

# THE VIKING SUN COMPASS

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# THE VIKING SUN COMPASS

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In 1948 a small fragment of wood was discovered at Uunartoq Fjord in Greenland. This surviving fragment is merely half of a disc, originally with a central hole and having regular cuts around its edge. It is now in the Danish National Museum in Copenhagen and was seen by SIS Delegates during the visit to Denmark in 2005. When the fragment is completed by replacing the missing half and the cuts are extended around its periphery we are fairly certain that there would be 32 of them, although the spacings do vary slightly around the disc edge (see between 9 and 15 in Fig. 1.). Therefore it is reasonable to assume that this could be some form of compass or navigational aid. As far as we know the magnetic compass did not exist in Europe at the time, not arriving until 14th century and this disc device was made somewhat earlier, probably between 1000AD and 1200AD. If it had been part of a magnetic compass it would probably have been of little use in far northern waters due to the large magnetic declination found near to the Earth's poles. However, it was thought that this little wooden disc was probably something to do with navigation.

Further studies have revealed some additional markings faintly cut into the disc surface. These were originally thought to be random scratches. One of these is a curved line similar to part of a declination line on a sundial and two other lines appear, one possibly the straight equinox line and the other the centre line of the gnomon.

It had often been wondered how the Vikings travelled across the vast tracts of the Atlantic Ocean and found their way back again. Other seafaring nations, such as the Phoenicians and later the Romans travelled mainly around the Mediterranean, seldom losing sight of land and certainly in much better weather conditions than the Vikings. Even sea travel in Northern Europe was done in much the same way with ships always travelling within sight of the coast. There was no alternative available to them without the compass and the much later chronometer. The Vikings, however, travelled widely across the North At-



Fig. 1. *Sun Compass fragment from Copenhagen Museum*

lantic and are even recorded as having discovered the Americas, 500 years before Columbus<sup>1</sup> – so how did they achieve this?

If we consider the reconstructed disc we will see that it could be used for navigation at a single latitude on four particular dates in the year, two dates for the curved (summer) declination line and two for the straight equinox line above it. If the disc is fitted with a central vertical pin gnomon it is possible to turn it until the shadow just contacts one of these lines. If correctly delineated the dial should now be aligned to north and it would be possible to track in a specific direction (towards one of the 32 points of the compass) for a whole day with reasonable accuracy. The disc measures 70mm diameter, 10mm thick with a 17mm hole. Naturally such simple devices would not be suitable for long dis-

tance north-south travel but would be ideally suited for east-west where the Sun's declination would remain virtually constant, at least for several days. We know from many sources that the Vikings travelled extensively from their home in Norway to places such as the Shetland Islands, the Faroe Islands, Iceland and Greenland. With a further extension from there it was a relatively short journey to the area now called Labrador on the American mainland. Therefore, even with only one declination line a voyage to America, and return, became a real possibility. Once at the North American coast they explored and some records suggest that they even went as far south as present day Boston.<sup>1</sup>

How would the declination lines have been determined? The answer here is most certainly empirically. The 'compass' would be fixed horizontally on shore and the track of the tip of the shadow formed by a central vertical gnomon would have been scratched on the plate regularly throughout a whole day, preferably the day before the start of the voyage. From the Norwegian coast the first stop would probably be the Shetlands or the Faroes and, if necessary, a new line could be drawn there. This would require at least one day's rest, hopefully a sunny one. The compass

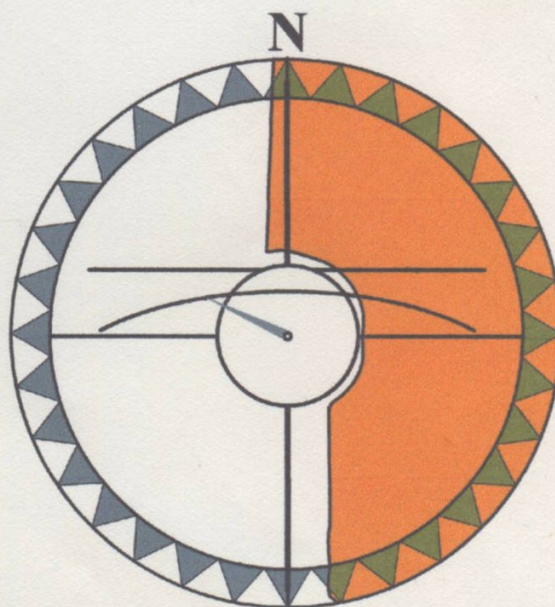


Fig. 2. *Sun Compass layout with its missing section restored.*



Fig. 3. Probable Track of the Vikings from Norway to Greenland and the North American coast, c1100AD, following the 61°N parallel.

would then automatically be corrected for any difference in latitude of the new port and the later date, so it was much more appropriate for the continuing voyage than the original calibration. From there the journey probably went via Iceland and Greenland with appropriate new lines being drawn at each opportunity. When the Vikings sailed directly to Greenland, they went due west, making landfall north of where they wanted to go, then a left turn would let them follow the coast down to their destination.

Most scholars of the Viking age are now convinced that by using this small device the Vikings were able to cross our oceans in relative safety. We find virtually nothing in Viking writings or stories about these marvelous little devices but navigation was a fine art and their captains would have carefully guarded its secrets.

Søren Thirslund has studied this device and has produced an informative

book in English<sup>2</sup> explaining in detail how the Vikings would have navigated using this type of Sun Compass.

#### Accuracy of the Sun Compass.

The actual accuracy is difficult to determine but replica devices of this pattern have been tried by several modern navigators and the results have been quite positive. Robin Knox-Johnson tried one for a 50-mile journey<sup>2</sup> and his error at the end was just ½ mile. For my own assessment a replica was constructed and tested at home confirming that a constant heading  $\pm 3^\circ$  is quite feasible, so certainly as good as any uncorrected magnetic compass. Even with a declination line that was not quite right for the particular date or intended latitude the result of errors accumulated in the morning would be reversed throughout the afternoon period, hopefully giving the same overall  $3^\circ$  accuracy at the end of the day. Accuracy during the morning and afternoon would be greater than around noon where any errors in the scratched line would become more significant. Close to noon they may not have been able to assess which side of noon they were, so steering may have been a bit erratic, perhaps between 11am to 1pm. They would probably have learnt not to use their compass at this time. The fact that the gnomon or handle hole is large suggests that this part of the device deliberately remained uncalibrated. They would also have noted the position of sunrise and sunset (although not registering as a shadow on their Sun Compass) and may have marked these positions around its

edge. They would soon have seen that the angles for sunrise and sunset were equal with respect to their north-south line. They could therefore use these times as additional references. The moon would rise and fall in a similar fashion and they may have used this for reference too.

There is, however, the main problem to be overcome, and the Sun Compass needs one very important thing to function – the Sun. Certainly in Northern Europe the Sun can be in short supply at times, but living in England (where the climate is somewhat similar, with clouds rolling off the Atlantic) we do find that the Sun can be seen on almost every day of the year at some time except in the worst of the winter weather. Therefore, even a single compass reading in the course of a day would have been a great advantage to the Viking navigators. Without the Sun they would

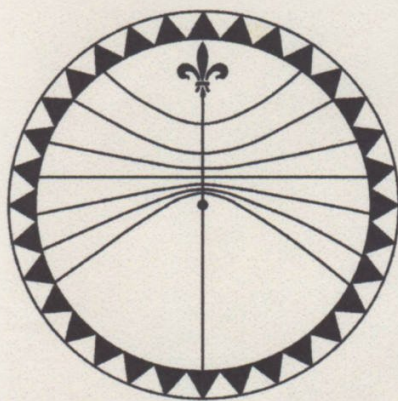


Fig. 4. Finished layout of the replica Sun Compass made for 52° North.

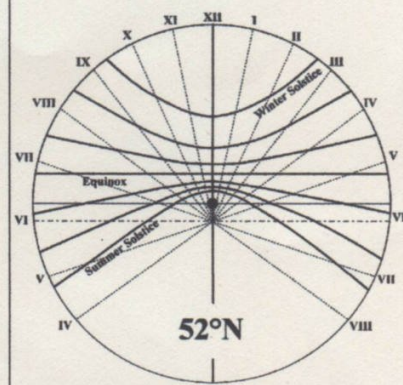


Fig. 5. Construction of the Sun Compass as a Horizontal Dial for 52° North.

soon lose their directional reference, particularly after turning to tack into the wind. However, there was still one good reference left to them. If the Sun or the stars were not showing there would almost certainly be cloud above them and a breeze - quite often a gale in the Atlantic. The clouds would therefore be travelling in a fairly constant direction for several hours or even days, so if the cloud direction was noted when the Sun shone then a mark could be put on the compass to act as a guide. They would have regularly checked the direction of the waves, and this would remain constant for long periods too. They would have been aware that the wind across the Atlantic blows mostly from the south-west, so if all other clues were absent, a guess that the wind was coming this way would generally be better than no reference at all. If the wind was particularly cold, perhaps with snow showers, they may have been able to deduce that the wind was coming more from the north or east.

Another way of 'reading' the wind direction may have been from a small pennant attached to the top of the mast. There would obviously be some errors due to the relative movement of the ship but I am sure that a competent navigator would have learnt how to make the necessary corrections for this. The worst conditions for navigation would have been in periods of fog and low visibility. Luckily, at such times, the weather would normally be

calm and they were unlikely to have travelled far in any case.

At night, there would be no Sun but the Viking navigator would have some knowledge of the stars and would probably know those placed in the ecliptic, and he would certainly be acquainted with the Pole Star. He would watch each star rise in the east and set in the west in almost the same position as that of the Sun (and the Sun Compass declination line would show him roughly where that point should be on the horizon). He would have known how the Pole Star became higher in the sky as he travelled north and vice versa. He probably had some way of measuring the height of this star (to determine his latitude), possibly no more than a stick held at arm's length. (A stick of length 600mm held at arm's length subtends an angle of around  $60^\circ$ .) Each navigator would have his own stick and his own way of holding it, thereby giving fairly reproducible results. The stick could even be notched with increments, perhaps of as little as one degree, but more likely arbitrary units to suit the user. A change of 10mm in the length of this stick would represent a difference in angle of just over  $1^\circ$ . However, the position of the Pole Star would give him a perfect reference for north at all times when the sky was clear, probably to a greater precision than the Sun Compass in the day.

Naturally, navigation without the Sun or stars would be less accurate but if we try to quantify the errors we can get an idea of how 'misplaced' they would be after a period of time. Primarily the main Viking voyages would almost certainly have taken place in the summer months, generally a time with fewer storms. In that case the daylight (and potential for sunshine) was longer than the night period, and at latitudes of around  $60^\circ$  north the summer Sun could shine for 18 or more hours each day. Therefore the night would probably only account for about 6 hours of each day. If we degrade the directional accuracy from  $\pm 3^\circ$  to  $\pm 15^\circ$  during the time when the sky was obscured by cloud, we would probably find that this would still give them less than 12 hours without any Sun or star reference during most summer days. The  $15^\circ$  error would be variable but one navigator would probably always err with each reading in the same direction (therefore the

readings would not cancel out), so an average error of perhaps  $\pm 7\frac{1}{2}^\circ$  could be expected. In the course of 24 hours we could estimate an average error of  $1\frac{1}{2}^\circ$  for the 14 clear hours and  $7\frac{1}{2}^\circ$  for the remaining 10 hours of cloud, an overall average of around  $4^\circ$ . In the course of a voyage of perhaps 1000 miles this would mean a maximum error of only 70 miles from their intended landfall. For a large continent like America, they could hardly fail to hit it. They would then sail some distance along the coast looking for a suitable natural harbour, river estuary or sheltered bay. After several voyages, parts of the coastline would soon become recognised. As with Greenland, they may have turned south each time to reach their destination. The technique of deliberately aiming to one side of a destination with a subsequent turn towards it at a coast or other feature has been practised by sailors and aviators until relatively modern times.

The equation of time will also cause small errors to the Sun Compass but throughout the summer months this will amount to less than  $1^\circ$  in most circumstances and may be ignored. The Vikings would certainly not have been aware of this factor.

Naturally the Sun Compass must be held level to get an accurate reading. Therefore on board a ship it can not be placed on the deck which will almost always be at an angle but it must be held horizontally in the hand (assuming that gimbals were not used in Viking times). To make this simpler a handle or stalk could be fitted below making the dial into a mushroom shape. If the stalk was made longer and was weighted, then the dial, if supported by the fingers just beneath its plate, would remain very close to a horizontal position at most times.

### Making the Replica Sun Compass.

I did not make my replica dial empirically but by using standard dialling techniques. These were the same as for making any horizontal dial with seasonal declination lines. Although we would normally include the various hour lines in this construction they have been omitted from the final model. It is not known if the Vikings divided up their Sun Compass to show divisions of the day, but if they did it would be by halving angles giving

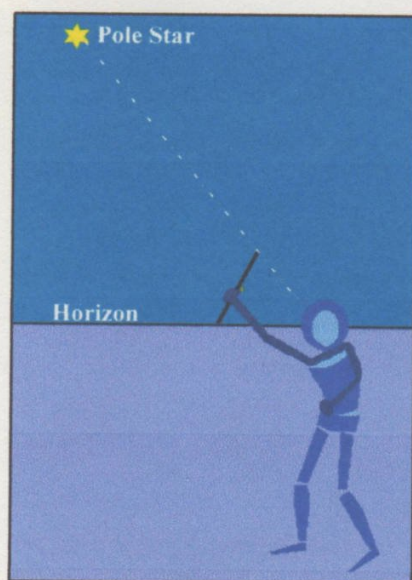


Fig. 6. Checking the altitude of the Pole Star with a simple stick

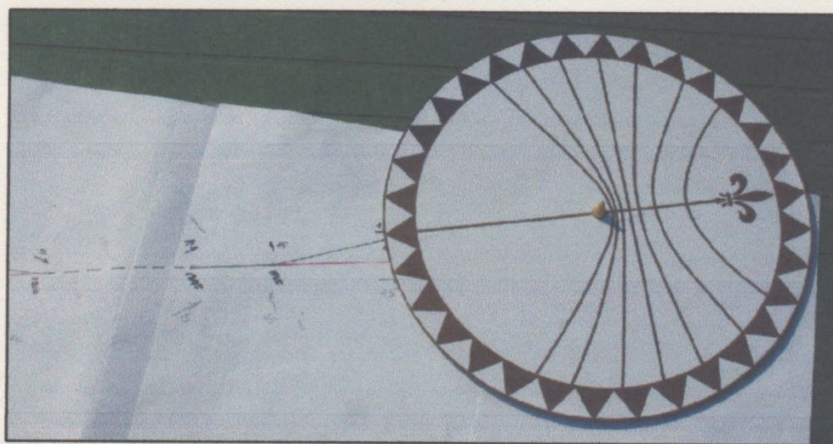


Fig. 7. The completed Sun Compass in use for my 'Trial Voyage'

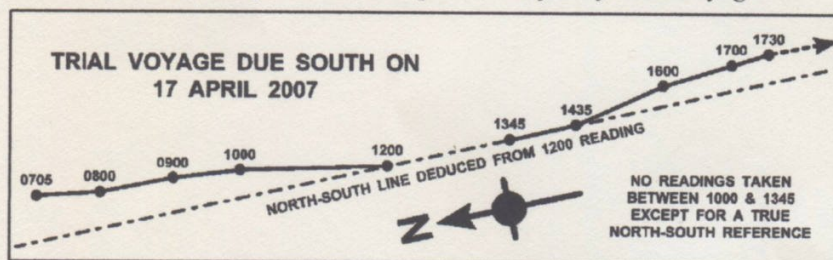


Fig. 8. The Plot of my 'Trial Voyage'

quarter or eighth days and almost certainly not by twelfths as we now do. I had considered showing declination lines for each month but keeping them equally spaced seemed more sensible in a sun compass than lines bunched near to the solstices.

Another important point that we may not appreciate is that the length of the pin gnomon (nodus) is relatively short if we are to include all the necessary declination lines for the whole year. In this replica I chose a gnomon height of just 15mm and this created a useful dial diameter of 170mm (200mm overall). This is about twice the diameter of the original Unartoq device. It would have been possible to offset the gnomon from the centre of the disc but on a Sun Compass for more northern latitudes this would not have made much sense so I stayed with the Viking layout even though my dial was delineated for my latitude of 52°N. With these dimensions it is possible to take readings from the Sun at any time of the year as long as it is higher than about 10° above the horizon. It does not need to show any lower lines as readings below this level would be difficult to see in any case.

The gnomon itself needs to be quite finely tapered or it can obscure its own shadow. Therefore the slope of its edges must be greater than the highest

altitude of the Sun at noon at the summer solstice.

#### Trial Voyage

In order to prove these theories I decided to take a trial voyage using my Sun Compass. I am not a sailor but have been an aviator for many years, so I have some idea of the concepts involved. I decided to do my voyage in the course of one day across a table set up in the garden. It does seem a rather strange way to do it but I believe that it replicates fairly well the conditions that would apply at sea, except that the table was steady and not heaving with the swell. Fig. 7. shows how this was done. The Sun Compass was laid on some paper and the tip of the gnomon's shadow was kept on the appropriate declination line throughout the day. The voyage was made to progress by approximately 4cm each hour and readings were taken at roughly hourly intervals. I did not take any readings over the noon period (actually 1000 - 1345) except for one exactly at noon so that I could create a line for true north against which to check my final results. The final plot of the 'voyage' is shown in Fig. 8. In the morning the error was to the west and in the afternoon the error was an almost equal amount to the east, so assuming a constant 'sea speed' the two errors virtually cancel. The rea-

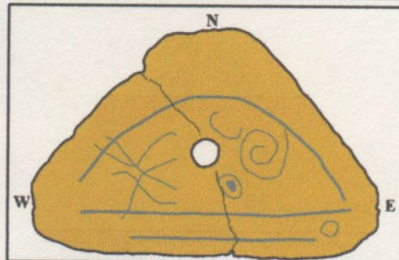
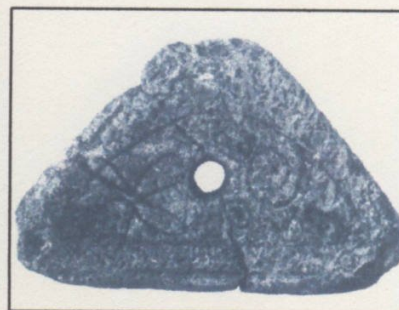


Fig. 9a & 9b. Triangular stone with various markings and possibly a declination line.

son for my error was that I was not using the correct declination curve for the date, it was just the nearest one that I had on my Sun Compass. I have also found out since that my gnomon was a little too high. However, it was useful to show how close I was to my N-S line even with a wrong declination line and gnomon height. The voyage could still be done quite accurately. As can be seen the error was slightly more in the morning than afternoon but well within my desired limits. I then applied the Equation of Time correction to my noon line and the results, surprisingly, showed an almost perfect track due south at the end of my voyage. The results of this test were really too good to be true but it

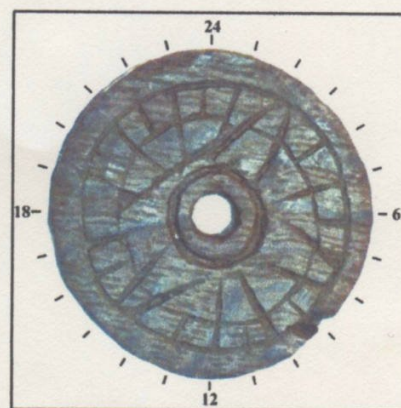


Fig. 10. Sun Compass from Wohlin showing various markings, thought to be declination lines. Note that it has been divided into 24 segments rather than 32.

shows the potential accuracy of such a simple navigation device. Further complications would have worsened the results had it been a real sea voyage. The heaving of the deck has already been mentioned, but the ship, if powered by sail would have been tacking, port and starboard, at regular intervals making it more difficult to keep an exact track of progress. In the hands of a good sailor this potential for error would be very small.

#### Other Sun Compasses.

A triangular piece of soapstone was found among unknown artefacts in the Danish National Museum. It had been excavated from the Norse East settlement of Vatnahverfi, quite close to Uunartoq in Greenland. This stone was about 160mm across, with a central hole and had various markings on its surface. The most significant of these is a curved line, which is said to correspond to a declination line for near the summer solstice at 61°N when a 16mm high gnomon is fitted. The other markings are probably just decoration. This too may be a direction finding device or even a Sun Compass.

A further device, similar to the first is now in the Museum at Wolin, Poland. It has been dated from the first half of the 11th century. Unlike the first, this appears to be divided into 24 sections rather than 32. On its surface are several lines, thought to be declination lines, placed there over several journeys. However, this dial is not so convincing as the others because there are no obvious 'summer' lines (concave with respect to the gnomon)

but only 'winter' ones and with the possibility of a straight equinox line. None of the lines seem to continue across a whole day as would be necessary for a voyage at sea.

#### Conclusions.

The wood fragment found at Uunartoq in Greenland was only about half the size of my replica, so quite portable, and would therefore have had a very short gnomon, perhaps only around 5mm in height. This small size would not give great precision but still would have been capable of keeping a ship on a reasonably accurate course. The gnomon would probably not have been of the diameter suggested by the hole left in the disc because such a gnomon would have obscured its own shadow around noon in the summer months. Therefore, this hole was probably to take the supporting handle and the gnomon may have been no more than a nail or fish bone sticking up from its centre. Due to the fact that the compass would not be accurate around noon, they may not have bothered with declination lines where the handle went.

The triangular stone does not seem to be so practical for navigation purposes and may be more of a record of the Sun's movements over the course of just one day. It could, of course, just be a plain decorated stone.

The object from Wolin, although with many similar characteristics to the Uunartoq dial, is not totally convincing and may just have been a decorated disc of wood or an early type of button. However, it is amazing to find such accurate division of the outside

into 24 segments, perhaps within 3° all round.

Sun Compasses as described must have existed in quantity at the time of these voyages and hopefully further examples are yet to be found, maybe preserved below the ice on the coast of Greenland. They would almost certainly have been disposable, probably being used just for one voyage each.

It seems amazing that these little instruments are capable of such great navigational feats but I hope that I have shown how such journeys were possible.

There is little hard evidence that a Sun Compass, such as I have described, ever existed but if it was not like that described, then what did the Vikings use to navigate on these great journeys without sight of the land?

#### REFERENCES

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- 2 S Thirlund: *Viking Navigation*, Thirlund, Denmark, c1996.

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