Small Publications in Historical Geophysics

No. 10

The Visibility of the Midwinter Sun at the First Viking Settlement in America - Calculations Compared with the Icelandic Sagas

Martin Ekman

Summer Institute for Historical Geophysics
Åland Islands

2002

Small Publications in Historical Geophysics

No. 10

The Visibility of the Midwinter Sun at the First Viking Settlement in America - Calculations Compared with the Icelandic Sagas

Martin Ekman

Contents

Summer Institute for Historical Geophysics
Åland Islands

2002

1. Historical background

During the Viking Age, starting around 800 A.D. and fading out towards 1100 A.D., Scandinavian vikings travelled in their specially designed longships along the coasts of almost the whole of Europe. Some of the vikings even went to the adjacent parts of Africa and Asia. Others crossed the Atlantic Ocean and reached as far as North America.

Starting as warriors and explorers, the vikings gradually developed into merchants and society builders, spreading their form of early democracy to several of the North Atlantic islands. Their legislative assembly, "thing" or "ting" in the Nordic languages, usually gathered outdoors on a hill in a field, "thingvellir" or "tingvall". This tradition still survives at "Tynwald" on the Isle of Man, the autonomous island in the central Irish Sea; Isle of Man thus has the world's oldest parliament still in operation. The viking parliaments - although nowadays only indoors - also survive on the Faroe Islands and on Iceland.

Iceland was colonized in 874 by Norwegian vikings. About one hundred years later, in 985, one of the Icelandic vikings, Eiríkr Rauði or Erik Röde (Erik the Red), moved to Greenland together with a number of his fellow Icelanders. He had a son called Leif Eiríksson. In the year 1000 Leif sailed with 35 men from Greenland to settle at the east coast of North America, in an area named Vínland by them. A few years later another 160 vikings, among them Leif's brother and sister, moved to the same place. Thus the first viking settlement on the American continent was created. However, it lasted only for some years. This was partly because of external problems due to emerging native inhabitants, partly because of internal problems due to the uneven ratio of men to women (there were too few of the latter kind). Although no permanent settlement seems to have been established, repeated sailings to the American coast have been recorded since then, e.g. in order to cut trees.

Some decades ago the remnants of a small short-lived Nordic settlement were discovered and excavated on northern Newfoundland in eastern Canada (Ingstad & Ingstad, 1985). This was the first archeological confirmation that vikings had actually lived on the American continent. However, the location does not seem to fit the descriptions of the original settlement of Leif and his people as given in the old Icelandic sagas.

2. The Icelandic sagas and the sun at Leif's settlement

Most of the information on the first viking settlement in America is to be found in two Icelandic documents dating from about 1250. One is the Eiríks saga rauða or Eriks Rödes saga, i.e. Saga of Erik the Red. The other is the

Grænlendinga saga, i.e. Saga of the Greenlanders. The first one is said to stem from Eirík, the father of Leif, who led the first expediton. The second one is said to stem from Thorfinn, the leader of the large expedition a few years later. These two Icelandic sagas disagree on a number of minor points but agree quite well on the main issues.

Scrutinizing the two Icelandic sagas and other historical information, together with modern maps and personal travels along the coasts, Larsson (1992, 1999) has recently succeeded in pointing out a most plausible location of Leif's settlement; see Figure 1. It is in south-eastern Canada, southern Nova Scotia, at the mouth of the Chegoggin River, where there is a tidal inlet. The tidal inlet is described in both Erik's saga and the Greenlanders' saga; in the first one it is called Hóp. The settlement itself is called Leifsbúðir or Leifsbodarna (Leif's sheds) in the latter saga. Some recent comments on the more exact location of the place in relation to the tidal inlet have been given by Bruzelius (2000).

In the description of Leif's settlement in the Greenlanders' saga there is a piece of astronomical information of great interest. It says:

"The days there were of more equal length than on Greenland and Iceland; the sun had *eyktarstaðr* and *dagmálastaðr* on the shortest day of the year."

The words in italics in the quotation denote certain azimuths of the sun, used by the vikings to specify times for meal breaks at work (Lárusson, 1961). "Eykt" is related to "eight", and connected to their division of the horizon into eight octants, while "dagmál" is related to "daily meal", indicating a meal break.

It is not known exactly what azimuths the viking explorers meant by the above concepts. However, there is an Icelandic law (Grágás) dating from about 1260, containing a written definition. This definition was interpreted by Storm & Geelmuyden (1886). The law states:

"It is *eykt* when the sun has passed two thirds of the south-western octant and has one third left."

The word *eykt* here is simply the event when the sun is in the horizontal direction of *eyktarstaðr*. This means that *eyktarstaðr* would correspond to an astronomical azimuth of

$$a = 45°/2 + 2 \cdot 45°/3 = 52.5°$$

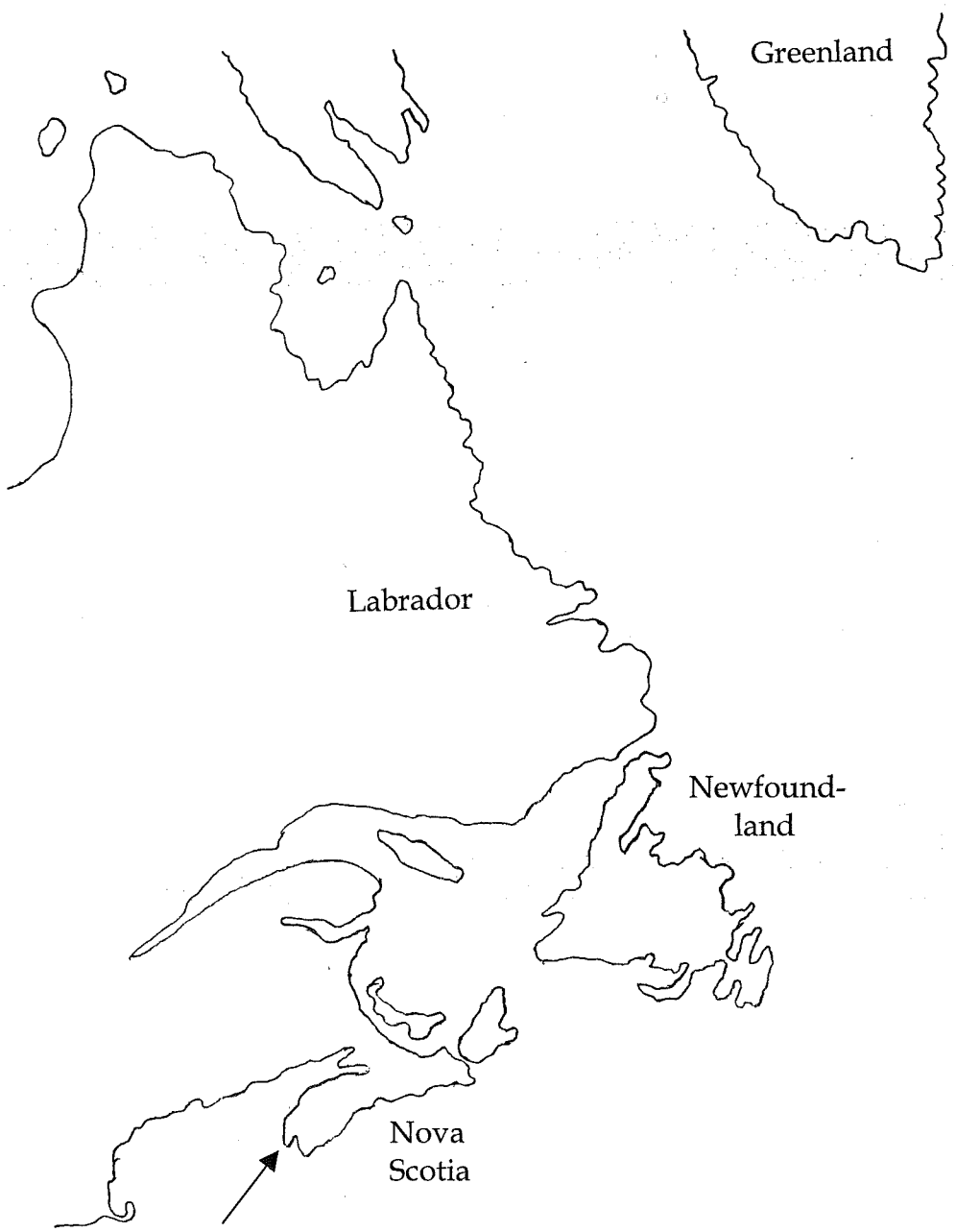

Figure 1. The location of Leif's settlement in Canada (at the arrow) according to Larsson.

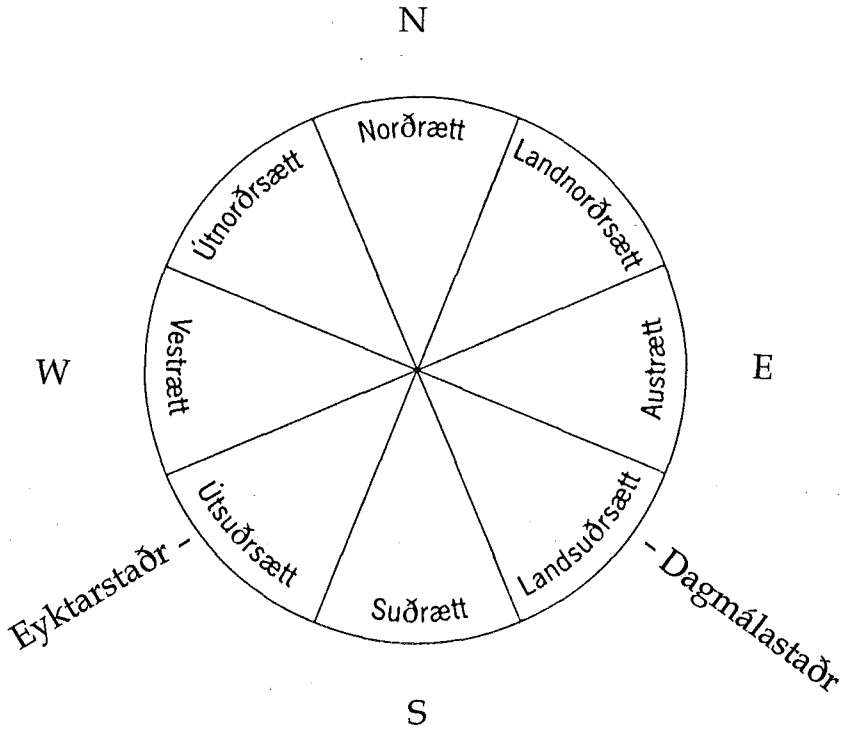

Figure 2. Eyktarstaðr and *dagmálastaðr* in relation to the four cardinal points and the viking horizontal octants.

as illustrated by Figure 2. This was an important azimuth since the sun's position there defined when work was to cease at the last day of the week. *Dagmálastaðr* is the corresponding azimuth on the other side of the meridian, i.e. - 52.5°.

It should be pointed out that the vikings seem to have been well acquainted with astronomical navigation and, thereby, with observing the height and azimuth of the sun. Around 1150 Oddi Helgason constructed a quite accurate table for the sun's azimuths and heights on Iceland during a year (Barfod, 1967). The azimuths are given in parts of horizontal octants, the heights are given in "half wheels", one wheel being equal to the sun's angular diameter.

Let us now make some solar calculations, and see how they fit into Larsson's identification of Leif's settlement combined with the texts in the Greenlanders' saga and the old Icelandic law.

3. The sun's midwinter height at *eyktarstaðr*

The height h of the sun above the horizon can be computed by applying spherical trigonometry to the fundamental astronomical triangle; see Figure 3. The spherical law of cosines yields

$$\sin\delta = \sin\varphi\sin h - \cos\varphi\cos h\cos a \qquad (1)$$

(see e.g. Smart, 1962). Here φ is the latitude of the place, a is the azimuth of the sun, and δ is the declination of the sun. In our case we want to study the sun at the shortest day of the year, i.e. at winter solstice. Hence h must be a small quantity, allowing us to safely put cos h = 1. This makes it possible to solve (1) for h through

$$\sin h = \frac{\sin\delta + \cos\varphi\cos a}{\sin\varphi} \qquad (2)$$

The latitude of Leif's settlement is φ = 43.9° according to Larsson (1999), and the sun's azimuth at *eyktarstaðr* is a = 52.5° according to above, or to Storm & Geelmuyden (1886). The sun's declination at midwinter, i.e. at the winter solstice, is equal to the inclination of the ecliptic to the equator. This inclination undergoes a slow decrease due to the gravitational attraction of the planets on the Earth, perturbing the Earth's orbit around the sun. The inclination and, thereby, the sun's midwinter declination for the year 1000 can be calculated according to Meeus (1991); we find δ = - 23.6° (today - 23.4°). Inserting the above values into (2) we obtain h = 3.2°. However, at low heights like this,

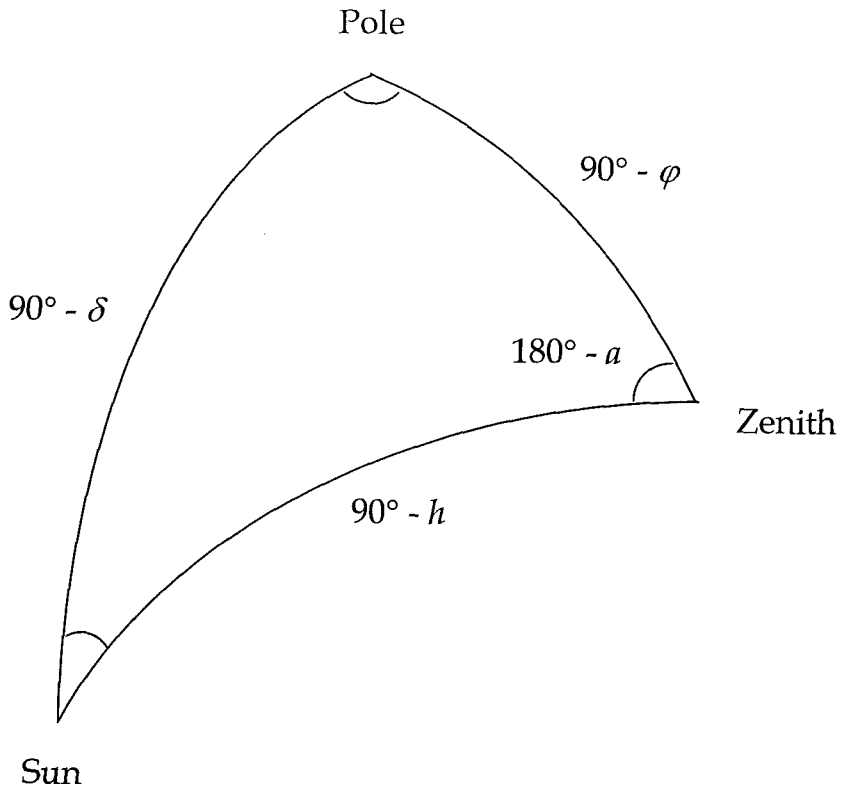

Figure 3. The fundamental astronomical triangle involving the sun.

refraction in the atmosphere will cause the sun to be observed slightly higher than at its astronomical position. The refraction is a function of the height of the sun as given e.g. by Hoyle (1977). Adding this effect we finally obtain

$h = 3.4°$

Thus, at Leif's settlement as located by Larsson the midwinter sun at *eyktarstaðr* would be 3.4° above the horizon at sea. The sun's angular diameter is 0.5°, so that in terms of the viking unit of wheels (sun diameters) the sun at this event could be seen 7 wheels above the horizon. Consequently, the sun at this event would also be observable in a moderately hilly landscape, typically just above a 60 m hill at a 1 km distance. This must have made the sun at *eyktarstaðr* useful for time-keeping even at winter solstice.

4. The sun's invisibility at *eyktarstaðr* on northern latitudes

Obviously there is a latitude north of which the midwinter sun cannot be observed at *eyktarstaðr*. This latitude can be found by inserting δ and a from Section 3 into (1), together with h = - 0.6°. The last-mentioned value differs from 0° to compensate for the horizontal refraction. Solving for φ, which requires an iteration, we find $\varphi = 49.9°$. This result was found already by Storm & Geelmuyden (1886), although their calculations were not published. The small viking settlement found on Newfoundland (Section 1) is in this respect situated too much to the north, at $\varphi = 51.6°$.

Leif and his viking settlers came from Greenland and were born on Iceland, both on latitudes well north of 49.9°. For how long time during winter was the sun not visible at *eyktarstaðr* there? This can be found out by again using formula (1), now in order to calculate the sun's declination, which varies with the time of the year. Putting $\cos h = 1$ we have

$$\sin\delta = \sin\varphi \sin h - \cos\varphi \cos a \qquad (3)$$

Leif and most of the other settlers came from Brattahlid on south-western Greenland, where φ = 61.0°. They were born in different parts of Iceland, but Iceland can here be represented by its central place Thingvellir, where $\varphi = 64.3°$. Inserting these latitudes together with h = - 0.6° and a = 52.5° into (3), we find δ = - 17.7° for Bratthalid and δ = - 15.9° for Thingvellir. These solar declinations correspond to the dates

11 November - 31 January	for Brattahlid
5 November - 6 February	for Thingvellir

Thus at the viking home districts in Greenland the sun at *eyktarstaðr* was invisible for nearly 3 months, and in Iceland for precisely 3 months, during winter. The visibility of the sun at *eyktarstaðr* even in the middle of the winter at Leif's new settlement must have appeared a considerable contrast to what the vikings were used to.

5. Conclusion

Our calculations show that the midwinter sun at *eyktarstaðr* could be seen 7 wheels (sun diameters) above the sea horizon by the vikings at Leif's suggested settlement in North America. Hence it could also be observed on land in a moderately hilly landscape with an average slope of up to 1 : 16. This points to an excellent agreement between Larsson's location of Leif's settlement, the solar piece of information in the Greenlanders' saga and the definition of *eyktarstaðr* in the old Icelandic law.

The calculations also show that the same phenomenon was impossible to observe at Brattahlid on Greenland or Thingvellir on Iceland for a period of close to 3 months during winter. The visibility of the sun at *eyktarstaðr* at Leif's settlement even in the middle of the winter formed such a contrast that it seems quite reasonable that this specific piece of information was remembered and later on preserved in the Icelandic sagas.

References

Barfod, J H P (1967): Navigation. Kulturhistoriskt lexikon för nordisk medeltid, 12, 260-263.

Bruzelius, N (2000): Vinland, Hop och Leifsbodarna. Sjöfart och sjöförsvar, 2000/4, 14-15.

Hoyle, F (1977): On Stonehenge. W H Freeman & Co., 157 pp.

Ingstad, A S, & Ingstad, H (1985): The Norse discovery of America. Norwegian University Press, 2 vol., 495 + 573 pp.

Larsson, M G (1992): The Vinland sagas and Nova Scotia - A reappraisal of an old theory. Scandinavian Studies, 64, 305-335.

Larsson, M G (1999): Vinland det goda - Nordbornas färder till Amerika under vikingatiden. Atlantis, 184 pp.

Lárusson, M M (1961): Horisont. Kulturhistoriskt lexikon för nordisk medeltid, 6, 669-671.

Meeus, J (1991): Astronomical algorithms. Willmann - Bell, 429 pp.

Smart, W M (1962): Text-book on spherical astronomy. Cambridge University Press, 5th edition, 430 pp.

Storm, G, & Geelmuyden, H (1886): Om betydningen af "eyktarstaðr" i Flatøbogens beretning om Vinlandsreiserne. Arkiv for nordisk filologi, 3, 121-131.