

**LANDSCAPE CHANGE AND HUMAN RESPONSE DURING A
THOUSAND YEARS OF CLIMATIC FLUCTUATIONS AND
VOLCANISM:
SKAFTAFELL, SOUTHEAST ICELAND¹**

JACK D. IVES*

ABSTRAC.- The ancient farm of Skaftafell, dating from the Saga Period in Icelandic history is taken as the center-piece for depiction of climatic and landscape change from the earliest settlement in the ninth century AD to the present. The study of landscape evolution is divided into four main periods: 1) the Saga Period, AD 874-1350; 2) the beginning of glacier advance and volcanic activity, AD 1350-1500; 3) the Little Ice Age, AD 1500-1900; and 4) the Modern Period, AD 1900-1990. Maps have been produced to represent each period; they show the positions of farms which have survived far more than a thousand years, and churches that have been overwhelmed by catastrophic geomorphic processes, the positions of the glacier termini, meltwater rivers, and main pasture lands. These reconstructions are based upon a mixture of physical evidence and folklore and historical documentation. Landscape evaluation is also described through the eyes of historic personalities who lived at Skaftafell.

Survival of a rich culture in this region is remarkable in face of a series of almost overwhelming disasters. Today the biggest threat, or challenge and opportunity for sustainable development, is the vast influx of tourists to this region, one of the most isolated in the world. They are drawn to Skaftafell through the establishment of a National Park in one of the most scenically dramatic and beautiful landscapes in the world.

RESUMEN.- La antigua granja de Skaftafell, que data del periodo de Sagas de la Historia islandesa se ha tomado como el eje en torno al cual gira la explicación de los cambios climáticos y paisajísticos que han tenido lugar desde el primitivo asentamiento del siglo IX hasta el presente. El estudio de la evolución del paisaje se divide en cuatro periodos principales: 1) El Periodo de Sagas, 874-1350; 2) El principio del avance glaciario y la actividad volcánica, 1350-1500; 3) la Pequeña Edad del Hielo, 1500-1900; y 4) el Periodo Moderno, 1900-1990. Se han elaborado mapas que representan cada periodo; muestran las posiciones de las granjas que han sobrevivido más de un millar de años, y las granjas e iglesias que han sido destruidas por procesos geomórficos catastróficos, las posiciones de los frentes glaciares, los ríos alimentados por la fusión de los hielos y las principales tierras de pastos. Estas reconstrucciones se basan en una mezcla de evidencias físicas y de documentación

¹ Received March, 1991.

* Department of Geography, University of California, Davis, Davis, California 95616 USA.

folclórica e histórica. La evolución del paisaje se describe también a través de los ojos de personas históricas que han vivido en Skaftafell.

La supervivencia de una rica cultura en esta región es muy notable teniendo en cuenta la serie de destructivos desastres que han acontecido. Actualmente la mayor amenaza, a la vez que desafío y oportunidad para un desarrollo sostenido, es la gran frecuentación turística en esta región, una de las más aisladas del mundo. El turismo acude a Skaftafell atraído por la creación de un Parque Nacional en uno de los paisajes más hermosos del mundo.

RESUME.- L'ancienne ferme de Skaftafell, qui date du temps de Sagas de l'Histoire de l'Islande, est l'axe autour duquel tourne l'explication des modifications climatiques et du paysage qui ont eu lieu depuis les premiers peuplements du IXème siècle jusqu'à nos jours. L'étude de l'évolution du paysage est divisée en quatre périodes principales: 1) la période de Sagas, 874-1350; 2) le début de l'avancée glaciaire et de l'activité volcanique, 1350-1500; 3) le Petit Age Glaciaire, 1500-1900; et 4) la Période Moderne, 1990-1990. Des cartes représentant chaque période ont été élaborées; elles montrent la situation des fermes qui ont survécu pendant plus d'un millier d'années, ainsi que les fermes et les églises qui ont été détruites à cause de processus géomorphiques catastrophiques, la position des fronts glaciaires, les fleuves alimentés par la fonte des glaces, et les principales terres de pâturage. Ces reconstitutions sont basées sur un mélange de preuves physiques et de documentation folklorique et historique. L'évolution du paysage aussi est décrite, vue par les yeux de personnages historiques qui ont vécu à Skaftafell.

La survie dans cette région d'une culture très riche est un fait remarquable, si l'on tient compte de toute la série de désastres qui l'ont ravagée. Actuellement, la menace la plus importante, qui est cependant aussi un défi et une possibilité de développement soutenu, est la grande fréquentation touristique de cette région, l'une des plus isolées du monde. Les touristes viennent à Skaftafell attirés par la création d'un Parc National dans l'un des plus merveilleux paysages du monde.

Key words: lanscape, climatic fluctuations, volcanism, touristic impacts, southeast Iceland.

Today, the southeast coast of Iceland, from the old farm of Núpsstadur, situated beneath the great crag of Lómagnúpur, eastward to the thriving little town and por of Höfn í Hornafjörður, could be considered amongst the most desolate areas of the inhabited world. Here, in a narrow, irregular and broken strip of land, about 120 kilometers from west to east and in places as little as three kilometers wide between the great ice cap of Vatnajökull and the grey Atlantic, shelter a few hundred Icelanders in scattered farms. The farms are the focal points of patches of emerald green, almost lost amongst the great glaciers, glistening snowfields, and the vast tracts of boulders and sands, fed incessantly by the meltwaters of the ice cap (Figure 1).

Öraefajökull, a dormant, ice-enshrouded volcano, which forms Iceland's highest summit (Hvannadalshnúkur, 2.119 m, part of the crater rim), is the dominating landform. Vatnajökull almost reaches to the sea on each side of Öraefajökull: in the outlet glacier of Breidamerkurjökull and its outwash plain to the east, and in Skeidarárjökull and its outwash plain to the west. In

CLIMATIC FLUCTUATIONS AND VULCANISM IN S.E. ICELAND

between lies Öraefi, a district of the county of Austur-Skaftafellssýsla, which takes its name from the almost legendary farm of Skaftafell, with its antecedence extending back into the early days of the Settlement of Iceland after AD 874.

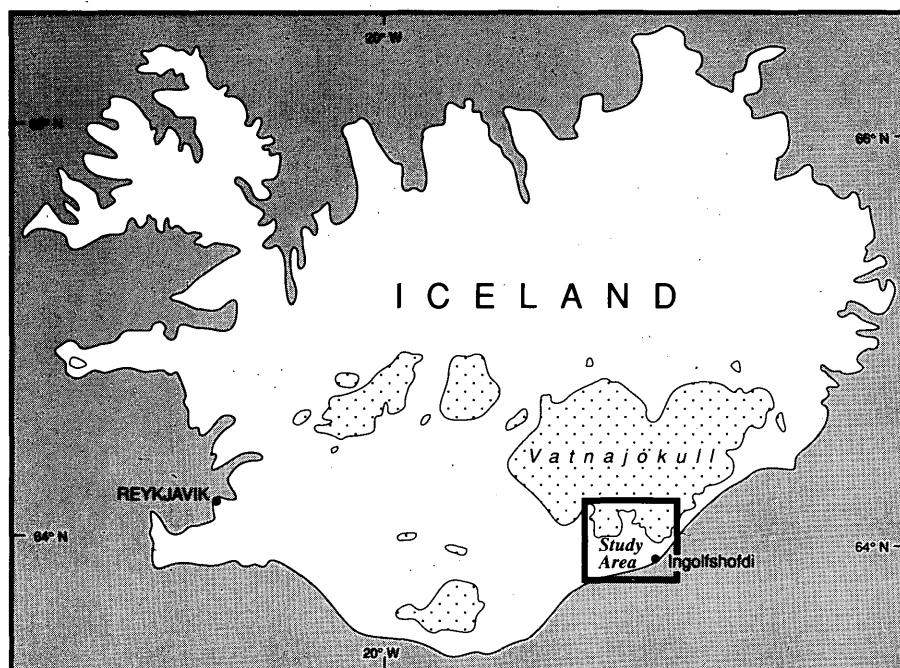


Figure 1: Location map: Vatnajökull and southeast Iceland, with inset map of Iceland.

Skaftafell and its neighboring groups of farms, Svínafell, Hof, Fagurhólsmýri, Knappavellir, and Kivísker, and the recently abandoned Sandfell, demark a horseshoe-shaped pattern of settlement at the foot of the volcano, in turn separated by the radiating tongues of a series of steep, cascading outlet glaciers. Views from Skaftafell take in the great expanses of outwash plain (Icelandic: sandur, pl. sardar), glaciers, distant mountains and ice caps, and the monotonous sandbar-encased marshes that merge with the ocean. The original name of the district was *Hérad milli sanda* (the district between the sands), and extensive old accounts indicate that for several centuries after the Settlement, it was prosperous and much more densely populated than today. The name "Öraefi" means "desert" or "land without life", and appears to have been introduced after the devastating eruption of Öraefajökull (then called Knappafellsjökull) in AD 1362. This single, catastrophic event, although repeated on a somewhat smaller scale in 1727, seemed to herald the onset of the Little Ice Age, conventionally dated to have persisted from about AD

1500 to 1900. The late Professor Sigurdur THORARINSSON (1938, 1956, 1957 a and b, 1958), more than any other person, has documented the Icelanders' "thousand years of struggle against ice and fire", and has produced a series of specific studies on the vulcanology, glaciology, and human geography of Iceland. But the great bulk of the relevant historic documents, the oral traditions, and the natural science evidence, remains to be collected and unravelled.

The recent acceleration of interest in world-wide climatic fluctuation and predictions of future climatic warming (the so-called "greenhouse effect") has also been reflected in renewed research on Icelandic material. OGILVIE'S (1981, 1984) assesment of the Icelandic climate from the sea-ice record up to AD 1780 is perhaps the most remarkable example, while GROVE'S (1988) masterly overview of the Little Ice Age in its global entirety, includes a most valuable summary and discussion of the Icelandic material. And there are many specific accounts of glacier fluctuation that deal with one or more individual glaciers (PRICE 1969, 1970; THOMPSON, 1988).

The intention here is to attempt a synthesis of what is known about Öraefi from the perspective of Skaftafell and its long unbroken line of farmers; to provide a tentative outline of climatic fluctuation, glacier response, volcanic eruption, and the human adjustments. This is perforce a mixture of human geography, glaciological investigation, sequential landscape assessment, with a measure of intuitive interpretation based upon forty years of acquaintance with Skaftafell and its people.

The distant past is clouded in uncertainty and can be perceived only dimly from myths that emerge from the Icelandic Sagas, and the local oral tradition. The very recent period, of course, is quite detailed. From 1931 onward, for instance, the positions of the glacier termini have been measured annually by the farmers, initially under the supervision of the late Jón EYTHÓRSSON (1963), and subsequently that of Sigurjón RIST (1984) and climatic records are available from the middle of the last century (Stykkishólmur station, western Iceland, 1850). In this context, the fact that mean annual and mean summer air temperatures began to fall after 1960, and many of the Icelandic glaciers began to advance after about 1965, and many were still advancing in 1987, is of more than passing importance. It has long been recognized (AHLMANN, 1949) that past climatic fluctuations have been characterized by progressively larger in-phase responses with increasing latitude in the North Atlantic region as a whole. Thus, the continuing advance of many of the Icelandic glaciers, within a generally perceived period of climatic warming, is worthy of more detailed attention for its own sake.

1. Historical setting

The Old Icelandic literature is remarkable in that it allows the most detailed understanding of a pre-Christian European society available. It also gives an extensive chronology of the actual settlement of Iceland between about AD

CLIMATIC FLUCTUATIONS AND VULCANISM IN S.E. ICELAND

874 and AD 930, naming most of the farms that are still identifiable on the current topographical maps, together with most of the local place names, as well as the genealogies of the principal settlers. It also provides a stirring account of the introduction of Christianity (MAGNÚSSON & PÁLSSON, 1960; ALLEN, 1971; MAGNÚSSON, 1984), and the subsequent downfall of the Republic. When later (post-AD 1300) church records, land registers, family histories, and local oral tradition are added, a broad outline of the establishment of the world's first democracy (with female suffrage), its waxing, waning, and eventual collapse, can be fashioned together with an understanding of the Little Ice Age centuries when human habitation was close to the total annihilation that occurred in Greenland. In fact, after the Laki Fissure (Skaftáreldar) eruption in 1783, close to one of the peaks of the Little Ice Age, the Danish Government contemplated the evacuation of the entire island.

Despite the unparalleled detail of the early documentation and the dramatic narrative of the Sagas, only a very general picture of climatic and landscape conditions emerge. And this needs to be supplemented with detail from other areas of the North Atlantic and the Alps (GROVE, 1988). Authenticated detail normally required by scientific journals is rarely available until the present century. Nevertheless, a reasonable outline can be drawn, and this has been attempted for Öraefi by reconstruction of conditions during four somewhat arbitrarily defined periods:

1. The Saga Period	AD 874-1350
2. The beginning of glacial advance and volcanic activity	1350-1500
3. The Little Ice Age	1500-1900
4. The Modern Period	1900-1990

Today one can stand in front of the Skaftafell farms and look southward along the western flank of Öraefajökull to an island-like tabular block of basalt that projects above the coastal marshes 30 km away. This is Ingólfshöfði, named for Ingólfur Arnarson, who ran his longboat ashore in AD 874 and became the first human to be recorded as wintering in Öraefi, and later founded Reykjavík (Landnámabok, I. 3.5-8). Some years after Ingólfur's historic landfall, one of the many other flotillas came ashore. In this case Thorgerdur, wife of Ásbjörn Heyanger-Bjarnarson of Sogndal, widowed during the sea-crossing from Norway, took in land according to the prevailing law; thus she led her two-year-old heifer on a spring day, between sunrise and sunset, from under Tóftafell, near Kvía in the southeast, as far as Kidjaleitur, under Jökulfell in the west (northwest). This entitled her to the great tract of land between the River Kvía (which drains from Kvíárjökull) and Jökulsá (later to be known as Skeidará) (Landnámabók IV. 15.2-4). She and her sons established Sandfell, which was abandoned as recently as 1935, and their descendants are associated with Knappavellir, Svínafell, and Skaftafell.

From *Njáls Saga* we learn about Flosi Thordarson (the burner), district chieftain, or *godi*, and his Svínafell establishment, and his brother, Thórgeir, who dwelt at Skaftafell. The sole survivor of the burning of Njáll and his family, the young man Kári Sólmundarsson, became preeminent at Breidá, to the east of Kvía. Other farms and churches, mentioned in the Sagas and early literature, include Fjall in the east, Raudilaekur, Freysnes, and Eyrarhorn, and an unnamed settlement north of Skaftafell in Morsárdalur (Jökulfell). All of these can be related to the period at least as early as AD 1000. And even if we accept the argument that the Sagas are only dramatic narratives of little historic authenticity, it is unlikely that a hero of Kári's stature would have been placed by the story teller in an inconsequential farm. Since Njál's Saga was written down during the thirteenth century, it can be concluded that Breidá was still a notable property at that time (this is of special significance as both Fjall and Breidá were subsequently overwhelmed by the Little Ice Age advances of Breidamerkurjökull and Fjallsjökull: see below).

Eiríkur Birkibeinn, who fought for Óraekja Snorrason against Earl Gissur in the battle of Kirkjugardinum (the graveyard), is firmly placed at Skaftafell in AD 1242 (*Sturlungasaga* - a strictly historical document) and his son and grandson, Ormur Eiríksson and Ormur Ormsson. The latter died at Skaftafell on 26th September, 1270 and had retained the family allegiance to the Sturlungs. The last in the succession, prior to the 1362 eruption of Óraefajökull, is Jón Sigmundsson. The gap of about 40 years after 1362, during which the whole of Óraefi is assumed to have been devastated and rendered uninhabitable, is difficult to bridge. However, Ragnar Stefánsson, the present farmer, refers to Jón Tómasson who "moved back to Skaftafell in 1402" and is presumed to have been related to Jón Sigmundsson on the maternal side, although no name is available for the mother. From Jón Tómasson the genealogy is fairly complete to the present day.

If we accept the presumptions and bridge the gap between 1362 and 1402, then we accept the claims that the present farmer can trace his antecedence into the myths of Njál's Saga, and to the reckonings of *Landnámabók*. But regardless of this, on a personal level this chronicle is the story of Ragnar Stefánsson. The names of the farm, Skaftafell, and of the man, Ragnar, are indelibly linked across a time-span far greater than normal families can usually contemplate. The possibility that some of the strict genealogical linkage may be in doubt hardly affects the spirit and intent of this narrative. The ebb and flow of Icelandic lore, and of the great scholarship and debate concerning the authenticity of the Sagas, together with the 1362-1402 hiatus, must be pointed out. These problems are not particularly relevant to the present purpose, however. Thus I chose to acknowledge the lack of strict historic authenticity and then adopt the broadest possible interpretation, one of *spiritual* continuity and of the physical continuity of a farm that was named over a thousand years ago; thus Ingólfur, Thorgerdur, Flosi and Njáll, Eiríkur, Ormur, Einar and Jón, Stefán and Ragnar, Laufey and Anna-María, are all real people. They are associated in time and place; they have lived, stood,

worked, hurt, rejoiced, and loved *and* survived in an almost incomparable spiritual descent of lineage, and in an inestimable landscape of stark beauty, danger, and challenge.

The device used here to depict the changing landscape dynamics is not a particularly original one. It involves the production of a series of descriptions, each one tied to the same locality; only the sense of time and space is allowed to vary, through the use of a succession of individuals from the thousand-year spiritual lineage. The place chosen for this purpose is Sel, a farm built in about 1840, and now abandoned - yet under preservation as an embryo museum. It is one of the group of three farms, including Bolti and Haedir, Ragnar's farm, that together comprise Skaftafell. Sel, in Icelandic means "sheep stall" or "saeter" or "chalet", or somewhat more broadly "alpage". The three homesteads, Sel, Bolti, and Haedir, were built between 1830 and 1850 since the original site of Skaftafell had to be abandoned when it was threatened by the ravages of Skeidará, the most destructive of the Icelandic glacier meltwater rivers. The distance moved was little more than a kilometer, about 100 meters higher up the green slopes of Skaftafellsheidi, above the plain, so that no significant change of place had occurred. Also, because of its name, Sel, it can be assumed that some form of building had existed on the site for a long time - probably a very long time - if only to house sheep; and without the sheep there would have been no survival of human habitation.

The most recent owners and active farmers of Sel left Öraefi in 1947. Ragnar and his family acquired the beautiful turf-roofed buildings and their tún (home field, or ley, fenced off from the sheep for hay production). Since Sel is situated only 150 meters from Haedir, the site of this narrative can be expanded to include the two. I lived in the partially abandoned Sel intermittently between 1952 and 1954. In the late 1950s the roof collapsed. Subsequently, with assistance from the Icelandic Government, it has been rebuilt with a view to establishing a small museum and remnant of traditional Öraefi in the center of what is now the Skaftafell National Park. The aspirations of those who have worked toward this goal have not yet been realized since the reconstruction is incomplete, the interior is only partially furnished, and the door is locked, despite the 24,000 overnight stays at the National Park campground by the mid- 1980s.

The widow of the farmer (Oddur) at Bolti moved to Reykjavík in 1952 and Jakob Gudlaugsson and his family moved in the following year as tenant farmers. Both farms, Bolti and Haedir-Sel, were purchased by the Government, assisted by a grant from the World Wildlife Fund, in 1968. This creation of a National Park and the progressive reduction in the number of sheep -now perceived in the national capital as a mayor environmental threat- may cause the lineage, which is the central theme of this narrative, to come to an end: upon the deaths of the present farmers, or before, should they choose to leave, farming will end and nature conservation will take its place entirely.

On a clear summer's morning the fortunate visitor to Skaftafell, pausing from assisting with mowing the hay in front of Sel, can look up, across the

roaring Skeidará, across Skeidarársandur (the western "sands" of Hérád millisanda) and its great glacier, Skeidarárjökull, onto the 700-meter precipice of Lómagnúpur 25 kilometers to the west. He will then understand the meaning of that beautiful piece of Icelandic cynicism that, if he is lucky, Ragnar, leaning on his scythe, may repeat for his benefit:

Fjarlaedin gerir fjöllin blá,
(The mountains are blue in the distance!)
Og mennina mikla

-the second half is more difficult for the linguistically inept. The literal translation would read "and men are great". Thus: while the distant mountains may appear to be blue, we know that they are not; and, likewise, a man from far away may appear greater than he really is. But the story of Skaftafell is a history of men and women, who are much greater than they may first appear. The word "history" is intended to convey an account of the changing dynamics of the natural setting as well as a narrative for the lives of the inhabitants- the two, of course, are inextricably interwoven for, while the forces of nature may appear as the dominants and for the most part seem to reign supreme, the act of survival is much more than a human counterpoint. Nor has it been mere brutal survival. The culture and hospitality of Skaftafell is legendary: just as the shipwrecked sailors of the eighteenth century would be welcomed to share the near-starvation on equal terms, so too those who attempted to cross the rivers on horseback in the better times of the 1930s, or those of the very different times of today, would be exhilarated by the kindness and warmth, and by the extensive understanding of nature and appreciation of history of the Skaftafellingar- the People of Skaftafell.

2. The Saga Period - AD 874 - 1300

Thorgeir Thordarson, brother of Brennu-Flosi, standing at Sel, his sheep pen, in the early morning light in mid-September: about AD 1010

The level plain to westward shimmered in the early morning light; it glinted, now purple, now green, almost, but not quite reflecting the great mass of Lómagnúpur that arched its long back 25 kms off. Still further west rose the slopes of Skálarheidi; further still, Hjörleifshöfði seemed to float in the sea, and to its north the gentle flanks of Mýrdalsjökull sparkled on high as they caught the first rays.

Thorgeir subconsciously absorbed the wide landscape that extended seemingly forever westward. Hard by, to the north, the mountain Jökulfell, from this angle a baffle to the great glacier from which it took its name, also anticipated the morning sun. The immediate foreground was a rich mixture of shaded greens: grass greens, willow greens, birch greens. The farmer-warrior leaned back against his sheep pen straining his eyes to see further

west. But the clearest possible light would not give him access to that which he sought, and this morning would rival most with its clarity. Only in his mind's eye could he grasp the long low shoreline beyond Mýrdalsjökull, with its small hillocks -the land islands, home of Njáll. He wrestled with the terrible thought that his brother, Flosi, had thrown out the previous evening. Could they possibly proceed with such a plan? Would they really use fire to overcome what they knew would prove a mighty resistance?.

Thorgeir's vantage point was a small grassy clearing surrounded by birch and willow, with the occasional rowan, about 200 meters above sea level and about half that above the plain. The purpose of the low turf and stone buildings, dug into the slope of the hill, was for temporary shelter for their sheep, penned after completion of the arduous task of herding them in from the wide heath above and the precipitous slopes of Kristínartindar, out of sight and behind his back to the east. A slight turn of his head brought into view the steely white domes of Knappafellsjökull (Öraefajökull) and the black rocks of Hrútsfjall, still in the shadow of the low easterly sun and to his southeast.

Again, as he contemplated the wide view, he struggled with the enormity of the deed that was so vividly anticipated. His thoughts drifted to his origins. Below the mountains and riding on the sea to the south, also like an island, counterpart to Hjörleifshöfði, stood the much nearer basalt promontory of Ingólfshöfði, named for Hjörleif's foster brother, Ingólfur Arnarson, the chieftain who had made the first landfall and overwintering over a hundred years previously. From Ingólfur his mind turned briefly to his great grandmother, Thorgerdur, who had driven her two-year-old heifer from Kvíá, over a distance of more than 50 km, to Jökulfell, in a single equinoctial day and had so claimed all the land that now supported such a prosperous community.

As the sun's rays began to illuminate the small grassy knolls around him and to turn them into vivid green, the edge of the purple shadow advanced toward him across the plain below, the rising sun progressively consuming it; rivers began to sparkle, green fields to shine, enhanced by the expanses of boulders and coarse gravel in between. Soon the entire view was alight and the air warmed noticeably: a whimbrel whistled on the heath.

He must return to the farm; this day would see the completion of the final hay-making of a long summer. Then the community would readily produce the forty armed horsemen destined to ride westward, to be augmented by others from Núpsstadur and points further west. It was imperative that, once contemplated, the deed be completed. Not a single survivor could be tolerated. Bergthórshvoll, Njál's farm, must be destroyed and the consequences not taken into account.

Commentary

Much has been written about the climate that prevailed during the "Saga Period", and much of this is speculation or indirect deduction. The sagas

themselves are disappointing in this respect, and even references to local vegetation are incidental. It is generally concluded that the climate was appreciably warmer than during the period AD 1300-1920 and, as evidence are cited the open sea lanes to Greenland and the eastern coasts of North America, the fact that the barley ripened regularly in Iceland, the location of the actual farmsteads and churches in relation to the present limits and Little Ice Age limits of many of the glaciers, and so forth. But as OGILVIE (1984) points out, other environmental factors also would probably have been more favorable to agriculture: for instance, soil fertility, and actual extension of the soil cover, and the very large area occupied by birch forest and birch shrub prior to human occupation. After the Settlement extensive burning and clearing of the forests, and probably early overgrazing, induced rapid erosion of the friable volcanic soils. Ogilvie also draws attention to the occurrence of occasional decades with severe weather, referenced to extensive sea ice. A further complicating factor is the irregularity in frequency and magnitude of volcanic activity.

Despite these qualifications the Saga Period as a whole was very mild compared with the following centuries, and an attempt can be made to depict the approximate conditions that would have faced Thorgeir in AD 1010 as he looked westward from Skaftafellsheidi. This is shown graphically in Figure 2. Its somewhat intuitive construction hinges on the reasonably well-known sites of several farms and churches which today could not exist: these include Breida and Fjall in the east of Öraefi, and Raudilaekur, Eyrarhorn, Freysnes, and "Jökulfell", closer to Skaftafell. The location of these subsequently abandoned farms and churches leads to an approximate reconstruction of the margins of the glaciers, and also to a realization that Raudilaekur and Eyrarhorn could not have existed at all if the great glacier river, Skeidará, had followed anything like its present course let alone had it been subjected to the spectacular flooding following the outbreak of glacier-dammed lakes (Icelandic: *jökulhlaup*). These jökulhlaups are well documented from about 1820 until present, and somewhat less well documented during the eighteenth century and earlier. This in turn indicated a much smaller and thinner Skeidarárjökull during the early centuries. These issues will be discussed in more detail below. But, whatever the reasons for its subsequent collapse and near annihilation, Öraefi, before AD 1362 known as Hérád milli sanda, or in some sources as Litlahérád, was a thriving district with at least seven churches and between thirty and fifty farms, twenty-five of which are known by name (THORARINSSON, 1958). Today only 23 farms in six clusters remain. Certainly some birch forest existed until well into the Little Ice Age and, indeed, one small remnant, Baejarstadarskógur in Morsárdalur, has survived until today.

There is much local folk lore concerning both the glaciers and the birch forest, and frequently-travelled routes across the present-day site of the great ice cap of Vatnajökull. Admittedly, much of this is rather vague and cannot be placed in a proper chronology; nonetheless, it adds to the inference

CLIMATIC FLUCTUATIONS AND VULCANISM IN S.E. ICELAND

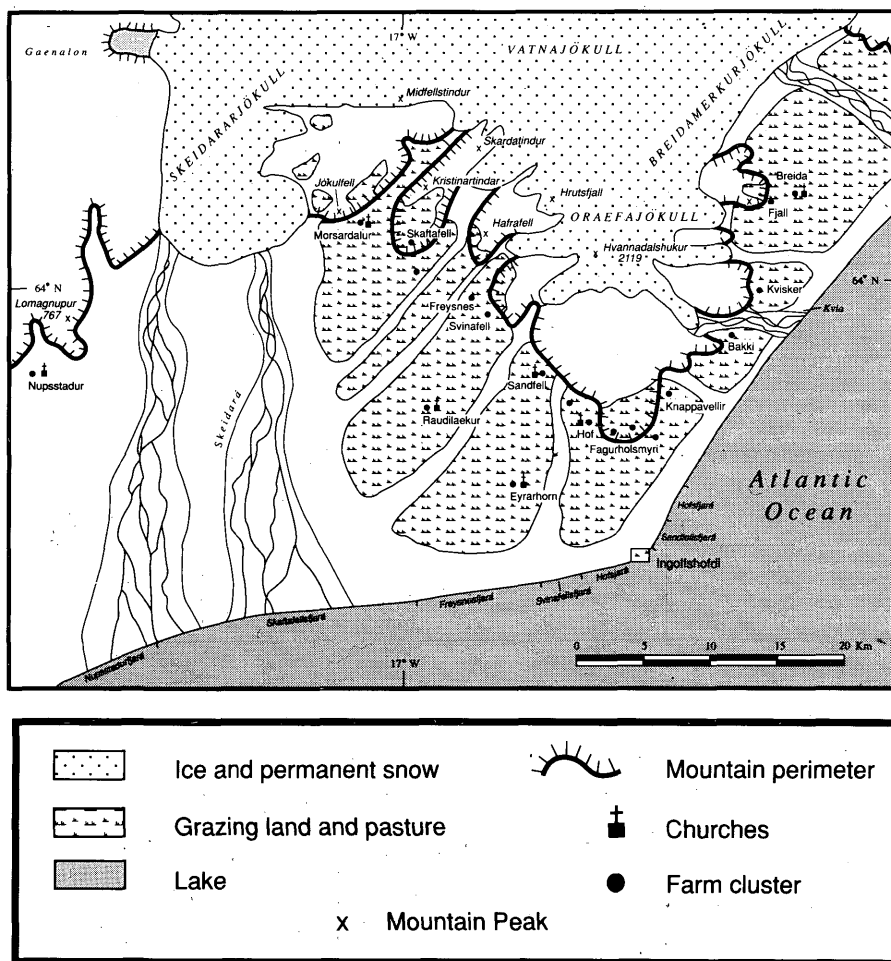


Figure 2: Oraefi: The saga period - AD 874-1300: Period I: Schematic map showing conjectured extent of glaciers and grazing land and the sites of former and existing farm groups and churches. (The same legend for Figs. 5, 6 and 12).

of prosperity and much more favorable landscape conditions. Thus there is widespread assumption amongst the local people that the glaciers were much less extensive than they are even today after the massive thinning and retreat that occurred between 1890 and 1965.

There is a long tradition in the history of Skarðafell that the farmers of Mördudalur, to the north of Vatnajökull, had an agreement to cut birchwood from Bæjarstadarskógur in return for allowing the Skarðafell farmers to graze horses on their land. This issue fascinated Sveinn Pálsson, father of Icelandic

galciology, in the late eighteenth century. In the Skaftaffell tradition several sacks of birch logs were found in a small valley, appropriately named Birkidalur (birch valley) high above Morsárjökull and beneath the pinnacle of Skardatindur. Pálsson believed he had found an artificially constructed 'road' cut into the south face of Midfellstindur (north of Morsárjökull) by which the horses were led onto the ice cap (Figure 3), but no living person has found any trace. My own and my colleagues' attempts in the early 1950s to traverse the Midfellstindur and Birkidalur routes produced only amazement that such an undertaking would ever have been contemplated on foot, let alone with horses. Yet, even if the story is true, I cannot conclude that a warmer climate, and hence a reduced ice cap volume, would have made the journey any easier. In an entirely different setting, birch logs collected by Ragnar Stefánsson and carefully preserved since the 1930s, were radiocarbon dated at 2020 ± 80 BP (Lab N.º GX-13965). They were found close to the terminus of Skaftafellsjökull deposited with gravel and boulders by glacial meltwater from beneath the glacier as part of the outwash and subsequently exposed by local stream down-cutting. There was a sufficient quantity to be "mined" locally for fuelwood for some years. This discovery was perceived to be the remains of a birch forest, part of the local Svínafell and Skaftafell folk lore that maintained that the terminus of Skaftafellsjökull had been 4 - 6 km behind its 1930s position and that Morsárjökull had been virtually non-existent below the main ice falls of today. This belief, and it certainly deserves careful consideration, would indicate that glaciological/climatic conditions were considerably more favorable to human settlement than during the warmest decades of the twentieth century. Thus we had anticipated a "Saga Period" or "Settlement Period" age for the birch logs; the 2020 BP ^{14}C date raises more questions than answers, but certainly indicates that a fuller investigation is warranted.

A final point concerning Figure 2 is the persistence, through hundreds of years, of the ownership names of the Óraefi foreshore. It is remarkable that, despite changes in the position of the shoreline, and of the major meltwater rivers, the shoreline divisions have remained intact. As farms and churches disappeared, the surviving farms accumulated additions to their shoreline ownership. Skaftafell benefitted especially from this process acquiring the shoreline that originally belonged to the Morsárdalur farm, "Jökulfell", and that belonging to Freysnes, presumably following the 1362 Óraefajökull eruption, but possibly later. This resulted in Skaftafellsfjara (the shoreline of Skaftafell) extending over a distance of nearly 15 km. The importance of legalized restrictive access to sections of the shoreline is related to the shortage of large timber, a shortage at least partly filled by flotsam in the form of mature trees from the Eurasian north coast, and of wreckage from stranded ships. The case of a Dutch East Indiaman, the Wapen, wrecked on Skaftafellsfjara in 1667 is perhaps the most dramatic example. The ship was reported to be carrying a large treasure of jewels, precious stones, copper, and silks, as well as gold and silver specie. The Crown laid claim, and

CLIMATIC FLUCTUATIONS AND VULCANISM IN S.E. ICELAND

probably some treasure was salvaged illegally, although a modern technological search for the long buried hull has been underway for the last twenty years. If this is ever successful a proportion will revert to Ragnar



Figure 3: The south face of Midfellstindur (1.430 m) as seen in 1987. A Skafafell legend maintains that a route for men and laden horses from Skafafell to Modrudal traversed the face of Midfellstindur and proceeded onto Vatnajokull.

Stefánsson. And in 1987 I witnessed a contest over the demarcation between Skaftafellsfjara and Núpsfjara, that is still in progress. It is especially interesting that the traditional demarcation, based upon line of sight alignment to prominent mountain pinnacles north of Lómagnúpur, probably dates from a thousand years ago. In this case the motivation behind the contest is not clear. Nevertheless, fishing net floats and related equipment that are being brought ashore constantly by the tide are recovered for resale in Reykjavik. And the large timbers (Figure 4) are being harvested to provide some of the main support beams for a new hotel at Freysnes that Ragnar Stefánsson and his family are building.



Figure 4: Timbers on Skaftafellsfjara awaiting transport to Freysnes for use in construction of the new hotel - a gift from Siberia, based upon centuries old formal allocation of stretches of the coastline.

Eiríkur Birkibeinn, AD 1242: Mid-Winter

Eiríkur had walked up the hill from the farm to pause, lean against the sheep stall, and give vent to his anger. While the battle at Kirkjugardinum (graveyard) had gone well, and he had been expressly commended by Öraekja Snorrason, son of Snorri Sturluson, the district of Hérad milli sanda had not prospered during the long period of upheaval. The rich plains had

produced well, and the luscious green heaths had supported all the sheep, and more. Too often, however, was the work force reduced in response to the cry to arms, and too often, on their return, there were fewer than had set out. Without many hands the offerings of a bounteous nature seemed to be perpetually cast aside. Where will it all end?

The low winter light barely broke through the mists that overhung the plain to the west. It was nearly midday and there was only a hint of the sun low over the ocean to the south and almost invisible through the great bank of fog that had rolled in to enshroud Ingólfrshöfði. At least the autumn had been warm and long, and the sheep and cattle still had plenty of open grazing. New snow only capped the upper tent peak of the Jökulfell and the far higher crests of Hruttsfjall at the opposite extreme of his view.

Commentary

Other factors than nature obviously affected Skaftafell and its people. The social and economic disruptions of the Sturlunga Age led to the downfall of the Commonwealth and the incorporation of Iceland under Norwegian sway in 1262-4. Danish rule was established over both Norway and Iceland in 1360. As Magnusson relates (S. A. MAGNÚSSON, 1984: 106):

"By 1400 much of the old culture and way of life was extinct in the daily life of the nation, even though it might linger on as a distant memory and a dream. Foreign rule was now an established fact and the church had a stranglehold on the people. Living conditions had greatly deteriorated and the Icelanders were entirely dependent upon foreign trade".

3. The beginnings of glacier advance and volcanic activity ad 1300-1500

Jón Tomásson: AD 1402: An Evening in May

Jón rested wearily against the sheep stall and gazed out across the plain. A chill breeze swept in from the sea and clouds were baked up high on the leading edge of Jökulfell, extending rapidly, beyond his view, into Morsárdalur. The once rich farmland below the mountain of the glacier would remain a ruin; its church would never be rebuilt. Lómagnúpur was lost to view and, beneath its sombre awning of cloud and rain, the dirty blue-black ice seemed to threaten.

He had worked all day raking piles of pumice. The winter, although long, cold and wet, had at least done a lot of their work for them by washing off much of the suffocating ash from much more of the plain and the hillslopes. To the southwest on the plain, remnants of farms and churches were clearly visible in the translucent light beneath the rapidly spreading cloud base. Hérad milli

sanda lived on, barely, as some kind of legend. That the legend was based upon fact was clearly evident from the ruins of the former habitations, and from the treacherous morass between Sandfell and the remnants of Eyrarhorn, which was appropriately named Svartijökull - black glacier. But overall, Öraefi -the lifeless land- seemed a likely name for the district.

The small but growing tracts of emerald green, hard back against the mountain slopes, and now identifying the sites of Skaftafell, Svínafell, Sandfell, and Hof, all that remained on this side of the volcano, only served to emphasize the brutality of the eruption of Knappafellsjökull some 40 years ago. It was small comfort that the newest building at Skaftafell had been roofed with the fine stout center beam from the main house at Freysnes. The devastation amongst which they lived was still all pervasive; the newly returned were changed people; their very outlook was different. It seemed that even the climate was changing: a long succession of cold wet winters and cloudy summers. Although they had reoccupied Skaftafell only three years ago, and were now confident that they would succeed in making a living from this wasteland, it seemed that the great glacier between Jökulfell and Lómagnúpur was decidedly closer. Those above Sandfell had reformed after the heat of the volcano in 1362, and old men claimed that they had crept closer to the plain than they had been before the eruption. While it was the heat from the volcano that had caused them to advance so catastrophically and to send down torrents of hot water and mud from the high slopes on that fatal day in June 40 years ago, something else was causing the infinitely slower but still threatening advance today. It must be the longer winters, with all their heavy snowfall high on the slopes, together with the cooler summers during which less ice and snow was able to melt. And behind all this were two numbing thoughts: The Commonwealth was no longer free but, because of the incessant family feuding, had been engulfed into the politics of Norway and Denmark; and, perhaps of more immediate concern, when would the volcano erupt again?

Commentary

Figure 5 is an attempt at reconstruction of conditions as they are perceived to have obtained in the early part of the fifteenth century. Undoubtedly, the single most dramatic change in the landscape and life of Öraefi accompanied the explosive eruption of Öraefajökull (originally Knappafellsjökull) in AD 1362. Extant accounts are terse and contain little detail. However, the much more exact descriptions of the somewhat smaller eruption of 1727 by Jón Thorláksson, priest at Sandfell, and the tephrochronological reconstructions of THORARINSSON (1956, 1957a) provide a grim picture indeed. Thorarinsson concludes that the 1362 eruption was the biggest in Iceland in historic times, ranking third in postglacial times, and the largest in Europe since the destruction of Pompeii by Vesuvius.

CLIMATIC FLUCTUATIONS AND VULCANISM IN S.E. ICELAND

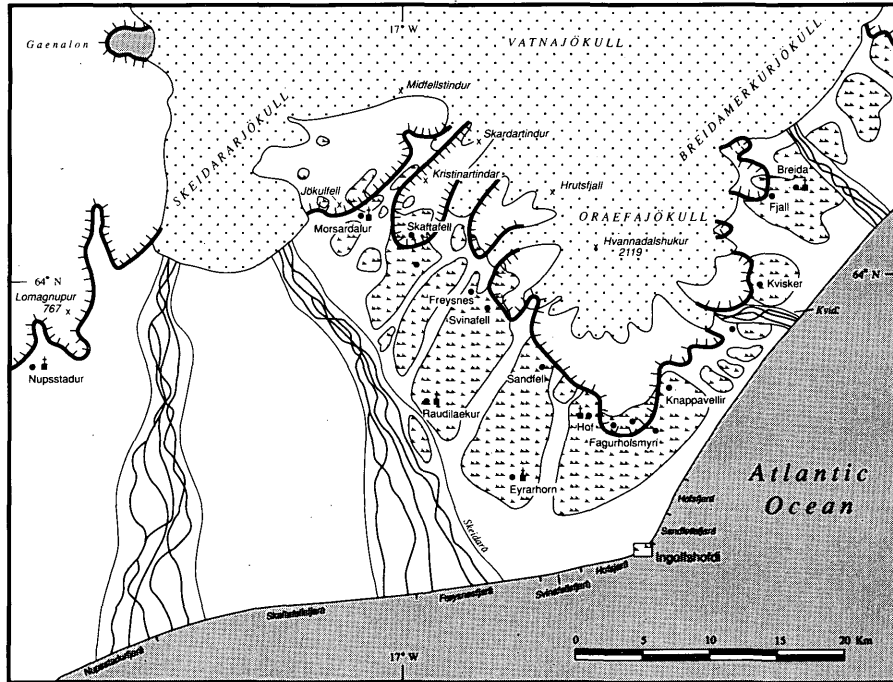


Figure 5: Oraefi: The beginnings of glacier advance and volcanic activity - AD 1300-1500: Period II: Schematic map showing conjectured extent of glaciers and grazing land, and the sites of former and existing farm groups and churches.

While torrents of hot mud and water, pouring down from the Óraefajökull outlet glaciers, would have caused much total damage, and several of the glaciers themselves seem to have surged catastrophically onto the farmlands, Thorarinsson calculated that 10 km^3 of ash was deposited. Most of Hérad milli sanda and its farms and churches were likely buried in ash and deluged by volcanic bombs. The extent of the devastation is documented in several church annals. For example, the Skálholt annals in 1362 describe:

"Eruptions in three locations in south Iceland, which lasted from mid-June until autumn. They were of such an extent that Litlahérad and large sections of the districts of Hornafjörður and Lón (to the east) were devastated. Due to the eruptions of Knappafellsjökull, mud and debris were washed into the sea, building up a sandbank where the sea was previously thirty fathoms deep. The parishes of Hof and Raudílaekur were completely destroyed -in the lowlands the ash was knee-deep and accumulated in large dunes so that houses were hardly visible any more".

There is no information about deaths or injuries, but it has always been assumed by the local people (pers. comm. Ragnar Stefánsson) that the entire district was rendered uninhabitable and remained deserted for about forty

years. Upon the return of people to the once prosperous Hérad milli sanda (or Litlahérad), the new name, Öraefi (desert, of lifeless land) was adopted. While there is some evidence for initial reoccupation as early as the 1380s, Skaftafell appears to have been rebuilt by Jón Tómasson and his family nearly forty years after the eruption. That the hiatus in the settlement is not more than twenty to forty years is supported by the survival of the shoreline ownership patterns as well as the place names themselves. Skaftafell appears to have acquired not only the shoreline sections that previously belonged to the Morsárdalur farm and to Freysnes, but also what remained of the actual farm lands. Perhaps most important of these was the birch forest, Baejarstadarskogur (the forest-skógur = near the place of the farm), in Morsárdalur. And these properties and surrounding mountains and glaciers remained as part of Skaftafell until the present century the establishment of the national park in 1968.

The devastation of a major eruption certainly did not totally eliminate the Öraefi settlements. Nonetheless, whatever the lapse of time that might have been required for fuller restoration, such was offset by the approach of the little Ice Age. There are indications that glaciers were advancing by the end of the fourteenth century. OGILVIE (1984), also, basing her conclusions on references to the distribution of sea ice, describes the second half of the century, particularly the 1350s to 1380, as experiencing colder climate with many long and severe winters. The last two decades may have been rather mild. There is a scarcity of reliable or detailed sources for the entire fifteenth century, however, and it is difficult to choose a rational "starting date" for the Little Ice Age. I have chosen AD 1500 in conformity with reconstructions of climate in the Alps (PFISTER, 1981; GROVE, 1988).

4. The Little Ice Age: 1500-1900

Jón Einarsson, 1787: Mid-Summer's Night

Jón stamped his grandfather's seal on the still warm wax and, with a sigh, finally acknowledged that the letter to the Governor of Iceland, a representative of the King, while an act of audacity by a mere tenant farmer, was nonetheless essential. The 1727 eruption of Öraefajökull, while not so disastrous as the earlier one, had cost the farmers of Öraefi dearly. Skaftafell had been abandoned, if only briefly, by his grandfather and namesake. The dammed priest at Sandfell, never satisfied to share their hardships, had complained to Skálhot that a living from the Öraefi parish was no longer possible and, for his pains, the bishop had added to his direct income the entire excess earnings of Skaftafell. This situation had persisted for over fifty years. Then in 1740 a terrible fishing accident in the surf east of Ingólfshöfði had claimed the lives of most of the able bodied men of the district. Fortunately his father, Einar's, strange foreboding had prompted him to be late for the launching and he had

arrived only to witness the confusion in the pounding surf. In addition the King had issued a proclamation only eleven years previously to the effect that all Icelandic farmers were obliged to build stout walls around their home fields as the most effective way of keeping the sheep out of the hay as well as holding off trespassers: heavy fines were the prospect of non-compliance. Finally, a succession of cold wet winters and atrocious summers had reduced his family to hunger; and the glaciers appeared to be moving forever closer.

With the cares of his family -and curses on Church and King- lying heavily upon him, Jon climbed the slopes of the heath to his favorite resting place and look-out, a hundred metres above his farm buildings. It was a rare warm night: the uppermost slopes of Öraefajökull reflected a soft pink light from the high, flushed mackerel sky; shafts of light from the north struck the quiet bulk of Skeidarárjökull. It was an old folks tale that his ancestors, from the very spot where he sat, had been able to see Lómagnúpur extending high above the mass of ice. If that were true then conditions had certainly changed, for it was now necessary to take a horse and ride half way across the sandur toward Núpsstadur before that mighty cliff came into view, or else climb high up the heath onto Skerhóll behind him. And it seemed that, not only Skeidarárjökull, but also Morsárjökull, Skaftafellsjökull, and Svínafellsjökull would continue to expand and reduce the chances of their survival. Even worse were the jökulhlaup.

Only three years ago, in April, another jökulhlaup had occurred. It had cut a great swath from the westernmost section of his grazing land out on the plain. It seemed that the giant jökulhlaup came about once every ten years and that, with each one, the middle of the sandur had grow higher from the heavy deposit of boulders and sand, pushing Skeidará ever eastward against the farmland.

Jón and his brother, Eiríkur, had discussed the growing emergency all winter long. Of course the glaciers moved -like so much pitch, under their own weight. But it also seemed that some great force was pushing them from behind, and that they were actually sliding over their beds - perhaps it was the great weight of snow that accumulated each winter and slowly changed into ice as it partially melted and froze again. That would be something to explain to Sveinn Pálsson when he extended, as he had promised, his naturalist surveys to Skaftafell. Jón's father, Einar Jónsson, had been caught on the glacier during the hlaup that had occurred in 1774. He had been on his way to Faerines to try to surprise some of his sheep that he had not been able to catch the previous summer. He had actually felt a terrible movement in the glacier, and a heaving motion. Fortunately, he had been able to get off and climb back over the ridges above Langagil and into Réttargilsdalur before anything worse had happened. By the time he had got home "she" (local usage in referring to Skeidará) had spread her banks, and the plain was almost entirely submerged by her roaring waters. Worse still the air was foul with the smell of sulphur, killing off birds and some of the vegetation, and great masses of ice, up to 70 meters thick, had been broken off the front of

the glacier and driven southward by the flood waters. If the good doctor wished to write a book about the mysteries of nature, he surely deserved help from the farmers who had to live with the glaciers and their rivers. Yes, of course they moved. Had he not seen them move? His father had indeed felt them move.

Despite such worries and anxieties about how his letter would be received by the King's man a Bessastadir, this mid-summer night convinced him that it was good to be alive. His family was part of this land and had been since the Settlement. They had maintained it, and themselves; at times it was hard and brutal, but it was also beautiful. Nevertheless, perhaps his brother, Eiríkur, was right in asking how much longer would the glaciers continue to advance and how much more of their land would be stripped away by Skeidará. If conditions continued to deteriorate they would have to think about moving the farm building themselves up onto the slopes. Perhaps this old sheep stall should be torn down and new farm buildings erected here - at least this site would provide a wonderful view far across the sandur, and all the way to Mýrdalsjökull, 100 km on a clear day, and would be far removed from the raging waters of Skeidará.

Commentary

The eighteenth century must have presented conditions such that the people of Skaftafell and their Óraefi neighbors to the south, were reduced to the utmost extremity in their efforts to survive. Óraefajökull erupted again in 1727; the Laki fissure eruption (Skaftáreldar) of 1783 is credited with pushing the entire Icelandic community close to extinction; the depredations of Danish governance and the demands of the Church added further heavy burdens. This century also witnessed a Little Ice Age maximum with the glacier termini close to their post-glacial greatest extent. And major jökulhlaup not only overran the sites of Eyrahorn and Raudilaekur at approximately decadal intervals (Figure 6), but Skeidará had been shifting progressively eastward and was now clearly reducing the westerly grazing lands of Skaftafell, Svínafell, Sandfell, and Hof. Some clear instances of glacier advance are provided by the church and land registers, from the accounts of travellers, such as Sveinn Pálsson, and from local oral tradition.

Skaftafell again provides a dominant personality in the form of Einar Jónsson, and the three generations (including both his father, Jón Einarsson, and his sons, Jón Einarsson and Eiríkur Einarsson) leave us with clear indications of learning, culture, artistic and technical skills, and an understanding of natural processes that are remarkable. The strong presence of Einar also allows us insights into the local traffic with trolls and trollwives and an interesting mix of Christianity and relic Irish and Old Norse beliefs. But for someone who has at least heard a trollwife throwing rocks on a still, lonely night in Morsárdalur, this apparent inconsistency is understandable.

CLIMATIC FLUCTUATIONS AND VULCANISM IN S.E. ICELAND

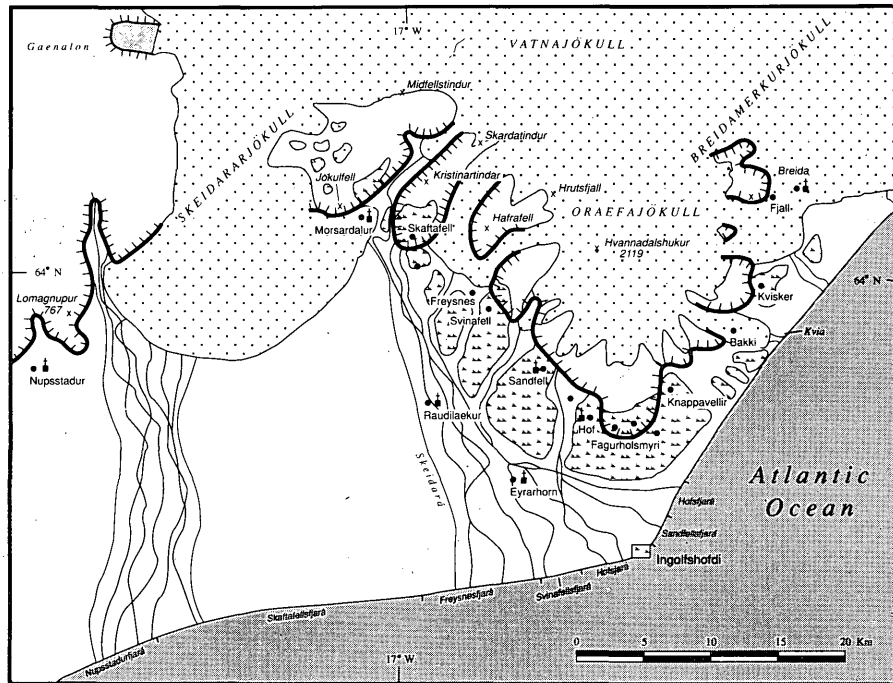


Figure 6: Oraefi: The Little Ice Age - AD 1500-1900: Period III: Schematic map showing maximum extent of the glaciers, the acute reduction in the useful land on the sandur, and the remnants of the Oraefi settlements.

No certainty can be attached to attempts at a precise delineation of the extent of the Óraefi glaciers during the eighteenth century. A very good approximation, nevertheless, is possible. In general, significant glacier advance occurred in the early and middle parts of the century, and THORARINSSON (1943:47) believed that most Vatnajökull (including Óraefajökull) outlet glaciers reached their maximum, or near-maximum, extent shortly after 1750. Some of the most significant data are available from repeated references to the farms of Breidá and Fjall in eastern Óraefi.

It has already been pointed out that Breidá, situated close to the foot of Breidamerkurfjall, was chosen by the unknown author of Njals Saga as the homestead of Kári, an indication that it was a prestigious property as late as the end of the thirteenth century when the saga was committed to written form. The church registers demonstrate the existence of a substantial farm and church. Its location is derived, in part, from the name of a prominent summit of the Breidamerkurfjall group (its name, Míðaftanstindur, indicates its use as a fixed point for local land ownership delineation—that is, during equinox, the sun would be exactly over the summit as seen from the farm at 6:00 p.m., therefore due west). Two kilometers west of Breidá the other farm,

Fjall, was located, while a third, Bakki, as well as the extant farm of Kvísker, lay further south. Bakki, of which no trace remains, appears to have been situated close to the outermost end moraines of Kvíárjökull and would likely have been destroyed by the early eighteenth century advance, if it had been reoccupied following the 1362 eruption. Local place names around Fjall and Breidá, such as Hrossadalur (horse valley) and Geldingadalur (wether valley) indicate normal accessibility of mountain valleys that were blocked by the confluence of Breidamerkurjökul and Hrútárjökull, according to the glacier margins surveyed in 1901-2 and published as the 1904 edition of the Danish General Staff map, scale 1:50,000. The 1901-2 glacier extent was at least equalled, if not exceeded, by the early eighteenth century advance at which time Breidá and Fjall would have been overrun. The most recent topographical map, a 1979 revision based upon air photographs taken between 1961 and 1969, shows the site of Breidá to be beneath the waters of the proglacial lake, Breidárlón, and that of Fjall, while once more uncovered, uncomfortably close to the glacier margin. The site is also cut off from the new automobile road by other lakes and large meltwater rivers. It is most probable that for the two farms and church to flourish, conditions would have had to be much more favorable than even those of today. It is also unlikely that the present-day large ice-dammed lake on the northeastern margin of Breidamerkurfjall could have existed as the resulting jökulhlaups would have annihilated Breidá at least.

Breidá and Fjall most likely suffered the general fate of all the Öraefi farms and churches during the 1362 eruption and were probably abandoned for several decades. In 1387 there is a reference to the Breidá church having lost its ornaments and indicating that the farm was without livestock. Farming activity was certainly underway in 1525, and there is a similar reference to 1587. However, a 1708-09 land register comments that "fourteen years ago the tún (home field) and ruined buildings (of Fjall) were still to be seen, but everything is now covered by ice". Breidá appears to have been abandoned by 1698. It is even claimed that at that time the tombstone of Kári Sólmundarsson could be seen in the ruins, but had been covered by ice by 1712. Breidamerkurjökull and Hrútárjökull must have united in the vicinity of the two settlements between about 1700 and 1710.

Similar reconstructions can be made from information from Skaftafell and Svínafell, as well as from Nüpsstadur. Hafrafell (rams' mountain) is the steep ridge that today separates Skaftafellsjökull and Svínafellsjökull (Figure 17). It provided summer grazing for the farm of Freysnes. Isleifur Einarsson's land register of 1708-09 claims that access by then was prohibited by the advance and confluence of the two glaciers (quoted in GROVE, 1988:43); similar references are available for 1746. Ragnar Stefánsson (pers. comm.) believes that Freysnes actually ceased to exist after the 1362 eruption so that the grazing access refers to the Skaftafell and Svínafell farms, as is the case today. In any event, it is certain that Skaftafellsjökull in 1700 and 1750 was about 2 km more advanced than it is today.

There are also many references to the western sections of Skeidarárjökull, both from Núpsstadur and from travellers crossing Skeidarársandur during the late seventeenth and the first half of the eighteenth centuries. Skeidarárjökull certainly thickened and advanced appreciably, but volcanic activity in Grímsvötn and jökulhlaup activity render direct climatic extrapolations impossible. Perhaps the most important changes were brought about by the jökulhlaups and the related Grímsvötn eruptions.

Ragnar Stefánsson's family have maintained a record of jökulhlaup (Skeidarárhlaup) occurrences from the middle of the last century and incomplete references are available for the preceding several centuries. Until the late-1930s the interval between jökulhlaups was almost constant at 9-10 years, and Grímsvötn eruptions seem to have accompanied each event. THORARINSSON (1953) hypothesized that the release of the vast volume of meltwater in the Grímsvötn depression was the actual triggering mechanism for the eruption rather than the reverse. The recurrence interval and magnitude (volume of water released) are believed to be dependent on the thickness of Skeidarárjökull, and thus, in turn, related to climate. With the pronounced thinning and retreat of Skeidarárjökull during the 1930s and 1940s, therefore, smaller hlaups at shorter intervals have prevailed. Since the 1954 medium-sized hlaup, the floods have been relatively insignificant: at least the Icelandic government was prompted to bridge the Skeidará in 1971 thereby closing the last gap in the island's coastal highway. Nevertheless, massive hlaup protection barriers were deemed advisable, although no significant damage has been incurred. Skaftafell since has enjoyed the possibility of daily access by road from Reykjavík.

Figures 7 and 7a are photographs taken during the 1954 medium-sized hlaup. The view is to the south from Skaftafell toward Ingólfshöfði. The approximate sites of Raudilaekur and Eyrarhorn are indicated by arrows. Rist estimated a peak discharge of 10,500 m³/sec for this hlaup and a total runoff of 3.5 km³ (RIST, 1956). Thorarínsson has estimated 2-3 times this magnitude for the major 10-year hlaups, equal to the maximum peak flow of the Amazon. This latter situation must have prevailed possibly from as early as the late sixteenth century while events comparable to the 1954 hlaup may have occurred from the late fifteenth to the late sixteenth century. During the 1954 hlaup virtually all the traditional Skaftafell farmland (that is, on the plain) was under water. The available information from the Skaftafell family history makes it clear that both the course of the Skeidará and the main jökulhlaup discharge had been shifting progressively eastward for at least 150 years and probably for twice as long (by 1830 the original site of the farms on the plain was endangered and was abandoned during the next twenty years in favor of the present hillside site -see below). Thus the destruction of the major settlements of Raudilaekur and Eyrarhorn, on the plain, by the 1362 eruption of Öraefajökull, was rendered permanent by the onset of jökulhlaup occurrence, indicated by the thickening and advance of Skeidarárjökull and

by the easterly shift of the Skeidará. Eyrarhorn and Raudilækur could not have withstood even the small jökulhlaup characteristic of the last three decades.



Figure 7: The 1954 Skeidararhlaup at its maximum, 18th July 1954. View from Skaftafell toward the south across the roof-tops of Bolti. The approximate sites of Eyrarhorn and Raudilækur are indicated by arrows.

THORARINSSON (1958) has calculated that jökulhlaup occurrence accounts for at least twice the 1950s volume of the glacier below the equilibrium line. The fact that Skeidarárjökull advanced at all during the Little Ice Age (and it advanced considerably) is an indication of a major climatic deterioration. And Grímsvötn volcanic eruptions do not appear to have been triggered by jökulhlaup after the 1938 event. Thus it may be concluded that comparable inactivity was characteristic of the Saga Period and that those hlaups that are referenced originated from Graenalón, the very large ice-dammed lake on the northwestern perimeter of Skeidarárjökull, rather than Grímsvötn.

Determination of the actual glacial maxima of the eighteenth century remains something of a scholarly debate. Svínafellsjökull is flanked by high and massive end moraines and its terminus has fluctuated comparatively little over the last 250 years (KING & IVES, 1955; THOMPSON, 1988). The high,

unstable moraines (which were probably formed after the 1840s) are fronted by a lower series of end moraine ridges (Stóralda) which have stable, well-vegetated slopes and deep soils. THORARINSSON (1958) analysed a soil profile on the outer Stóralda ridge and determined the presence of the 1727 Öraefajökull ash layer and also the distinctive light-colored pumice and ash of the 1362 eruption. He concluded that the Stóralda moraines must date from the Subatlantic period (about 2,500 BP) if not substantially earlier. Recent work by THOMPSON (1988) and THOMPSON and JONES (in progress) challenges this interpretation and raises the possibility that the Stóralda may have been formed during the early or mid-eighteenth century advances. This debate is also relevant to similar forms in front of Kviárjökull and several other Icelandic glaciers. Such "old" well-vegetated moraines are comparatively rare in Iceland presumably because the massive fluvio-glacial and jökulhlaup activity, so characteristic of the island, tends to eliminate end moraines. Regardless, the differences in extent and thickness of the Öraefi glaciers during the eighteenth and nineteenth century Little Ice Age maxima were probably slight, and of little significance in terms of farming activities and human survival. Ragnar Stefánsson's grandfather (Jón Einarsson, 1846-1925) told him that he had learned from an old woman from Svínafell relevant information concerning the nineteenth century position of Svínafellsjökull, since she died about 1900 and was reciting information passed on to her by her own grandparents, the reference must relate to the early nineteenth century. Thus, in the valley now covered by Svínafellsjökull, there were low ridges, grown over with berry bushes, that were similar to Stóralda. The sheep stall on Stóralda, the ruins of which can still be seen, was also built during the last century. This would indicate that, some time in the first half of the nineteenth century Svínafellsjökull had retreated a significant distance behind its present frontal position.

Jón Einarsson's letter to the King's representative provides some idea of the difficulties of life at Skaftafell during the eighteenth century. He explained the plight of his family and emphasized that the homefield walls, as stipulated by the royal proclamation of 1776, were beyond the capacity of the people because of shortage of manpower. There is no record that any response was made nor that the walls were ever built.

Jón's father, Einar Jónsson, is a specially interesting character. He was widely recognized as a great leader and wise man and his advice was often sought after. He had considerable metalworking skills, as well as impressive handwriting accomplishments. Figure 8 is a photograph from a page of a homemade, leather bound book consisting of passages that Einar copied from the Bible; Figure 8 also shows his homemade seal and "prismatic" compass. But a somewhat sinister and mysterious air seems to have surrounded Einar: it was believed that before he came to any important decision, or offered any advice, he consulted with trolls, and one special trollwife. Even today, this duality in his personality has intrigued, if not worried, Ragnar Stefánsson since he is Ragnar's favorite ancestor. However, recently

a remarkable explanation has evolved. While Einar lived a Skafafell a murder was committed in Sida (the district to the west of Skeidarársandur). The murderer, reputed to be a large and powerful man, and consequently much feared, escaped and sought the protection of Einar. This much seems logical since Einar's wife came from Sida. However, little is known of the murderer's eventual fate. It is well known throughout Öraefi that Einar granted wood-cutting privileges in Baejarstadarskógur, but only on condition that, as the horsemen approached the wood, while still a good distance away on the Morsárdalur valley floor, they should shout out as loudly as possible: "Einar sends his greetings". This was stipulated as necessary to secure the protection of the trollwife who lived in the cliffs of Raudhellrar and "owned" the forest. This instruction was complied with apparently for many years.

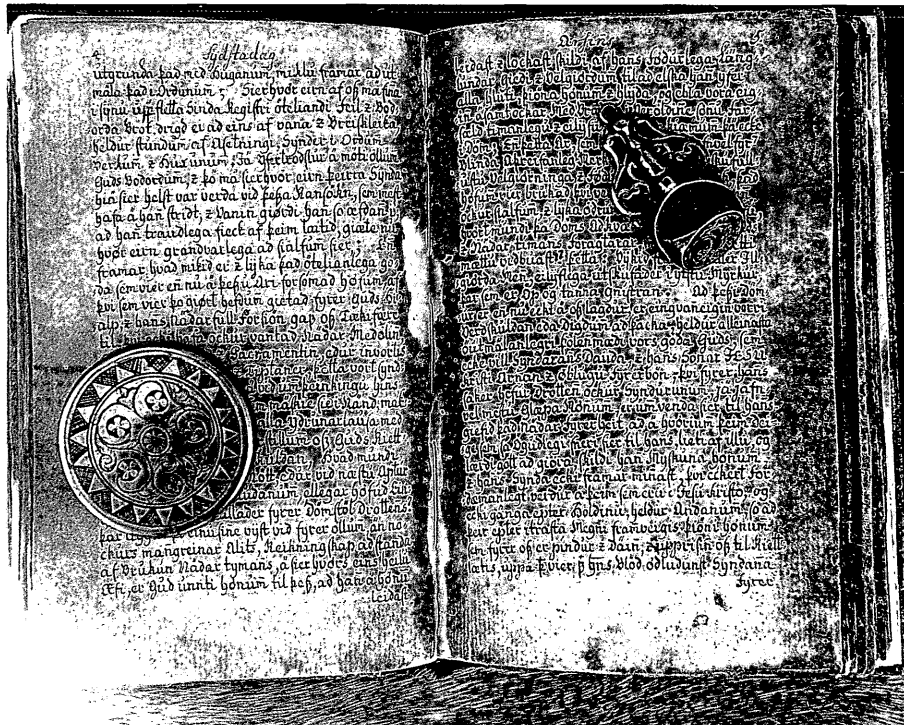


Figure 8: Einar's compass (closed) and his father's seal on an open page of his book, preserved at Skafafell by Ragnar Stefansson.

In recent years, Ragnar Stefansson accidentally discovered what he took to be the remains of a small house amongst the crags on the hillslope above and to the east of Baejarstadarskógur. This, in itself, was an unusual discovery because it has been the tradition in Öraefi that a farmer provide his sons with

complete and minute information about all structures (usually stone shepp pens), boundary markers, mountain trails, and advice on what places are accessible and those that should be avoided. Stefán Benediktsson, Ragnar's father, did this but omitted reference to this particular ruin, indicating that it was not a sheep pen and that its origin had been kept a secret. Ragnar's interpretation is that he had discovered the shelter of the murderer who was protected by Einar - "Einar sends his greetings", was to warn him, under the guise of placating a troll, to hide while the woodcutters were in the vicinity.

It needs to be explained that the only normal approach to Baejarstadarskógur is to travel north along the trail from Skaftafell, for the Morsá, and ride directly across the valley floor toward the forest. Thus anyone watching from the "house" would spot visitors while they were more than a kilometer distant. Despite careful instructions from Ragnar, I found the murderer's (or the trollwife's) house ruins in July 1987 only after a great deal of searching. Figure 9 shows the remnants of the doorway; while at the ruin it is easy to slip back into the eighteenth century and see the approaching horsemen crossing the valley floor below. The crustose lichens growing on the structure have diameters compatible with an age of 200-300 years for the building. Thus, Einar's sinister relationship with the local trolls may have a rational explanation; on the other hand, both explanations are by no means mutually incompatible.

Einar also had a reputation for the manufacture of line firearms that competed favorably with the best from Copenhagen. His sons, Jón and Eiríkur, carried on the father's and grandfather's reputations for wisdom, learning, local leadership, and technical ability. Jón and Eiríkur are known to have built a 4-wheeled wagon with a sail for collecting flotsam and seal carcasses from the foreshore, a considerable undertaking in a timberless and isolated region. There is also a local story that, during a time of especially severe hardship and near-starvation following the 1783 Laki eruption Jón Steingrímsson, the famous clergyman whose prayers turned aside the lava flow from his church, went down to the coast looking for seal to provide food for his starving parishioners. There he met Eiríkur who had killed 190 seal. Eiríkur gave the seal to Jón and transported them in his wind-driven wagon. Eiríkur, who died of cow-pox, before his brother, had a reputation for unusual strength. The brothers also informed Dr. Sveinn Pálsson about the movements of the glaciers and may even have laid the groundwork for Pálsson's reputation as one of the first glaciologists to deduce that glaciers moved "like a plastic mass". Pálsson climbed Öraefajökull on 11 August 1794 with guides from Skaftafell and is recorded as having looked down the length of Kvíárjökull, noted this glacier's magnificent ogives, and made his oft-quoted deduction. To me it seems more likely it was the local Öraefi farmers, possibly Jón and Eiríkur, who undoubtedly crossed the glaciers frequently and were intimately acquainted with their threatening advance and with the destructive force of

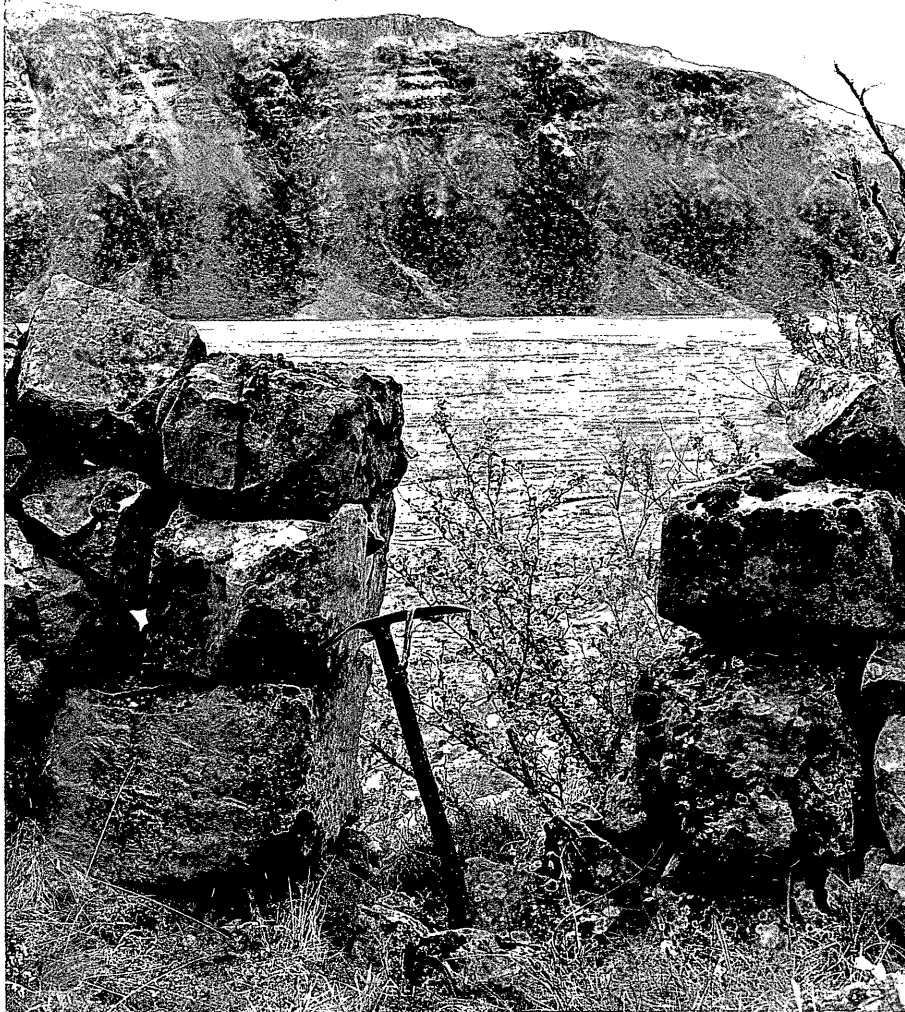


Figure 9: Remnants of the doorway of the ruins of an old house believed to date from the mid-Eighteenth Century. The view is toward the south across the glacial outwash plain of Morsardalur onto the slopes of Skaftafellsheidi (Skerholl). Ragnar Stefansson speculates that this is where his forefather, Einar, concealed the murderer that he befriended.

their meltwaters and jökulhlaup, who at least “primed” Pálsson for his historic conclusion. It is unfortunate for the Icelandic claim to glaciological precedence that Pálsson’s writings were virtually unknown in Europe and were not translated until as recently as 1884. He is also the author of one of the first glacier maps (Figure 10).

CLIMATIC FLUCTUATIONS AND VULCANISM IN S.E. ICELAND

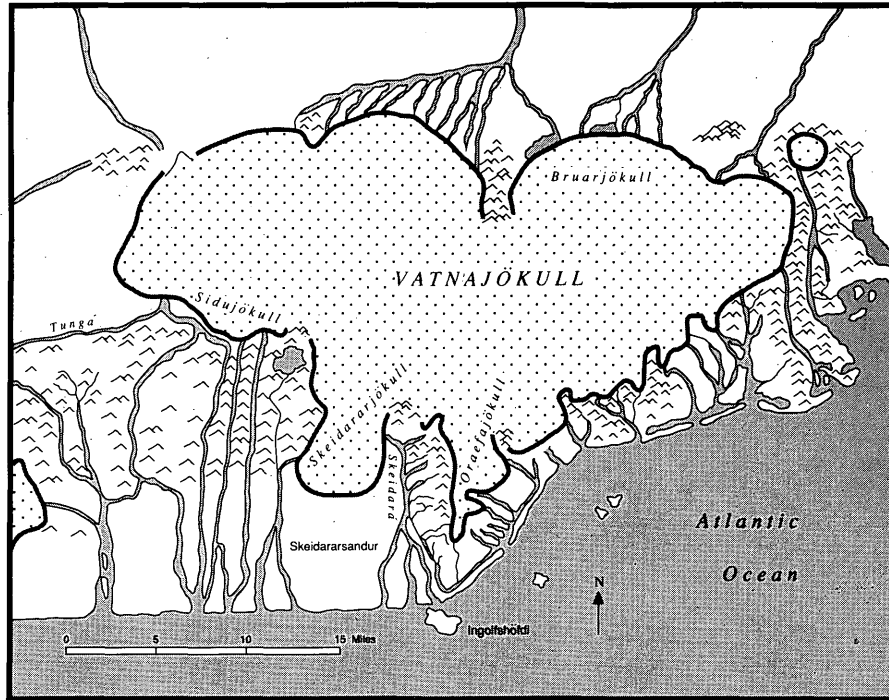


Figure 10: Map on Vatnajökull procuded by Dr. Sveinn Palsson in 1794. Redrawn in 1945 (Eythorsson), and in 1976 (Grove, 1988). Note the large amount of detail, although the individual Oraefi valley (outlet) glaciers are not indicated.

The first references to the loss of Skaftafell farmland due to the Skeidarárhlaup are found in Jón Einarsson's letter of 1787. During the next forty years the danger became progressively more acute and ultimately forced a series of moves. Remnants of some of the old buildings can be seen today close to the National Park compground. Known as Gamlatún (old tún), they were abandoned over a fifteen-year period following initial moves in 1834-36. Gudný, a widow with eleven daughters and two sons, Thorsteinn and Jón, built a new house a little upslope from Gamlatún, keeping the eastern half of Skaftafellsheidi, which is the best land because its southerly exposure ensures that it loses its snow cover more rapidly in winter. Thurídur, one of the daughters, married Brynjólfur, a man from the east, and they built Haedir. Jón, Thórsteinn's brother, moved to Sel, converting it from sheep stall to farm house. There follows a complex family history, including in-migration and out-migration, usually associated with marriage. Gudný's original move was abandoned in 1850 when she and her son Thorsteinn completed the process by building the present-day Bolti farm houses. Thus by 1850 the three separate farms, Haedir, Sel, and Bolti, came into existence, although

Haedir was moved once more, if only a short distance, onto its present site. However, Skaftafell, as well as most of the other Öraefi settlements, Svínafell, Sandfell, Hof, Fagurhólmýri, and Knappavellir, were probably clusters of three to seven distinct farmsteads throughout much of their long history. The same is probably true for Raudílaekur and Eyrarhorn, and possibly others, known by name only, that were abandoned or overrun as a result of volcanic eruption, glacier advance, and jökulhlaup.

A very detailed history of the Skaftafell families is available from about 1834 onward. This includes stories of food shortages, such that children had to be distributed to distant farms, and loss of children, due primarily to throat and bronchial infections. Adult males were also lost in the rivers and by falling in the mountains while chasing sheep. Despite the difficulties of travelling, however, remarkably few lives were actually lost in the rivers. Vigfus, brother of Jón Einarsson, Ragnar's grandfather, was lost in a iceberg-well (melting kettle hole) shortly after the 1861 Skeidarárhlaup. About the same time a woman was lost in the Skaftafellsá. These are the only documented instances of drownings in the rivers, although fording the rivers has always been regarded as a dangerous occupation that required great skill. Most lives, involving a single accident, were lost in the sea during an occasion when the Öraefi farmers were presumably pushed into attempting sea fishing because of food shortages. The sandbar coastline, without harbors or anchorages, is not conducive to the standar Nordic fishing-farming subsistence economy. There is also a terrible story of frost-bitten feet during the return from a seal hunt in 1904. This ended with amputations at Svínafell, without anaesthesia, of course. Sigudur Sigurdsson, the amputee, learned how to make leather saddles and built himself special leather boots to support his damaged feet and so provide himself with a degree of mobility.

The problems of survival were also related to survival of the cows. To be safe, each farm had to have three cows-to ensure against the loss of one when two were an absolute minimum. As is usual in high altitude and high latitude subsistence farming areas, a limiting factor was the need to accumulate four months' supply of hay to last the winter (grazing in the open was often possible into December). A similar struggle existed with maintenance of the minimum number of sheep. In the early part of the present century Haedir and Sel maintained about 100 sheep each (not counting lambs), but the Bolti brothers tended to keep between 300 and 400, a source of friction in terms of management of the common grazing lands. They became "rich" quickly, but always over-extended themselves and suffered heavy losses during bad winters. This led to overgrazing and soil erosion, and loss of birch forest, believed by Ragnar to be the result of winter sheep grazing in the forest and shrublands. This dispute is being played out to this day. Now, however, it takes the form of attempts by the Nature Conservancy, on behalf of the Skaftafell National Park, to exclude sheep entirely.

The noticeable extension of birchwood since my first visit in 1952, therefore, is related both to the management of the sheep as well as to the sustained

warmer climate of the twentieth century. It is nevertheless reported informally that the Svínafell farmers, concerned that good sheep pasture is going to waste, surreptitiously infiltrate small numbers of sheep onto Skaftafellsheidi. The remaining Skaftafell sheep are today confined to the rapidly revegetating sandur.

The 1904 Danish General Staff map (Sheet 87, Örjk. S.V., 1:50,000) demarcates the position of the glaciers based upon J.P. Koch's survey of 1901-02. By comparison with the location of the outermost end moraines, shown on the same map, it can be seen that the Öraefajökull glaciers were then within about 250 meters of their greatest historical extent. The only exception in the Skaftafell area is the Stóralda moraines that lie about 350 meters beyond the front of Svínafellsjökull. Thus the maximum historic extent, whether occurring in the eighteenth or nineteenth century, was only slightly greater than the 1901-02 positions. Thus the 1904 maps become the critical benchmark for study of subsequent glacier fluctuations. In 1901-02 the combined piedmont lobe of Skaftafellsjökull, Svínafellsjökull, for instance, blocked access to Hafrafell with about one kilometer of crevassed ice. It is likely that Hafrafell had retained its status as a nunatak from at least the late-seventeenth century. Frontal fluctuations occurred throughout the nineteenth century and GROVE (1988), citing Helland, Bárðarson, Ahlmann, and Thorarínsson, shows that the most pronounced fluctuations were those of Skeidarárjökull. These, of course, reflect the impacts of the Grímsvötn eruptions and the jökulhlaups. HELLAND (1882) recorded over 600 meters retreat between 1857 and 1881. Hrútárjökull and Breidamerkurjökull were in an advancing mode in 1894 (THORODDSEN, 1914).

Much more relevant to the life of the area than these rather modest fluctuations close to the historic maximum, of course, was the decadal succession of giant jökulhlaups and the progressive eastward shift of Skeidará. Hence, the abandonment of the traditional site of Skaftafell between 1834 and 1850 and the crippling loss of grazing land along the western perimeters of Svínafell, Sandfell, and Hof. Throughout the Little Ice Age (and possibly earlier) fuel was in short supply. The shoreline flotsam and horseback journeys to Bæjarstadarskógur have merited repeated references. Even Skaftafell, always supplied by copious quantities of birch shrub, and owning Bæjarstadarskógur, must have experienced grimly cold winters. Much of this, however, was related to the condition of the small, damp, farm houses, turf-roofed, often dug into the hillslope, and constructed largely with blocks of local, uncut field stone, and with wooden fronts (Figure 11). Ragnar's grandfather lost a lot of sheep in the 1880s and 1890s, and by 1900 his father, Stefán, had "less than fifty". It took Stefán more than ten years to build the herd back up to a hundred animals. Sel had about the same number as Haedir while Bolti was reduced to about 100. Geldings, however, were kept in the mountains unattended, in part to utilize this distant grazing and in part to avoid state and church taxes. Nevertheless, these animals sometimes went one or more seasons without human contact and when attempts were made to

shear them they had to be run down on foot and often required a flying tackle to bring them under control. Fat sheep were the main source of income for Skaftafell and were sold abroad. The sale of sheep "on the hoof", however, was relatively rare: most sales depended upon rendering fat, especially from the intestines. There were many difficulties with wool production: the wool pulled off on the birch shrubs and, together with the steep mountain slopes, gave Skaftafell a reputation for producing skinny naked sheep.

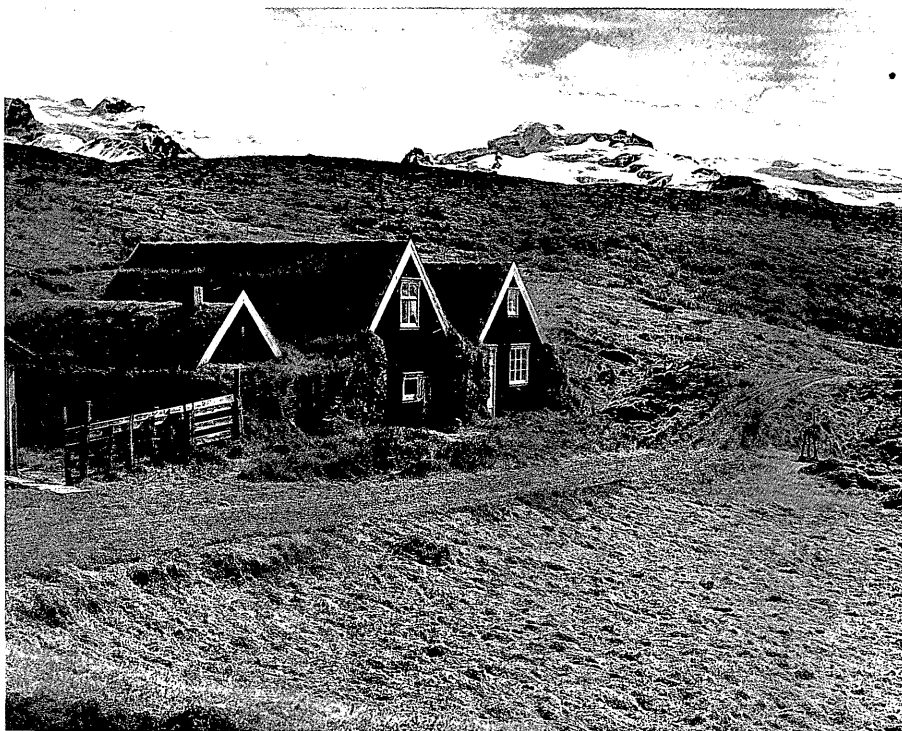


Figure 11: Sel, Skaftafell, a reconstruction of the original turf-roofed farm established 1830-1850 and partially collapsed in 1959. It is now an ambryo museum within the Skaftafell National Park. Above the slopes of Skaftafellsheidi (heath) rise the ice-mantled slopes of the Oraefajokull volcano-Hvannadaishnukur (2119 m) on the right and Hrutsfjall (1875 m) on the left.

Traditionally, much of the wool was sold as cloth and weaving was done on the farms. Ragnar Stefánsson believes that housing conditions must have been much better 250-300 years prior to the 1850-1930 period because good dry houses with space for looms would have been needed, and this luxury was not available during the latter period. A lady visitor to Skaftafell in 1987 described to me her recollections as a child and young woman living at Sel between 1904 and 1926 (this would amply approximate living conditions

of the previous century). She spoke about how she always felt cold: heat was derived from a single wood-burning cast iron stove operating in one room only. Even then, it was only lit at four p.m. The kitchen had a separate open hearth fire and no chimney; it was in a small building separate from the main house on account of the fire hazard, and cooking was a very smokey experience. Birch twigs, some logs, scraps, and hay residue were used for fuel, and in this respect Skaftafell fared better than the other Öraefi farms. This situation prevailed until the 1950s except that a large iron cooking range with chimney had by then become the essential element for both kitchen use and heating Haedir. Sel had ceased being a working farm in 1947. Even in springtime, Haedir was cold, and warm sweaters and down sleeping bags for night-time, were essential.

5. The Modern Period: 1900-1987

Ragnar Stefánsson and Anna Pálsdóttir, July 16th, 1954

Five of us (University of Nottingham students) had walked back to Skaftafell from our base camp in Baejarstadaraskógur. Skeidará had been rising rapidly over the previous 6-8 days. We had been waist-deep for over half a kilometer in Morsárdalur as the increase in height of the Skeidará had caused the Morsá to back up and turn into a broad shallow lake. Our eyes were red and running from the hydrogen sulphide, but we were excited because we realized that we would witness the climax of a Skeidarárhlaup. Professor Sigurdur Thorarinsson (Siggi - our friend and Icelandic supervisor, and friend of all English students who visited Iceland with at least half serious intent) had published his opinion in the major newspaper, Morgunbladid, that there would be no Skeidarárhlaup that year. Ragnar had challenged his professorial friend and had indicated otherwise. I was especially concerned as my future was beginning to take shape and I was shortly to be married and to emigrate to Montreal. But I had to experience a jökulhlaup. To assuage my anxiety and at Anna's request, Ragnar had consulted his "bible" on Skeidarárjökull two weeks previously. He had been prepared to declare that a jökulhlaup would climax between 16 and 20 July. But if he were too optimistic I must nevertheless stay "for an Englishman will witness a jökulhlaup only once in his life, but he can get married any time. And Pauline would surely understand". Thankfully it was not necessary to put this to the test. The climax occurred on 18 July. And taking the horses, Ragnar and I galloped to Fagurhólsmýri to catch the weekly Flugfélag Íslands DC-3 flight to Reykjavík and eventually that vital sailing of the M.S. Gullfoss back to Edinburgh and so home.

Before the jökulhlaup we had sat on the doorstep of Haedir looking out across the sandur and the roaring, early summer waters of Skeidará onto distant Lómagnúpur. Ragnar had taken an interest in my surveying aneroid. He indicated that Skeidarárjökull had appreciably thickened since we had sat in the same place a year earlier when a notch in the Lómagnúpur ridge had

been just visible in line with the upper surface of the glacier. He took me up the hillside until we had the same alignment of glacier surface and rocky cleft and told me to read the difference in altitude between our new position and the doorstep of his house. "Now you can calculate, how much thicker Skeidarárjökull has become in on year". The answer was about ten meters! It was on that same doorstep that Ragnar and Anna told me of the many family experiences that led to the writing of this narrative. Over a period of a few years. Ragnar was to lose his first wife, Anna Pálsdóttir, and children, a very dark period for Skaftafell.

Commentary

"The Modern Period", to all intents, can begin with the date of the Danish geodetic survey of the Öraefi district. After 1901-02 climatic warming and general glacier retreat set in, accelerating in the 1930s and 1940s (Figure 12). With occasional minor readvances and stillstands, massive thinning and frontal retreat continued until about 1965 since which date readvance has

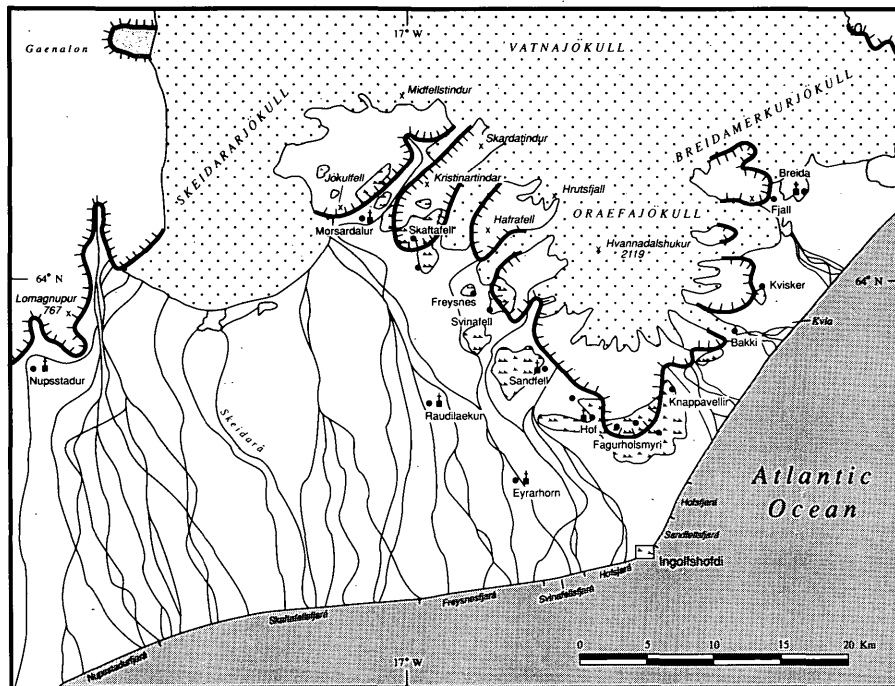


Figure 12: Oraefi: The Modern Period - AD 1990-1987; Period IV: Extent of the glaciers based on airphotography, 1961-1969; this is approximately the minimum position since 1900.

predominated. It is convenient to divide the modern period into two. 1965 can be used as a dividing point, but perhaps of much greater significance is the formation of the Skaftafell National Park in 1968 and especially the completion of the road and the Skeidará bridge in 1974.

During the 1930s a number of illustrious visitors came to Skaftafell: Professors Niels Nielsen, Arne Noe-Nygaard, and Hans Ahlmann, and Dr. Jón Eythórsson, and their wives; also the then young students, Carl Mannerfelt and Sigurdur Thorarinsson, who won the nickname "Skallagrim" on account of his ferocious physical energy and poetic prowess. The attractions were the jökulhlaup, the Grimsvötn eruptions, and Vatnajökull mass balance studies; undoubtedly, to experience the hospitality of Skaftafell must have been added.

Always, the approach to Skaftafell was on horseback across Skeidarársandur. The Skaftafell farmers, with their famous vatnahestar (water horses), were essential for crossing the main and most dangerous obstacle Skeidará. Ragnar tells the story of how on one occasion, Oddur of Bolti led across the ladies (Mrs. Ahlmann and Mrs. Eythórsson), giving the scientists more than a few minutes of despair, and of the party afterwards when Oddur, as usual, was happy to display his generosity with considerable supplies of aquavit and cognac, filling the glasses so that they overflowed. Ahlmann begins a chapter in his book (*Land of Ice and Fire*). "This was no place for a farm..." a remark arising from his first view of the lower slopes of Skaftafellsheidi from the desolation of the sandur.

Some small things had changed from the maxima of the Little Ice Age: a telephone link had been established between 1929 and 1936; by 1935 there were several mini-hydroelectric units harnessed to local streams that provided power for a few light bulbs; and there was radio. But the postman came only a dozen or so times a year; there was no doctor, no clergyman, only a midwife, and a visiting school teacher lived on the individual farms for short periods of intensive instruction. The men-folk, with their horses, journeyed out twice a year across the sandur and rivers either westward to Vík í Mýrdal or eastward to Hornafjordur. These were major journeys that took many days, or even weeks; the object was to sell their produce and purchase supplies for the months ahead. This practice ended in 1916, however, when a small motor ship, the "Skaftafellingar", began running supplies from Reykjavík to the anchorage at the east end of Ingólfshöfði. The supplies were taken ashore by rowing boat, itself a rather hazardous operation. And the church and farm of Sandfell was finally abandoned in 1935, a delayed victim of the ravages of volcanic eruptions and the Little Ice Age, which could not be adequately offset by the ameliorating climate of the present century.

In 1952 it was still necessary for me to approach Skaftafell on horseback, but I had the advantage of a weekly DC-3 flight from Reykjavík onto the beach at Fagurhólmsmýri that was initiated in 1946 so that the crossing of Skeidará was circumvented. I literally met Ragnar for the first time in the middle of the Skaftafellsá close to midnight while the alpenglow lit up the great dome and gently curving slopes of Öraefajökull 2000 meters above us.

Ragnar and Laufey, July 1987

The doorstep of Haedir has replaced Sel, only 150 meters away. But still the view westward is essentially the same in its grandiose sweep as that which molded the spirits of Thorgier Thordarson, Flosi, Eiríkur Birkibeinn, Jón Tómasson, Einar and his son Jón, Gudný and Thorsteinn. Many important details had changed over the centuries, details but also matters of life and death in terms of the survival of the local people. But the broader elements of the westward and southward prospects remained as a general framework. Nevertheless, the glaciers had made their catastrophic advance, and had diminished. Öraefajökull had twice spread ruin over Öraefi and beyond, and the farms and churches on the plain had vanished as Skeidará had spread its sands and gravels eastward across the farmlands. Another, almost equally dramatic change was symbolized by the small puffs of dust that we were watching, aligned across the sandur, allowing us to pick out the positions of cars and buses. And the Skeidará bridge and ramparts, which made this possible, interposed sharp linear features across the otherwise sinuous curves of the sandur and the braided channels of the meltwater rivers. Smaller jökulhlaup, plus partial control of the Skeidará, and probably a purely natural process, are causing the main river to move westward away from the lower slopes of Skaftafellsheidi: Thus today a green sward camp site, situated between Gamlatún and the snout of Skaftafellsjökull, provides tent space for several hundred visitors, who are served with hot showers, a grocery store, and a restaurant.

Other changes have occurred on the heels of the establishment of the national park. Ragnar and Jakob, his Bolti neighbor, have become part-time farmers and part-time park officials. The farm buildings have been substantially enlarged and can accommodate guests who prefer not to pitch a tent on the newly established meadow of the camp ground below Gamlatún. Only three of the famous vatnahestar remain, Haedir has none, and the automobile reigns even in this unlikely landscape. Walking trails are spreading across Skaftafellsheidi, together with tourist litter, and there is a sense of overcrowding and environmental damage; sheep are rarely seen on the heath, but at least the ban on all-terrain vehicles still holds. The vast sandur is greening over from the drab and sterile greys of my first visits, and birchwood is rapidly spreading over the lower slopes. This is also true of Morsárdalur, but here another botanical change has occurred.

In the 1960s the Alaskan lupin was introduced into Iceland. A local teacher is reported to have seeded the badly eroded slopes above Baejarstadarskógur supposedly to protect Iceland's most beautiful birch forest from additional gullying and wind erosion. After nearly twenty years of little impact a surge in lupin colonization has occurred. In June both the slopes above the forest and much of the valley floor are ablaze with color. On a still day, the air is heavy with a rich mix of lupin and birchwood aroma. Now the Nature Conservancy is facing a difficult task of eradicating an exotic addition to the park flora.

With up to 24,000 overnight stays in a short summer season, and with over half being from abroad, a new series of threats and challenges has arisen. A

CLIMATIC FLUCTUATIONS AND VULCANISM IN S.E. ICELAND

tourist opinion poll, organized by the Icelandic hotels in 1984, indicated that Skaftafell was the single most popular place to visit in the whole of Iceland. If this implies a continued increase in the number of overnight stays, then park management problems of some magnitude are likely.

Commentary

Figure 13 illustrates in graph form the 1931-1986 fluctuations in the terminal positions of Morsárjökull, Skaftafellsjökull, and Svínafellsjökull. This

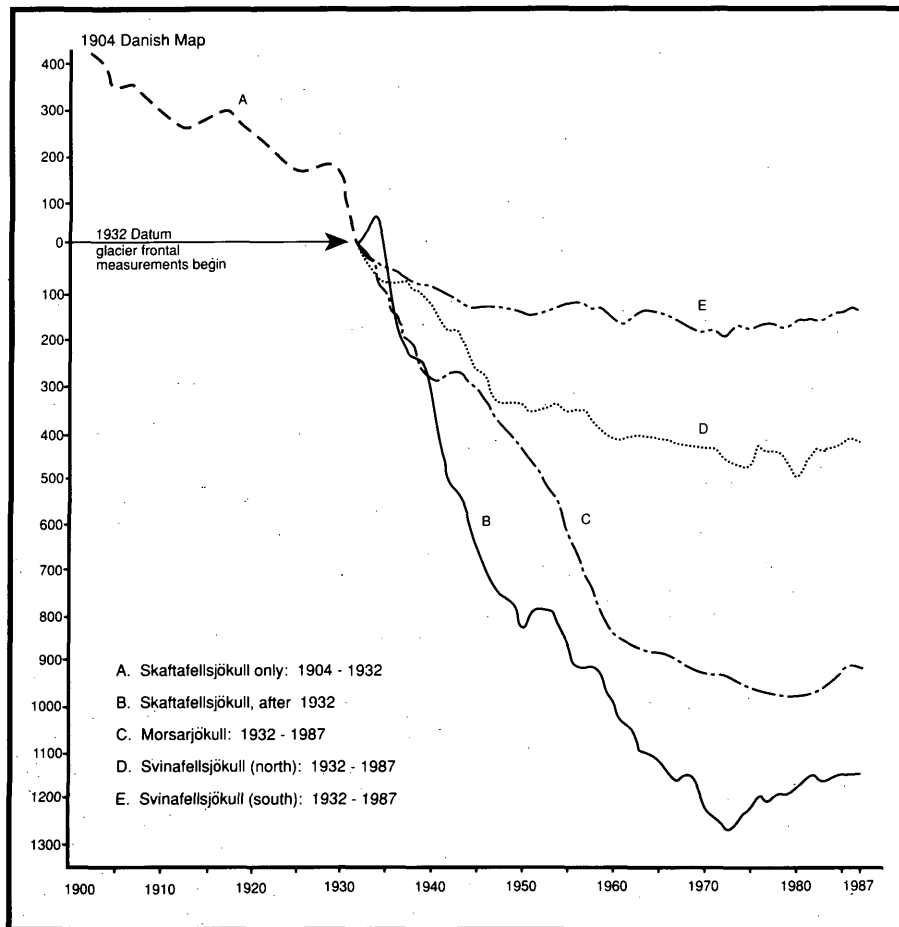


Figure 13: Cumulative recession of the Skaftafell glaciers, 1932-1987. During this period regular annual measurements were made by Ragnar Stefansson and other farmers onto fixed markers from the frontal ice margins (sources: Ives, 1956; Eythorsson, 1963; Rist, 1984; Thompson, 1988; and others).

demonstrates the spectacular retreat, accompanied by thinning of the glacier tongues, that characterized the 1930s and 1940s, a process that appears to have culminated in the early 1960s. Figure 14 shows the matching trend in the mean annual air temperatures for Stykkishólmur, a distant western Icelandic station, and Fagurhólsmyri. Visually the correlation is remarkable, even surprising. It appears that, contrary to glaciological theory, which would presuppose a significant time-lag in glacier response to climatic change, the termini of the Skaftafell glaciers are responding virtually instantaneously. To fully understand the glacier changes, ablation season temperatures, and annual and seasonal precipitation data are required from the higher altitudes of the glaciers' accumulation areas as well as from the lower tongues.

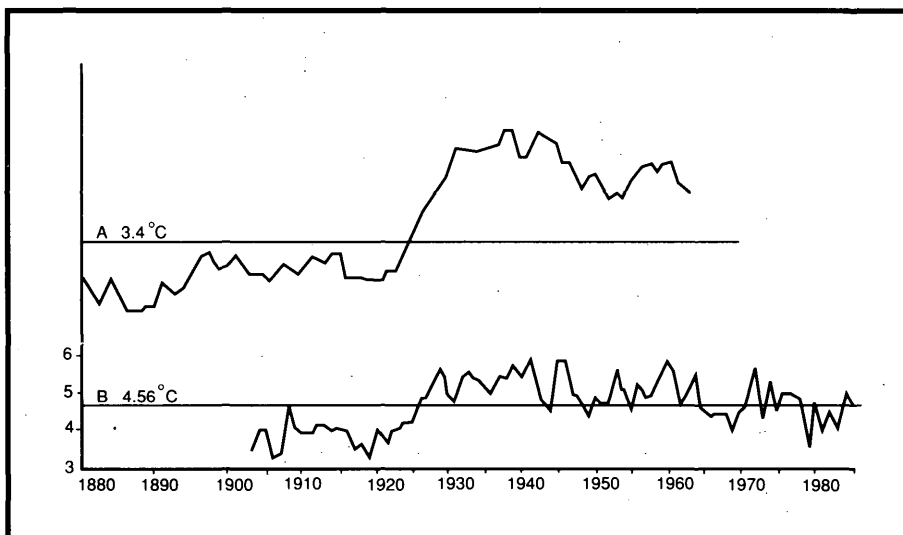


Figure 14: Mean annual temperatures, Stykkishólmur, 1880-1964; Fagurhólsmyri, 1903-1985. The latter station is located at the southern foot of Öraefajökull about 20 km south of the glaciers shown in Figure 13. The "twentieth century warming" is well demonstrated for the period 1920 to 1960. Even here, the warming peaked in the 1940s and the recent period after 1960 shows fluctuation with significant cooling. Compare with fluctuations of the Skaftafell glaciers, Figure 13.

Figure 15 is a plane table map of the Morsárjökull terminus made in 1953 (IVES & KING, 1954), and Figure 16 a similar map of the other two glaciers (KING & IVES, 1955). Since then repeated high quality air photographs allow a precise reconstruction of the terminal and proglacial landscape (THOMPSON, 1988). The contrast in glacier tongue changes between Skaftafellsjökull and Svínafellsjökull is probably caused by the much greater altitude of the latter's accumulation area. The increase in precipitation with altitude, while there is no data available, must be considerable. Speculation of a total annual precipitation figure in excess of 4,000 mm for the upper reaches of Svínafellsjökull and Öraefajökull is not unreasonable.

CLIMATIC FLUCTUATIONS AND VULCANISM IN S.E. ICELAND

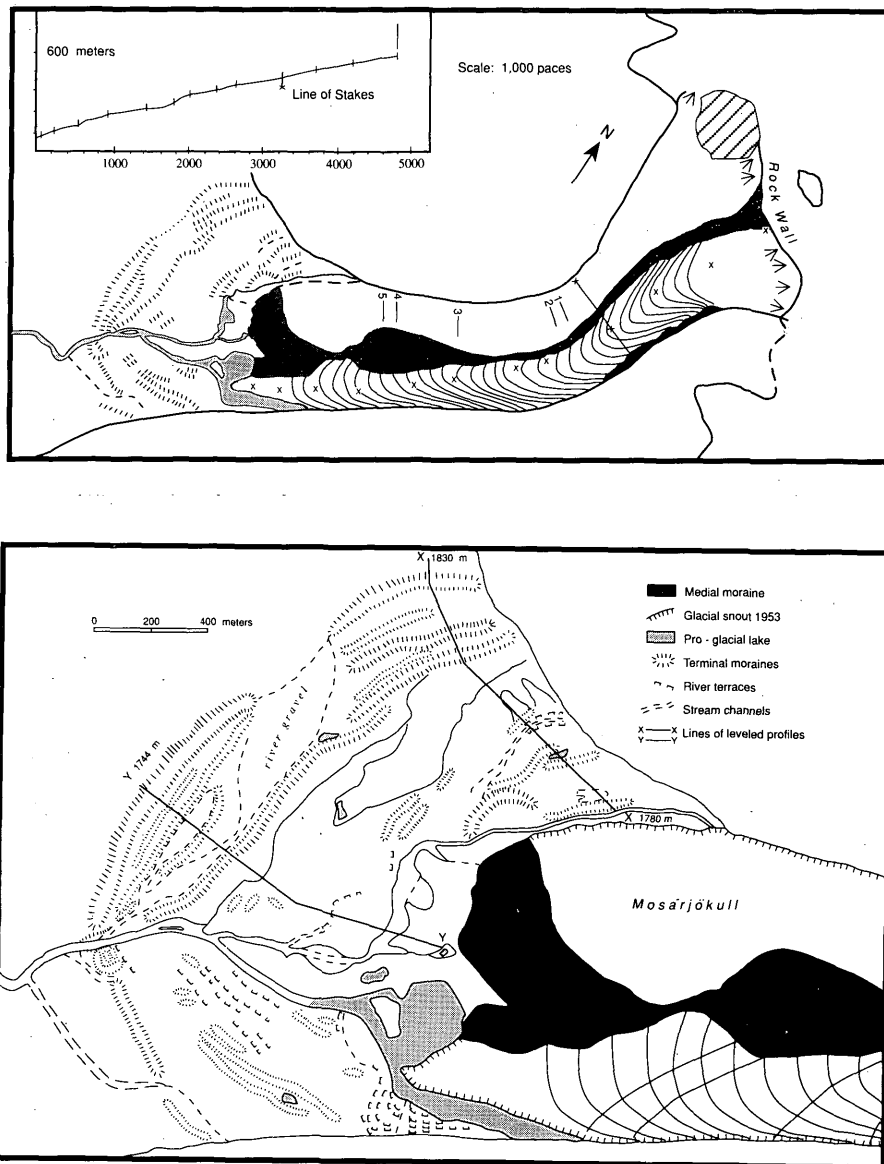


Figure 15: Plane table map of the terminal zone of Morsajökull, 1953; from Ives and King, 1954.

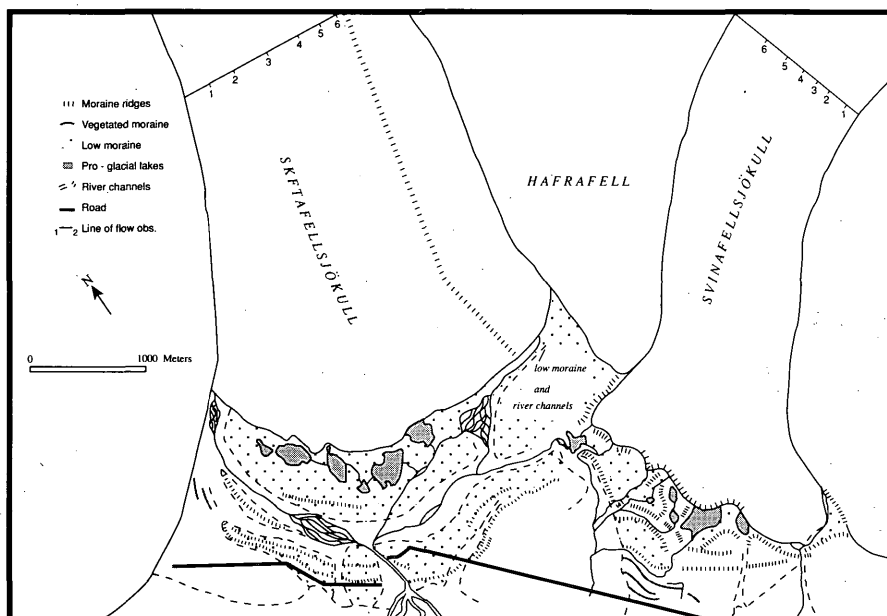


Figure 16: Plane table map of the terminal zone of Skaftafellsjökull and Svínafellsjökull; from King and Ives 1955.

Local information about the glaciers is also available. Skaftafellsjökull and Svínafellsjökull separated in 1940 thus providing renewed access to Hafrafell: this was primarily due to the rapid retreat of the former, which continued for another two decades (Figure 17). The small glacier in Birkidalur ("Birkijökull") was confluent with Morsárjökull until the early 1930s. The main glacier is actually two contiguous ice streams that cascade more than 400 meters off the high accumulation area of southern Vatnajökull and, in the lower, deep U-shaped valley, display a remarkable double set of ogives. My 1952 photograph (Figure 18) shows that the right hand ice fall is completely severed while the left hand one is only partly connected. The break across the right hand ice fall became apparent in 1938 (IVES & KING, 1954; 426) and was complete before 1950 (Ragnar Stefánsson, pers. comm.). The rapid exposure of the "blackwall" between the ice streams occurred between 1930 and 1950 and it is supposed that the great bulge on the lower medial moraine, apparent on the 1952 photograph, resulted from a massive collapse and rock fall consequent upon this recent sub-aerial exposure. Since it was demonstrated that the main set of ogives are formed one each year, counting the ogives upstream of the morainic bulge indicates that a rockfall(s) occurred in the early 1930s. Figure 19 is a panorama of these spectacular ice falls, taken from the summit of Kristinartindar in 1984. It is one of a series taken from the same spot at irregular intervals since 1937.

CLIMATIC FLUCTUATIONS AND VULCANISM IN S.E. ICELAND



Figure 17: The terminal zone of Skaftafellsjökull and Svinafellsjökull (1987) looking south from Skaftafellsheidi. Hafrafell lies between the two glaciers.

1987 and 1988 provided warm sunny summers for Skaftafell and this alone may have checked the advance of the three glaciers, although no recent information on glacier response is available. GROVE (1988:63) believes that the 1960s-1980 advance of many Icelandic glaciers was a minor and temporary phenomenon which ended in the early 1980s. Many glaciers continued to advance up to 1986, however, and both Morsárjökull and Skaftafellsjökull were piling up small fresh moraines in the summer of 1987. The issue remains open: it certainly warrants much closer attention since glacier advance in Iceland in the late- 1980s is anomalous in the context of Northern Hemisphere "greenhouse" warming.

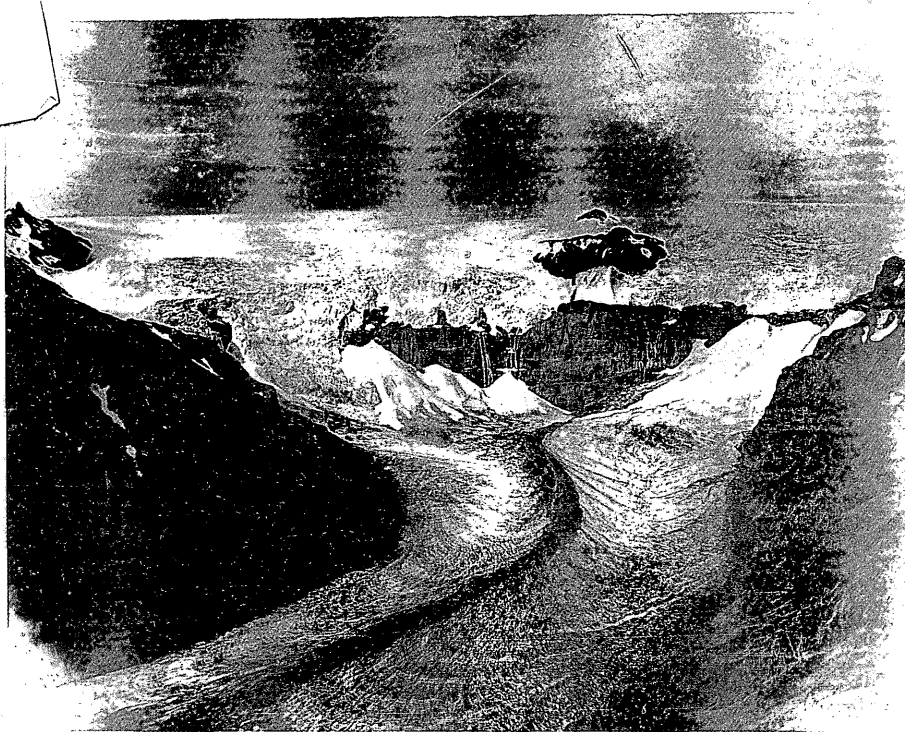


Figure 18: The Morsarjokull icefalls from the summit of Kristinartindar (1126 m), July, 1952.

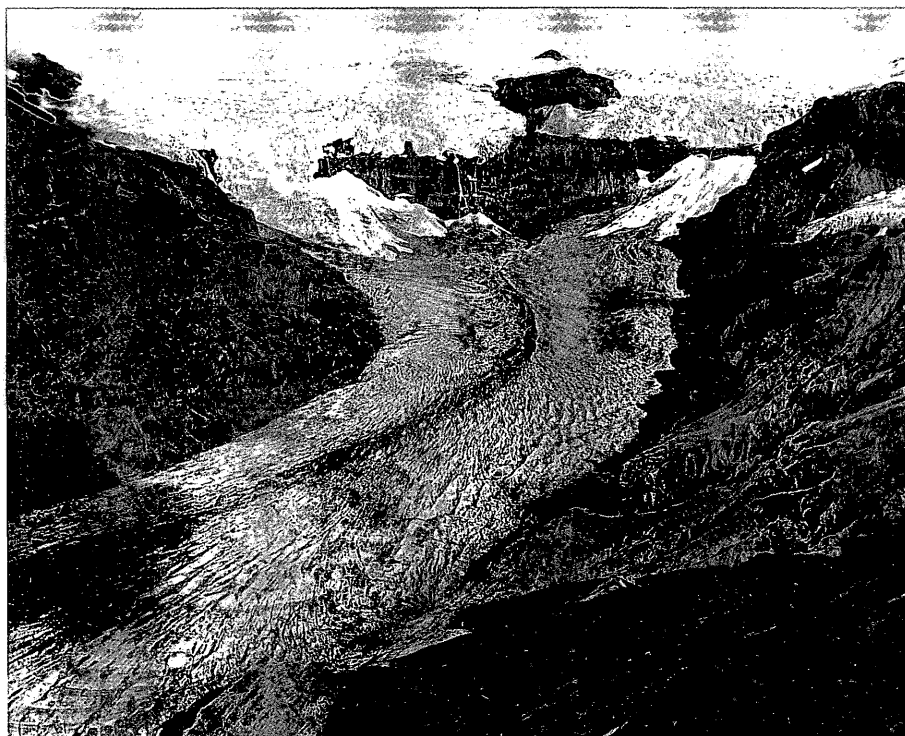


Figure 19: The Morsarjokull icefalls from the summit of Kristinartindar (1126 m), June, 1987.



Figure 20: The Morsarjokull icefalls, September, 1984. The separate right-hand glacier is "Kirkijokull" and was confluent with the main glacier until the early 1930s. The middle icefall was severed in the late-1940s and the supply of ice to the lower glacier tongue is now entirely by avalanching. The left-hand icefall is still partially connected. Note the two sets of ogives on the surface of the lower glacier.

6. Conclusions

Ragnar and his family are leaving Skaftafell. They are not moving far! While the main Skaftafell farmlands were incorporated into the national park in 1968, his family had retained the remnants of Freysnes as well as the Skaftafellsfjara. So, Ragnar and Laufey, Anna-María and Jón, are building a new house and a small hotel on the Stóralda moraines just beyond the park boundary. Thus the spiritual link is not broken, and the new park superintendent is to be Stefán Benediktsson, who carries the same name as his grandfather, who was Ragnar's father.

Some of the recent changes, while seemingly trivial, such that the casual summer visitor would not notice, have significance. The scythe, for instance, is no longer in use, except on occasion as if as a ritual protest against modernization. But with the withdrawal of the Skeidará it has been possible to create new hayfields on the flat sandur and to harvest with mechanical

equipment. Thus the need to scythe the roofs of the houses and sheep stalls, and the hummocky ground of the tún, has passed -but the result is the loss of one special element in the beauty of Skaftafell. The emerald green of the farmhouse roofs and the tún and the unforgettable scent of freshly mowed hay are gone. In time, those who control national parks and tourism in Iceland may follow the Swiss and recognize the need to subsidize hand mowing as a means of preserving a significant tourist attraction. Most regrettably, the evolution of Icelandic national park policy, despite many commendable elements, has been molded closely on the North American tradition - parks are nature preserves in which people are (ideally) light-treading visitors, but never inhabitants. And "people" includes their domesticated animals. There appears to be no room for culture, for the relics of centuries of Icelandic sheep farming; and the sheep today, in the mind of the city dweller, is the enemy. Perhaps a compromise can be reached before it is too late, but without a compromise the heart of Skaftafell will be torn out. It is remarkable that the Skaftafellingar, who have survived blood feuds, foreign domination, volcanic eruption, plague, the Little Ice Age, and the overriding of their homes by ash, ice, river, and gravel, may succumb to the late twentieth century wilderness and nature preservation ethic, and the touristhlaup.

Acknowledgments

Fieldwork, based on Skaftafell in June and July 1987, was made possible by a grant from the National Geographic Society. Field assistance was provided by Colin and Pauline Ives and Harry and Fay Gleave. Generous assistance with climatic and glaciological data was given by Adda Bára Sigfúsdóttir and Dr. Sigurjón Rist. Drs. Alan Thompson and Arnold Jones, and members of the Liverpool Polytechnic-Liverpool University Joint Iceland Research Expedition, 1987, generously shared their field data and ideas. Many visitors to Skaftafell, specially invited by Ragnar Stefánsson, assisted with translation and interpretation. Barbara Stanziet kindly provided accommodation in Reykjavík as well as assistance with interpretation. Drs. Gísli Gíslason and Eythór Einarsson of the Nature Conservancy and the Icelandic National Research Council (Rannsóknarád Ríkisins) provided guidance, permissions to work and camp in the Skaftafell National Park, and general encouragement: they served as liaison for the National Research Council and their long-standing friendship is much appreciated. Jón Didriksson translated essential documents. Drs. Áskell and Doris Löve, by numerous acts of translation and friendship helped keep alive my link with Skaftafell over a thirty-year period. Skipper Sigurdur Thorsteinsson of the Steam Trawler *Lifeguar*, Grimsby, first fascinated me with stories of Iceland and Icelanders, which prompted me to make my initial visit to Iceland in 1952. Special thanks are also due to Professor Cuchlaine A. M. King, my undergraduate tutor, University of Nottingham; she was also a decisive

member of our 1953 and 1954 student expeditions and provided me with my first supervision in field geomorphology. I would also like to remember the unique contributions of my old friends Ian Harrison and Tony Prosser who died in the ice fields in 1953 during a traverse from our camp on Vatnajökull to the summit of Öraefajökull. This paper, in many respects, is a tribute to their memory. Most of all, not only this narrative, but my doctoral dissertation of over 30 years ago, my appreciation of the intricate association between nature and culture in extreme environments, and the foundation of my professional career, have depended upon the life-long friendship of Ragnar and his family: this must inevitably include Laufey and Anna, Anna-María, Jón Stefánsson (Ragnar's late brother), Stefán Benediktsson and old Stefán, but also, Einar Jónsson and his trolls, Jón Tómasson, Eiríkur Birkibeinn, Thorgeir and Flosi, and so back to Thorgerdur and Ingólfur.

References

- AHLMANN, H. W., 1938.- *Land of Ice and Fire*, Kegan Paul Trubner: London, 282 p.
- AHLMANN, H. W., 1948.- *Glaciological Research on the North Atlantic Coasts*, Royal Geographical Society, Special Research Pub., No. 1, 83 p.
- ALLEN, R. R., 1971.- *Fire and Iron: Critical approaches to Njal's Saga*, Univ. Pittsburg Press: Pittsburg and London, 254 p.
- BARÐARSSON, G. G., 1934.- Islands Gletscher Beitrage zur Kenntnis der Gletscherbewegungen und Schwankungen auf Grund alter Quellenschriften und neuester Forschung, Visindafelag Islendinga. *Societas Scientiarum Islandica*, No. 16.
- EINARSSON, I., 1708-09.- *Land Register of Austur-Skaftafellssysla*, Reykjavik.
- EYTHORSSON, J., 1963.- Variation of Iceland Glaciers, 1931-1960, *Jökull*, 13:31-33.
- GROVE, J. M., 1988.- *The Little Ice Age*, Methuen: London and New York, 498 p.
- HELLAND, A., 1882.- Om Islands Jökler og om Jökulelvenes Vandmaengde og Slamgehalt, *Archiv. fur Mathematik og Naturvidenskab*, 7:200-232.
- IVES, J. D. & KING, C. A. M., 1954.- Glaciological Observations on Morsarjökull, SW. Vatnajökull. Pt I - The Ogive Banding, *Journ. Glaciol.*, 2(16): 423-428.
- KING, C. A. M., & IVES, J. D., 1955.- Glaciological Observations on some of the outlet glaciers of south-west Vatnajökull, Iceland: Pt I - Glacier Regime, *Journ. Glaciol.*, 2(18): 563-569.
- MAGNUSSON, M. & PALSSON, H., 1960.- *Introduction to the translation of Njal's Saga*. Penguin Books Ltd: Aylesbury and Slough, pp. 9-35.
- MAGNUSSON, S. A., 1984: *Northern Sphinx. Iceland and the Icelanders from the Settlement to the Present*, Snoebjorn Jonsson & Co., h. f., Reykjavik, 259 p.
- NJAL'S SAGA: Translated by Magnusson, M., and Palsson, H., 1960: Penguin Books: Aylesbury and Slough, 375 p.
- OGILVIE, A. E. J., 1981.- *Climate and Society in Iceland from the Medieval Period to the late Eighteenth Century*, unpub. Ph. D. dissertation, Univ. of East Anglia, Norwich, U.K.
- OGILVIE, A. E. J., 1984.- The Past Climate and Sea-Ice Record from Iceland, Pt I: Data to A. D. 1780, *Climatic Change*, 6: 131-152.
- PALSSON, S. 1945.- *Physisk, geografisk og historisk Bestrivelse af den islenske Isbjerge*, Written in 1794 and published by Helland, A., in Den Norske Turistforening,

- Arbok, 1882-84; republished in 1945 by Eythorsson, J., in *Ferdabok Sveins Palssonar*, Reykjavik.
- PFISTER, C., 1981.- An analysis of the Little Ice Age climate in Switzerland and its consequences for agricultural production. In Wigley, T.M.L., Ingram, M.J., and Farmer, G., (eds): *Climate and History: Studies of Past Climates and their Impacts on Man*, Cambridge Univ. Press: Cambridge, pp. 214-248.
- PRICE, R. J., 1969.- Moraines, sandar, kames and eskers near Breidamerkurjokull, Iceland, *Instit. of Brit. Geographers*, 46: 17-43.
- PRICE, R. J., 1970.- Moraines at Fjalljokull, Iceland, *Arc. & Alp. Research*, 2 (1): 27-42.
- RIST, S., 1956.- Skeidararhlaup 1954, *Jokull*, 5: 30-36.
- RIST, S., 1984.- Joklabreytingar 1964/65-1973/74, 1974-75-1982/83 og 1983/84, *Jokull*, 34: 173-178.
- SKALHOLT ANNALS, 1362.- Diplomatarium Islandicum, p. 226, cited in Thorarinsson, S., 1958:26.
- STURLUNGA SAGA, 1970.- Translated by Julia H. McGrew and R. George Thomas, 2 vols., 476 and 530 pp., Twayne Pub. Inc., New York, and the American Scandinavian Foundation.
- TOMASSON, T., 1980.- *Skaftafell: thaettir ur sogu aettarseturs og atvinnuhatta*, Bokautgafan Thjodsaga, Reykjavik, 264 p.
- THOMPSON, 1988.- Historical development of the proglacial landforms of Svinafellsjokull and Skaftafellsjokull, Southeast Iceland, *Jokull*, 38, (in press).
- THORARINSSON, S., 1937.- Vatnajokull, Scientific Results of the Swedish-Icelandic Investigations. Chap. 8. Hoffelsjokull. *Geografisker Annaler*, 21 (3-4): 189-215.
- THORARINSSON, S., 1943.- Vatnajokull, Scientific Results of the Swedish-Icelandic Investigations. Chap. 11. Oscillations in the Icelandic glaciers in the last 250 years. *Geografisker Annaler*, 25 (1-2): 1-54.
- THORARINSSON, S., 1953.- Some new aspects of the Grimsvotn problem, *Journ Glaciol*, 2 (14): 267-275.
- THORARINSSON, S., 1956.- *The Thousand year Struggle Against Ice and Fire*, Bokaugata Menningarsarsjods: Reykjavik.
- THORARINSSON, S. 1957a.- The Jokulhlaup from the Katla area in 1955 compared with some other jokulhlaups in Iceland, *Jokull*, 7: 21-25.
- THORARINSSON, S., 1957b.- Der Oraefajokull und die Landschaft Oraefi, *Erdkunde*, 13: 124-138.
- THORARINSSON, S., 1958.- *The Oraefajokull Eruption of 1362*, Acta Naturalia Islandica, 2(2): Reykjavik.
- THORODDSEN, T., 1914.- An account of the physical geögraphy of Iceland, IN Rosenvinge, L, K., and Warming, E. (eds): *The Botany of Iceland*, Volume 1, Copenhagen and London, pp. 190-343.