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Polar Mirages as Aids to Norse Navigation

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Summary. The possibility is examined that the Norse may have gleaned information from polar mirages for their westward expansion across the North Atlantic. Two types of superior mirages, the *hillingar* and the Novaya Zemlya effects, are explained briefly. Examples reported by early explorers are used to familiarise the reader with the effects and to illustrate both their informative and confusing natures. Specifically, optical theory is applied in an attempt to establish the Gunnbjorn Skerries as images of the Greenland coast, transmitted by mirage across the Denmark Strait. This hypothesis is supported by an examination of the available historical evidence.

Zusammenfassung: Untersucht wird die Möglichkeit, daß die Wikinger die nötigen Kenntnisse, ihren Drang nach dem Westen und die Entdeckung Grönlands zu verwirklichen, durch Luftspiegelungen gewonnen haben. Zwei Typen der Luftspiegelung nach oben, der Hillingar- und der Novaya Zemlya-Effekt, werden kurz erklärt. Der Effekt wird durch Beispiele aus den Berichten der Seefahrer auf ihren Entdeckungsreisen in höheren Breiten erläutert. Insbesondere wird mit Hilfe eines Rechners die Theorie der meteorologischen Optik angewandt, um die Gunnbjorn-Schären als verzerrte, durch Luftspiegelungen übermittelte Bilder der Grönlandküste zu erklären. Eine erstaunliche Übereinstimmung erweist sich in einer weiteren Untersuchung der vorhandenen historischen Unterlagen.

Introduction

The general hypothesis that polar mirages may in some way have had an influence on the migrations of early peoples has periodically appeared both in anthropological and historical works (JONES, 1964:1; LEE, 1968:28—29; TAYLOR, 1971:79). However, very little has been done to find and analyze specific examples in an attempt to identify precisely how the mirage was used.

The intense scientific activity in Greenland between 1910 and 1935 provided scientists an opportunity to observe the frequent refractive anomalies that occur in these regions. These observations led to numerous attempts at scientific analysis and generated a great deal of interest in the field of atmospheric optics (WEGENER, 1914, 1918; NÖLKE, 1917; WÜRSCHMIDT, 1919; PERNTER & EXNER, 1922; KOCH & WEGENER, 1930; HUMPHREYS, 1940; etc.). Familiar with these effects and aware of the latest scientific evidence, TORNØE (1935) made the first serious attempt to integrate this evidence into the interpretation of Norse history. Nevertheless, a general lack of familiarity and inadequate computational resources hindered the application of theory to relevant situations.

The question was reopened by SAWATZKY & LEHN (1976), based on a detailed computer model for anomalous refractive effects (LEHN & SAWATZKY, 1975). A computer graphics analysis allowed a redefinition of the *hafgerdingar* as a specific optical phenomenon (LEHN & EL-ARINI, 1978), and photographs of this effect were first published in 1978 (LEHN et al., 1978).

The other two forms of the mirage, i. e., the *hillingar* and the Novaya Zemlya effect (LEHN, 1979), which constitute possible aids to Norse navigation, will be discussed in this paper. In an attempt to familiarise the reader with the visual impression, examples will be given, both of modern day sightings and as they appear in early sources. Specifically, optical theory will be applied to the many descriptions of the Gunnbjorn Skerries

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which, when re-examined in this way, gain both clarity and significance. This information will be integrated into a general historical framework in order to gain a greater appreciation of early Norse practices and achievements.

Nature of the Mirage

Arctic mirages, though confusing and meaningless to the uninitiated, can provide the observer with useful information about his environment. Since light rays travel in approximately straight lines under normal atmospheric conditions, we perceive our environment as seen in this way. Because the path of a light ray is dependent on the density of the material through which it passes, it need not follow this general rule. The temperature gradient of the atmosphere, which determines the density, can vary a great deal; hence light ray paths can assume many different shapes, resulting in distorted or dislocated images — mirages. Temperature inversion, common in polar regions, will cause light to bend downward to the colder, denser layers, producing abnormal visual effects. These inversions are created when heat loss from the surface exceeds „input", or when warm air masses over-ride colder ones due to cyclonic movements. Based on his findings in Greenland, WEGENER (1926) noted that the former was the major cause for mirages at continental stations while the latter produced the most dramatic mirages observed from his coastal station at Danmarks-Havn.

The two basic types of mirages that convey information which could be useful to line-of-sight navigation will be described.

The *hillingar* effect, which can greatly extend the distance over which an object can be seen and recognized, occurs when light rays are bent gently around the curvature of the earth due to a mild temperature inversion at the earth's surface. Objects normally below the horizon are "lifted" into view and are seen as if the earth were flat. This is especially noticeable on over-water sightings, when from water level a low beach 20 or 30 km away becomes visible. As there is virtually no distortion of the image within the inversion itself, any estimation of distance becomes difficult, because objects do not drop below the horizon as expected with distance. Abnormal viewing conditions become obvious only if objects rise above the inversion layer and are compressed.

In polar regions where the air can become extremely clear, especially in cold weather due to very low aerosol content (MIDDLETOWN, 1957), the second clue in estimating distance, clarity of the image, also exceeds normal expectations. The *hilligar* effect coupled with the clarity of polar air is so deceptive that an accurate estimation of distance, both of medium and long range sightings, becomes impossible (HOBBS, 1937).

The Novaya Zemlya effect is even more powerful than the *hillingar* and will transmit light rays for hundreds of kilometers through the atmosphere over flat uniform areas of the earth's surface (LILJEQUIST, 1964; LEHN, 1979), but the resulting image is usually so badly distorted that it bears no resemblance to the real thing. This effect is due to the fact that light rays have been trapped and are "bounced" between the earth and an inversion layer which exists at some elevation above the earth's surface. One property common to all Novaya Zemlya images is that the image occurs only in a narrow horizontal band, or window, parallel to and near the horizon. Above and below this window one observes the nearer environment (sea or sky).

In the past, this effect, first observed by Barentz in 1597 and reported by DE VEER (1609), was recognized only when it caused the sun to appear during the polar night some days or weeks before its predicted reappearance. It would go largely unnoticed as a grey

band on the horizon if no definite image appeared within the band (SHACKLETON, 1920:56). Furthermore, if it conveyed the badly jumbled image of land well beyond the horizon it would be dismissed as an illusion in familiar waters, or incorrectly charted as an island or coastline in uncharted areas. On the other hand, the experienced navigator, familiar with this effect, can use such information, much in the same way that Eskimos use ice blink.

Examples of Anomalous Sightings

The early 19th century scientist-navigator, William SCORESBY (1820:110—111), discussed the difficulty in estimating distance under certain weather conditions which occasionally arise in the North Atlantic:

> "When at the distance of 20 miles, it would be no difficult matter to induce even a judicious stranger to undertake a passage in a boat to the shore, from the belief that he was within a league of the land."

Another excellent example of this visual effect is SCORESBY's description (1820:111) of a situation frequently experienced by navigators as they approached Spitzbergen:

> "Thus, in clear weather, the high land of Spitzbergen is perfectly well defined, and every thing on it appears distinct, when at the distance of forty miles. If, after sailing five hours towards the shore, ... the atmosphere should become a little hazy, or even only dark and cloudy, the land might appear to be further distant than before."

Though SCORESBY (1820:384—391) was aware of refraction problems when the images were distorted, he failed to recognize this type of situation as another example of anomalous refraction. The most deceptive situation arises when the image is first seen aided by a *hillingar* which raises a coastline into full view, i. e., as it would normally be seen from a much closer range. If the temperature gradient of the atmosphere normalises, probably due to the advance of a front, the image seen will change very little, or even drop slightly below the horizon as the ship advances. Scoresby attributed this "remarkable deception as to distance" simply to the clarity of the air and the strong contrast of light and shade; a necessary but not sufficient condition.

Even though Scoresby did not clearly understand this phenomenon, his familiarity with the effect and with the resulting errors in judgement is demonstrated by his analysis of Mogen Heinson's "loadstone" (SCORESBY, 1820:122):

> "... he, after proceeding several hours without appearing to get any nearer the land, became alarmed, tacked about and returned to Denmark. On his arrival, he attributed this extraordinary circumstance, magnified, no doubt, by his fears, to his vessel having been stopped in its course by 'some loadstone rocks hidden in the sea.' ... The true cause, however, of what he took to be a submarine magnetic influence, arose, I doubt not, from the deceptive character of the land, as to distance, which I have attempted to describe."

This explanation, while not included in any of the standard history texts, remains by far the most plausible cause for Heinson's story. Unless this type of mirage has been experienced personally, it is so foreign to the normal range of visual experiences that it cannot be fully appreciated. To the inexperienced, like Heinson, a fading *hillingar* would be both confusing and frightening, since the distance gained sailing would be offset by the shortening of the horizon distance.

An excellent example of the distorted information that can be conveyed under mirage conditions was reported by members of Shackleton's expedition when caught in the ice

in the Antarctic Ocean. Members of the *Aurora*'s crew saw a large headland appear, only to disappear again. Though they had drifted only very little, the same land was seen again the next evening when it reappeared as a low coastline (SHACKLETON, 1920:332). This, in spite of the fact that the nearest land in that direction was about 300 km away. Though not accurate as to distance and form such sightings do impart some knowledge of the environment well beyond the horizon.

A phenomenon well-known to navigators in polar regions, frequently used as a source of reliable information, is water-sky: a dark band that occasionally appears on the horizon. SHACKLETON (1920:23, 30, 54—56, etc.) relates that navigators caught in the ice would look for this band, which would indicate to them the direction in which to seek open water. It is of course nothing more than an image of open water, transmitted over long distances due to anomalous refractive conditions. (For photographs see SHACKLETON, 1909:68; LEHN & SCHROEDER, 1980:33).

Anomalous sightings by scientific parties working in polar regions in the early 20th century were accepted as a natural phenomenon and led directly to the development of the underlying optical theory. Sightings like that of the British Arctic Air Route Expedition of Mount Forel at a distance of 220 km were considered of sufficient interest to be reported but common enough not to be questioned. D'Aeth was as impressed by the clarity of the image as by the actual distance of the sighting (MIRRLEES, 1932:29).

HOBBS (1937), aware of these effects from his work in the Arctic, wrote a series of articles in which he attributes many of the mapping errors made by 19th and early 20th century explorers to unrecognized long range sightings. Even though it may be argued that Hobbs was somewhat over-optimistic in his attempt to positively identify the sightings, and that some may have been mere illusions, the many examples analyzed clearly indicate the unique problems posed by the mirage.

The problems experienced by these highly skilled explorers reveal the difficulties that must have beset the early cartographers and navigators in their attempts to chart the North Atlantic. Sightings, like that of Davis who reported seeing land both to the east and the west when off Holsteinsborg (67°N) in the Davis Strait (MARKHAM, 1880:xxix), cannot in all fairness be dismissed as impossible. Nor can the many imaginary islands found on the early North Atlantic maps be regarded simply as figments of a cartographer's imagination. These islands no doubt reflect the many reports of actual sightings under mirage conditions, both of real land and of illusions. As Europeans became more and more familiar with the North Atlantic, these mapping errors were slowly corrected wherever no corresponding land was found. It was during this time that mirages became known, not for the information they imparted but for the confusion and errors they caused (e. g., PONTOPPIDAN, 1755, II:214).

Another source that provides examples of anomalous sightings is the many legends of appearing and disappearing islands found among most seafaring folk (NANSEN, 1911, I:374—380). Stripped of their mythological trappings, some become accurate descriptions of carefully observed natural phenomena. Their popularity among the Norse and Irish is no doubt due to the fact that temperature inversions necessary for this type of phenomenon are much more common in polar regions than in the warmer latitudes. Excellent examples of relatively short range sightings, as a direct result of an inversion due to overnight cooling, are the many fairylands along the coast of Norway which would disappear as the day progressed. According to legend, these islands would rise out of the sea at night and sink in the daytime. Since many of the islands first seen in this way were relatively near by, they could easily be reached and identified. Legend therefore had it that such islands had been "fixed" by a man or animal who had brought fire or steel to

them, and had then been settled. Nansen explains that these fairy islands were often given qualities such as happiness or abundance and can still be identified by their place names.

As NANSEN (1911, I:374) points out, such legends may well explain why Thorolf, on reaching Iceland, said that "it dripped butter from every blade of grass in the land they had found." He concludes that the many myths of fairylands "... may easily be suggested by mirage or other natural phenomena, and ideas about happiness are universal among men" (NANSEN, 1911, I:380). The many examples of the linguistic evidence given by Nansen indicate that the concept of floating islands and the possibility of fixing some of the land first seen in this way was very much part of the Norse culture.

Norse Navigation

A major difficulty in recreating history from early sources is to determine the level of knowledge and understanding achieved by the Norse of their own environment. The necessary knowledge and skills to carry out a task were simply taken for granted. These depended not on written instructions but on observations and practical experience passed on from one generation to another (TAYLOR, 1971:96, JONES, 1968:192). In spite of the tremendous wealth of information from early Norse literature about their achievements, very little direct information is given about the underlying pool of knowledge available to them. From the early records a great deal can be learned about their shipping practices and their seamanship, but very little about the necessary knowledge, the art of navigation, which made these achievements possible (MARCUS, 1953a:16). This must be pieced together from incidental remarks which found their way into the sagas and early histories.

The frequency with which the Norse travelled the open sea is a clear indication not only of the well-attested sea-worthiness of their ships but also of their self-assurance in navigating these waters and reaching their goal (MARCUS, 1953b; BRØGGER & SHETELIG, 1971; SAWYER, 1962; etc.). This confidence is revealed in the KING'S MIRROR (157):

> "Small seas have no great perils, and one may risk crossing them at almost any time; for one has to make sure of fair winds to last a day or two only, which is not difficult for men who understand the weather. ... If the circumstances are such that a man can wait for winds in a good haven or may confidently expect to find good harbors as soon as he has crossed, or if the sea is so narrow that he needs to provide for a journey of only a day or two, then he may venture to sail over such waters almost whenever he wishes."

This simple matter-of-fact statement reveals a great deal about both the knowledge and habits of Norse navigators. The author obviously attaches a great deal of significance to a safe harbour, not only to avoid the obvious physical landing hazards, but also as a safe place to wait patiently for ideal weather conditions (SHETELIG & FALK, 1937:352). The best-known example which illustrates this element of patience among Norse navigators is William the Conqueror's six-week delay on the French coast, waiting for stable weather conditions before attempting to cross the English Channel (TREVELYAN, 1942:87).

Since weather systems move with some regularity across the waters traversed by the Norse, the changing wind patterns could be used to advantage by the patient sailor (TAYLOR, 1971:17, 75). The statement that men who understand the weather could virtually assure the traveller a fair wind for a day or two implies that the weather could

be predicted with a reasonable degree of certainty. In order to make such a weather prediction, the regular variation of wind direction and cloud cover must have been carefully noted and correlated; a rather sophisticated achievement indeed.

This ability of the Norse to observe natural phenomena is noted by most historians, yet mirages are rarely included in the list of possible natural navigational aids used by the early sailors. Since mirages occur frequently during the preferred sailing seasons, spring and fall, mariners had ample opportunity to see distorted land images, and could easily have correlated them with subsequent land sightings. Examples of unsophisticated peasants observing and correlating mirages with natural events (in this case, impending storms) are reported by PONTOPPIDAN (1755, II:215) and SCORESBY (1820:385).

The *hillingar* effect, often present under fair weather conditions, would allow land to be sighted much earlier than would normally be expected, thus reducing the time spent out of sight of land. For example, the *hillingar* would explain the early reports that both Iceland and Greenland can be seen at one time. Though Nansen dismissed these early reference as inaccurate, TORNØE (1935:431—432), on the basis of a number of such reports by modern sailors when mid-channel at about 68°N, questioned Nansen's conclusions. As Tornøe points out, Snaefjallanes in north-west Iceland, which is visually closest to Greenland, and the mountains of the Blosseville coast to the north-west are only 15 nautical miles

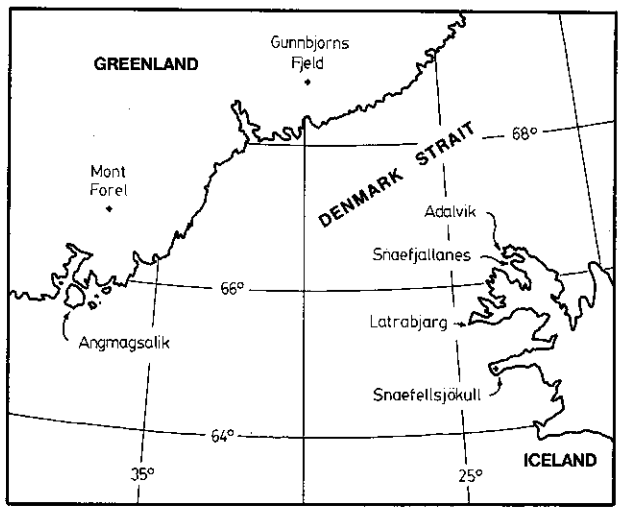

Fig. 1: Index map.

Abb. 1: Lageplan.

short of intervisibility under normal atmospheric conditions (See map, Fig. 1.). In this area of the Denmark Strait even a very mild *hillingar*, the normal situation under stable weather conditions, would make the two lands intervisible. Based on this information and on evidence found in original sources, TORNØE (1935:433—440) identified Hvitserk, the landmark used in the ancient sailing directions, as the highest peak in the Watkins Range, Gunnbjorns Fjeld. This thesis, though carefully developed, has received little attention from modern historians unfamiliar with the mirage, and deserves careful re-examination.

Though intervisibility is not mentioned in the sagas, it is associated with both Gunnbjorn's and Eirik's voyages in the Grönlands Annaler, and should therefore be considered as a possible factor in any attempt to establish old Norse landmarks. However no

historical evidence has been found to indicate that the Norse had first sighted Greenland precisely this way, as suggested by OLESON (1964:14). Rather, the discovery of Greenland has consistently been associated with the sighting of skerries.

The Nature of the Gunnbjorn Skerries

Though early records and maps place the Gunnbjorn Skerries somewhere between Iceland and Greenland, generally off the Vestfirthir coast, no such skerries have been found. In 1836, GRAAH (1836:159), well aware that islands were still being charted in arctic regions only to be removed in subsequent journeys, made no attempt to identify these skerries. He simply dismissed them as a possible landmark since "... the fact of Gunbiörn's Skerries being situated half-way between Iceland and Greenland, is not only disproved by the experience of the Icelandic traders and fishermen, but by that also of the English and Dutch whalers." Later scholars tried to identify existing islands on the east coast of Greenland with the ancient sightings but never seriously questioned the nature of the skerries. Fridtjof NANSEN (1911, I:261) placed the skerries off Cape Farewell or possibly as far north as Angmagsalik. O. Pettersson, in 1913, placed the skerries at Cape Dan, latitude 66°N, an opinion also held by Steensby (see the definitive study by HOLM, 1917, in which he establishes the skerries at Angmagsalik). Though GJERSET (1924:93) postulated that Gunnbjorn "may have seen also only a mirage or a drifting ice-floe," this theory was never fully developed. Holm's thesis, though not entirely satisfactory, remained the most plausible; and historians have continued to think of the skerries as actual islands, probably the Angmagsalik group.

The possibility that the skerries were but distorted images of land beyond the horizon should be seriously considered. Images recognizable as land to the Icelander would be seen most frequently when off the Vestfirthir coast, in the narrowest part of the Denmark

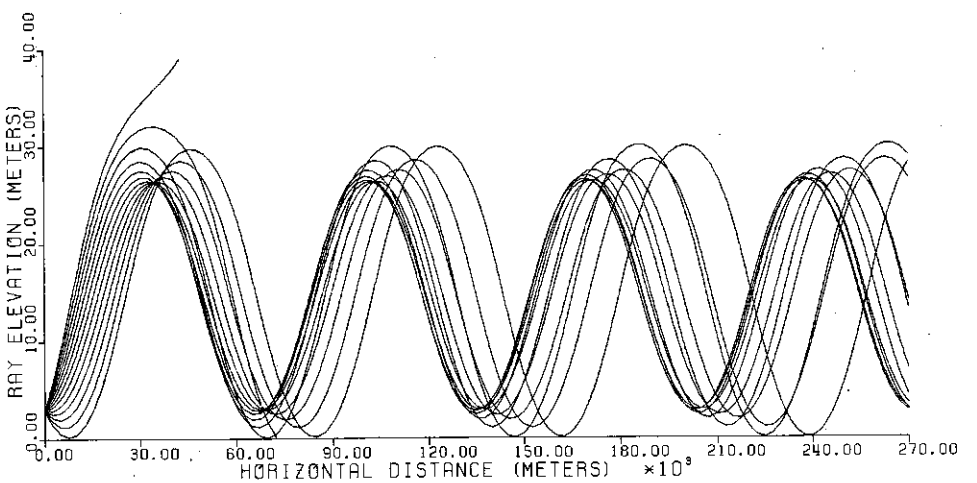

Fig. 2: Typical paths described by light rays under Novaya Zemlya conditions. The abscissa measures distance along the earth's surface from the observer's eye, which is at an elevation of 3 m. The rays are computer-generated at intervals of one-half arcminute. The lowest ray entering the observer's eye makes an angle of — 2½ minutes with the horizontal; the highest an angle of + 3½ minutes.

Abb. 2: Lichtstrahlbahnen bei einem typischen Novaya Zemlya-Effekt. Die Höhe der Lichtstrahlen über dem Meere ist gegenüber der Entfernung, vom Beobachter entlang dem Meeresspiegel gemessen, dargestellt. Der Abstand zwischen benachbarten Strahlen entspricht einer halben Bogenminute. Am Auge des Beobachters, in 3 m Höhe, schneidet der unterste Strahl die Horizontalebene mit einem Winkel von — 2½ Minuten, und der oberste mit Winkel + 3½ Minuten.

Strait. Such images would probably be due to the Novaya Zemlya effect since this effect produces a larger image than the *hillingar* over long distances. Though distorted, the image would be easily recognizable as land and would appear as low flat islands, or skerries, with ice, water or sky behind them. That such sightings would tempt the ever land-hungry Norse can hardly be doubted.

Depending on the exact location of the observer, the bearing angle at which this land was sighted would vary. Since such sightings would be reported in the area from Latrabjarg northward looking across the channel, the direction given would vary from west, to north-west, to north-north-west, which is consistent with 17th century sources. The direction given in the earlier sources is consistently west from the Vestfirthir. The only exception is Snaebjorn, who according to the poem recorded in the Landnamabok *, sailed to the north-west in search of the skerries. Since the Norse travelled by landmark (JOHANNESSON, 1974:106—107) and since the directions given are not entirely reliable (e. g., GATHORNE-HARDY, 1970:218—220; TAYLOR, 1971:6—8, 85), it is impossible to establish an exact location for the skerries based on this information.

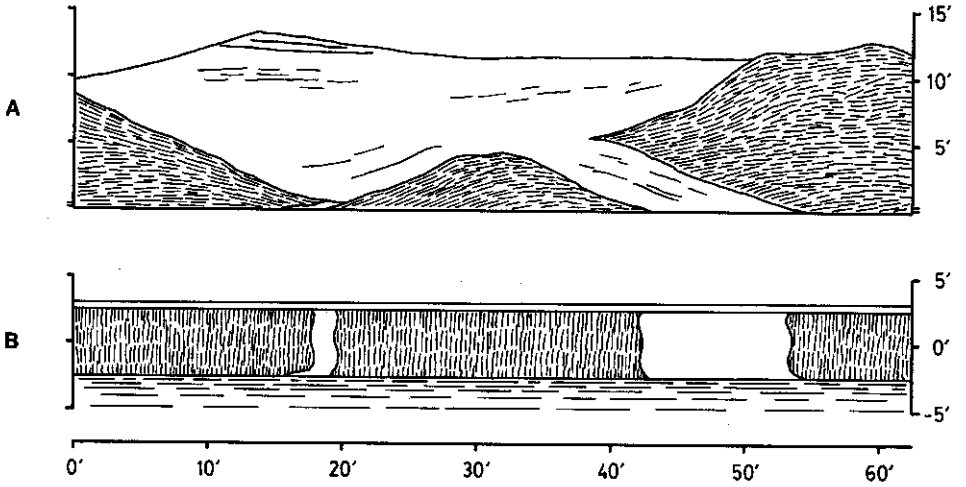

Fig. 3: A. This view represents a portion of the Blosseville coast, as seen at close range under normal atmospheric conditions. The Novaya Zemlya window, as generated by the rays of Fig. 2, extends from evelation 0.07 minute to evelation 0.4 minute (indicated by the short horizontal bars at the edges of the drawing). Only those objects within this narrow horizontal strip contribute to the Novoya Zemlya image.

B. The same coast as seen from 250 km under Novaya Zemlya conditions The whole window is filled by a distorted image of the objects within the narrow strip indicated in A, above.

Abb. 3: A. Eine typische Ansicht der Blosseville-Küste vom nahen Standpunkt unter normalen atmosphärischen Verhältnissen gesehen. Der Novaya Zemlya-Streifen, durch die Lichtstrahlen der Abb. 2 erzeugt, besteht zwischen den Höhen von 0.07 bis 0.4 Bogenminuten. Die kurzen Horizontalstriche am Bildrand deuten die Grenzen dieses Streifens an. Nur diejenige Objekte, die sich innerhalb des Streifens befinden, tragen zum Novaya Zemlya-Bild bei.

B. Das Novaya Zemlya-Bild der abgebildeten Küste, bei einer Entfernung von 250 km. Ein verzerrtes Bild nimmt die ganze Streifenbreite ein.

To receive such images, the elevation of the observer is not critical; it is only necessary that he is within or below the inversion layer itself. Since such inversions are seldom more than a few hundred meters in height, sightings would be reported from at or near sea level and not from the uplands, a fact consistent with historical evidence.

In order to illustrate the effect, a sketch has been made of a mountainous coastline typical of northeast Greenland. From this a picture has been generated, as it would

* All references to Eirik's Saga, Groenlendinga Saga and Landnamabok are taken from JONES (1964).

appear to an observer in Icelandic waters under Novaya Zemlya conditions (See Figs. 2 and 3). The ray path calculations are based on a 5° temperature inversion, having a surface temperature of 6.7°C, and a maximum temperature of 11.8°C at an elevation of 45 m above the sea. Maximum slope of the temperature profile is 0.2°/m, between the elevations of 20 and 30 m. The observer's eye is 3 m above sea level, and at a distance of 250 km from the sighted coastline.

Historical Evidence

The legend of the Gunnbjorn Skerries originated in north-west Iceland, where Gunnbjorn had seen skerries to the west while on a voyage around Iceland toward the end of the 9th century. It has generally been assumed that the story was kept alive in the Vestfirthir by members of the Gunnbjorn family who settled in the Breidafjord area (e. g., JONES, 1964:45; INGSTAD, 1966:15). Rather than accept that one such sighting should become a destination point for expeditions a hundred years later, OLESON (1964:179) suggests that the skerries were not only sighted by Gunnbjorn but by others as well. That is, as the area became more populated and navigation in these waters increased, an ever increasing number of people would have had an opportunity to see these elusive islands. In the absence of concrete supportive evidence, this hypothesis had to be regarded as mere speculation. Now that the analysis of the Novaya Zemlya effect has provided an explanation for such sightings, the available source material can be re-assessed.

On the basis of information given in the early sources it is impossible to visualize the skerries, since they are never described in detail. The Landnamabok mentions the skerries in association with the first Norse voyage to Greenland, which it attributes to Snaebjorn. With a shortage of land in Iceland and spurred on by charges of homicide, Snaebjorn decided to search out the skerries to the north-west, reported by Gunnbjorn. Neither of the two surviving accounts (Landnamabok and Gr.h.M.I:105) gives any description of the skerries. After spending a feud-ridden winter snowed-in in a hut they had built, the survivors returned to Iceland via Norway. No claim is made at any time in the accounts that the skerries were found; they are simply not referred to again.

Both the Groenlendinga Saga and Eirik's Saga mention the skerries but again only incidentally, as an explanatory note to Eirik the Red's discovery of Greenland. According to these sagas Eirik, when banished from Iceland, sailed west to seek out the skerries seen by Gunnbjorn when he was windblown on his voyage around Iceland. Like Snaebjorn before him, Eirik made no claim to have found the skerries, but reported his landfall at Blaserk, on the east coast of Greenland.

That the skerries should turn out to be land seems not to have surprised the Norse seafarer. After they had served their purpose in establishing the heading for the discovery of new land, they seem to lose all significance. They are not used in the sailing directions of the Landnamabok, nor are they mentioned in any of the sagas from the early Landnama time. Once Eirik had reached Greenland's shores the skerries disappear from the literature, only to reappear three centuries later when ice had blocked all access to them (NANSEN, 1911, I:262). Familiarity with the nature of the information conveyed by the Novaya Zemlya effect would certainly explain this sudden disinterest: the skerries would simply have been accepted for what they were — a predictor of land. By the mid-13th century, the author of the KING'S MIRROR (138) advised mariners of the dangers of the ice and instructed them to avoid it by heading farther south; however no further details are given. The skerries first appear in the mid-14th century, when Ivar Bardsson, a priest sent to Greenland from Norway in 1341, attempts to give more

specific instructions. These begin with the old sailing directions as given in the Landnamabok; then, as a way of elaboration on that information, Bardsson inserts the Gunnbjorn Skerries (NANSEN, 1911, I:262):

> "Item from Snaefellsnes in Iceland, which is shortest to Greenland, two days' and two nights' sail, due west is the course, and there lie Gunnbjörnskerries, right in mid-channel between Greenland and Iceland. This was the old course, but now ice has come from the gulf of the sea to the north-east so near to the said skerries, that none without danger to life can sail the old course, and be heard of again."

After Bardsson has described the location of the skerries and the ice conditions in the area, he uses them in his sailing directions. Thus, when floe-ice made the skerries totally inaccessible and any closer observation became impossible, they regained their significance and became a distant landmark on the course to Greenland.

Though Bardsson uses the skerries as a landmark for travellers, he does not include them as part of Greenland itself. Because it is unclear from Bardsson's writings if he was personally familiar with the east coast, HOLM (1918:303) argues that there may have been some confusion as to place names: that Korsoe, the northern-most (eastern-most) place named, and the Gunnbjorn Skerries could have been one and the same place. Yet Bardsson clearly differentiates between the two. Korsoe is described as a big island near the ice-mountains where "... there is universal hunting of white bears." Bardsson further locates it at the limit of the Greenlander's hunting grounds, for "Still further east, as far as one can see, there is nothing but ice and snow both in land and on water" (BRUUN, 1918:173). The skerries on the other hand were described within the floeice itself.

After Bardsson's stay in Greenland, contact with Norway deteriorated very rapidly. From the 14th century onward, Viking sea power declined due to social, political and economic problems at home. Fewer and fewer long ocean-going voyages were undertaken; even voyages to Iceland became intermittent (MUSSET, 1951:223; NØRLUND, 1936:126, etc). It is only then that claims of actual landings on the skerries begin. The first such claim, toward the end of the 14th century, was made by Bjorn Jorsalafare, who was wind-blown onto some islands off the east coast of Greenland on his way from Norway to Iceland. To a traveller totally unfamiliar with the area, any islands would have served equally well. The Gunnbjorn Skerries, which until this time had been described as a distant landmark, had now had their first visitors. Jorsalafare is also the first to imply that the skerries were inhabited, for he reports seeing a farmstead. Since Jorsalafare's claim was recorded in his journal, it survived and eventually entered into the history. It is however impossible to ascertain when this claim first gained credibility.

By the 15th century there appears to have been essentially no contact between Norway and Greenland. With Norway controlled by the Hanseatic League and the Viking ship replaced by the cog, the skills developed by the Norse for ocean travel would have disappeared, for "the part played by personal knowledge and experience in the navigation of the Norsemen can scarcely be set too high." (MARCUS, 1953a:25). The widespread use of the compass furthermore enabled new navigational techniques to replace the old. Meanwhile, the British and Basque had gained domination of the North Atlantic, replacing the Norse. Since the Bergen mariners could no longer ply their trade with Greenland, the knowledge of the old sea routes would slowly be forgotten. The remnants of this knowledge, all available information about the old sea routes to Greenland, were collected by Archbishop Valkendorff early in the 16th century. Yet by 1579, when the Danish government finally sent out an expedition to look for the lost colonies in Greenland, the instructions could no longer be interpreted correctly (GAD, 1970:194—195).

Icelandic sources virtually disappear in the 15th century and except for one possible wind-blown voyage (Gr. h. M. I:119) there is no additional information on the skerries. Instead, based on a claim by Pining and Pothorst, an additional feature, the Hvitserk Rock, is placed midchannel in the Denmark Strait. However by the 16th century wind-blown travellers were again claiming to have reached islands on the east coast of Greenland. The reports found in the Grönlands Annaler are generally brief and their accuracy questionable; some claim Norse habitation of these islands, a claim generally discounted by historians. Two reports from this era which have been recorded in some detail by Jonsson will be examined here: an account of Latra-Clemens, and a description of Korsoe.

According to the report Clemens, a farmer, "cultured and honest", lived in the Adalvik area on the northwest tip of the Vestfirthir. Toward the end of the 16th century he joined an English ship to escape the authorities and reached the Gunnbjorn Islands, "which from appearances it would seem that they consisted of skerries and deserted islets". From there the narrative can be clearly divided into two parts. The first half relates claims made by local residents of the Adalvik district (Gr. h. M. I:127; authors' translation):

> "A great many reliable and true narratives and reports contain the statement, that the Gunnbjørn-Islands exist, and can be seen, when the air is clearest, from a rocky cave or cleft; the flagstones, that this hollow contained, are erected by the old ones on this mountain by the sea, called Ritur, that lies toward east from Isefjord's gap; it is also a bird-mountain."

The report indicates that such sightings were still being accepted in this part of Iceland; the Adalvik area, on the north-west tip of Iceland, would be an ideal location from which to see such images.

The second part of the account must certainly be another traveller's tale:

> "Clemens had said, that from the end of the islands where he had stayed, he had been able to see the top of the same mountain, which appeared of the size of a barrel, but could also see much more of the same land."

Even if Latra-Clemens did reach the Angmagsalik Islands, which is probable, it is most unlikely that he saw any part of Iceland loom on the horizon, a distance of over 600 km. Clemens probably made his claim in order to prove to his neighbours that he had actually been to the islands which they could see from time to time. More than anything else, his claim indicates a total ignorance of navigation; he seems to have had no idea of the distance covered, nor the direction taken. That the story should have had enough credibility to be included in Jonsson's history indicates that the Icelander's knowledge of the North Atlantic had become hazy indeed.

Bjorn Jonsson further confuses the issue with his description of Korsoe. As in Clemens' case the account includes the description of an actual island on the east coast of Greenland visited by an English ship, yet the location is given as seen from Iceland (Gr. h. M. I: 141):

> "But often and not rarely one sees these islands, and knows that they exist, as lying westward out in the sea, straight before Latrajarg or diagonally over from that, toward the mouths of Patrix-Fjord and Talkna-Fjord. . . . One often considered settling there, although that always goes in slow motion. A Danish skipper who now stays in Revet (in Snaefjeldsnaes Syssel) tells that he was well informed on these islands, and had seen them from a distance, but that he still had not been right near them nor went there on land."

Again we are given the description of a distant landmark which tempts local residents

but which no one has visited or even seen at close range. Unlike Bardsson, Jonsson no longer differentiates clearly between Korsoe and the Gunnbjorn Islands. He locates the two in essentially the same place, an area where no islands exist.

There is some indication that the reports from this area were conflicting since in the same report another description makes no mention of islands (Gr. h. M. I:143):

> "Seafarers have often, in this region, seen (in addition to birds and whales) Iceland's coasts, especially Snefjelds-Jøkel, but when these disappear, and they come some distance toward west, then they spot Greenland's glaciers; about this is much spoken."

Nonetheless, the consistent sightings across the narrowest part of the Denmark Strait had established a string of islands off the Vestfirthir coast from Latrabjarg northward. Bjorn Jonsson consistently chose to place his Gunnbjorn Islands off the Isafjardardjup, the area in which such sightings would most commonly be made, while placing his Korsoe just to the south. This northerly location was also accepted by Arngrimur Jonsson, a contemporary of Bjorn, who refers to the skerries as west, north-west and north of Iceland (JONES, 1964:44; NANSEN, 1911, I:263—264). As the Icelanders had heen dependent on Norway for ocean travel since the end of the 12th century, any ability to interpret such sightings correctly would long since have disappeared, leaving only folk-lore and legend as dim reminders of past skills.

In his discussion of the skerries, Jonsson also includes one account thought to be taken from older sources, no longer extant. It is this report which provides the best clues as to the nature and the general location of the skerries (NANSEN, 1911, I:263):

> "... that Gunnbjörn, Ulf Kråka's son, was thought to have seen a glacier in the western ocean, but Snaefells-glacier here, when he was carried westward on the sea, ... But this Gunnbjörn, who came next after him, he sailed round much farther out, but kept land in sight, therefore he called the islands skerries in contradistinction to the holm; but many histories have since called these islands land, sometimes large islands."

Though somewhat confused, the passage implies that Gunnbjorn saw both Snaefellsglacier and the Greenland mountains at one time when wind-blown to the west. Modern sightings would corroborate this claim if the Snaefjalla Mountain and the Watkins Range were meant. Though Snaefellsjökull and the Watkins Range cannot be dismissed entirely, intervisibility here would be a much rarer occurrence. Further, while intervisibility is claimed only when the ship was well out to sea, the sighting of skerries, in the same general area, is claimed while coasting around Iceland. As already seen, folk tradition of 16th and 17th century Iceland also maintained that the Gunnbjorn Skerries were islands sighted from north-west Iceland. The common association of a wind-blown voyage with the sighting of skerries is based on information found in the Groenlendinga Saga and Eirik's Saga in connection with Eirik's voyage.

Even more interesting is the fact that Jonsson must still have had access to information that reported these islands to be land for he includes this comment, but does not elaborate. From Jonsson's other reports it is evident that he no longer appreciated the significance of this information. Time had taken its toll; reports from the occasional traveller who had reached Greenland's east coast had given the Gunnbjorn Skerries a totally new dimension. They were no longer a distant landmark by which to set one's course, but had become small islands, possibly inhabited by Norsemen. This new dimension is reflected in Jonsson's choice of name, the "Gunnbjörn Islands"; which he consistently uses in preference to "Gunnbjorn Skerries", the name used in the Landnamabok and the sagas, as well as by Bardsson.

Conclusion

Both the *hillingar* and the Novaya Zemlya effect can be an aid to navigation since they impart information from well beyond the normal horizon. Though confusing and useless to the uninitiated, familiarity with the effects allows the astute observer to glean valuable information from images conveyed in this way. Examples given by explorers who relied on line-of-sight navigation clearly indicate that such images often led to confusion. To the 18th and 19th century explorers, interested in the accurate charting of new waters, mirages became known as a source of error. However, if interpreted correctly, as in the case of water-sky, such images remained an important aid to navigation in polar regions.

Nansen's discussion of the many Norse fairylands is a clear indication of the strong influence such mirages had on the early Norse. Since mirages of the Novaya Zemlya type are not uncommon in high latitudes, travellers or fishermen would have occasionally seen land appear off the Vestfirthir coast. History informs us that the legend of the skerries originated in the Vestfirthir, where it continued to tempt the inhabitants in their search for new land. Though the skerries disappeared from history once Eirik had reached Greenland's shores, they regained their function as an important landmark on the course to Greenland when ice made them inaccessible. Folk tradition and continued sightings kept the skerries alive even through Iceland's bleakest era, a time from which there are almost no written records. When they re-emerged in Icelandic history, unreliable accounts of actual landings had given them an entirely new dimension. Based on these reports and on information found in the early sources, navigators and scholars searched for the islands in vain. Later scholars again tried to establish the location of these elusive skerries by correlating them with existing islands. Though not entirely satisfactory, the Angmagsalik group seemed the only possible answer.

Their continued association with the Vestfirthir from the earliest days of Iceland's history onward, and their elusive character suggest that the skerries were but images of land beyond the horizon. The sighting of skerries cannot be doubted, nor can their influence on Norse history be disputed; their importance lies in the information they conveyed and not on their existence as actual islands.

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