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The grooves on the island of Gotland in the Baltic sea: a neolithic lunar calendar

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Introduction

On the island of Gotland, in the middle of the Baltic Sea, there exist about 3600 grooves cut in the bedrock or on big stones. They can be found on the ancient shores of lakes and in connection with the coastal settlements and finds of the Neolithic Pitted Ware Culture. The grooves have a typical length of 50-110 cm, width of 5-10 cm and depth of 1-10 cm. They follow closely a circular arc in both the length and width cross-sections (Fig. 1; 2). The surface is very smooth and they must have been cut by a stable machine, using quartz sand and water (Fig. 3) The mean of the radius of curvature for ca 400 grooves is 2.83 m.

The archaeological and geological investigations

There exists no continuous tradition about the use of the grooves. Montelius (*Montelius*, 1874. S. 162. Fig. 7) wrote that grooves on granite stones can be dated with certainty to the Neolithic. Lithberg correlated the distribution of the grooves with the simple shafthole axes (*Lithberg*, 1914. S. 132). They were also compared with similar grooves found along the shores of some of the large French rivers, always in connection with finds from the Neolithic Period (*Le Hon*, 1867. P. 129). In south-eastern Sweden and Gotland the Early Neolithic settlements have been dated by calibrated ^{14}C to ca 4000 BC and the Pitted Ware Culture to 3400-2400 BC. This Culture lasted even longer on Gotland. "Simple shafthole axes date mainly from the Late Neolithic but they may also have occurred during the Middle Neolithic" (*Segeberg*, 1999. S. 209).

The natural scientist, R. Sernander, investigated stones with grooves in Lake Fardume (*Sernander*, 1919. S. 177-190) at a level that was ca 1 m below the highest water level. These grooves must have been used during the later half of the Neolitic when the climate was very dry and the water level in the lakes in southern Sweden was low. A modern investigation has dated this period to 2500 BC ± 500 years (*Harrison, Prentice, Guiot*, 1993. P. 189-200).

Fig. 1. A granite boulder with 11 grooves lifted up from a river in the parish of Hörsne. Photo by G. Henriksson, 1985.

Fig. 2. A piece of stone that fits perfectly in the groove where it was found under layer of peat, by S. Dotes, at the farm Gannor in the parish of Lau. The peat-layer can be dated to ca 1500 BC. Photo by G. Henriksson, 1988.

Fig. 3. A low technology grinding-machine for grooves constructed by R. Högberg after a drawing by G. Henriksson in 1992.

The astronomical interpretation

The grooves are usually cut side by side in series of up to 15, but there exist a unique series with 32 grooves side by side (Fig. 4).

Sören Gannholm has studied astronomy and he discovered together with his father Karl Erland that some of the grooves were oriented towards the major stand-stills of the sun and of the moon (*Gannholm K.E.,* 1981. S. 4).

One month after Gannholm's publication of his astronomical interpretation of the grooves the author visited Gotland and studied the grooves at Hajdeby, in the parish of Kräklingbo. I noticed that most of the grooves had an intermediate orientation between the stand-still extremes of the moon. It seemed natural to assume that the grooves were made according to very strict principles because of the considerable investment in labour in their construction. The following assumptions were tested:

– They were made at new or full moon.
– They were made at the summer or winter solstice.
– They were made in chronological order from north to south or vice versa.

The full moon seemed more probable as its risings and settings fit the calculations and it has a bright upper limb which is easily observed when rising or setting. Observations of the upper limb of the new moon at the horizon during rising and setting, on the other hand, are in practice impossible to observe; also they do not fit the calculations. In ancient times Swedish farmers calculated the date of the new moon from observations of the rising or setting full moon (*Rudbeck,* 1937. P. 650).

A computed sequence of azimuths for the rising and setting full moon at the winter solstice have the same general shift from north to south as the sequences of grooves. But the azimuths depend on the obliquity of the earth's axis. If the grooves were made every 19th year, 3300-2000 BC, there was a good agreement with the computed azimuths. This early dating of the grooves was supported by Professor Bo Gräslund, chairman of the Department of Archaeology in Uppsala. The astronomical interpretation of the grooves on Gotland was published in the Swedish journal for archaeology, "Fornvännen" (*Henriksson,* 1983. S. 21-28).

In 1982 engineer Wilhelm Dec told me that two other directions closer to east-west were dominant for the grooves in the northern part of Gotland. I can explain these two groups as observations of the rising and setting full moon on the day it passes two of the brightest stars along the ecliptic, Antares in Scorpio and Spica in Virgo. The date when the full moon passes a certain star is changed by the precession of the earth's axis with a period of 25 800 years. This gives two independent datings of these grooves to ca 3300-2000 BC.

Single grooves can not be dated, but for groups of ca 10 grooves it is possible to find a combination of azimuths that only appear once in the computed table. In such cases the individual grooves can be dated. A computer program can compare the observed and computed azimuths, calculate the standard deviation, typically 1.5°, and the mean of the errors in azimuth. A deviation of ±1 day has been tolerated and three dates every 19th year have been tested. The horizon is low and flat, mostly the open sea. The climate was much dryer than nowadays.

The most challenging task was to date the longest series, with 32 grooves, at Hugreifs in the parish of Gammelgarn. The direction of all 32 grooves can be explained as observations of the azimuth for the rising or setting full moon on the day when it made its passage of Antares 3152-2569 BC (Fig. 4). This long series is very important because

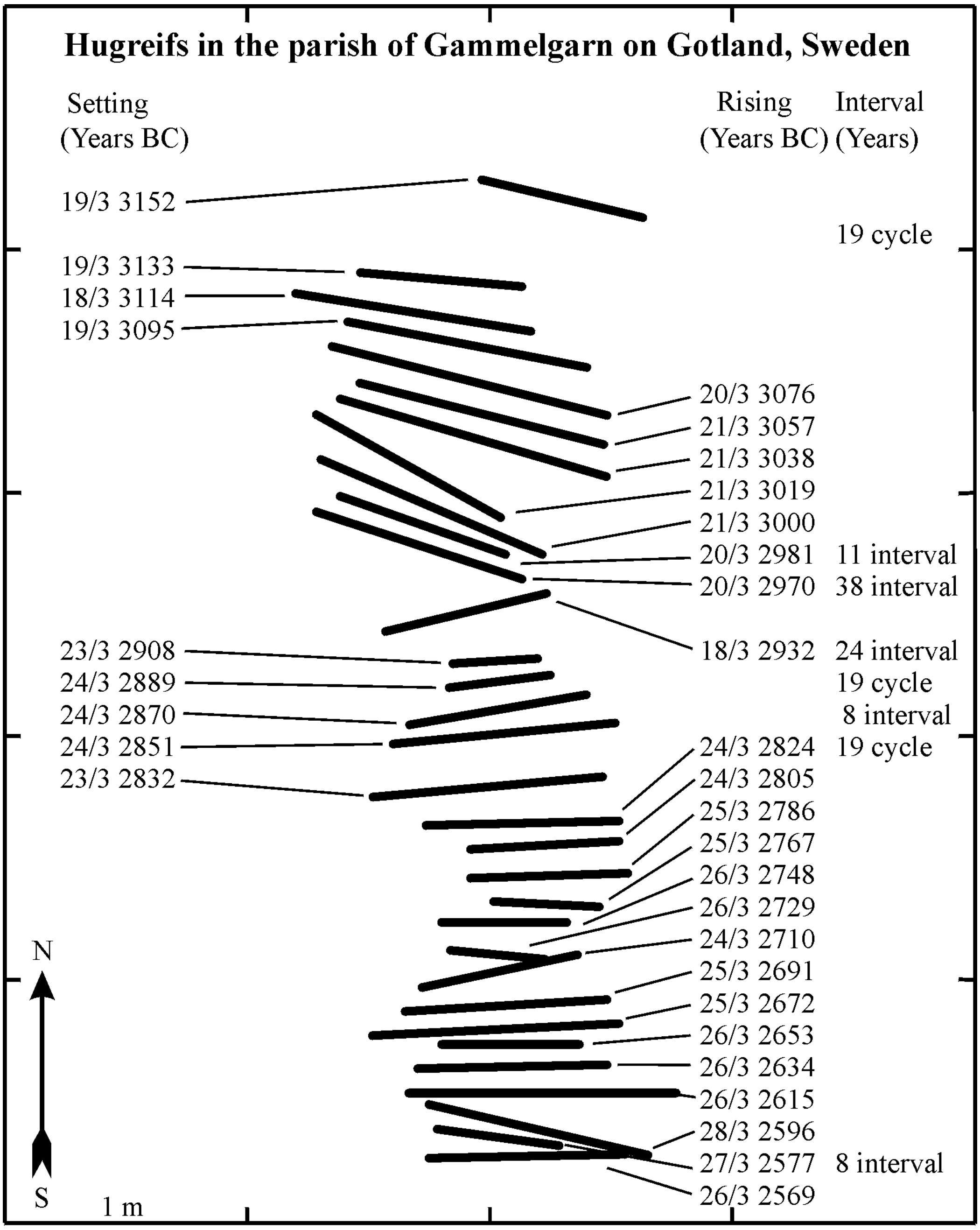

Fig. 4. This is the longest known series of grooves on Gotland (Sweden). It is situated at the farm Hugreifs, about 600 m south-east of the church at Gammelgarn. The 32 grooves mark the direction to the rising or setting full moon on the date of its passage of the bright star Antares in Scorpio. The dates are in the Gregorian calendar. (Measurements by S. Gannholm.)

chance identifications can be excluded and we can study the effect of the precession and shift between different 19-year cycles.

When the observations began in 3152 BC, the day of the vernal equinox coincided with the date when the full moon passed close to Antares. This may be the reason why this series was begun at that time. The day of the vernal equinox was equally necessary as the day of the winter solstice for the calculation of the important midwinter day, see

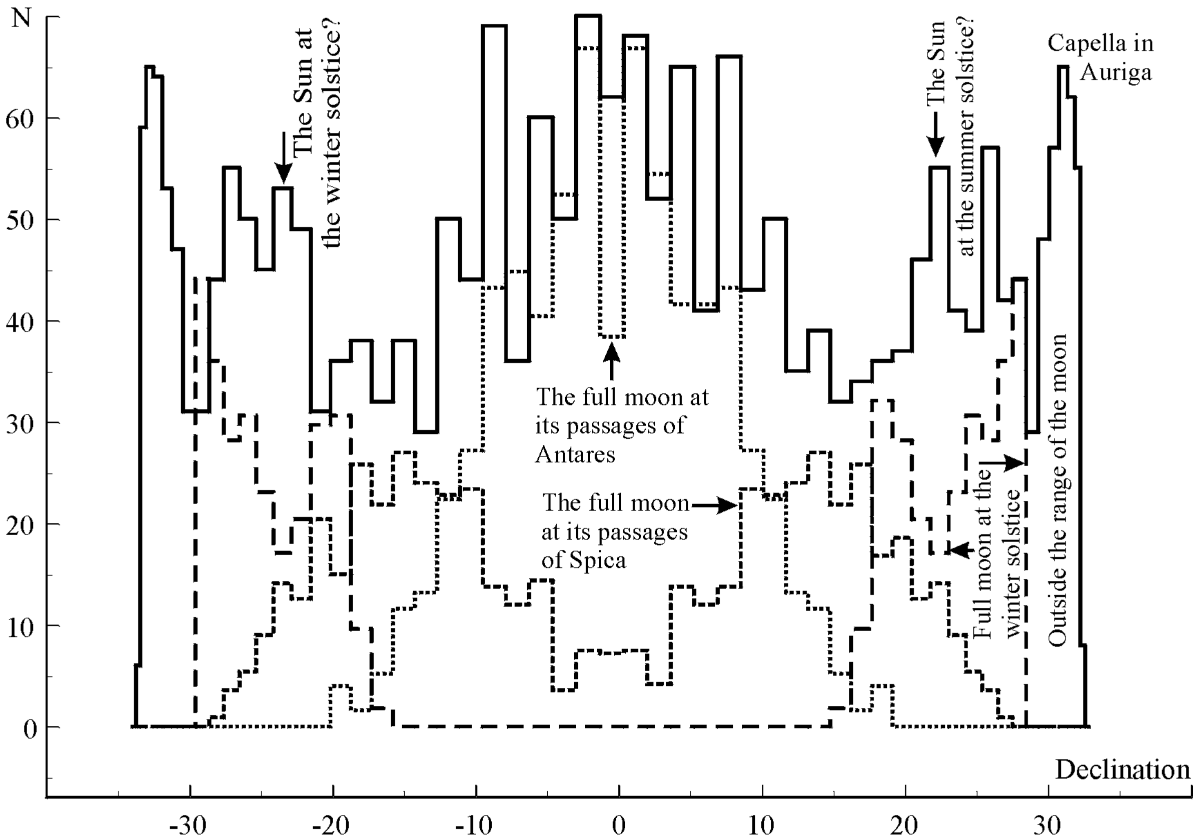

Fig. 5. The distribution of orientations, transformed to topocentric declinations, for all of the 1274 grooves on Gotland available to the author in June 2000 (solid curve). The data have mainly been obtained by theodolite by S. Gannholm and the author. The three differently dotted curves corresponds to theoretical distributions of declinations for the full moon at its passage of Antares and Spica and the full moon at the winter solstice. It has been assumed that the observation frequency has been constant between 3300-2000 BC. The declination intervals correspond to equidistant azimuth intervals of width 3°. The grooves are symmetrical and their azimuths are *a* and *a* + 180°. The theoretical declinations have also been computed for *a* and *a* + 180°. The orientations of the grooves outside the range of the moon can be interpreted as observations of the bright star Capella in Auriga that became circumpolar at the latitude of Gotland about 2000 BC.

below. After about 200 years the full moon passed Antares one or two days after the vernal equinox and the observers had to choose between observations at the equinox or when the full moon passed Antares. In 2932 BC the azimuth for the rising full moon at the vernal equinox was marked for the last time. From March 23, 2908 BC, the full moon was marked relative to Antares. The observers would have discovered by that time the 8- and 19-year cycle of the moon (*Henriksson,* 1986. P. 10).

235 lunar cycles are equal to 19 years, 2 hours and 8 minutes. This difference will add up to one day after 209 years. A new cycle, shifted by eight or eleven years, will then be more exact. This shift can be identified in long series of grooves as a sudden change to more northern azimuths.

The author made a statistical test of the orientation of 628 grooves in the bedrock, measured with theodolite by Sören Gannholm, and 625 grooves on boulders, measured with compass. A linear correlation test showed that there is a 93.5% probability that the two distributions of azimuths represent the same principle of orientation. The only useful principle in this case would have been observations of astronomical objects (*Gannholm S.,* 1993. S. 12). The distribution of 1274 azimuths transformed to topocentric declinations is presented in figure 5.

The oldest grooves dated so far were made in 3294 BC and mark the azimuth of the rising or setting full moon on January 27, when it passed Spica. The same date was important for the orientation of the passage graves in the province of Västergötland, from 3300 BC (*Henriksson,* 1998). January 28 was the first day of the midwinter sacrificial period, known from ca AD 500 (*Henriksson,* 1995. S. 337-394). The midwinter day is midway between the winter solstice and the vernal equinox (*Rudbeck*, 1937. P. 71) and was very important because it is the coldest time of the year and according to an ancient rule, farmers must have half of the food stored for man and animals remaining at that time. A long tradition?

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