A Contribution to the Morphology of Surtsey

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The conclusions outlined in the following are for the most part based on field-studies made during many years before the beginning of the Surtsey eruption, and also in my regrettably few visits to Surtsey in the time interval November 1963 to December 1964. These visits count only three landings for several hours on the island, eight voyages along its coasts, and five flights over it. The most part of these visits were made possible by the courtesy of the Icelandic Coast Guard primarily, and also the Civil Aviation Administration and the Icelandic Survey Department. For other visits I have paid the expenses myself. All last year, 1965, I was impeded from fieldwork in Surtsey by bad health.

My view, outlined below, that morphological features of Surtsey are analogous with those of a certain type of Pleistocene volcanoes in Iceland (the "stapis" or tablemountains) was advanced in a lecture, "Stapakenningin og Surtsey", at an ordinary meeting in the Societas Scientiarum Islandica, on November 25th, 1965. With a little addition this lecture was prepared to appear as an article in Náttúrufrædingurinn, 4th issue, 1965, but it has to wait till the next issue, the 1st of 1966. As this article (24 typewritten pages) is written in Icelandic it does not fit into the present "Reports". What follows is only the Summary in English and most of the pictures of the still unpublished article: A Comparison of Tablemountains in Iceland and the Volcanic Island of Surtsey off the South Coast of Iceland.

Terms like Inselberge, tablemountains and several others have been suggested by foreign explorers for a special type of volcanic mountains in Iceland. In Icelandic they are called stapar (sing. stapi). These are isolated mountains with steep sides and flat or gently convex tops. Near the base, and usually up to a level above the middle of their sides, the stapis consist of móberg (i.e. basaltic hyaloclastic and more or less palagonitized rocks) and pillow-lava, but the top with its sharp edges is made up of lava flows. All these rocks are of Late Pleistocene age.

In the first decades of this century it was debated by geomorphologists, mostly Germans, whether these volcanoes owed their peculiar shape to erosion or to tectonic forces, i.e. whether they were Zeugenberge or Horste. The latter view gained ground as time went on, without being proved, however, in the case of any single stapi. In 1943, after studying some stapis in South-western Iceland, the present writer pointed out a third possibility; the the stapis were piled up by subglacial eruptions. According to this hypothesis the móberg and the pillow-lava structures at the base are the result of rapid chilling in the melt water, whereas the normal flows of lava on the top were extruded subaerially when the mountain had emerged above the ice surface. The steep walls of the surrounding ice prevented the spreading of the erupted material and moulded the mountain almost into its present shape.

More recently similar views have been advanced on the origin of mountains of the stapi type, first by W.H. Mathews (1947) on the Tuyas in British Columbia, and later by R.V. van Bemmelen and M.G. Rutten (1955) on the tablemountains of

Northern Iceland, whereupon this theory of "interglacial accumulation" was accepted by most students of the móberg formation (including the present writer) as the most probable interpretation of the origin of stapis. However, the validity of the theory had not been fully proved in the case of any Icelandic mountain. It was opposed by Trausti Einarsson (1958 and 1963), and facts mentioned in the present article are not indicative of such an origin for all mountains of the stapi type. Further, the theory lacked actualistic support, as repeated subglacial eruptions in Iceland in historic time do not seem to have created any stapis.

It was not until the present writer's investigation of the volcano Leggjabrjótur in Central Iceland that evidence was brought forth of at least that mountain having been formed in accordance with his hypothesis of 1943 (Kjartansson 1964).

Finally, the eruption of Surtur, beginning in November, 1963, and still slightly active in January, 1966, has now piled up a kind of stapi before our eyes. But this new stapi, Surtsey, was not like its Pleistocene counterparts formed in an ice-sheet, but in the sea. Consequently it is somewhat anomalous, especially with regard to its shape. The lack of surrounding ice-walls may be responsible for less steepness of its submarine slopes and the heavy erosion of oceanic waves has already severely deformed its flanks at sea level.

In the formation of Surtsey as well as in that of the older stapis, mutatis mutandis, four different stages and four corresponding rock facies are distinguishable (Fig. 4):(1). Basaltic magma extruding on the bottom of deep water (or thick ice) forms a subaqueous pile of pillow-lava. High pressure prohibits explosive activity - (2). As the top of the pile reaches a level of sufficiently decreased water pressure explosions set in, probably at a depth not exceeding 20-30 metres. Explosive activity, conditioned by the easy access of water into the vent, continues with production of pyroclastic

material. Crater walls of this material rise above the water-level. - (3) When these walls become continuous around the crater and sufficiently watertight, the activity turns effusive. Lava of the shield volcano type covers the emerging top of the pile. - (4) Lava streams flowing into the water (or onto the ice) are solidified rapidly by its chilling effect and pile up to form high and steep subaqueous fronts consisting of a mixture of brecciated and pillowy lava.

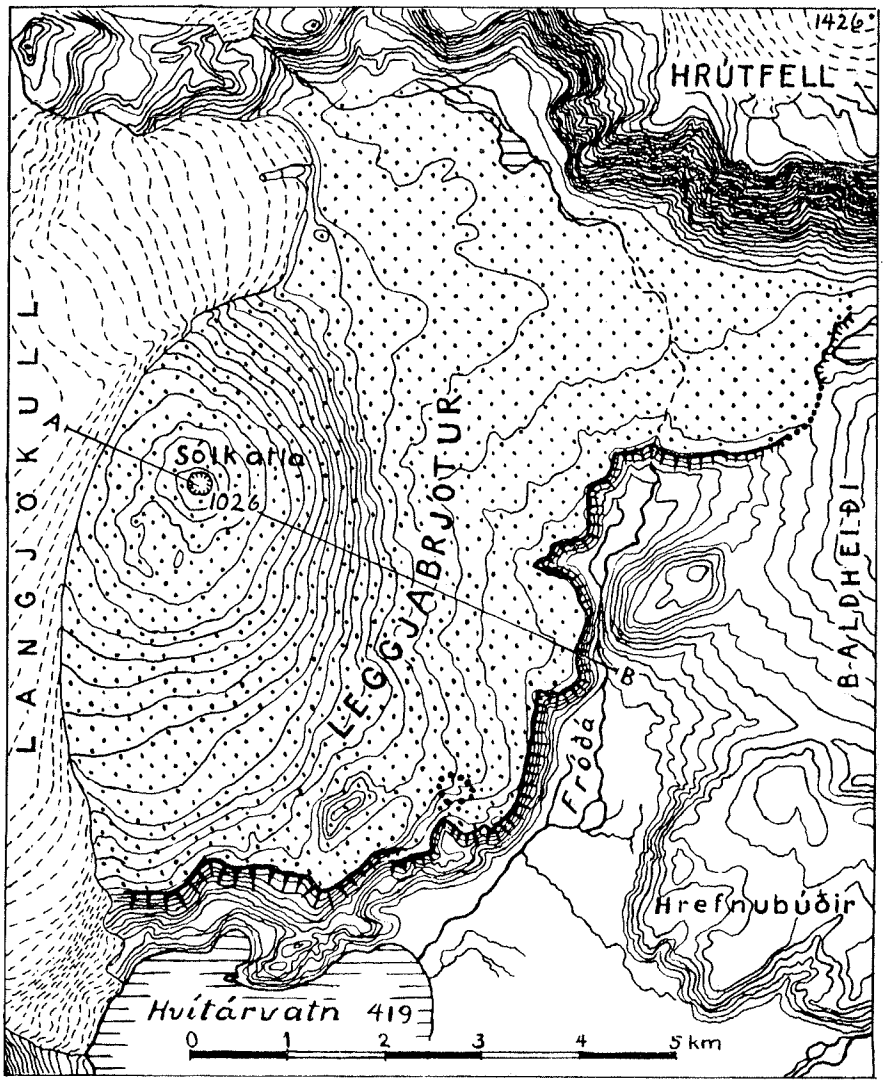


Fig. 5. The tablemountain Leggjabrjótur with its summit crater Sólkatla.

Dotted area: lava from Sólkatla, never glaciated. Thick toothed line: high edge of lava, come to rest in deep water or against the steep margin of the Pleistocene ice-sheet. Dotted line: low (normal) edge of lava solidified on land (visible only on a short section north-west of Baldheiði and around a small outcrop of bedrock near the south-eastern edge of the lava). Elsewhere, the edge of lava is buried under debris (in the north) and under glacier ice (in the west).
A - B: section shown in Fig. 4.
Contours according to the U.S.A. Army Map of Iceland.

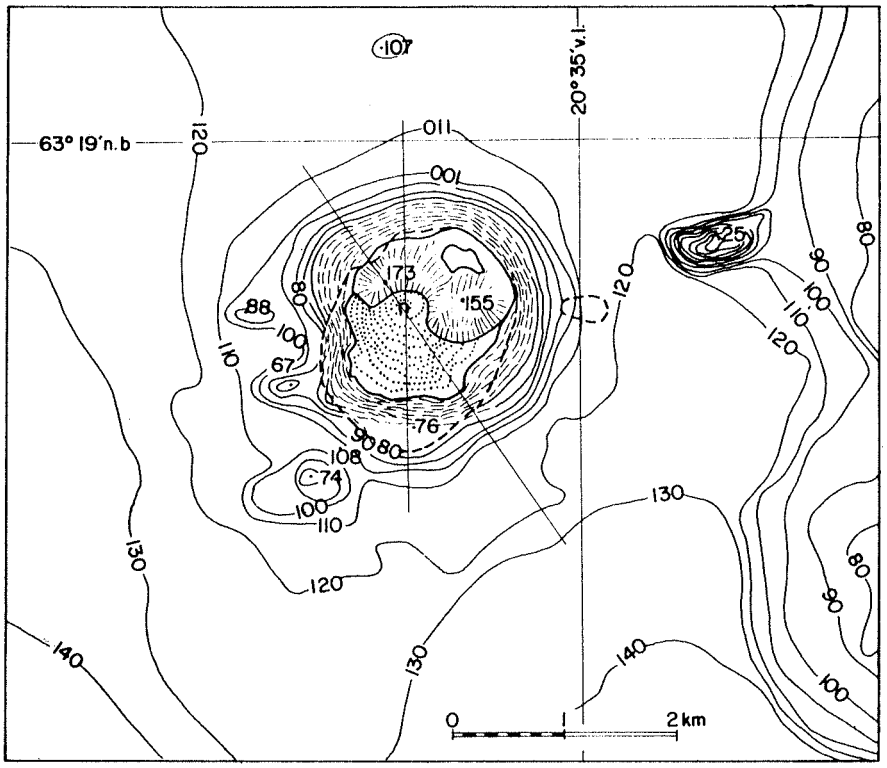
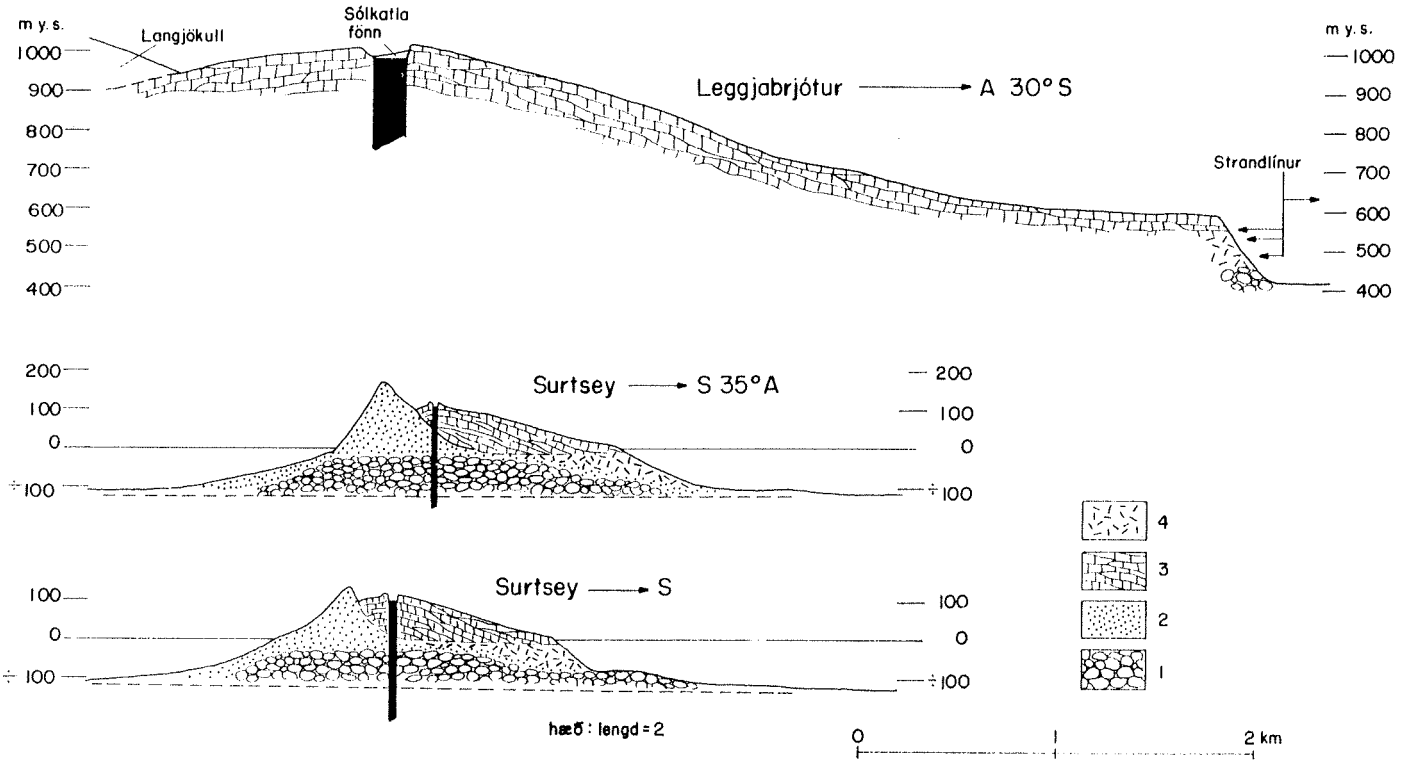


Fig. 3.

A chart of the surroundings of Surtsey according to echo soundings by the Icelandic Hydrographic Service in July - August, 1964. Coastline of Surtsey and Syrtlingur in August, 1965, inserted with thick dash-line.



E.B.

Fig. 4.

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Sections of Surtsey and Leggjabrjótur (cf. Figs. 3 and 5) in equal scale, vertical exaggeration 2 : 1. Rock structures below sea level, suggested. - 1 : pillowlava with increasing content of volcanic breccia and tuff near the top. 2 : tephra, mostly tuff. 3 : lava-flows of the shield volcano type, possibly with pillow structure near the base. 4 : Coarse breccia, probably containing pillows, scattered and in clusters. "Strandlínur" = shore-lines ; "fönn" = névé.

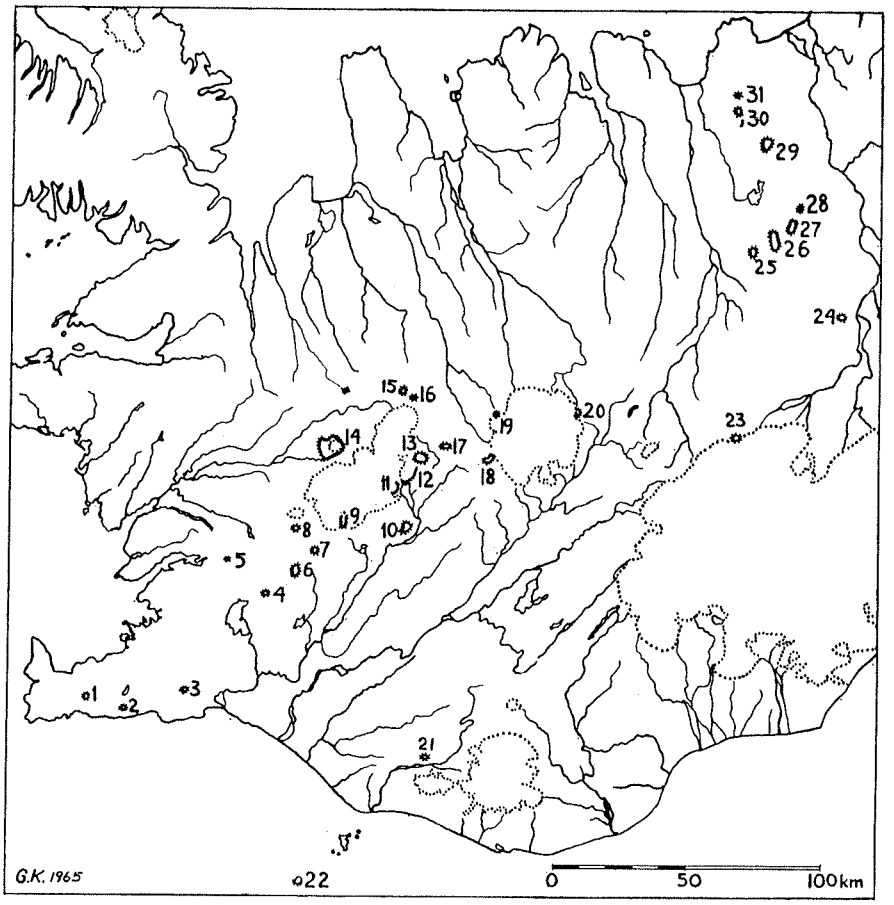

Fig. 1. Tablemountains in Iceland.

1 Fagradalsfjall, 2 Geitahlíð, 3 Geitafell, 4 Hrafnabjörg, 5 Hvalfell, 6 Skriðan, 7 Hlöðufell, 8 Stóra-Björnsfell, 9 Hagafell, 10 Bláfell, 11 Skriðufell, 12 Leggjabrjótur, 13 Hrútfell, 14 Eiríksjökull, 15 Krákur, 16 Lyklafell, 17 Kjalfell, 18 Blágnípa, 19 nafnlaust fjall upp af Álftabrekkum, 20 Miklafell, 21 Þórólfsfell, 22 Surtsey, 23 Kistufell, 24 Herðubreið, 25 Sellandafjall, 26 Bláfjall, 27 Bláfjallsfjallgarður, 28 Búrfell, 29 Gæsafjöll, 30 Lambafjöll, 31 Höfuðreiðarmúli.

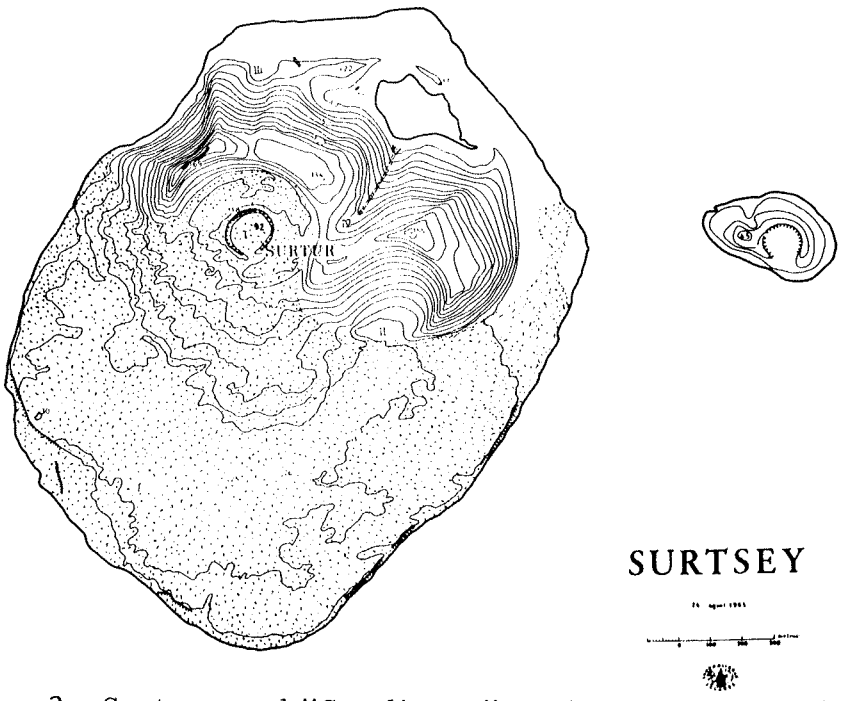

Fig. 2. Surtsey and "Syrtlingur" on August 24th, 1965. The lava is indicated by stippling: the hills consist of tuff, and the flat strip along the shore is made up of beach deposits.