Did Vikings rely upon sunset and sunrise to navigate? Sunstones give most accurate readings when sun is low in the sky

- **Vikings are thought to have used sunstones navigate in cloudy skies**
- **Researchers have tested whether it is possible to use these to navigate**
- **They found two calcite crystals can be used to determine the sun's position**
- **They also found the method was more accurate close to sunrise or sunset**

By RICHARD GRAY FOR MAILONLINE

PUBLISHED: 23:01 GMT, 26 July 2016 | **UPDATED:** 23:33 GMT, 26 July 2016

They were feared warriors who terrorised much of northern Europe and beyond through the Iron Age.

But carried by their longboats, the Vikings also circumnavigated across vast stretches of open ocean, travelling as far as the Middle East and even North America.

Now researchers have shed new light on how they may have achieved this feat – with the help of the sunrise and sunset.

The Vikings are thought to have navigated across the vast Atlantic Ocean and the North Sea with the help of sunstones (crystal of Iceland spar pictured) that allowed them to work out the position of the sun even when it was cloudy or foggy. New research has suggested this technique was most accurate at sunset or sunrise

Scientists have studied the techniques the Viking sailors may have used to help them pick their way from Scandinavia to far flung places.

Historians have long suspected the Vikings used sun-compasses to orientate themselves while at sea.

NAVIGATING WITH SUNSTONES

Dr Gábor Horváth and his team have

In cloudy or foggy weather, they also may have used crystals known as sunstones to help pick out the sun.

Now, in a series of studies published by the Royal Society, a team of physicists at Eötvös University in Budapest, Hungary, have tested whether this is possible.

They found that the Viking navigators would have needed to follow three steps to ensure they could keep their vessels pointed in the right direction.

First they would have determined the direction the light from the sky was being polarised using two sunstones.

They could then use this to determine the direction of the sunlight and calculate its elevation.

They could then use a 'shadow stick' to cast the appropriate shadow on the sun compase to work out where North was.

In two studies published earlier this year, the researchers showed that the first two steps were possible depending on the type of crystal used for the sunstone.

They found that in overcast conditions calcite gave the most accurate reading while cordierite and tourmaline were more error prone.

But in a new experiment, published in the **Proceedings of the Royal Society A**, the research team have shown that while the Vikings could have estimated the position and elevation of the sun with sunstone, they would have been best to do it when the sun was lowest in the sky.

This means that if the Vikings took readings shortly after sunrise and before sunset, they are most likely to have stayed on the correct course.

suggested the Vikings navigated using three hypothesised steps after calibrating the sunstone:

Calibration step: In cloudless weather, the navigator watched the sky through a sunstone while rotating it to and fro in front of his eyes. This allowed them to detect periodic changes in the intensity of transmitted skylight. He had to rotate the crystal until its well-determined orientation (eg minimal or maximal intensity of skylight transmitted through a dichroic sunstone, or minimal or maximal intensity difference between the two slots/spots of a birefringent sunstone), where it was fixed, and thereafter he calibrated the crystal by engraving the direction pointing towards the sun on the crystal surface.

Navigation step 1: Applying this sunstone rotational adjustment under a cloudy or foggy sky at two different celestial points, the navigator could determine the directions perpendicular to the local E-vectors of skylight shown by the engraved straight markings of the sunstones, pointing towards the sun.

Navigation step 2: The intersection of the two celestial great circles crossing the sunstones parallel to their engravings gives the position of the invisible sun.

Navigation step 3: Using the Viking sun-compass, the navigator could derive a true compass (e.g. North) direction from the estimated position of the invisible sun.

** source Royal Society Open Science*

Dr Gábor Horváth, an expert in environmental optics at Eötvös University who led the research, said: 'The theory of sky-polarimetric Viking navigation with sunstones is widely accepted.

The Vikings made long journeys at sea often in conditions that meant they could not see the sun (recreation of Viking longboat pictured). The sagas mention the use of mysterious sunstones and historians believe these could have been crystals found on the beaches of Norway and Iceland

The popular TV series Vikings (pictured) depicts how the Vikings may have used sunstones to navigate

'According to our findings, the ideal periods for sky-polarimetric Viking navigation are immediately after sunrise and before sunset, because the North errors are the lowest at low solar elevations.'

There are few clues as to how the Vikings navigated across the oceans in the archaeological record.

A fragment of a wooden dial, dating to the ninth century, found in the ruins of a convent in Greenland is thought to be part of a sun-compass.

With such a device the Vikings would have been able to find the direction of north, and so work out their own heading, with high precision, but only in clear weather.

Some experts have suggested that the Vikings used special crystals called sunstones that polarise the light to help

HOW DO SUNSTONES WORK?

Sunstones detect the 'polarisation' of sunlight - the way rays of light are scattered in different planes when they reach the atmosphere.

The stones act as a filter, similar to the filters used in polarised sunglasses.

Light can only shine through the crystal if it is polarised in a particular direction. All other types of light are blocked.

them find the sun when it was covered by clouds or fog.

Sunstones are described in some of the Viking sagas but there is little physical evidence of what these were.

Several potential crystals such as calcite, tourmaline and cordierite can be found on the beaches of Norway and Iceland where the Vikings are known to have lived.

The amount of polarised light in any particular direction depends on the position of the sun in the sky at the time.

Experienced navigators would quickly be able to work out the location of the sun by turning the stone around.

However, the theory that the Vikings used sunstones has been controversial.

In **a study published in January this year**, Dr Horváth and his team showed that it was possible to use these stones to work out the direction of light was coming from.

There is little hard evidence of how the Vikings navigated across the ocean (painting of Viking longboat pictured) but the new research suggests it may have been possible using sunstones

This is because the light passing through the crystals was polarised, meaning as it was rotated it would allow different amounts of light through depending on its orientation.

When the amount of light passing through was at its brightest, it means it is aligned with the polarisation of light in the atmosphere.

Markings on the crystal surface, made by calibrating the stone in clear conditions, could reveal where the direction of the light was coming from.

Dr Horváth and his team found using two sun stones and drawing two large circles parallel to these engravings it was possible to work out the position of the invisible sun.

In their latest paper the researchers examined whether it was then possible to estimate the elevation of the sun and so project an imaginary sunray onto the surface of the sun compass by adjusting the shadow stick to the appropriate height.

They claim this estimation of solar elevation was probaably performed using measures of fists and fingers.

FINDING EVIDENCE OF SUNSTONES UNDER THE SEA

In 2002, a dive to the wreck revealed, among many artefacts, the mysterious lump of crystal that is now the focus of international scrutiny.

As nobody knew quite what it was, it was put in a safe place and little notice was taken of it until Professor Albert Le Floch, head of the research team, spotted a reference to it on the website run by volunteers of the Alderney Maritime Trust.

He was further intrigued to discover that, in 2006, a set of brass dividers used for map-reading were also found in the wreck, just 3ft from where the crystal had been found.

This encouraged the idea that it had been part of the navigational equipment.

Following a visit by Professor Le Floch to the island last year, a small specimen was taken from the rock.

And, as the research paper is about to reveal, it has been confirmed as Icelandic spar — which, although common around Alderney, has never been found in blocks like this one, about the size and shape of a cigarette packet.

This implies it was indeed with the stricken ship when it went down.

Using 10 male partificpanets, the researchers asked them to estimate the position of the sun in a digital planetarium using black dots to represent the spot determined using the sunstones.

They found that in 2,400 tests, 48 per cent of them were more accurate than one degree.

They found that the most accurate estimations was when the sun was close to the horizon.

This, they claim, suggests the Vikings probably navigated immediately after sunrise and before sunset to ensure their headings were as accurate as possible.

Writing in the paper, the researchers said: 'In reality a Viking navigator had to perform such an estimation with regard to an actually unseen sun.

'The latter is obviously a more difficult task. Thus, the elevation errors presented in this work underestimate the real errors of the third step of sky-polarimeric Viking navigation.

'On the other hand, Viking navigators were surely more experienced in the estimation of elevation angles than our test persons.'

EVIDENCE OF SUNSTONES IN ANCIENT ICELANDIC LEGENDS

An Icelandic legend about the travels of the Norwegian king Olaf in the 11th century refers to sunstones.

One winter's day, Olaf met a farmer's son named Sigurour, who boasted that he could sense the position of the sun even in a snowy sky.

The story describes how the assembled company looked out of the window but 'could nowhere see a clear sky'. After asking Sigurour to tell him where the sun was, the king ordered his minions to fetch 'the solar stone' to test the young man's claims.

'He held it up and saw where light radiated from the stone and thus directly verified Sigurour's prediction.'

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