Grænavatn and Gestsstadavatn.

By S. Thorarinsson.

In the southernmost part of the volcano-tectonic valley which intersects the highland of the Reykjanes peninsula from Krísuvík towards NE there are two small lakes, Grænavatn and Gestsstadavatn, one on each side of the auto road. These lakes are situated short SE of the solfatara areas of Engjafell and Seltún, commonly called the Krísuvík area, where sulphur was mined during the times of the Danish Trade Monopoly.

Seen at a distance, e. g. from the solfatara area at Engjafell, the two lakes are of similar appearance and they have up to now been regarded as being both of the same origin, although opinions have differed as to what that origin is.

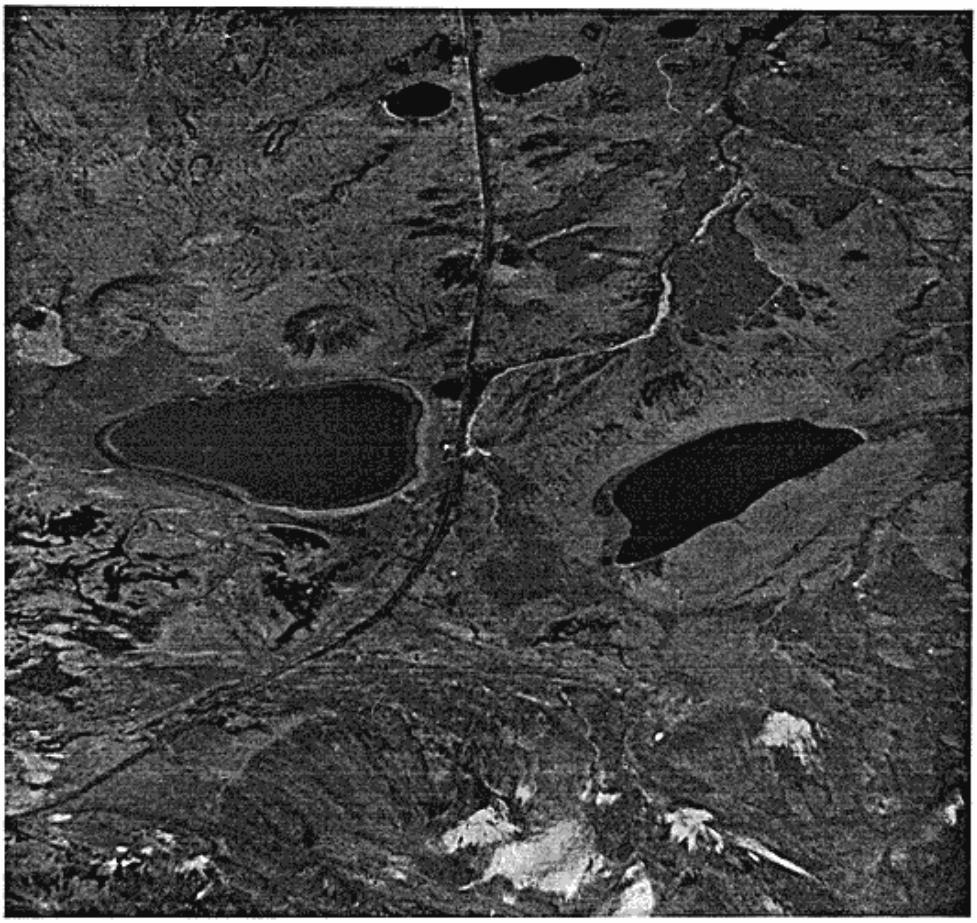
In written records these lakes are first mentioned in a paper on the sulphurmining in Krísuvík written by a Norwegian, O. Henchel, who later was appointed director of the Silver mines at Kongsberg. He spent some weeks studying the solfatara areas at Krísuvík in 1775. On the sketch map accompanying his paper both lakes are shown with their names. Henchel mentions that Grænavatn (Green Lake) derives its name from the colour of the water and states that the water tastes somewhat of vitriol whereas Gestsstadavatn neither has that taste nor the green colour (Henchel 1780, p. 680).

Skúli Magnússon, *landfógeti,* mentions both of the lakes in his treatise on Gullbringusýsla and Kjósarsýsla and says that no fish is in either of them (Magnússon 1785, p. 93).

The poet and naturalist Jónas Hallgrímsson, visited the Krísuvík area in 1840. He says that both lakes seem to be "formed by engulfment of the ground" (Hallgrímsson, p. 28—29).

In the account of his travels in 1883 Th. Thoroddsen says that both lakes are circular and very deep. "It is possible" Thoroddsen writes, "that these kettle holes were formed during the ice age by

the melting of big blocks of ice, such as still happens after the glacier bursts on some of the sandurs in Skaptafellssýsla, e. g. on Skeidarársandur". (Thoroddsen 1884, pp. 25—26). But in his "Lýsing Islands", published in 1908, Thoroddsen expresses the



Aerial photo: S. Sigurdsson 1946.

Fig. 1. Gestsstadavatn (to the left) and Grænavatn and their surroundings. The small lakes Litla auga and Stóra auga in the foreground. In the background the solfatara areas of Engjafell and Seltún.

opinion that the lakes are more probably old crater lakes (op. cit., p. 340) and so he says too in his "Ferðabók" (Thoroddsen 1913, p. 148).

The German volcanologist W. v. Knebel visited the Krísuvík area in 1905 and his countryman H. Reck did so two years later. In their book on Iceland both of the lakes are designated as maars (v. Knebel 1912, Tafel X) and v. Knebel stresses the similarity between lake Grænavatn and the maars in the Eifel district (v. Knebel 1905, p. 9).

On an unpublished geological map of Reykjanes by G. G. Bárdarson both lakes are designated as crater lakes and so are also the small lakes Stóra auga and Litla auga (cf. Fig. 1).

Photo: S. Thorarinsson 1950.
Fig. 2. The northern part of Gestsstadavatn. View to N.

M. Kúthan, a Czeck geologist, travelled on Reykjanes in 1934, 1936 and 1937. He mentions both of the lakes as crater lakes without describing them any further (Kúthan 1935, p. 138; 1943, p. 24).

In the autum of 1945 the attention of the present writer was caught by these lakes as he spent some days in the Krísuvík area surveying the solfatara fields. In February the director of the National Research Council, S. Sigurdsson, and the present writer sounded both of the lakes and the bathymetric contours on the map Pl. I are based ond these soundings. The map is for the rest based on tachymetric measurements carried out by R. Thorláksson C. E. and the present writer. For the drawings of the contours use was also made of aerial photos taken by S. Sigurdsson.

As already stated by Thoroddsen Grænavatn and Gestsstadavatn

are surrounded by moraines. The lakes are situated within a morainic belt ab. 1 km wide, which stretches straight across the southernmost part of the Kleifarvatn valley.

These moraines have been deposited in front of a glacier toungue which has stretched southwestwards along the Kleifarvatn valley. This morainic area is crowded with kettle holes and depressions of various sizes, resulting from the melting down of moraine-covered dead-ice.

The Gestsstadavatn depression (Fig. 2) is such a dead-ice hollow and thus not at all formed by volcanic activity. The area of this depression is ab. 95.000 m² and the area of the lake 45.000 m² (max. length 380 m, max. breadth 150 m). The greatest height of the surrounding moraine ridges above the lake bottom is 29 m. The angle of their inner slopes is practically the same everywhere, ab. 27°. The lake is very shallow, its max. depth being only 2.6 m.

The two small lakes Stóra auga and Litla auga are waterfilled kettle holes (depth of water ab. 5 m) while just south and southeast af Grænavatn there are two nearly circular kettle holes (cf. the map Pl. I) 15.000 and 20.000 m² in area and 16 and 7 m deep respectively, but without any water although the bottom of the deeper one is 3 m below the normal level of Grænavatn.

Th Grænavatn depression has the same area as Gestsstadavatn, 95.000 m², whereof the lake occupies ab. 73.000 m² (max. length 350 m, max. breadth 260 m). The lake is, like the other lakes in the area, without any outlet and the height of its level is somewhat variable. — On Aug. 29th 1951 it was 2.9 m lower shown on the map and at the same time Gestsstadavatn was 0.7 m lower.

A glance at the map and at the sections shown on Fig. 3 reveals that the shape of Grænavatn depression is quite another than of the other depressions in the area. The max. depth of the lake when sounded was 45 m which in relation to its area is an extraordinary depth, and the angle of slopes beneath the 10 m contour is ab. 52°, which is much more than the natural slope of any unhardened moraine or talus. It may thus be regarded as practically certain that these walls consist of hardened sediments or solid rock.

The slopes above the lake level consist of moraine of the same type as around Gestsstadavatn. But in the surface layer of this moraine along the south and southwestern shores of the lake one finds basic (SiO_2 49.56 % — Analyst. J. Jakobsson) volcanic scoria and lapilli and scattered bombs, and this volcanic material increases when one approaches the northern and northeastern shore of the

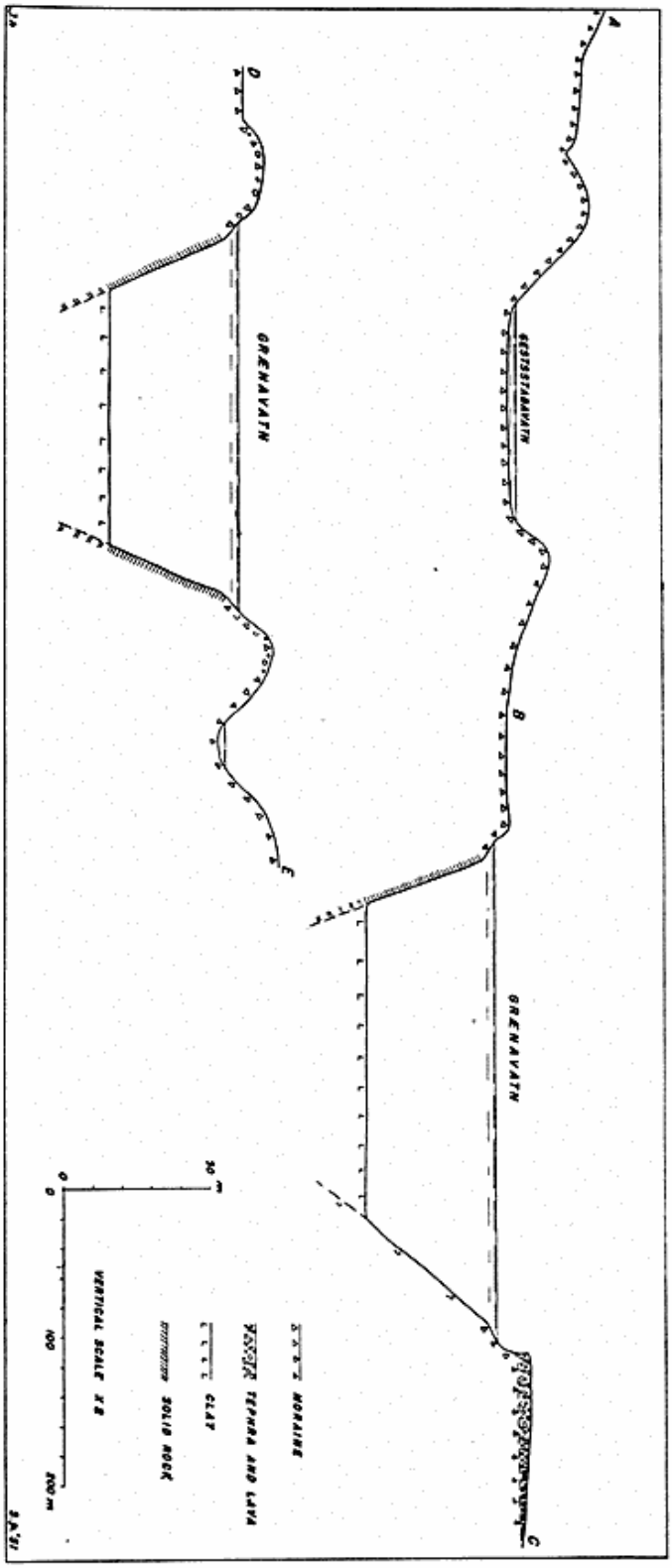


Fig. 3. Sections through Grenavatn and Gestsstadavatn based on the map plate I.

lake until it forms a continous layer superimposed on the moraine. Grænavatn is thus of quite another origin than the other depressions in the area. It is an explosion crater or maar. In size it ranks among the smallest Eifel maars but in depth the crater lake ranks among the deepest crater lakes in the Eifel region The layer of loose volcanic ejecta gradually changes into a compact layer which forms a nearly vertical wall above the moraine along the northern

Photo: S. Thorarinsson 1950.

Fig. 4. The northern part of Grænavatn. View to NE. The picture shows the vertical wall of tephratic lava superimposed on moraine.

and northeastern shore (Fig. 4). A typical section through this layer is shown on Fig. 5. The bottom layer of scoria, bombs and "schweiss-schlacken" gradually changes into a layer of lava, which has a porous structure typical of tephra, viz. the airborne volcanic material. It gradually changes upwards into a topmost layer of tephra, which on the surface is now sorted so as to form regular polygons (cf. Thorarinsson 1951, Fig. 2). The lava is thus not a lava *in sensu strictu,* viz. formed by material *flowing* from the craters but is formed by the running together of molten ejected lava lumps, and as the present writer uses the term *tephra* as a collective term for the airborne volcanis material this "wurzel-lose" lava has been designated as *tephratic* lava. Its extension is shown on the map Pl. I. Sheets and "aprons" of tephratic lava can be studied

in the walls of some explosion craters on Landmannaafréttur such as Ljótipollur (cf. Thorarinsson 1952, Fig. 22), the explosion crater just N of Tjörvafell and the explosion fissure short NE of Valahnúkur. The tephratic layer at Grænavatn continues towards E as a layer extends cannot be said with certainly, but the rapid decreasing the tephratic lava is shown by isopachytes on the map. The thickness distribution shows that during the formation of the layer the

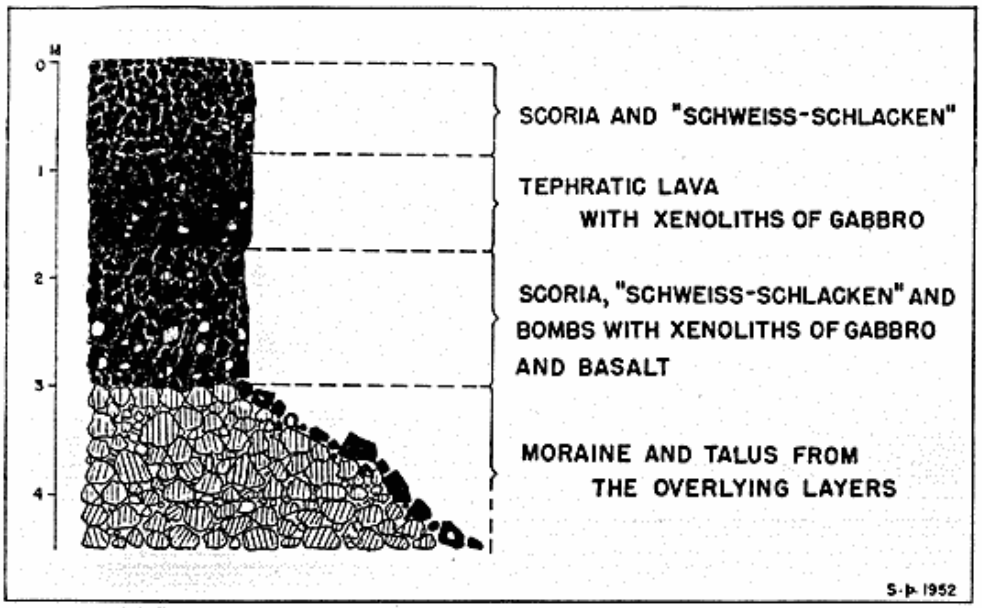


Fig. 5. A typical section from the northern shore of Grænavatn.

wind has been blowing from west. How far to the east the tephra layer extends cannot be said with certainty, but the rapid decreasing of its thickness shows that it cannot extend very far.

The total area of the sector where scoria and lapilli are now found is ab. 1 km² and the total volume of the scoria and lapilli now found within that area (including the tephratic lava), does not exceed 0.3 mill. m³. One has also to take in account the possibility that finegrained tephra may have been formed and carried farther away but the present writer has not been able to find any such layer and therefore does not think it likely that much finegrained tephra was produced. The volume of the Grænavatn depression is ab. 2.4 mill. m³ and thus far exceeds the volume of the now visible erupted material. It seems probable that before the eruption there existed a depression of the Grænavatn type which might count for some of the difference in the volume. But even if we suppose that only the depression beneath the 5 m contour in the lake was formed

by the eruption its volume is ab. 1.5 mill. m^3 so that it is hardly possible to explain the whole difference without presupposing also an engulfment in connection with the eruption.

As to the age of the crater nothing can be said with certainty. The erupted material is superimposed on moraines, the age of which we do not know, but they are almost certainly older than the Hólkot Stage in Northern Iceland, which means more than 10,000

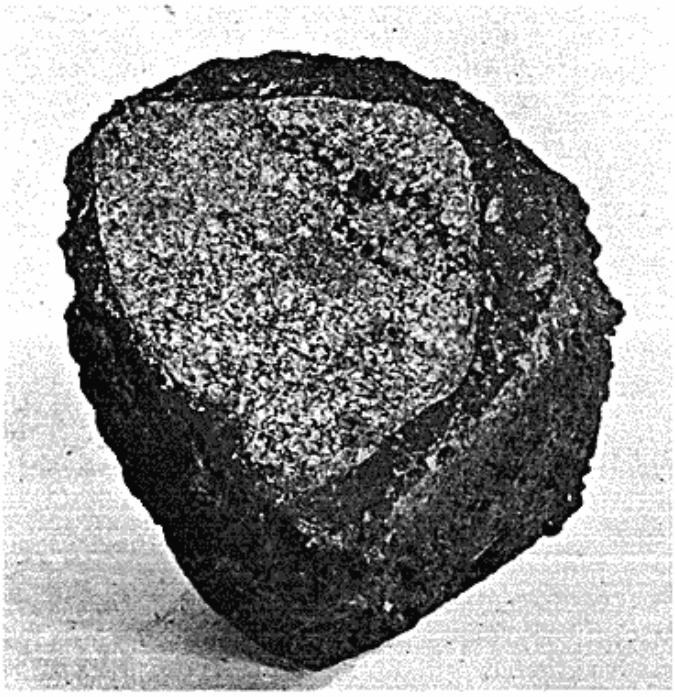


Photo: T. Tryggvason.

Fig. 6. The half of a bomb with nucleus of gabbro. ⅔ of natural size.

years (Thorarinsson 1950, p. 74 ff.), but probably not older than goti-glacial. In soil sections in the soil patches left by the deflation in the area where Grænavatn tephra is found, that tephra has only been found in the contact between the ground moraine and its soil cover, but as none of the approximately dated tephra layers, such as the rhyolitic layers from Hekla, are found in this area, the age of the soil cover cannot be determined, and it might possibly belong to a young cyclus. But most likely the Grænavatn crater is early postglacial.

In his paper of 1943 Kúthan mentions in a footnote (p. 24) that on the shores of Grænavatn he has found volcanic bombs with

nuclei of diallagic gabbro. Without knowing of Kúthan's paper T. Tryggvason and the present writer found such bombs when walking along the northern shore of the lake in the autumn of 1946. A short prelimiary description of the gabbro xenoliths is given below by Tryggvason.[1])

The bombs are mainly found in the layer beneath the tephratic lava (cf. Fig. 5). They are mostly globular. A common diam. is 15 cm, but bombs up to 40 cm in diam. occur. The gabbroic nuclei are usually rough edged. They are coated by 1—3 cm of lava in which there also are small fragments of gabbro (Fig. 6). In the tephratic lava layer rough edged xenoliths of gabbro also occur, but they get more sparse in the upper part of that layer and are rare in the topmost layer. These gabbro xenolithes come from some intrusive gabbro rock from which they have been torn loose by the explosive activity. Later gabbro xenolithes have been found in the craters Klausturhólar in Grímsnes and except for some boulders on Sólheimasandur these are the only places within the young volcanic area where gabbro has been found.

The nuclei in some of the bombs at Grænavatn are moraine boulders, mostly consisting of doleritic lava. One of the doleritic nuclei found there showed signs of having been affected by solfatara activity.

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[1]) The gabbro ejected as bombs by the Grænavatn explosion is a light grey rock, poikilitic to poikilophitic in texture, and rich in plagioclase. The plagioclase, which is a bytownite (An_{80}), occurs as grains and lathes of intermediate size (common size 1,0×0,3 mm). The crystals are fresh and clear, impurities are not common, and zonarity is rarely observed.

The host mineral, an augitic pyroxene, occurs in large crystals, sometimes several inches in diameter.

An olivine of basaltic type is also found as host to the bytownite. From petrological point of view, this fact might be the most remarkable feature observed in this rock.

Both the augite and the olivine are for the most part quite fresh, but on their borders some of the crystals have undergone a transformation to a hornblende like mineral, not yet determined with absolute certainty.

The most remarkable xenolithes as hitherto found, ejected by recent volcanism in Iceland, are as follows:

1) Kráblite, a granophyre found on Krafla, N. Iceland, first described by Forchammer 1842.
2) The Grænavatn gabbro, here shortly described.
3) An acid porphyry and a rhyolitic rock, ejected by the eruption in Hekla 1947.
4) A granular gabbro, newly found by road workers in the scoria hills Klausturhólar in Grímsnes, SW-Iceland. Not yet described.
5) A granophyre, similar to the krablite, found last summer by a tourist on the SE-slopes of Dyngjufjöll near the lake Dyngjuvatn. Not yet described.

A discussion of what has caused the Grænavatn eruption is beyond the scope of this short paper. The probability of a pre-existing dead-ice depression has already been mentioned and such a depression may well have been more or less water-filled. The Krísuvík area is an area of great seismic activity so there is the possibility that water may have come in contact with hot rock or magma as an after effect of an earthquake. The crater does not seem to be directly related to any postglacially active volcano-tectonic fissure.

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So are the two lakes Gestsstadavatn and Grænavatn, although situated so close together and at first view so similar, in reality of a fundamentally different origin, formed each by a different one of the two antagonic forces, which more than others have modelled the surface of Iceland and still are acting there with an intensity unsurpassed in any other country: ice and fire.

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