Titill
Glaciological knowledge in Iceland before 1800

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Tímarit
Jökull
10. árgangur 1960
1. tölublað
Bls. 1-18

Vefslóð
https://timarit.is/gegnir/000571477

JÖKULL

ÁRSRIT
JÖKLARANNSÓKNAFÉLAGS ÍSLANDS

10. ÁR REYKJAVÍK 1960

SIGURDUR THORARINSSON:

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A Historical Outline

It has often been emphasized, and not without reason, that the Icelanders have both in the distant past and in later times achieved great things in the sphere of literature. It is much less known what they have achieved in the field of natural science, and, on the surface at any rate, it seems of rather little account in comparison with the achievements of their poets and saga-writers. External circumstances have been the decisive factor in this respect rather than any lack of aptitude for the study of natural science. Natural science is more dependent on various external conditions than the arts. Its various branches, e.g. astronomy, physics and chemistry, cannot develop except to a very limited extent without scientific equipment and facilities for research work which did not exist in Iceland.

In some branches of natural science the Icelanders have, however, been in a position to achieve something. Their land has itself given them subjects for research and been to those who have kept their eyes open a better school than any university. One of the branches of natural science is glaciology.

Just to over one ninth of Iceland, or 11800 km^2, is covered by glaciers, which in some places stretch right down to inhabited areas. The Icelanders have travelled along their edges and across them since the beginning of the settlement of their country. It would seem strange, therefore, if the Icelanders had not in past centuries acquired some knowledge of glaciers and their nature. The fact is that although there is little mention of Icelandic and other Nordic people in connection with the history of glaciology Iceland has its history of glacier research which in earlier times was fully comparable with the history of glacier research found in countries where glaciology is supposed to have begun, i.e. the Alpine countries. An attempt will be made here to outline this history.

It may be taken for granted that some of the Norwegians who settled in Iceland in the second half of the 9th and the first half of the 10th centuries had personal knowledge of glaciers in their home country. It is noteworthy in this connection that many of the settlers came from parts of Norway where glaciers are particularly prominent, i.e. the Hordaland and Sogn and Fjordane districts. Some routes between Norwegian settlements approached these

glaciers. For instance, the routes from the innermost Eidfjord in Hardanger to neighbouring districts pass near the Hardangerjökulen and the glaciers on Hallingskarvet. The four words for *glacier* found in Icelandic *(íss, breði, fönn, jökull)* all occur in Norwegian glacier names. It is impossible to say, however, how closely the settlers knew glaciers before they came to Iceland or what knowledge of glaciers they really brought with them to Iceland. But the fact remains that already in the settlement period some of the immigrants set up their homes in the vicinity of glaciers, particularly those who settled along the southern margin of Vatnajökull (the present Skaftafellssýslur, especially Austur-Skaftafellssýsla). For instance, the settler Thórdur Illugi settled at the foot of Breidamerkurfjall near the margins of Fjallsárjökull and Breidamerkurjökull about 900 A. D. His farmstead, Fjall, was buried by the advancing glaciers between 1695 and 1709. During the settlement time people also settled near some outlets of Mýrdalsjökull and Drangajökull, and travels through the inland passes between the plateau glaciers in the interior soon became frequent.

The Nordic people, mainly Icelanders, who settled in the districts Eystribyggð and Vestribyggð in Southwest Greenland at the end of the 10th century did not only learn to know drift ice and its behaviour, but also glaciers which stretched down into the settlements, quite close to some of the farms. From written records and from archaeological finds such as the runic stone found at Kingiktorsuak, Lat. 72° 55′ N, we know for certain that Nordic Greenlanders hunted at least as far north as Upernavik and even wintered there. And accounts in Björn Jónssons Greenlandic Annals (compiled from old manuscripts and traditions that had verbally survived) as well as some archaeologic finds make it probable that they reached much farther north, to the head of Baffin Bay. Seafarers who sailed between Norway, Iceland and Greenland gradually became acquainted with the southern part of the E coast of Greenland, between Mt. Forel and Kap Farvel.

But no Nordic people and hardly any Europeans lived in so close contact with glaciers and were so affected by them and the glacier rivers as those who lived in Austur-Skaftafellssýsla. It is no wonder that this district became above all others the cradle of Nordic glaciology.

The oldest written account of Icelandic glaciers is to found in *Saxo Grammaticus'* famous history, *Gesta Danorum,* which was written about 1200 A. D. In the introduction to this remarkable work there is a description of Iceland which is no doubt based on the accounts of Icelanders. Having described the drift ice off the Icelandic coasts Saxo writes:

„Est et illic aliud glaciei genus, montium iugis ac rupibus intersertum quod certis vicibus constat superioribus ad ima deiectis infimisque rursum ad superna reflexis versili quadam mutatione transponi. In cujus assertionis fidem affertur, quod quidam, dum planum forte glaciale percurrerent, in obiectas voragines hiantiumque rimarum penita provoluti paulo post exanimes fuerint, nulla glaciei rimula superstante reperti. Quamobrem a compluribus existimare solet quod quos fundæ glacialis urna desorbuit, eosdem postmodum supinata reddiderit" (Saxonis Gesta Danorum Ed. J. Olrik & H. Ræder. Havniæ MCMXXXI, Tom. I, præfatio II, p. 8).

This is probably the oldest description of glacier movement ever written. And although somewhat confused it is in a way correct and certainly based on experience. Such a rotating movement as mentioned by Saxo, a movement which moves the bottom layers of the ice to the surface, is the rotational slippering along „Scherflächen" which really occurs in the frontal parts of some of the southern outlets of Vatnajökull when they move against terminal „Aufschüttungs" moraines and sandur sediments blocking their way with such a resistance that thrust planes are formed in the ice along which it moves. The story Saxo tells about people falling down in crevasses and later found dead on the surface of the ice is in all probability based on real happenings, as such happenings are rather common in Austur-Skaftafellssýsla where people sometimes have to cross the glacier snouts in order to get from one farm to another. Saxos story is strikingly like one that happened on Breidamerkurjökull in 1927. On Sept. 7 that year the postman Jón Pálsson and four horses were killed while crossing the glacier when a small strip of ice above the

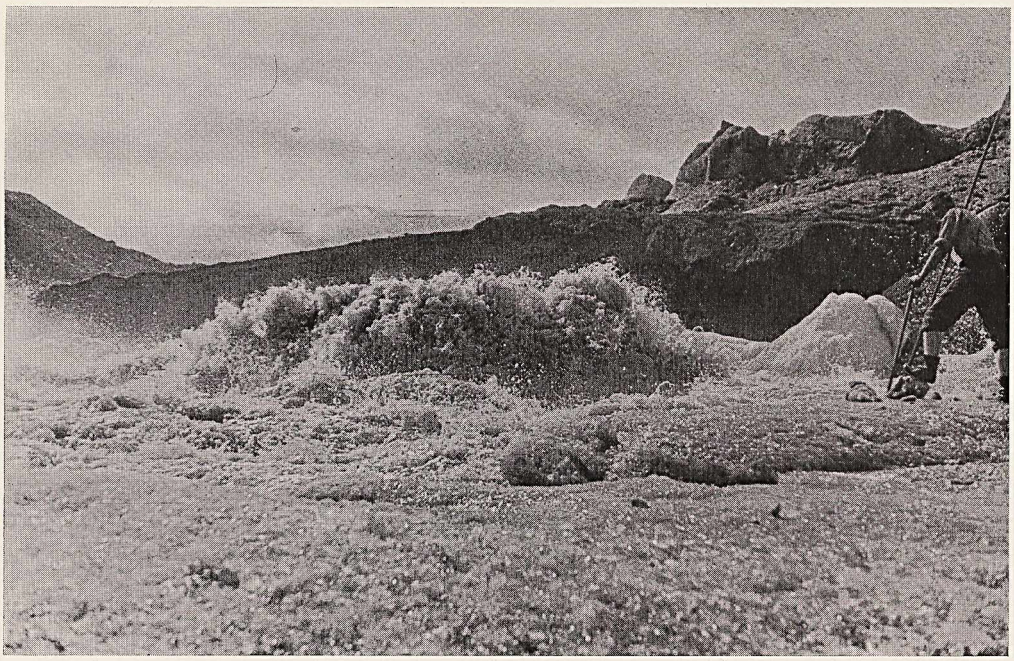

Fig. 1. "There are also ice-cold streams whch flow from underneath the glaciers with such violence that earth and rocks tremble" *(King's Mirror).* — The glacier river Austurfljót wells up in front of the margin of Hoffellsjökull.
„Þar eru og ísköld vötn þau er falla undan jöklum svo stór að berg og jörð er hjá liggja þá skjálfa" (Konungs skuggsjá). — *Austurfljót í Hornafirði byltast fram undan jaðri Hoffellsjökuls.*
Photo S. Thorarinsson, Aug. 1936.

outlet of the river Jökulsá suddenly sank deep down. On April 15 the following year both man and horses were found near and on the surface of the glacier. It is an old saying in these districts that „jökullinn skilar sínu", viz. that the glacier gives back what it takes. This is partly due to the rotational movement about which the Icelanders had told Saxo more than 7 centuries before rotational slipping was put forward by W. V. Lewis and others as one of the ways in which glacier move.

Konungs skuggsjá or The King's Mirror (quoted here, with a few corrections, from L. M. Larson's translation in *Scandinavian Monographs,* Vol. III, New York 1917), one of the most important Old Norse works, was written in Norway, apparently about the middle of the 13th century. It has a good deal of didactic philosophy and good advice, but this work derives most of its importance, however, from the information it contains on subjects of geography and natural history. Among other things it contains an important chapter on the nature of Iceland, most of which is probably derived directly or indirectly from Icelanders. The Norwegian scholars F. Paasche and D. A. Seip have advanced strong arguments in favour of the view that the author of the King's Mirror was an ecclesiastic, Einar Gunnarsson, who became the Archbishop of Nidaros in 1255 and died in 1262. Apparently the author of King's Mirror never went to Iceland or Greenland, but he most likely was personally acquainted with both Icelanders and Greenlanders of his own class, as well as with seamen who had sailed to these countries. Many of the things he has to say about glaciers, drift ice and weather conditions in Iceland and Greenland was probably common knowledge among farmers and seamen in Iceland and Greenland at that time and also among those in Western Norway,

sailors and others, who had the closest contact with these countries. But the clever Norwegian author of the King's Mirror has the honour of being the first to commit this knowledge to writing and he may have added something to it.

On the Icelandic glacier rivers the King's Mirror has this to say:

"There are also ice-cold streams which flow from underneath the glaciers with such violence that earth and rocks tremble; for when water flows with such a swift and furious current, the rocks will shake because of its vast mass and overpowering strength. And no men can go out upon these river banks to view them unless long ropes be brought to be tied around those who wish to explore, while farther away others sit holding fast the rope, so that they may be ready and able to pull them back if the turbulence of the current should make them dizzy" (pp. 130–131).

These words are indeed of greet interest. Here we do not only have a fairly accurate description of the sources of some of the Icelandic glacier rivers, where an enormous mass of water wells up almost vertically in front of the ice margin (Fig. 1). The last passage quoted also may indicate that during the latter part of the Commonwealth period there were men in Iceland who were so curious about the natural phenomena of their country that they went out of their way or even ran some risk in order to investigate them. And this activity took place at a time when scholasticism was firmly enthroned in most parts of the Continent. In another passage the author of the King's Mirror says: *"It is in man's nature to wish to see and experience the things that he has heard about and thus to learn whether the facts are as told or not"* (p. 142). These words could be chosen for a motto for all natural science.

On the reasons for glaciers in Iceland the King's Mirror has this to say:

"As to the glaciers that are found in Iceland I am inclined to believe that it is a penalty which the land suffers for lying so close to Greenland; for it is to be expected that severe cold would come thence, since Greenland is ice-clad beyond all other lands. Now since Iceland gets so much cold from that side and receives but little heat from the sun, it necessarily has an overbundance of ice on the mountain ridges" (p. 126).

This is most likely the oldest climatological explanation of glaciers met with in any literature. The same opinion is met with in a semi-mythological Icelandic Saga, *Bárðarsaga Snæfellsáss,* probably written down in the late 13th or the early 14th century. It begins with the following passage (Nordiske Oldskrifter XXVII, Kiöbenhavn, 1869, pp. 1–2): "Dumbr ("The Misty one") was the name of a king who reigned over the gulfs that lie to the north of Helluland and which is now called Dumbshaf, named after King Dumbr..... From Kvænland he took with him by force Mjöll ("Fresh Powdery Snow"), the daughter of Snær ("Snow") the Old, and made her his wife..... But when they had been together for one year Mjöll gave birth to a boy. He was sprinkled with water and given a name, being called Bárdr. This boy ... took after his mother, because she was so beautiful and fair of complexion that the snow which falls in calm weather and is whiter than any other is named after her and called *mjöll".* Bárdr Snæfellsáss is a kind of personification of Snæfellsjökull, but Dumbr, his father, is here a personification of the North wind and the drift ice fog that comes to Iceland from he North-West. We also have here a sound meteorological explanation of the formation of Snæfellsjökull, although its presentation is in a figurative garb.

The author of the King's Mirror states what is quite correct in connection with the drift ice, i. e. that it can also drift against the wind (p. 139), and he also makes the sensible comment "if the earth were wholly without warmth or heat it would be one mass of ice from the surface down to its lowest foundation. Likewise if the ocean were without any heat it would be solid ice from the surface to the bottom" (p. 152). The author gives the following graphic account of the climate of Greenland:

"In reply to your remark on the climate of Greenland, that you think it strange that it is called a good climate, I shall tell you something about the nature of the land. When spells of rough weather come, they are more severe than in most other places, both with respect to keen winds, hard frost and snowfall. But usually these spells of rough weather last

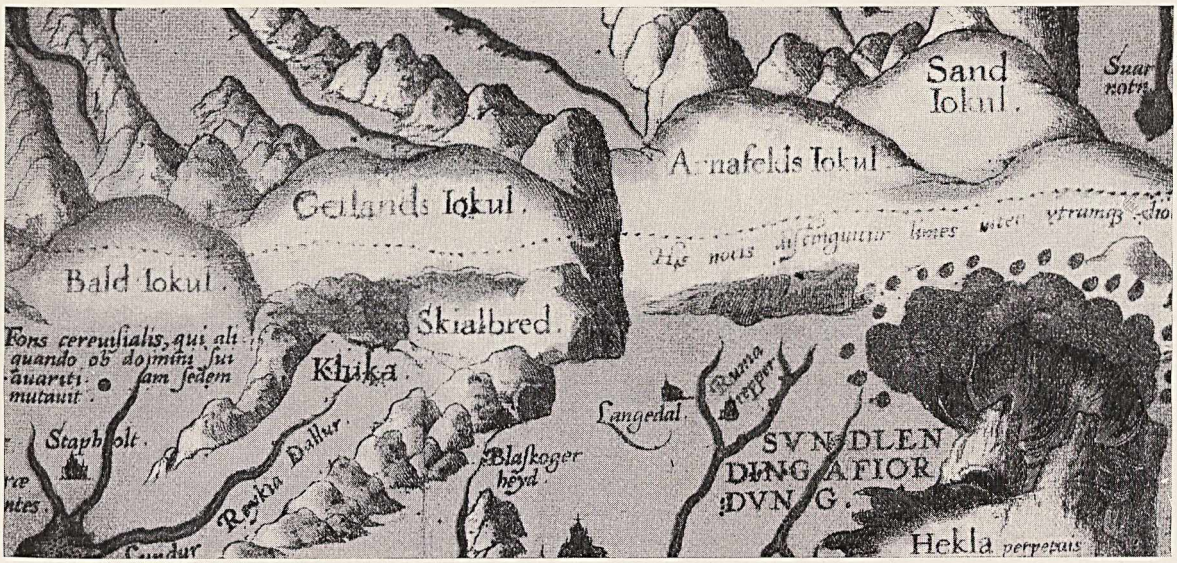

Fig. 2. Part of Bishop Gudbrandur Thorlákssons map of Iceland of 1590, showing some of the inland plateau glaciers. Full scale of the original map.
Hluti af Íslandskorti Guðbrands biskups Þorlákssonar, fyrsta korti, er sýnir jökla sérstaklega teiknaða.

only a short while and come at long intervals only. In the meantime the weather is fair although the cold is intense. For it is in the nature of the glacier [viz. the inland ice, auth. comm.] to throw continuously from its surface a cold wind which drives the snow showers away from its face so that the sky above is usually clear. But the neighbouring lands often have to suffer because of this, for all the regions that lie near get severe weather from this ice, inasmuch as all the storms that it drives away from itself come upon others with keen blases" (p. 153). — Here, in fact, the glacial anticyclonal theory is put forward six and a half centuries before W. H. Hobbs advanced it.

Quite a lucid description of Iceland, *Qualiscunque descriptio Islandiae* (Ed. F. Burg, Hamburg 1928), was written about 1590. Earlier scholars ascribed it to Sigurdur Stefánsson, the Headmaster of Skálholt, but it is now considered to have been written by Bishop *Oddur Einarsson* (1559—1630). In this work we find the first mentioning of glacier changes in Iceland, indicating that the glaciers were then increasing in size. The author writes (p. 6): "Ac sæpe uno vel altero die vel nocte tanta copia conglomerantur novæ nives in montibus et locis campestribus, ut earum profunditas aliquot cubitorum altitudinem excedat, unde quotannis major fit nivium accessio in locis montanis, quam debilis illa caloris operatio, qvæ in ista est regione, satis possit eam liqvores dissolvere". The same treatise also contains an excellent description of the arctic drift ice and its influence on the climate of Iceland.

W. Ygls map of Tirol from 1604 (Fig. 3) has been regarded as the oldest land map where a glacier (Ötztaler Ferner) is represented with a special signature. But in *Additamentum IV. Theatri orbis terrarum* by A. Ortelius, published in Antwerp 1590, there is a map of Iceland drawn by bishop *Gudbrandur Thorlákssson* in Iceland (1542—1627). On that map (Fig. 3), which Ygl may well have seen either in Ortelius Atlas or in Gerhard Mercator's Atlas published in Duisburg in 1595, the glaciers are designated in a similar way.

In this connection it may be pointed out, that not only were in olden times frequent travels across the central highland of Iceland, between the big plateau glaciers, but the biggest plateau-ice, the Vatnajökull, was also in all probability crossed many times. In the 15th and 16th centuries fishermen from North Iceland

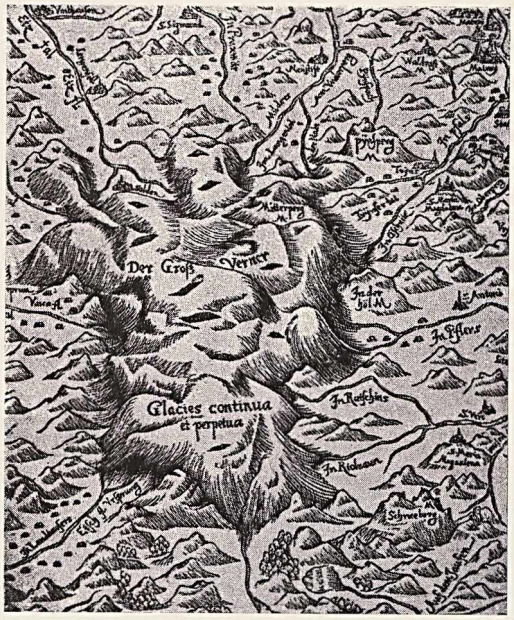

Fig. 3. Part of Warmund Ygl's maps of Tirol 1604, showing the Ötztaler Ferner.
Hluti af Tíról korti W. Ygls frá 1604, er sýnir jökulinn Ötztaler Ferner.

seem to have sometimes made their way straight across Vatnajökull to fishing stations on the south-east coast. The eruption centre situated near the middle of western Vatnajökull has got its name *Grímsvötn* (the lakes of Grímur) already before 1600, which indicates that it must have been visited before that time, as it is difficult to understand how such a name could be given to he place without any one having actually seen that there is really open water in the depression. But travels across Vatnajökull seem to have discontinued before 1600, and when the Scottish traveller W. L. Watts crossed Vatnajökull in 1875, the old travel routes long ago were quite forgotten.

In foreign outlines of the history of glacier research it is usually stated, that the Swiss scientist *Johann Jacob Scheuchzer* was the first one to propound the so-called Dilatation Theory on glacier movement, viz, the theory that water collecting in cracks in the ice expands by freezing and forces the ice downhill. This theory Scheuchzer put forward in his work *Itinera per Helvetiae Alpinas regiones facta,* Tom. II, which was published in 1705. But 10 years earlier, or in 1695, an Icelandic scholar, *Thórdur Thorkelsson Vídalín* (1662—1742) had finished his remarkable Treatise: *Dissertationcula de montibus Islandiæ chrystallinis,* in which the Dilatation Theory is propounded still more clearly and thoroughly than by Scheuchzer. — Vídalín had studied medicine and natural science in Copenhagen and became schoolmaster at Skálholt in 1687. In 1690 he resigned office and after that worked mainly as physician. He lived for some years on a farm, Thórisdalur, in the Lón district south-east of Vatnajökull and thus became closely acquainted with the southern outlets of Vatnajökull by travels within Skaftafellssýsla.

On the glacier movement he writes (in German translation by *P. Bjarnason Vídalín,* cf. later): "Die Ursache dieser Bewegungen ist nicht schwer zu ergründen. Man vergleiche nur die Wirkungen der Kälte, die man sonst in andern Fällen spuhret, mit denen, die in unsern Eisbergen vorkommen. Wann dass Wasser gefriert, so nimmt es einen grösseren Raum ein, als zuvor, vielleicht weil der Frost seinen Theilen eine andere Gestalt giebt, und denenselben nicht erlaubet, so nahe an einander zu kommen, als wenn es flüssig ist. Daher muss das Gefäss, darinne das zugefrorene Wasser enthalten ist, nothwendig ausgedehnet werden, oder wie Glas, Töpfe und dergleichen, welche mehrentheils zugleich einigen Knall von sich geben zersprengen. Eben dieses sieht man an kleinen Hügeln: wann die darinne verschlossene Feuchtigkeit dem Froste des Winters nicht mehr widerstehen kann, so springen sie nicht ohne Geräusch oft mitten von einander: wann aber der Sommer kömmt, wird dieser Schaden wider durch die Wärme geheilet. So ist es auch mit den Eisbergen. Ihre unzähligen Oeffnungen und Klüfte werden im Sommer mit dem Wasser von dem zerschmelzten Eise angefüllet. Im Winter friert dieses ganz und gar zu, und dehnet sich also mehr aus, als es seine Gefässe wohl zulassen. Daher brauchet es Gewalt und zersprenget dieselben, und schiebet sie auf die Seite, bis es Platz hat. Eine zulängliche Menge des Eises ist auch ohne Zweifel eben so wohl fähig, eine grosse Last zu bewegen und durch die Kräfte ihrer Elasticität von sich zu stossen, als eine Menge Pulver, Klippen zu zersprengen" (pp. 207 ff.).

Vídalín's opinion of the formation of glacier ice is rather absurd. His common sense is here clouded by academic theories current at the Copenhagen University when he studied there, such as the theory propounded by R. Bartholin and others that ice is formed by a mixture of saltpetre and snow. The saltpetre comes in Vídalín's opinion from the substratum of the ice.This opinion is in glaring contrast to the astonishingly correct opinion of the Icelandic farmers at his time as regards the formation of the glacier ice. Vídalín writes, alluding to the opinion of his countrymen: "Die gemeinste und von den meisten angenommene Meynung von dem Ursprunge dieser Eisberge, ist, dass sie von dem Schnee, der sich auf den Bergen im Winter gehäufet habe, und im Sommer nicht wieder aufgelöset worden, entstanden sind, weil die Berge allezeit kälter als das platte Land sind, und im Herbste eher mit Schnee bedecket, im Frühjahre aber später davon befreyet werden, und also habe sich dieses Uebel von denselben auch das flache Land ohne Maass und Ziel ausgebreitet" (pp. 20—21). Vídalín does not agree with this opinion of the local farmers as he sees no possibility of snow changing to ice without melting first. He also discusses stones that melt out from the surface layer of the glaciers and states that they cannot all have fallen from the valley sides on the ice surface as "die meisten sind, obgleich nicht gänzlich, doch einigermassen rund, wie man es an so vielen und grossen Haufen, die unten den Bergen liegen, wahrnimmt; dahingegen diejenigen, die aus andern Bergen weggerissen werden, länglicht oder eckickt zu seyn pflegen" (p. 26). Obviously Thórdur Vídalín has been a keen observer. He discusses scientifically the oscillations of the glaciers. He writes (pp. 207—208): "Etwas merkvürdiges ist es bei unsern Eisbergen, dass sie sich von einem Orte zu andern bewegen: und ich glaube wenn sie den altem Griechen bekannt gewesen wären, so würden diese unfehlbar dafür gehalten haben, dass sie ein Leben oder eine Gottheit in sich hätten. Denn sie beobachten hierin nicht einmal eine gewisse Zeit, sondern gehen bald im Sommer hervor, im Winter aber zurück; bald ziehen sie sich im Winter hervor, und im Sommer wieder zurück. Mann sieht aber, dass sie am meisten fortrücken wenn sie die meisten Flammen und Wasser vor sich geworfen haben. Das habe ich von denen in ihrer Nachbarschaft wohnenden Leuten selbst erfahren; welche darauf bestanden sind, ungeachtet ich mit Fleiss das Gegentheil behauptet. Und heraus erhellet, das darinne eingeschlossene Wasser, von welchem einige glauben dass sie so sehr aufschwellen und aufgeblehet werden, an dieser Bewegung keine Schuld habe. Sie rücken vor, aufs meiste ungefähr 200 Schritte, manchmal aber nur 100, 60, 20, und so weiter. Sie gehen aber weniger urück und brauchen mehr Zeit dazu. Doch findet man, dass sie oft über 100 Schritte zurückgehen; und dass ihre Theile oder Stücken alsdann bald wie die steilesten Klippen, und als wenn sie abgebrochen wären, hervorragen, und dazwischen unzählige tiefe Klüfte zeigen, bald aber sind sie niedrig und eben..... Weil aber in Island die Kälte weit länger anhält als die Wärme, insonderheit auf den Bergen, wo die Sonne niemals so stark als in den Thälern wirket: so ist es leicht zu errethen, warum diese Berge immer mehr zu-als abnehmen, und warum sie mehr vor- als zurückwärts gehen, da die Sonne niemals so viel auflösen kann, als der Frost des Winters und der Salpeter zu Eise gemacht haben."

It seems obvious that the glaciers in Skaftafellssýsla were on the whole advancing rather than retreating when Vídalín lived there, and his description of the difference between advancing and retreating glacier fronts is realistic and convincing.

Following passage in Vídalíns paper is also worth quoting:

"Zwar hat vor etlichen Jahren ein glaubwürdiger Mann, John Ketelsson mit Namen, gelebet, dessen noch lebende Dienstbothen mir folgendes, welches sie aus seinem eigenen Munde gehöret, erzählet haben: Es habe dieser Mann einmal versuchen wollen, ob es nicht möglich seyn sollte, die Breite dieser Berge [viz. Vatnajökull] zu erforschen. Er wäre aber, nachdem er darauf zween Tage zugebracht, wiedergekommen, und hätte gesagt, dass er hinter dem einen Eisberge, eine sehr weite sandichte Gegend, und in der mitte einen einzelnen, von allen andern abgesonderten und ziemlich mit Grase bewachsenen Berg, allwo auch eine Heerde Schefe und Rauch, der (wie er glaubte) aus einer Feuerstäte hervor stiege, gesehen hätte. welches letzte er aber, wegen des gar zu hohen Eises, das ihn verhinderte herunter zu steigen,

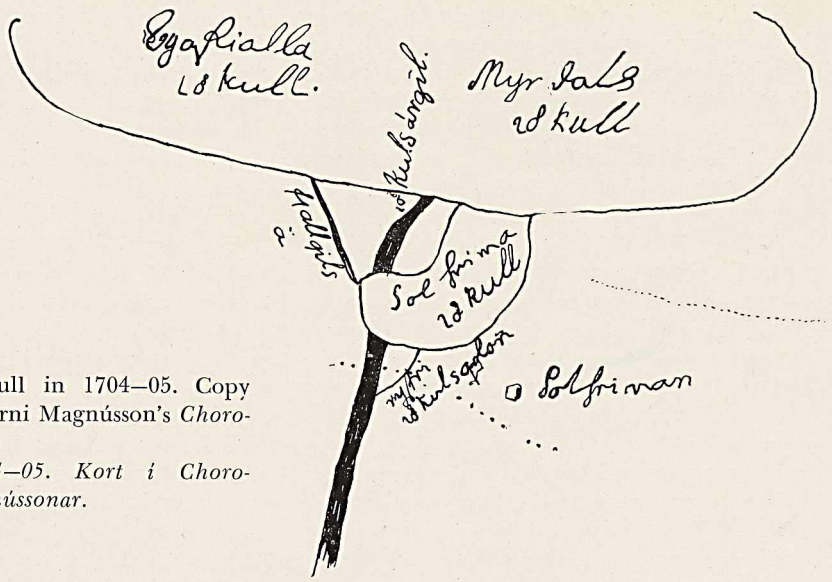

Fig. 4. Sólheimajökull in 1704–05. Copy of a sketch map in Árni Magnússon's *Chorographica Islandica.*
Sólheimajökull 1704–05. Kort í Chorographica Árna Magnússonar.

nicht zu Genüge untersuchen können" (pp. 18–19).

This story – and there is no reason to doubt it – tells us of a rather remarkable enterprise of an Icelandic farmer about the middle of the 17th century or somewhat earlier, an attempt to explore Vatnajökull. From the travel account it seems likely that he crossed the eastern part of Vatnajökull and that the mountain he saw was the extinct volcano Snæfell.

Vídalín's treatise, which is dated July 1st, 1695, was not published until 1754, and then in the German translation quoted here, done by a relative of his, *Páll Bjarnason Vídalín,* and printed in Hamburgisches Magasin, Hamburg und Leipzig 1754, pp. 9–27 and 197–210. The translator adds some comments of his own and among other things discusses the annual stratification of the ice (op. cit. pp. 211–212), clearly without knowing *J. H. Hottingers* paper of 1703 *(Montium glacialium helveticorum descriptio)* where the annual stratification of the firn on Grindelwaldgletscher is correctly explained.

In a note book called *Chorographica Islandica* (AM 213 8°) the famous founder of the Arnamagnæan Collection in Copenhagen, *Árni Magnússon* (1663–1730) has written down a lot of memoranda on the topography and general geography of Iceland during his travels of inspection through the country 1702–1712. The note book contains some interesting particulars on glacier changes. It also contains a sketch map of Sólheimajökull (Fig. 4) and a very full description of glacierbursts *(jökulhlaups)* caused by a lake dammed by that glacier. The following is quoted from that description: "Sólheimajökull is a flat, low outrunner from Mýrdalsjökull, extending in a bend southwards from the glacier and then to the W. When in the beginning it was growing towards the west it met and filled a canyon, continuing afterwards towards the W. .... A glacier river runs through this canyon under the N margin of the glacier, subsequently appearing from its S margin, where it flows out as through a tunnel. This tunnel is occasionally blocked, making the river smaller than usual. The reason for this is the stoppage of that part of the river which otherwise runs underneath the ice from Mýrdalsjökull itself. When the tunnel is stopped up, the water, which otherwise would have run out of the canyon mentioned above, forms an enormously deep lake. When the ice blocks stopping up the tunnel can no longer withstand the pressure of the water, the tunnel is opened *cum impetu,* and everything inside it

is crushed. Thus arise the "jökulhlaups" in Jökulsá. These jökulhlaups usually occur once a year, and the shorter the intervals are between them the smaller they are" (op. cit.). Neither the sketch map nor the description are in Árni's handwriting (the description probably in the handwriting of his secretary, M. Einarsson) but both were certainly made during Árni's tours of inspections in Vestur-Skaftafellssýsla in 1704 and 1705. The description is in all probability derived from a local farmer and is still another proof of the keenness with the farmers observed nature.

A description of Austur-Skaftafellssýsla, written by the district sheriff, *Sigurdur Stefánsson,* and dated July 21st, 1746, contains a fairly thorough description of all glacier rivers in that district and some important information on the position of the glaciers at that time (Sýslulýsingar 1744—1749; Sögurit XXVIII, pp. 1—23).

The poet and naturalist *Eggert Ólafsson* (1726—1768) studied natural history in Copenhagen. Together with the physicist Bjarni Pálsson he travelled through Iceland every summer from 1750 to 1757 studying every aspect of the natural history and geography of the country, and wrote a very comprehensive account of these travels (*Vice-Lavmand Eggert Olafssens og Landphysici Bjarne Povelsens Reise igiennem Island.* Soröe 1772). In this work Ólafsson repeatedly discusses glacial phenomena, without however adding much new knowledge.

Ólafsson was more affected by academic theories than Vídalín and had still less respect for the opinion of common people. Most noteworthy is probably what he has to say of a small cirque glacier on the northern side of Skardsheidi: "when we passed here on August 6th [1752, auth. rem.], we noticed high up on the mountain a fairly large patch, which looked like glacier ice. The owner of the nearest farm, Mófellsstadir, in reply to our question whether the ice on Mófell did not melt in summer, not only answered no, but added that when he was a boy he never saw any ice at all there; but that wen he after many years absence returned some years ago he had noticed a beginning accumulation of snow, and that gradually less of it melted away in the summer. The place is facing NW, and the ice already shows cracks of a green colour due to the refraction usual on thick glaciers. This indicates that the ice may increase and new glaciers form even on moderately high mountains in this neighbourhood, provided the periodical cold winds persist year after year" (op. cit. p. 83).

Besides a remarkable description of the origin of a cirque glacier, we have here an attempt at a climatological explanation of that phenomenon.

Ólafsson makes an attempt at a morphological classification of the glaciers in Iceland. He distinguishes between *"Haa-Jöklar"* or high ice mountains .... *"Skrid-Jöklar"* or low glaciers resulting from ice slips and ice falls and *"Grunn-Jöklar"* where the ground freezes to ice on flat, low-lying land. "Breidamerkurjökull is the only one we know of this kind" (op. cit. p. 788). This is the first mention in literature of the Icelandic term *skriðjökull* (from the Icelandic *skríða* = creep, glide), which literally means glacier that glides. In all probability this term is much older, however. Ólafsson writes rightly about the high glaciers: "The ice mountains or high glaciers reach, as mentioned above, high up in the air where it is much colder than on flat, low-lying land. On them rain will change into snow and ice and as they always attract rain, clouds, and fog, they will maintain their size and grow unless the sun can every year melt as much as is added to them", but after this correct conclusion he rambles off into fantasy, saying that a better explanation of how a glacier ice is maintained is that the glaciers have free communication with the sea by hidden channels and increase from below (p. 788). Academic theories conflict here again with common sense and with facts that seemed obvious to the local farmers. The same applies to an older paper of his, *Enarrationes historicæ de natura et constitutione Islandiæ* (Hafniae 1749), where he disputes the opinion of his countrymen on what causes the colour of the glacier rivers. They maintain that the rivers get their light colour from the glaciers. Olafsson contends that they get it from lime (pp. 132—173). In Iceland there is hardly any lime.

Ólafsson is the first man in Iceland and probably in the world to discuss the formation of dirt cones on glaciers. In the Alps dirt cones are for the first time mentioned by *Gruner* in

Sveinn Pálsson.

1760 (in *Die Eisgebirge des Schweizerlandes.* I, p. 30, 45) and their formation is discussed there for the first time by *S. Studer* in 1783 (in *Auszug eines Briefs aus dem Mühlethal im Oberhasli, von 22ten Heumond 1783.* Höpfners Mag. Nat. Helv. I. Zürich 1787, pp. 210–211). Ólafsson thinks that the sand, covering the dirt cones, has been blown in over the glaciers from ice-free areas outside in wintertime and he maintains that it is a hard blowing wind that causes their form to be conical (op. cit.).

Ólafsson and Pálsson were the first to climb the ice capped cone volcano Snæfellsjökull, on July 1st, 1754.

The big name in the 18th century glaciology in Iceland is *Sveinn Pálsson* (1762–1840). The son of a farmer in Skagafjördur, N.-Iceland, he studied medicine and natural history at the University of Copenhagen in 1787–1791. Having finished his academic studies in natural history he spent four summers (1791–1794) on journeys through Iceland for geographical, botanical and geological studies.

In 1799 Pálsson was appointed doctor for the South of Iceland, serving an area stretching right from Hellisheidi to Skeidarársandur as well as the Westman Islands. Besides, he frequently had to attend patients in Austur-Skaftafellssýsla. Pálsson held this extremely difficult office until 1824, living for most of the time on the farm Sydri Vík in Mýrdalur. Whenever

he had a time off from his large practice and strenuous farming he did research work in the field of natural science as well as much writing.

Among other things he made careful weather records from 1791 to his death. His comprehensive research and writings will not be described here, except that some reference will be made to that work of his which more than any other will save his name from oblivion. In 1795 Pálsson sent to the *Naturhistorie Selskabet* (Natural History Society) in Copenhagen, which had financed his research travels, a treatise on the glaciers in Iceland entitled: *Forsög til en Physisk, Geographisk og Historisk Beskrivelse over de islanske Is-biærge. I Anledning af en Reise til de fornemste deraf i Aarene 1792—1794* (An attempt at a physical, geographical and historical description of the Icelandic glaciers. Based on travels to the most important of them during the years 1792—1794). This work was written in Danish and was not published *in extenso* until 1945 and then in Icelandic (in *Ferðabók Sveins Pálssonar. Dagbækur og ritgerðir 1791—1797*. Ed. J. Eythórsson. Reykjavík, pp. 425—552). Parts of the treatise were published in *Norsk Turistforenings Aarbog,* Kristiania, in 1883. Had this remarkable treatise been translated to some big language and printed shortly after it was written, it would now rank as a classic, not only in Icelandic but also in the international glaciological literature as the probably most important glaciological treatise of the 18th century.

As to what Pálsson had read on glaciology before he wrote his treatise the following may be quoted from its introductory chapter: "The glaciers in Helvetia and adjoining areas have, as is well known, been described by *Grüner, Saussure, v. Moll, Schranck, Walcher* and *de Luce,* although I have not read anything of this, except that little which is quoted by *Fleischer* in his Natural History..... In Norway I don't know of any glaciers having been described except Justedalsbræen, about which professor *Ström* writes in his description of Söndmör and professor *Vahl* in Vol. II. 1 of the papers of the Natural History Society, which I have not yet had an opportunity to read" (op. cit. 426).

E. Fleischer (1732—1804), a Danish naturalist, wrote a comprehensive work (16000 pages) on natural history: *Forsög til en Natur-Historie* etc. that was published in 10 volumes and 26 parts in 1787—1804. Of this Pálsson has read the first three volumes before he wrote his glacier treatise. In these volumes Fleischer quotes the authors mentioned by Pálsson, except the Norwegian ones, and also Vídalín and Ólafsson. His own comments on glaciology are often rather fantastic and show the standard of academic glaciology at his time. The following may be quoted as an example. In Vol. II, p. 375 Fleischer writes about ice dammed lakes in Switzerland and says that among them are "the so-called Pilatus lakes which are situated at the foot of the lofty mountain Pilatus. It is believed that at the time the unjust judge [i.e. Pilate] had to leave his court of justice the Devil took him to the Alps to entomb him in those mountains. And as two marks like those of a horseshoe can be found in a rock not far away it is maintained that the Evil one set off with him so violently that in his impetuosity his footprints left holes in the rock itself. (But must Satan then have himself shod?) Perhaps only this time since he knew that the route he had to take over the rocks was so rough and stony."

Of a quite another and higher standard is the Norwegian *Hans Ström's* work: *Physisk og Oeconomisk Beskrivelse over Fogderiet Söndmör,* printed in Sorö 1762. It contains a remarkable description of the oscillations of some outlets of Justedalsbræen, which Ström received from a clergyman, *Hans Viingaard*. Ström himself describes glacier rivers and their daily variations. He states, contrary to Ólafsson, that common people in Iceland and Norway are right in maintaining that the light colour of the glacier river comes from the glaciers.

It is not known whether or not Pálsson did ever read *M. Vahl's* paper: *Nogle Iagttagelser ved en Reise giennem Norge til dets nordlige Dele* that was published in 1792 (Skrivter af Naturhistorie-Selskabet 2det Bind. 1ste Hefte, pp. 1—71), but it was read before the Natural History Society in Copenhagen on Jan. 28, 1791, while Pálsson was still in Copenhagen. In this paper Vahl discusses the oscillations of Justedalsbræen and has some interesting and partly correct comments on their causes.

Pálsson often quotes Fleischer and is somewhat influenced by him, but he does not hestitate to criticise him, however, if he feels

that his own experience of glaciological phenomena conflicts with his theories. Much more than Ólafsson he is prepared to take the experience and view of the laymen of his country into account. However, contrary to the views of the local people he belives that the eruption centre at Grímsvötn is the same as the ice-dammed lake Grænalón, but in that case the local people were right.

Pálsson's morphological classification of glaciers (op. cit. p. 429–432) is based on Fleischer and Ólafsson. Pálsson denies emphatically that glaciers of the type Ólafsson called Grunn-Jöklar (cf. p. 9) exist in Iceland. He maintains that there are only two main types of glaciers, *Hájöklar* and *Falljöklar*.

Hájöklar are perpetually snow covered mountains rising high above their surroundings. These glaciers, he writes, could also be called *Hjarnjöklar* (firn glaciers) as they are covered by *hjarn* (firn). They are in their turn of three types: *fjalljöklar* (mountain glaciers), which are rather steepsided cupolas, *hveljöklar* (ice cupolas), which are more flat and extensive, and *toppjöklar* (cone shaped glaciers).

Falljöklar (falling glaciers) are, according to Pálsson heaps of snow that has glided from the hájöklar and been transformed to ice, and could thus be called ice glaciers in order to distinguish them from the firn glaciers. They are also of three types: *Jökulvangar* (ice cheeks), *skriðjöklar* (creeping glaciers), and *hrunjöklar* or *jökulföll* (icefalls). From Pálsson's further description it is clear that by *jökulvangar* he means cirque glaciers and by *skriðjöklar* valley glaciers of the type most common among the southern outlets of Vatnajökull. On the whole his classification fits well with the glacier types found in Iceland.

Pálsson is one of the founders of the Plasticity Theory of glacier movement. The idea that the glaciers move as a plastic mass seems to have struck him for the first time in the summer of 1793, when he was studying the front of Breidamerkurjökull. Having described the oscillations he writes (p. 478):

"I cannot help mentioning here an idea, however absurd it may be, which struck me when I was studying the eastern part of Breidamerkurjökull before it advanced. It is well known how fragile pitch is when it has been well refined, but yet it has the nature of liquid materials even in cold weather, to the extent that when it is placed in a reclining position it gradually, very slowly and almost invisibly falls to a horizontal level under the force of gravitation. If a few pieces of solid pitch are placed in reclining receptacle it will appear after a while that the pitch has not only made its way to the lowest point of the receptacle, but all the pieces have merged into one. The possibility of a similar liquid nature of the ice occurred to me, and if this idea is based on facts we have found a new and contributory cause of the formation of many ice-falls and glaciers as well as of the disappearance of glacier crevasses in a short time. There is no conclusive evidence to support this theory, however."

A year later he became still more convinced of this idea, when on Aug. 11, 1794, he climbed Iceland's highest mountain, Öræfajökull, that had never been climbed before. From the nunatak Hnappur he had a good view over the glacier Fjallsárjökull and its ogives and he writes in his diary:

"I particularly noticed the above-mentioned glacier, which has advanced just to the east of Kvísker. Its surface seemed all to be covered with curved stripes, lying right across the glacier, especially near the main ice cap. The top of the curves stretched towards the lowland just as if this ice-fall had slid down in a halfmelted state or as a thick, semiliquid material. Is this not evidence in support of the theory that the ice is by nature — without melting — partly liquid like various kinds of resin, as I suggested in the above article?" (p. 495).

Little did Pálsson know that a similar idea had struck a French naturalist, *A. C. Bordier,* 20 years earlier, although he did not enforce it so fully. In his work, *Voyage Pittoresque aux Glaciers de Savoye fait en 1772,* Bordier writes (p. 223) that the glaciers are "comme un amas de matiére coagulée, ou comme de la cire amollée fléxible & ductile jusqu'à un certain point". Bordier's work lapsed into oblivion like Pálsson's treatise and was not unearthed until *B. Studer* did so in 1863.

Although not the first one to describe the glaciers as a plastic mass Pálsson was certainly the first one to state that convection plays a greater role in the ablation on temperate gla-

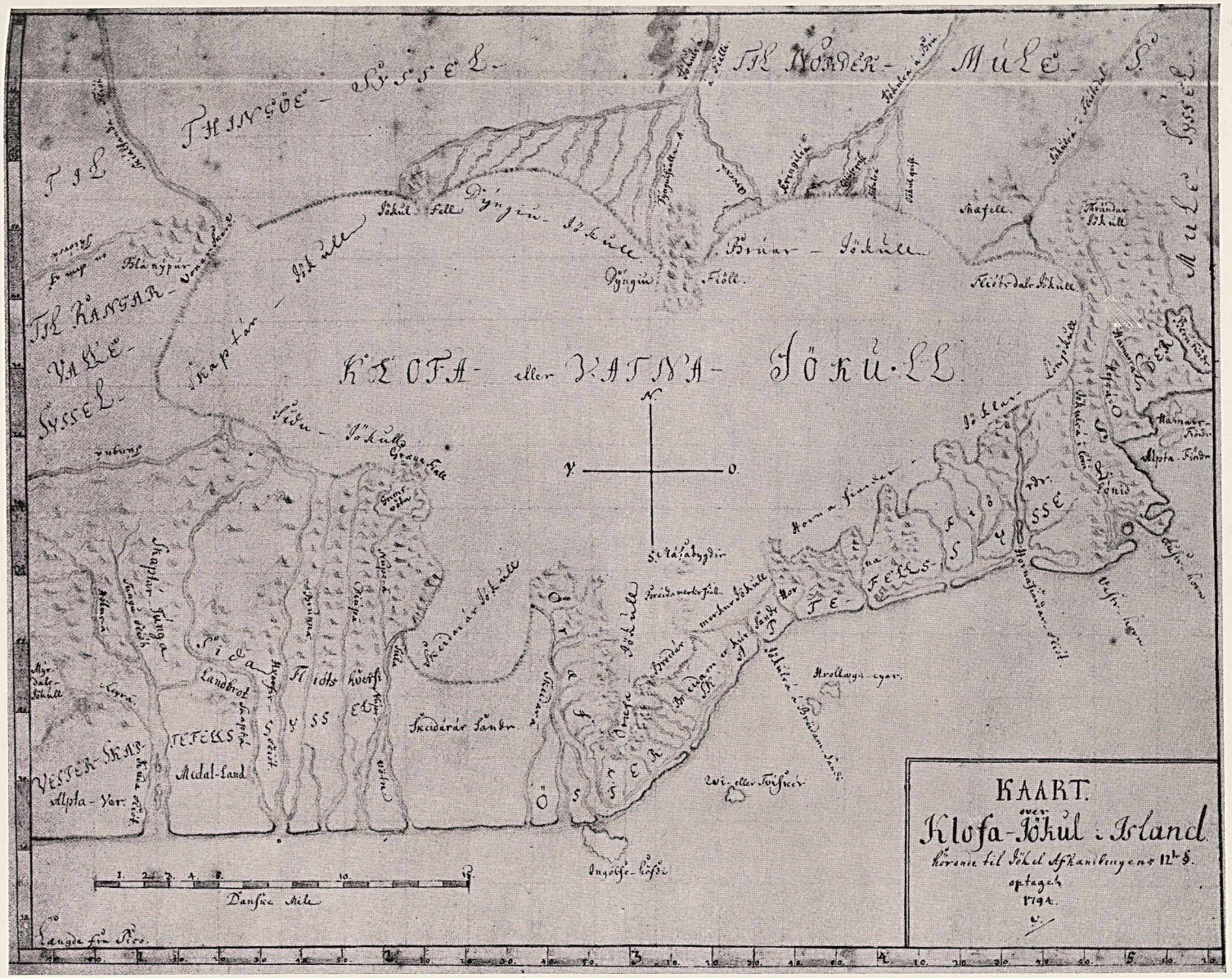

Fig. 6. Sveinn Pálsson's map of Vatnajökull 1794. Size of original map is 29.5 × 37.0 cm.
Vatnajökulskort Sveins Pálssonar frá 1794. Rétt stærð kortsins er 29.5 × 37.0 cm.

ciers than radiation. He writes (p. 433): "I also venture to affirm that the rays of the sun do not play as much part in melting the firn of the plateau ices, not even in calm weather when they fall direct on them, as misty weather without precipitation does. It would, indeed, seem quite natural that the large ice caps reflected the sun rays without their being able to affect the firn of the plateau ices to any appreciable extent." Not until thorough ablation measurements were carried out by the Swedish-Icelandic Vatnajökull Expeditions in 1936—37—38, was this view fully confirmed. Pálsson also discusses the formation of superimposed ice (p. 434). His descriptions of glacier rivers and their behaviour, formation of underwater ice etc, is thorough and so are his descriptions of glacier bursts. He distinguished between glacier bursts, caused by the tapping of ice dammed lakes, and those caused by subglacial volcanism. Some volcano-glacial bursts before his time had been excellently described by eye-witnesses, e.g. the Katla bursts of 1625, 1660, 1721, and 1755. Pálsson is the first to differentiate clearly between volcanogen and climatogen oscillations of the Vatnajökull outlets. He says of the volcanogen oscillations that "it is not known if this apparent forward and backward movement of the glaciers in this country is definitely periodical. Something of the kind is certainly said in respect of Skeidarárjökull, but no conclusions can be drawn from that for lack of reliable information" (p. 454—455). As regards the climatically conditioned variations he stresses that "like the climate itself they certainly are periodical to some degree" (p. 455). He also discusses the Föhn effect of Vatnajökull (p. 457), but on the whole he goes too far in stressing the ameliorating influence of glaciers on the climate of Iceland. He really seems to have loved his glaciers.

Pálsson describes in detail many individual glaciers and he has drawn maps and profiles of most of the plateau ices. By far the best of these maps is that of Vatnajökull (Fig. 6), which is amazingly correct for its time. The representation of the glacier's northern margin is particularly good. That part of the map is based on information which Pálsson received from a young Icelander, *Pétur Brynjólfsson,* who had crossed the northern highland from E to W, short N of Vatnajökull, in the summer of 1794. The map of the southern margin of Vatnajökull is probably partly based on the Danish geodecist *Th. H. Knopf's* map of that area, surveyed by him in 1732.

Although Sveinn Pálsson lived until 1840 he belongs to the 18th century as a glaciologist. What he wrote on Natural History after 1800 chiefly concerns some of its other branches. His treatise on glaciers constitutes the last phase and the culmination of a glaciology which may be called Icelandic in the sense that it was principally based on knowledge of Icelandic glaciers. To a large extent that knowledge was common to the country people who lived along the southern margin of Vatnajökull, in close contact with its advancing glaciers, glacier rivers and sandurs, knowledge which had gradually accumulated during 9 centuries because these people were in a large measure endowed with *"man's nature to wish to see and experience the things that he has heard about and thus to learn whether the facts are as told or not".*

ÁGRIP:

ÞEKKING ÍSLENDINGA Á JÖKLUM FRAM TIL 1800

Því hefur löngum verið á lofti haldið, og ekki að ástæðulausu, að Íslendingar hafi bæði fyrr og síðar afrekað miklu á sviði húmanistiskra bókmennta og fræða. Hitt hefur legið meira í þagnargildi, hverju þeir hafa áorkað á sviði náttúruvísinda, enda virðist það í fljótu bragði a. m. k. næsta fátæklegt í samanburði við afrek skáldanna okkar. Hér munu ytri aðstæður þó hafa ráðið meiru en skortur á hæfileikum til náttúrufræðilegra iðkana. Náttúruvísindin eru háðari ýmsum ytri aðstæðum en húmanistísk fræði. Það er hægt að þeysa á Pegasusi berbaka og við einteyming, en ný frumefni verða trauðlega fundin í fjósbaðstofu. Flestar greinar náttúruvísinda geta ekki þróazt nema að vissu marki án vísindatækja.

En í sumum greinum náttúrufræðinnar hafa Íslendingar þó haft góð skilyrði til að ná nokkrum árangri. Þar hefur landið sjálft lagt þeim verkefnin upp í hendurnar og verið þeim, sem

opin hafa augun, betri skóli en nokkur háskóli. Ein þessara fræðigreina er jöklafræðin. Jöklar þekja níunda hluta landsins og ná sums staðar niður í mannabyggðir. Með jöðrum þeirra og jafnvel yfir suma þeirra hafa leiðir Íslendinga legið frá upphafi Íslandsbyggðar. Það mætti því undarlegt heita, ef Íslendingar hefðu ekki á umliðnum öldum öðlazt einhvern skilning á þessu náttúrufyrirbæri, enda er það raunverulega svo, að þótt Íslendinga sé að litlu sem engu getið í þeim fræðiritum erlendum. sem fjalla um sögu jöklafræði, á Ísland sína jöklaannsóknasögu, sem vel þolir samanburð við samsvarandi sögu þeirra landa, sem talin eru vagga jöklafræðinnar, Alpalandanna. Hér skal þess freistað að rekja í stuttu máli þessa sögu.

Telja má öruggt, að einhverjir þeirra Norðmanna, er hér námu land, hafi haft kynni af jöklum úr sínum heimahögum, en ekkert verður fullyrt um það, hversu náin kynnin voru. En á Íslandi lentu þeir þegar á landnámsöld í nábýli við jökla, einkum þeir, er tóku sér bólfestu í Skaftafellssýslum. Nægir að nefna sem dæmi Þórð Illuga, er braut skip sitt á Breiðársandi, en honum gaf Hrollaugur, sonur Rögnvalds Mærajarls, land milli Jökulsár og Kviár, og bjó hann að Felli við Breiðá, en sá bær huldist jökli nálægt aldamótunum 1700.

Elztu skráðu heimild um íslenzka jökla er að finna í hinni miklu Danasögu Saxa, Gesta Danorum, sem skrifuð var um 1200. Í þessu mikla ritverki er meðal annars að finna Íslandslýsingu, sem án efa er byggð á frásögnum Íslendinga. Eftir að hafa lýst hafísnum skrifar Saxi: „Þar er einnig önnur ístegund, sem liggur á milli fjallshryggja og kletta, og ber mönnum saman um það, að ístegund þessi skipti um legu sína á víxl eftir vissu lögmáli, með nokkurs konar hverfihreyfingu, þannig að hið efra kastast niður til hins neðsta, og hið neðsta hverfur aftur upp á yfirborðið. Til sannindamerkis um þetta er það sagt, að sumir menn hafi fallið í gjár og djúp gapandi sprungna, sem urðu á vegi þeirra, er þeir fóru yfir ísfláka, og hafi þeir nokkru síðar fundizt dauðir án þess að nokkur glufa á ísnum næði upp yfir þá. Þess vegna álíta margir, að hin djúpa ísgjá hverfist um og gefi frá sér síðarmeir það, sem hún hefur gleypt í sig."

Þetta er ekki aðeins langelzta lýsing á hreyfingu skriðjökla, sem skráð er. Hún er og á sinn máta alveg rétt, þegar um er að ræða hreyfingu íss í jökulsporðum. Skaftfellingum er enn í dag kunnugt um það, að jökullinn skilar sínu, þótt í djúpar sprungur falli. Fyrr eða síðar er það aftur komið upp á yfirborð jökulsins, og það meðal annars vegna þeirrar hverfihreyfingar, sem Saxi ræðir. En þessu hafa erlendir fræðimenn ekki veitt athygli fyrr en á tuttugustu öld.

Konungs skuggsjá er eitt hið merkasta norrænna fornrita, skrifuð í Noregi, að því talið er um miðja 13. öld. Margt er þar af góðum lífsvísdómi og hollráðum, en einna merkast er ritið þó vegna þeirra upplýsinga náttúrufræðilegs efnis, sem þar er að finna. Meðal annars er þar gagnmerkur kafli um náttúru Íslands og má öruggt telja, að flest í þeim kafla sé beint eða óbeint frá Íslendingum runnið. Höfundurinn ræðir meðal annars um jökulár og skrifar: „Þar eru og köld vötn þau er falla undan jöklum svo stór, að berg og jörð er hjá liggja þá skjálfa fyrir þær sakir, að vatnið fellur svo stritt og með svo stórum fossum .... og eigi mega menn til ganga að forvitnast á þá árbakka, nema löng reipi hafi, og sé borin á þá menn, er til vilja forvitnast að sjá, og hinir sitji fjarri, er gæta reipsins, svo að þeir eigi kost að draga þá þegar aftur til sín, er stríðleiki vatnsins ærir þá."

Þessi orð eru ekki aðeins skilmerkileg lýsing á íslenzkum jökulám, sem belja fram undan jökuljöðrum, svo sem þær gerðu áður en jöklarnir tóku að hörfa vegna veðurfarsbreytingar síðustu áratuga (sbr. 1. mynd). Þau benda einnig til beinna náttúrufræðilegra athugana og sýna, að til voru á þjóðveldistímanum Íslendingar, sem voru svo forvitnir um náttúrur lands síns, að þeir lögðu sig í nokkra hættu til að athuga þær.

Um jökla Íslands segir í Konungs skuggsjá m. a. „það þykir mér vera mega um ísa þá, er á Íslandi eru, að það land gjaldi návistar þeirrar, er það liggur nær Grænalandi og er þess von, að þaðan stafi mikill kuldi, með því að það er um fram öll lönd ísum þakið. En nú með því að Ísland tekur þaðan mikinn kulda og hefur þó litinn varma af sólinni, þá hefur það fyrir því svo mikinn gnótt ísa yfir fjallgörðum sínum".

Þessi merkilegu ummæli sýna, að höfundi Konungs skuggsjár hefur verið ljóst, að skil-

yrðin fyrir jöklum Íslands er lega landsins og veðurfar, og er þetta elzta loftslagslega skýring á jöklamyndun, sem kunnugt er um. Vart hefur höfundurinn þessa vizku aðeins frá eigin brjósti og er sönnu nær, að þetta hafi verið almenn skoðun á Íslandi á 13. öld. Til þess bendir upphafið á Bárðarsögu Snæfellsáss, sem einnig mun vera frá 13. öld eða byrjun þeirrar 14. Bárður Snæfellsáss, sem er eins konar persónugervingur Snæfellsjökuls, er sagður vera sonur Mjallar dóttur Snævar, og líkjast móður sinni að útliti, en faðir hans er sagður vera Dumbr, sá er réði fyrr hafsbotnum þeim, er ganga norður af Hellulandi. Þetta er veðurfræðileg skýring á myndun jökulsins færð í goðfræðilegan búning. Dumbr er hér persónugervingur norðanáttarinnar og hafíspokunnar, sem kemur til Íslands úr norðvestri.

Höfundur Konungs skuggsjár kann einnig glögg skil á veðurfari á Grænlandi og áhrifum meginjökulsins á það, enda lifðu íbúar Eystri- og Vestribyggðar á Grænlandi í nábýli við jökla og veiðimenn úr þeim byggðarlögum þekktu vesturströnd Grænlands norður fyrir 72. breiddargráðu og líklega allmiklu norðar, en þeir, sem voru í förum milli Noregs, Íslands og Grænlands, kynntust smám saman austurströnd Grænlands milli Hvítserks og Hvarfs.

Leidd hafa verið allsterk rök að því, að höfundur Konungs skuggsjár sé Einar Gunnarsson, smjörbakur kallaður, sem varð erkibiskup í Niðarósi 1255 og dó 1262. Hefur hann vafalítið bæði þekkt geistlega menn frá Grænlandi og Íslandi og farmenn, sem siglt höfðu til þessara landa. Má telja líklegt, að mest af þeirri þekkingu á jöklum, sem kemur fram í Konungs skuggsjá hafi verið sameign Íslendinga, Grænlendinga og þeirra manna í Noregi, sem höfðu nánast samband við þá, en vera má að hinn glöggskyggni höfundur Konungs skuggsjár hafi eitthvað bætt um af eigin hyggjuviti.

Í Íslandslýsingunni Qualiscunque descriptio Islandiæ, *sem samin er um 1590, líklega af* Oddi Einarssyni, *Skálholtsbiskupi, er aukningar jökla á Íslandi vegna versnandi veðurfars getið í fyrsta sinn.*

Því er haldið fram í erlendum ritum um sögu jöklarannsókna, að kort Austurríkismannsins W. Ygls *af Tíról frá 1604 (3. mynd) sé elzta kort í veröldinni, er sýnir jökla sem sérstakt landfræðilegt fyrirbæri. En þar skjátlast þeim, blessuðum, því jöklar eru sýndir og raunar á svipaðan hátt á Íslandskorti* Guðbrands *biskups* Þorlákssonar, *sem birtist í fyrsta skipti á prenti í kortabók Abrahams Ortelíusar 1590 (2. mynd). Líklegt er, að Ygl hafi séð þessa kortabók.*

Talið er í erlendum fræðiritum, að Svisslendingurinn Jóhann Jacob Scheuchzer *hafi fyrstur manna sett fram hina svokölluðu dilatations- eða frostþenslukenningu um hreyfingu skriðjökla. Þetta gerði hann í riti sínu:* Itinera per Helvetiae Alpinas regiones facta, *sem út kom 1705. Samkvæmt þessari kenningu er aðalorsök jöklaskriðsins þensla vatns, er það frýs. Á daginn leysir ís á yfirborði skriðjöklanna og vatn safnast í sprungur og glufur, á nóttum frýs vatnið og þenst út og spyrnir jöklinum áfram. Þessa kenningu aðhylltust flestir jöklafræðingar allt fram á 19. öld.*

En 10 árum áður en Scheuchzer birti þessar niðurstöður sínar hafði Þórður *Skálholtsrektor* Þorkelsson Vídalín *lokið ritgerð sinni:* Dissertationcula de montibus Islandiæ chrystallinis: *Smáritgerð um jökulfjöll Íslands. Þar setur hann fram frostþenslukenninguna og það bæði skýrar og rökfastar en Scheuchzer. Margan fróðleik um jökla er að finna í riti Vídalíns, en jöklum kynntist hann einkum í Austur-Skaftafellssýslu. Hann bjó um hríð að Þórisdal í Lóni. Hann hefur meðal annars veitt því eftirtekt, að grjót í jökulurðum er sorfið og máð. Vídalín skákar þó ekki Skaftfellingum um skilning á myndun jökla. Hann segir það skoðun manna — og á þá eflaust við fólk austur þar — að snjór safnist á vetrum á fjöll meir en nær að þíðna á sumrum, af því fjöllin séu kaldari en flatlendið, en þar af leiði að jöklarnir sigi niður og breiðist út á láglendinu. Sjálfur aðhyllist Vídalín eigi þessa skoðun. Þá getur Vídalín þess, að einn trúverðugur maður, Jón Ketilsson, hafi, að sögn vinnufólks hans, sem enn sé á lífi, lagt á Vatnajökul til að kanna breidd hans. Hafi hann komið til baka eftir tveggja daga ferðalag og komizt að norðurrönd jökulsins, en ekki komizt norður af vegna bratta. Af lýsingu Jóns á landslagi norðan jökla að dæma er helzt að ætla, að hann hafi komizt norður á jökul nærri Snæfelli. Ferð þessa skaftfellska bónda, sem líklega hefur verið farin um miðja 17. öld, er fyrsta jöklaferð í rannsóknarskyni, sem mér vitanlega hefur*

nokkurs staðar verið farin og hefur þessi Skaftfellingur verið haldinn sömu fróðleiksfýsn og þeir forfeður hans, er Konungs skuggsjá greinir frá. En ferðir þær yfir Vatnajökul, sem líklegt er að hafi átt sér stað fyrr á öldum, voru fyrir all-löngu aflagðar, er Jón Ketilsson lagði í sína reisu.

Jöklarit Þórðar Vídalíns er vafalítið merkasta jöklarit 17. aldar. En ekki komst það á prent fyrr en 60 árum síðar, er frændi Þórðar, Páll Bjarnason Vídalín, *snaraði því af latínunni á þýzku og birti það í þýzka tímaritinu Hamburgisches Magazin. Fylgja þýðingunni ýmsar athugasemdir Páls og sumar skynsamlegar.*

Í samtíningi Árna Magnússonar, *Chorographica Islandica, frá ferðum hans um Ísland 1702—1712, er að finna ýmsan fróðleik um jökla, m. a. gagnmerka lýsingu á Sólheimajökli og jökulhlaupum frá honum. Þeirri lýsingu fylgir kortskissa (4. mynd).*

Í hinni greinargóðu lýsingu Sigurðar Stefánssonar *á Austur-Skaftafellssýslu, dags. 21. júlí 1746, eru mikilsverðar upplýsingar um jökla og jökulár í þeirri sýslu.*

Eggert Ólafsson *(1726—68) minnist víða á jökla bæði í vísindaritgerðum sínum á latínu og í Ferðabókinni, en ekki bætti hann mikið um þekkingu Íslendinga á þessu sviði. Hann var of bundinn erlendum akademiskum skoðunum. Þá verður hann fyrstur manna til að reyna að skýra aurkeilur (dríli) á jöklum. Flokkun hans á jöklum er ekki fráleit.*

En stærsta nafnið í jöklafræði 18. aldar er Sveinn Pálsson *(1762—1840). Hann átti það sammerkt Þórði Vídalín að vera læknir Skaftfellinga og hefur vafalaust margt af þeim lært um jökla. Hann las læknisfræði og náttúrufræði við Hafnarháskóla, en ekki hefur það allt verið þungt á metunum, sem hann nam í þvísa landi. Sem dæmi um það, hvernig ástatt var um náttúrufræðina í Kaupinhafn í þann tíð má nefna, að í því ritverki erlendu, sem Sveinn vitnar oftast í, náttúrufræði E. Fleischers, sem kom út í fjölda binda (sennilega um 16000 bls.), er kafli um jökla. Þar segir í sambandi við fjallið Pílatus í Sviss, að Kölski „i hiin Tid da denne uretfærdige Dommer [þ. e. Pilatus] maatte forlade sin Domstol, har fört ham til Alperne, for att indslutte ham i dette Biærg, og da man i en Klippe ikke langt fra finder tvende Tegn som af en Hesteskoe, paastaaer man, at hiin Onde har faret saa stærk af sted med ham, at han endog ved den Heftighed har traadt Hul i Klippen selv (Men bruger Satan da at lade sig beslaae?). Maaske ikkun denne Gang, siden han vidste han havde saa skarp og stened en Vei over alle Klippene at vandre."*

Þess er þó að geta, að Sveinn mun hafa þekkt til greinargóðrar lýsingar á Justedalsbræen, sem birtist í riti Hans Ströms um Sunnmæri, prentuðu í Sórey 1762, og e. t. v. einnig rit M. Vahls um Noreg.

Rit Sveins Pálssonar um jökla ber heitið Forsög til en physisk, geographisk og historisk Beskrivelse over de islanske Is-biærge. *I Anledning av en Reise til de fornemste deraf i Aarene 1792—1794. Þetta rit er án nokkurs vafa merkasta jöklarit, sem skrifað var á 18. öld, og var liðið all-langt fram á þá 19. áður en sambærilegt rit væri skrifað. En rit Sveins lá óprentað, gleymt og grafið, þar til nokkur hluti þess var prentaður í ársriti Norska ferðafélagsins 1882. Í heild kom það ekki út fyrr en 1945, í íslenzkri þýðingu Jóns Eyþórssonar, sem hluti af Ferðabók Sveins Pálssonar. Hér skal þess aðeins getið, að í þessu riti setur Sveinn skýrt fram þá kenningu, að jöklar hreyfist sem seigfljótandi efni, og þekkti hann ekki til rits Frakkans A. C. Bordiers, sem sett hafði fram svipaða skoðun 20 árum áður. Sveini kom þetta fyrst í hug, er hann var að rannsaka Breiðamerkurjökul 1793, og hann sannfærðist um þessa skoðun, er hann leit svigður eða skára Fjallsárjökuls ofan af Öræfajökli hinn 11. ágúst 1794. Sveini verður langfyrstum jöklafræðinga ljóst, að sólargeislun ræður minna um jöklabráðnun hérlendis en hlýir loftstraumar, og í mörgu öðru er hann á undan samtíð sinni. Hina djúpstæðu þekkingu sína á jöklum byggði hann að verulegu leyti á eigin reynslu, en sitt hvað hefur hann vafalítið lært af Skaftfellingum, svo sem fyrr getur, og þekkingu sína á norðurjaðri Vatnajökuls hefur hann að miklu leyti frá* Pétri Brynjólfssyni, *ungum Austfirðingi, sem fór merkilega könnunarferð með norðurrönd Vatnajökuls sumarið 1794. Hefur Pétur sá verið bæði athugull og greinargóður, því kort Sveins var í nær hálfa aðra öld réttasta kortið af norðurrönd Vatnajökuls, réttara en kort Gunnlaugssens og Thoroddsens.*

Segja má, að jöklarit Sveins Pálssonar sé há-

EYSTEINN TRYGGVASON:

Earthquakes, jökulhlaups and subglacial eruptions

INTRODUCTION.

There are many records of volcanic eruptions in the glaciers Vatnajökull and Mýrdalsjökull connected with great jökulhlaups (glacier bursts). There are also many records of similar jökulhlaups from Vatnajökull without any connection with visible volcanic eruptions. In case of Grímsvötn eruptions, the jökulhlaups generally begin several days before the visible eruption. This has led to the opinion, that the jökulhlaup, by reducing the pressure on the subglacial surface, is the primary cause of Grímsvötn eruptions (Thorarinsson 1953). If this is right, the water must be stored over long periods, several years in case of Grímsvötn, to escape suddenly when the amount of water has reached some critical point. There are evidences of such a process in Grímsvötn: A large depression in the glacier, which can serve as water reservoir, and thermal activity continuously melting the glacier ice, in addition to surface melting.

There are serious obstacles against generalizing this opinion to cover jökulhlaups from Mýrdalsjökull. Here jökulhlaups are very rare, exept in connection with eruptions in the subglacial volcano Katla. The glacier surface does not indicate any marked subglacial depression, where the water can be stored between jökulhlaups.

Seismic observational data support the opinion, that jökulhlaups from Grímsvötn are the primary cause of Grímsvötn eruptions, but these data indicate a different relationship between jökulhlaups and eruptions in Mýrdalsjökull. Here the most probable physical relation between these two events is, that the heat energy of the eruption produces the water of the jökulhlaup by melting the glacier ice.

OBSERVATIONAL DATA.

We have seismograph records from Reykjavík at times of several jökulhlaups from Icelandic glaciers. During four of these jökulhlaups, small earth tremors were recorded with epicenter in or near the point of origin of the jökulhlaups. Table I shows all recorded earthquakes, which can be correlated with the jökulhlaups. During the Skeidará-hlaup of 1913 or jökulhlaups during the period 1926—1960, not mentioned in Table I, no earthquakes were recorded. The sensitivity of the seismographs in Reykjavík was however very low prior to 1951, so earthquakes of magnitude less than 3½ to 4 were not detected on the seismograms. After 1951 earthquakes of magnitude about 3 can be detected, if the epicenter lies in Grímsvötn, and earthquakes from Mýrdalsjökull of magnitude as low as 2½ are recorded, if conditions are favourable.

DISCUSSION.

In a search for a physical relation between earthquakes and jökulhlaups, the writer assumes, that only the following five explanations of this relationship are possible.

1. A subglacial volcanic eruption causes the melting of the glacier ice, and the earthquakes are associated with the eruption.
2. The jökulhlaup is caused by emptying of an ice dammed lake, and the pressure release caused by the escape of a great mass

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punktur og um leið lokapunktur þróunar þeirrar jöklafræði, sem nefna mætti íslenzka í þeirri merkingu, að hún byggðist að mestu leyti á reynslu íslenzkra manna af íslenzkum jöklum. Þessi jöklafræði þolir fyllilega samanburð við þá, sem þróaðist samhliða og óháð í Alpalöndunum og sú íslenzka var löngum feti framar í þróuninni. En með 19. öldinni breytist þetta. Íslenzk jöklafræði staðnar, en þróunin í Alpalöndunum verður brátt örari, og smátt og smátt verður fræðigreinin alþjóðleg. Á síðustu áratugum hefur Ísland aftur orðið vettvangur jöklarannsókna — en það er önnur saga.