand was formed because of fragmentation of the pahoe-hoe lava surface by rapid cooling, and also by the crushing effect of the breakers and the grinding of blocks by the surf. The sand thus formed builds up a collar of sand in front of the lava flow so that at low tide one can walk on a sandy beach in front of the advancing lava. The lava is thus constantly advancing over a layer of wet sand at sea level. How thick this layer is we do not know yet, but it may be assumed that

from sea level and down to the former sea-floor at 130/140 m depth, there is some mixture of coarse sand, intrusive lava and pillow lava, which also may be intruded into the water soaked sand to some extent. Only by drilling through the new lava can we get a definite knowledge of the submarine structure of the lava flow, and such a drilling is highly desirable, as it may throw light on the formation of pillow lava and other features of submarine flows.

Where the lava has ceased to flow it takes only few weeks for the marine abrasion to form vertical cliffs up to 40 feet at the lava front. Above high water level these cliffs are mainly built up of thin lava sheets, in places intercalated by layers of sand. Below high water level there is in places a clear tendency towards the formation of pillow lava. Occasionally a few, rather well developed pillows have been observed; typical pillow lava has not been observed, but one may expect it to be formed below low water level.

Geomorphological studies.

Surtsey is a true Paradise for geomorphologists. The fight between the constructive and destructive forces is fascinating, but also, when the eruption has come to an end, it will be interesting to follow the work of the exogenic forces: marine abrasion, the erosion of wind and running water, landsliding, frost action, etc., which will continue to change the shape of the island. Most of these forces work there with nearly incredible speed and efficiency, and illustrate how relative the time factor is in geomorphological processes.

Morphoscopic studies, which started in April, 1964, reveal that the rounding of blocks and gravel on the shores is an extremely fast process, and on the whole it is astonishing how fast various landscape forms are created on the new island.