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RAFORKUDEILD

GEOLOGICAL INVESTIGATIONS IN GRINDAVIK SW-ICELAND

General geology
Jón Eiríksson

Report on borrow areas
Björn Jóhann Björnsson

RIT
OS-ROD 7408

PREPARED FOR
THE ICELANDIC HARBOUR AUTHORITY
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CONTENTS

PART I GENERAL GEOLOGY OF THE AREA

I. Introduction

Following is a report on the general geology of the Grindavík area in connection with the harbour project in Grindavík. The most important aspect of this study is the prediction of the extension of lava flows into the harbour area and whether they flowed there subaerially during a period of a slightly lower sea-level, or flowed into the sea. The conclusion is, that most of the flows in the harbour area are subaerial in character, but the youngest flows may be brecciated in the lower parts due to flow into water.

Geological mapping of the area was performed by Jón Jónsson, geologist at the National Energy Authority, Department of Natural Heat, and the stratigraphical information in this report is based on his work.

2. Geological outline

2.1 General setting of the Grindavík Area

The southern part of the Reykjanes Peninsula is a landward continuation of the submarine Reykjanes rift zone SW of Iceland. The axis of the zone is displaced laterally to the east along the Reykjanes Peninsula, the southern part of which is characterized by tectonic and volcanic activity. The whole peninsula is built up of volcanic products of basaltic composition. Geological mapping has revealed two distinct stratigraphical units, differing in age. The older unit is of Pleistocene age, and is composed of interglacial lava flows and subglacial and/or submarine table mountains and ridges. The younger unit is represented by postglacial lavas, originating in two main types of volcanoes; eruptive fissures (crater rows) and shield volcanoes (generally one crater). The shield volcanoes are generally older than the crater rows. The bedrock and

lavas are sometimes covered with a thin layer of soil and Recent sediments. Tectonic faults and open fissures are common and generally trend NE. The bedrock and lavas are fresh and rather porous, at least outside areas of hydrothermal activity and runoff is confined to groundwater flow.

2.2 Glacial volcanism

Products of glacial volcanism are exposed in the mountains north of Grindavík. These are entirely built up of moberg (hyaloclastic material, tuffs and pillow lavas) formed by subglacial volcanic eruptions. Only at the top of Svartsengisfell there is a small remnant of a lava flow. The age of the mountains north of Grindavík is probably late Pleistocene. To the NE of Grindavík there are two mountains of similar structure, but both have a lava cover on the top (table mountains). It is possible that these mountains were formed by submarine eruptions.

2.3 Postglacial volcanism

1. Shield volcanoes.

Two shield volcanoe lavas are exposed near Grindavík. Shield volcanoes have the form of very flat cones, and can have a diameter of tens of kilometers. Some 7 km NW of Grindavík there is a large shield volcano named Sandfellshæd. Lavas from this volcano (S1) are seen in two places near Grindavík; on the peninsula west of Stóra-Bót and (probably) on the plain south of Lágafell. Between these two outcrops, S1 is covered by a younger lava flow from a now hidden crater row, dissecting the eastern flank of Sandfellshæd. Another fissure eruption has taken place south of Lágafell, also dissecting the Sandfellshæd lava.

Three relatively small shield volcanoes (S2) are seen north of Húsafjall. They are probably contemporaneous and seem to have formed in one eruption.

The eastern part of Grindavík village is situated on lavas from this eruption, which are also seen at sea level east of Thórkötlustadanes.

The lavas from Sandfellshæd and Vatnsheidi are built up of numerous thin lava-belts, scoriaceous material being found only near the craters. If, however, the lavastreams have flowed into the sea, the picture may be different, and considerable brecciation and pillowformation is likely. This problem is discussed in a later section. The shield volcanoe rocks are of olivine-basalt composition and are coarsely jointed, where the lavas have flowed subaerially.

2. Lavas from fissure eruptions.

The most recent eruptions in the Grindavík area have all been fissure eruptions. Five lava flows (designated L1-5) are of importance in this connection. A relatively old lava stream has reached the sea in the lagoon which now forms the Grindavík harbour. This lava (L1) stems from a crater at the southern end of Hagafell, but is largely covered by a younger lava (L5). Two small crater rows are observed south of Lágafell (L2 and L3). It is doubtful, whether lavas from these eruptions have reached the sea or not, because they are partially covered by younger flows. The westernmost lava (L4) shown on the map reaches the sea between Stóra-Bót and Litla-Bót. The craters from which the L4 lava flowed, have been covered by still younger eruption products west of the Grindavík area. The largest and probably youngest lava (L5) that reaches the sea near Grindavík, stems from a long crater row which starts just SW of Hagafell and can be traced some 10 km to the NE. This lava stream formed Thórkötlustadanes. Carbonized plant remnants have been found under L5, and C^{14} dating reveals that the eruption took place 2400 C^{14} years ago.

2.4 Tectonic activity

The Grindavík area is characterized by several faults. A small graben runs across Thorbjarnarfell, and faults also dissect Hagafell from SW to NE. Although the faults are most numerous in the oldest parts of the area, the Hagafell fault continues to thw SW across L5. This shows that tectonic movement along the faults has been active during Late postglacial time, a fact supported by observations after an earthquake in this area in the autumn 1973. Just west of Grindavík village there is a system of several open fissures, some of which are rather deep and filled with sea water.

3. Recent sea-level fluctuations and possible submarine extension of lavas

When the nature of the bedrock under the Járngerdarstadavík is considered, it is necessary to review what is known about sea-level fluctuations in this region. Contact of flowing lava with sea-water usually causes a fundamental change in the physical properties of the solidified rock, as compared with subaerial flows.

Few data exist about sea-level changes on the Reykjanes Peninsula itself. On a regional basis, however, observations at localities adjacent to Reykjanes indicate considerable changes of shore-lines during Recent times. These indicators are ancient shorelines of Late-Glacial age and submerged peat formations which have been C^{14} dated.

Broadly speaking, the history of relative sea-level changes and land uplift and subsidence seems to have been as follows. Following the retreat of the ice-cap at the end of the last glaciation, sea transgressed over the still depressed land to reach a shore-line some tens of meters higher than at present in the Reykjanes area, more than 10.000 years ago. Between 10.000 and 9.000 years the sea-level dropped below the present one due to isostatic uplift, as indicated by peat formation in Faxaflói. Rapid eustatic rise of sea-level continued until 4 000 years ago, but has been slow since that time. Isostatic uplift of land has been slow since 6 000 years ago, and in volcanic zones it may have terminated several thousand years ago due to piling up of volcanic products. This has probably been the case in the Grindavík area. During historical times the Reykjanes Peninsula as a whole seems to have subsided slowly relative to sea-level, as indicated by numerous forced shifts of human habitats and typically destructive beaches.

The picture emerges that sea-level was lower than now between 9 000 and 2 000 years before present, but it is not known how much lower. A lava stream reaching the sea east of Ölfusá river some 8 000 years ago is solid down to 15 m below present sea-level, indicating subaerial flow at that time. However, local variations are to be expected in a tectonically active area like the Reykjanes Peninsula.

It was noted earlier that the youngest lava (L5) in the Grindavík region is 2400 years old. This lava, which forms Thórkötlustadanes, is likely to have flowed at a somewhat lower sea-level than the present one (possibly a couple of meters). Considering the essentially flat surface of the peninsula, it is probable that the lava flowed into sea-water, which has hindered the formation of a normal downslope lava flow. Thórkötlustadanes peninsula may therefore be a formation analogous to a lobate delta, and some brecciation in its lower part is possible. Another tongue of the L5 lava has flowed into the Járngerdarstadavík from the west. That tongue probably reaches to Sundbodi, and the present inlet to the harbour is between the two tongues.

Another fissure eruption lava which has certainly reached the sea in Járngerdarstaðavík is L4. Depth contours in the bay indicate that sea-level may have been some 5 m lower than now when L4 flowed. Probable submerged margins of this lava are shown with broken lines on the geological map accompanying this report.

Physiographically, Járngerdarstadavík is an inlet between two cone-shaped shield-volcanoes, Sandfellshæd in the west and Vatnsheidi in the east. It is likely that these shield-volcanoes were active during the period between 9000 and 5000 years before present, i.e. at a considerably lower sea-level than now. The shield-volcanoes form the basement to the fissure eruption lavas and probably extend considerably further out into the sea. These lava flows probably form the bedrock in Járngerdarstadavík, and flowed subaerially down to 10-15 m depth below the present sea-level.

4. Comments on samples from drillings in the Grindavík Harbour Area

1. Sampling area A (Sundbodi).

Sample No. -	Description of sample
A3 (Surface sample)	A piece of basaltic lava. Finely porous
A7 (" ")	" " " " " " "
A9 (" ")	" " " " " " "

The uppermost layer in sampling area A is everywhere a 1-2 m thick massive lava. Under this lava there is softer material, which could be brecciation in the lower part of the lava (L4 ?) due to lava flow into the sea. This would indicate a rise of sea-level amounting to some 5 m since the time of formation of this lava. It is also possible that the soft layer is of a sedimentary origin, interbedded between the lavas L4 and S1.

2. Sampling area B (western flank of Thórkotlustadanes)

Sample No.	-	Description of sample
B2 Cuttings		Basaltic glass, fresh (black) and altered (brown)
B2 Surface sample		A piece of basaltic lava, finely porous
B7B Cuttings		Basaltic glass, fresh (black) and altered (brown)
B7B Surface sample		" lava

In the sampling area B the drillholes seem to penetrate breccia, which is composed of alternating tuff (altered basaltic glass) and more massive rock fragments. It is likely that this is the part of L5 lava that flowed into the sea.

3. Sampling area C (near the inlet into the present harbour)

Sample No.	-	Description of sample
C7		Sand and gravel

All drillholes in sampling area C seem to penetrate Recent sediments.

PART II POSSIBLE BORROW AREAS IN THE VICINITY OF GRINDAVÍK

1. Introduction

This report is made by Orkustofnun for the proposed harbour project in Grindavík SW-Iceland.

The possibilities of borrowing rocks for the proposed harbour fall into two disinct catagories.

1. The possibilities of borrowing rocks without making a quarry.
2. The possibilities of quarrying rocks.

These categories will be described briefly in the two following sections. For locations see the accompanying geological map.

2. Borrow areas where quarrying is not needed

In this section four areas are described.

2.1 Hraunsvík

This area is east of Grindavík, approximately 6 km by road.
Here the coast is built up of postglacial lava under which tuff and fine grained breccia are exposed. Under the steep coastal cliff along a 300-400 m strip, big rocks have fallen from the lava. Here rocks of sufficient size are found, and the ocean has washed away the finest grained material.

The rock is vesicular and the lava is rather heterogeneous. The quantity of rocks of sizes $> 2\ m^3$ is estimated some few hundreds, besides smaller rocks in larger quantities.

2.2 Klaufir

This is the only area on the coast west of Grindavík in which rocks of sufficient size are found. The rocks have been broken from a post-glacial lava (marked L6 on the geological map).

The rocks are found mainly under the eastern part of this lava and high percentage of them are 2-3 m^3 in size or even larger.
The rock is very homogeneous and non-vesicular and coarsely jointed.
The thickness of this lava flow is about 10 m at the coast.

The estimated quantity of rocks of sizes $>$ 3 m^3 is 1000 besides some smaller rocks of less quantity.

2.3 Fiskidalsfjall

Fiskidalsfjall is a moberg mountain but has some basalt lava on top. From this lava big boulders have fallen down the north side of the mountain and made a good borrow site for rocks at the bottom of the slope. This borrow site was utilized for the present breakwater in Grindavík and very little is left. But there is a possibility of simulating mother nature´s processes and blast rocks down from the lava at the top of the mountain. This would probably yield stones of sufficient size, but it is possible that some of the finer material might stop on the way down the mountain side.

2.4 Siglubergsháls

Here north of Hraunsvík there is an area in which there are inter-glacial basaltic lavaflows.

The surface of the flows is much broken up because of frost weathering. It is possible to work this area by using only the loose lava fragments, but this would probably yield low percentage of stones of sufficient size. Probably the most common size is between 1-2 m^3. The quantity is 250.000 - 500.000 m^3.

3. Quarrying rocks

For quarrying rocks the possibilities are either to use the postglacial lavas in the neighbourhood of Grindavik or the interglacial lava.

Below these possibilities are discussed briefly.

3.1 Postglacial lavas

In connection with the building of the present breakwater in Grindavík a quarry was made in the L5 lava just out of the town. The rock there is vesicular and the lava seems to be rather heterogeneous. Judging from the material in the present breakwater it is also doubtful whether this quarry will yield rocks of sufficient size.

If worked, it is recommended that the quarry should be worked in direction north or south, since working east towards the eastern margin of the lava might produce more scoriacleous lava.

For most of the other lavas it is very difficult to predict the possible outcome of a quarry. This is because no sections through the lavas are exposed.

East of Grindavík there are two lavas S2 og L1.

S2 The S2 lava seems unsuitable because it is too thin layered and scoriaceous.

L1 About L1 very little is known but off hand it does not look very suitable.

West of Grindavík there are several lavas.

The fact that all but one of these lavas do not yield any big boulders along the coast may not be significant because the ocean seems to be working on the tops of the lavas but not cutting a section through them.

L2 and L3 The L2 and L3 lavas do not look promising because they are exposed so near to their origin and therefore might be scoriaceous.

S1 The S1 lava in cut by numerous faults and fractures. The lava is made of series of flows of an extremely varying thickness. In this lava it should be possible to find a flow with thick enough to yield sufficiently large boulders, but the percentage of such flows is expected to be low.

L4 No sections through this lava are available. It probably originates from a crater row. This would indicate that it is of the same character as L5, but has flowed a longer distance from the crater than L5 and should therefore be less scoriaceous.
Nothing is known about jointing in this lava.

L6 The last lava taken into consideration here is L6.
This lava was mentioned before in connection with boulders broken from it. The rock has been described before in the chapter on Klaufir in Section I.
The top of the lava is covered with scoria.
As far as can be judged from the section exposed on the coast this lava will yield rocks of sufficient sizes.

3.2 Interglacial lavas

This formation is not well exposed, but it seems to be made of layered series of basaltic lava, i.e. a similar formation as the S1 lava.

Glacial erosion has left the more resistant material which is the thicker flows.

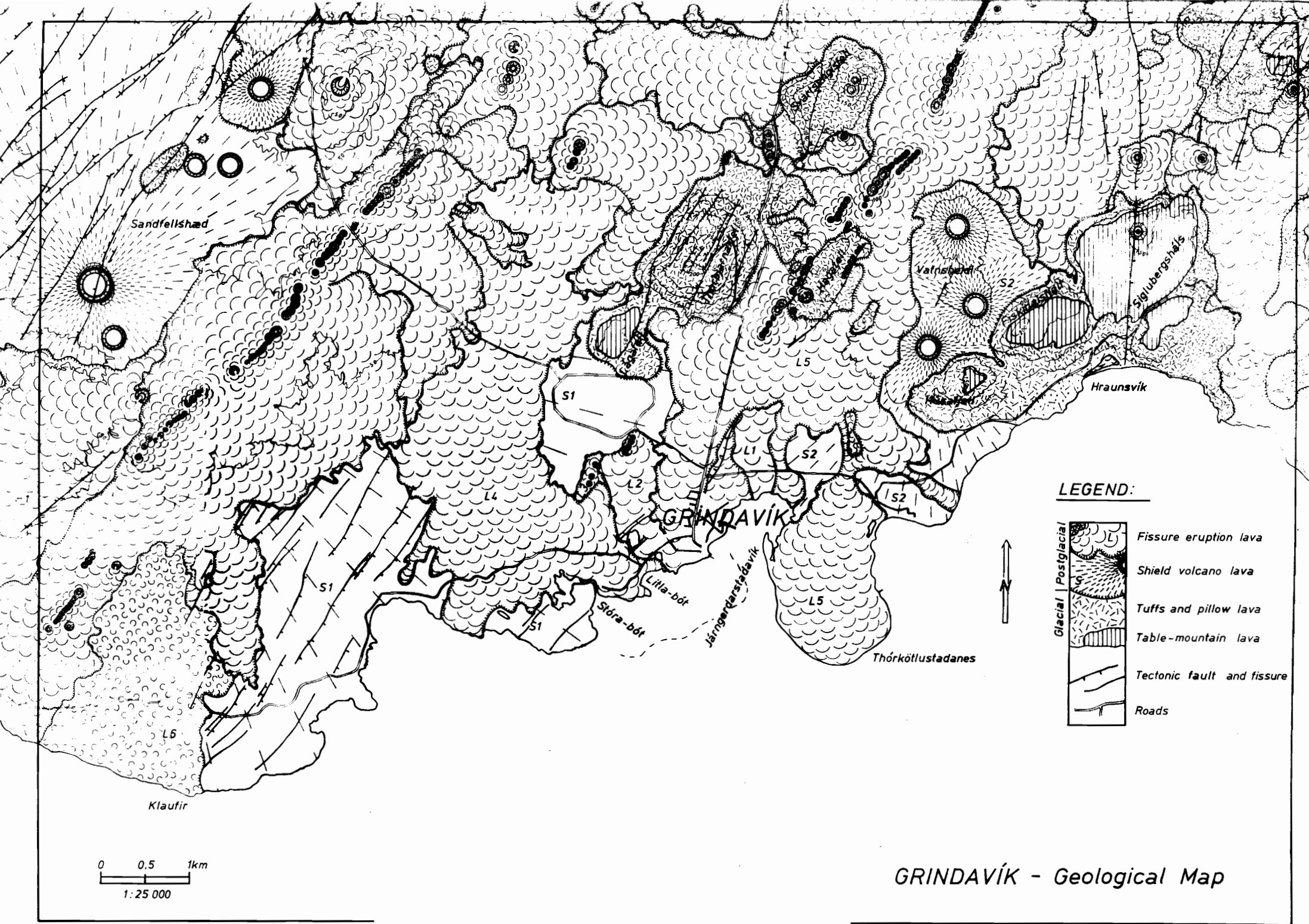
It is doubtful whether this formation would give higher percentage of big rocks than some of the before mentioned postglacial lavas. The rockheads that stick out might just be shields over much thinner lava layers.

4. Summary

It is evident that the sources of loose rock that have been described are all of a different character. The highest percentage of large rocks is found at the coast along the L6 lava.

Predicting the outcome of quarrying in the different postglacial lavas is difficult.

One lava the L6 would yield good results, but this lava has the disadvantages of being approximately 7 km away from Grindavîk along the present road. Next to L6 one would recommend the L4 lava or the interglacial lava, but very little is known about these.



GRINDAVÍK - Geological Map