

# THE ORIENTATIONS OF CENTRAL ALENTEJO MEGALITHIC ENCLOSURES

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The Orientations  
of Central Alentejo  
Megalithic Enclosures

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## Abstract

In this work we conduct a study of the orientations of 12 megalithic enclosures in the Alentejo (southern Portugal). Some of these sites date back to the sixth or fifth millennia B.C., and so are among the oldest stone enclosures in Europe. The results of the survey show a pattern of easterly (rising) orientations. In particular, we relate our results to previous studies by Michael Hoskin and colleagues, on the orientations of the seven-stone dolmens in this area, which have shown the existence of a possible sun rising orientation custom.

Key words: megalithic, enclosures, orientations, archaeoastronomy, Portuguese archaeology.

## Introduction

This paper discusses the orientations of 12 megalithic enclosures in the Alentejo province of southern Portugal. Despite various attempts to address this question (Alvim 1996-97, 2004; da Silva 2000), there lacked a comprehensive orientation enquiry (Cardoso 2002, p.235) grouping together all enclosures, including those that are completely dismantled.

The Alentejo extends, roughly, southwards from the Tejo river to the northern part of the Algarve, a southern coastal province. The scattering of enclosures is located in the Évora district, mostly in the western part. The landscape here, between the Tejo and Sado river basins, is largely flat with just modest rises.

Today archaeologists believe that the megalithic enclosures of central Alentejo were built during the Early/Middle Neolithic, i.e. in the sixth to fifth millennium B.C., pre-dating the communal seven- and nine-stone megalithic tombs in the same area (Calado 2004). There is no direct radiocarbon dating evidence available from these sites. The established chronology arises mainly from materials found in excavations or from associations with nearby settlements or surface remains.

According to Portuguese archaeologist Manuel Calado (Calado 2004, p.72, 82) the basic structure of the enclosures was a modified horseshoe shape, open to the east. In most of the monuments the largest menhir is located outside the line of the horseshoe, in one "focus" of the (broadly elliptical) enclosure.

Today only 12 sites are known, ranging from the smallest (but perfectly horseshoe-shaped) Vale d'el Rei, with 12 menhirs, to the monumental Almendres with

94 standing stones and a much more complex structure. Also included in this group are sites where the menhirs are completely dismantled and no information was found concerning their original positions.

Excluding cup-marks, all the engraved menhirs are found in the large enclosures of Almendres, Portela de Mogos and Vale Maria do Meio. The most common motifs are crescents, circles, horseshoes and crosiers. Many of the decorations show an apparent anthropomorphised composition (Vale Maria do Meio menhirs n. 10 and 18, for example). Despite the obvious ambiguity in interpreting them, some authors (Gomes 1989, p.264; Calado 2004, p.130-138) have sustained the notion that the circles and crescents may be representations of the sun and moon.

In order that our study can include different types of monument in different states of preservation, we will not focus upon any particular features of each enclosure but consider only the common characteristics. In this way we will also try to avoid problems of biased selection.

One of the initial group of monuments, Xarez, was excluded from this study. It was excavated in 1972 and its menhirs re-erected, but this work generated a heated controversy within the archaeological community (Calado 2004, p.149). The rebuilt monument had a very anomalous square shape. Although a few other examples of quadrilateral enclosures do exist in Brittany and England (Burl 1999, p.337, 339) the archaeological uncertainty about Xarez suggested its exclusion from the data set. Recently Xarez was dismantled and rebuilt again in a different place, owing to the construction of a dam. Prior to its removal, a second excavation revealed the socket of the large central menhir, complete with

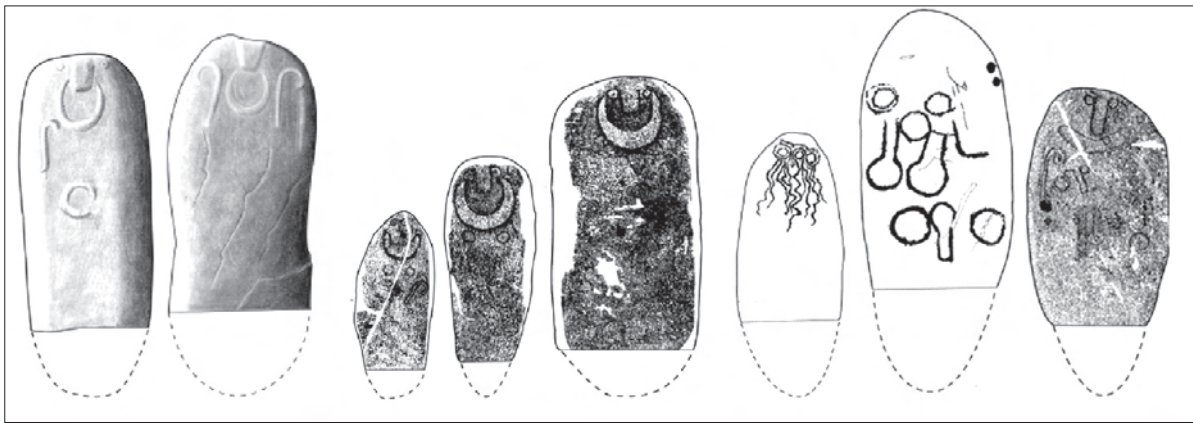


Fig. 1. Left: engraved menhirs n. 10 and n. 18 at Vale Maria do Meio (Calado 2004, II, p.27). Middle: engraved menhirs n. 2, n. 25 and n. 33 at Portela de Mogos (Gomes 1997). Right: engraved menhirs n. 58, n. 64 and n. 65 at Almedres (Gomes 2002).



a) With 94 standing stones, the complex enclosure of Almedres is the largest in Iberia. Photo mosaic courtesy of Pedro Ré.



b) Cuncos is one of the dismantled enclosures where some menhirs are still near their original positions. Photograph by Luís Tirapicos.



c) Vale d'el Rei is a perfect horseshoe and the only one on level ground. Photograph by Fernando Pimenta.

Fig. 2. The different forms and states of preservation of the Alentejo enclosures.

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chocking stones, but no other structures were found, thus sustaining the pessimism regarding the initial reconstruction.

In the Cuncos and Sideral enclosures, all the menhirs are recumbent. In the case of Cuncos, no stone-holes were found during excavations and four menhirs identified in the excavation plans have been moved since the excavation. Both enclosures were in a highly dilapidated state. At Tojal, all the menhirs are also lying down but the archaeologist who briefly investigated the site believes that they are approximately in their original positions (Calado 2004, p.72-73), since a small excavation revealed what appear to have been stone sockets by two of the menhirs. In Casas de Baixo and Monte da Ribeira the menhirs were all displaced from their original positions and it was not possible, at this point, to reconstruct a plan for these enclosures.

At all the other monuments, excavations were able to locate the original sockets of most of the fallen menhirs, which were then re-erected in their original positions. Where no trace of a stone-hole could be found, the menhir in question was left lying down.

## Survey and Data Reduction

### Topographic Survey

At each of the sites, we started by undertaking a topographic survey with a theodolite in order to build a Digital Terrain Model (DTM). Sun azimuth readings were used in order to determine geographical north. The data, after reduction, was exported to Surfer software<sup>1</sup> for the kriging interpolation that produced the DTM grid.

During the course of each topographic survey the menhirs were also measured and subsequently placed on the relevant DTM grid. The results were then compared to the topographic plans available for some of the enclosures that have been made by Pedro Alvim<sup>2</sup> and published by Manuel Calado (Calado 2004) or Varela Gomes<sup>3</sup> (Gomes 1986).

In order to determine the azimuth of the steepest slope we used two procedures.

1) The closed triangulation coming directly from the topographic survey was used to manually calculate the azimuth of the steepest slope and the maximum slope for each triangle, using the plane equation:

$$H=ax+by+c, \theta_{\max}=\arctan(a/b) \quad (1),$$

for the azimuth and

$$\delta_{\max}=a*\sin(\theta_{\max})+b*\cos(\theta_{\max}) \quad (2),$$

for the slope.

2) The tools provided by Surfer software were used to determine the magnitude and direction of the steepest slope (in the downhill direction) at each grid node.

In order that our statistics should be robust against outliers we used the median from each set of calculated data. The results were essentially the same with the two methods. For our statistical uncertainty we used the inter-quartile distance divided by 0.6745, which can be interpreted roughly as a  $\pm 2\sigma$  interval. The results are represented in Figure 3.

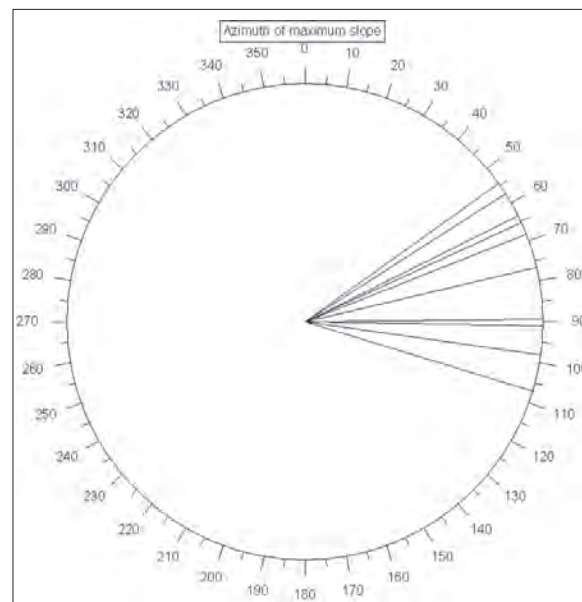


Fig. 3. Azimuths of the steepest slope (downhill) for 10 sites.

### Horizon Profile

At each site we undertook a horizon survey in order to build a profile in distance and elevation, checking for features of possible significance such as hills and depressions. To fill in parts obstructed by vegetation, we used mosaics of 1:25000 maps extending for 20-25 km around each site, with the true elevation corrected to apparent elevation in order to account for the effects of the earth's curvature and terrestrial refraction. We used the following simplified correction factor (taking the speed of red light at an average level of 250 m above

<sup>1</sup> Surfer software is available from [www.goldensoftware.com](http://www.goldensoftware.com)

<sup>2</sup> Topographic plans made by Pedro Alvim for some of the enclosures can be found at [www.crookscape.org](http://www.crookscape.org)

<sup>3</sup> We found that the north indication in the Cuncos excavation plan must correspond to magnetic north. The 3 southern menhirs represented in that plan are now lying against the central menhir and the westernmost menhir is now located in a different position. This last menhir was discarded for the symmetry axis calculation.

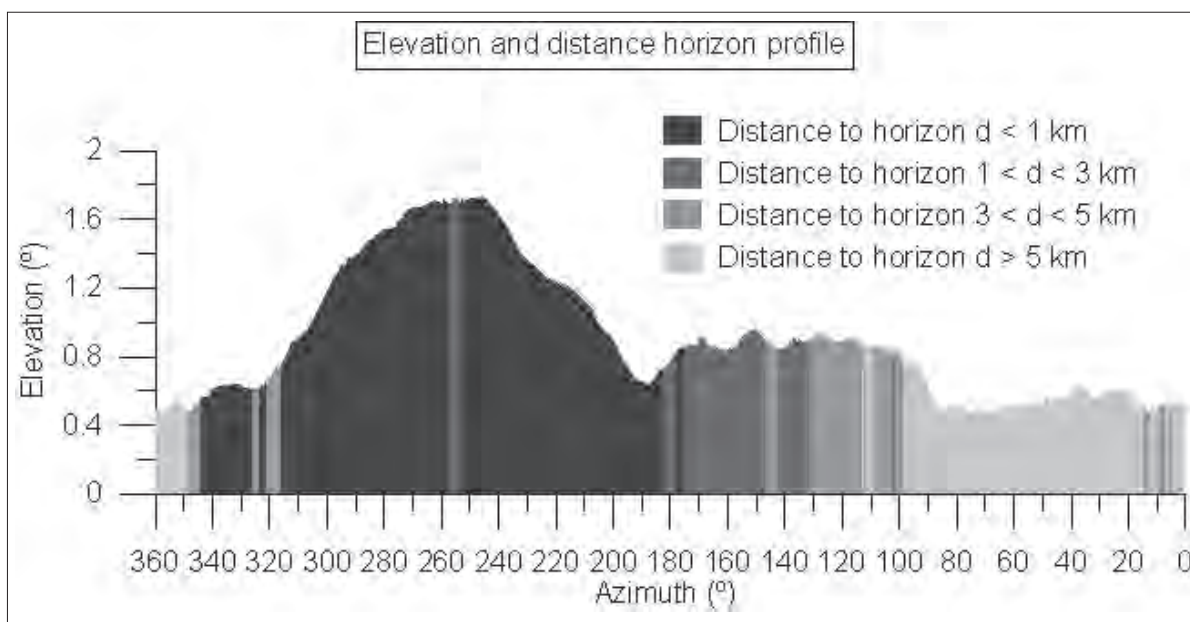


Fig. 4. Average elevation profile with average distance to horizon.

sea level), where  $d$  was the distance in metres from the site, measured over the maps:

$$d^2 \times \left[ 2,55 \times 10^{-5} - \frac{1}{2 \times 6371} \right] \times 10^{-3} \quad (3).$$

This data was compared with the profiles that Andrew Smith kindly produced with his software, based on the SRTM elevation data from the Space Shuttle radar. The results are presented in Figure 4.

An algorithm using numerical differentiation to detect features in horizon elevation profiles was passed over Andrew Smith's data in an attempt to find possible horizon features. Only horizon segments at least 3 km distant were considered.

Generally, speaking, the sites have a distant but smooth horizon to the east and north-east. The enclosures seem to have been erected in places with selected terrain characteristics, and in this they differ from the seven-stone tombs in the same area. We did not find any horizon features common to more than 5 sites.

### Symmetry Axis Calculation

We determined the coordinates of each menhir's centre from the DTM (the x-axis being the E-W direction and the y-axis the N-S direction), specifying an uncertainty of 0.5 m for standing menhirs and 3 m for recumbent ones, in both the x and y directions.

For the determination of the symmetry axis of each monument we used a procedure based on non-linear regression for fitting to the general quadratic equation of a conic, which offered a good fit to the shapes of the enclosures:

$$Ax^2 + Bxy + Cy^2 + Dx + Ey + 1 = 0 \quad (4).$$

For this equation the slopes of the two axes are  $q$  and  $-1/q$ , calculated using the expression

$$q = \sqrt{\left(\frac{B-A}{C}\right)^2 + 1} + \left(\frac{B-A}{C}\right) \quad (5).$$

The axis passing through the opening of the enclosure and/or corresponding to the longest enclosure dimension was chosen as the symmetry axis.

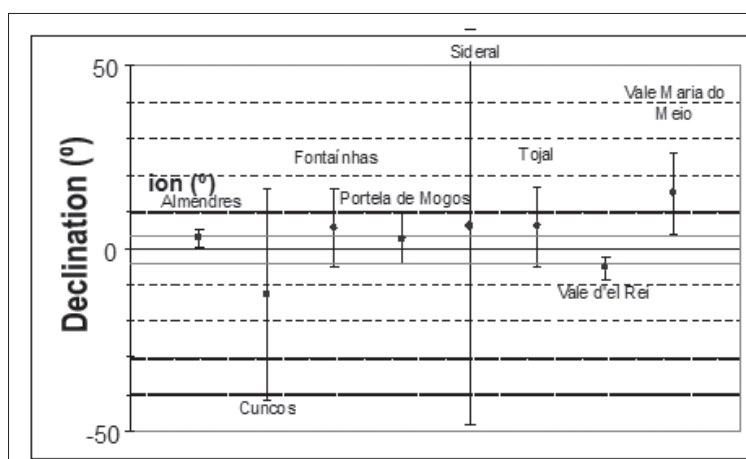


Fig. 5. Symmetry-axis declinations of the 8 enclosures with 2-sigma error bars.

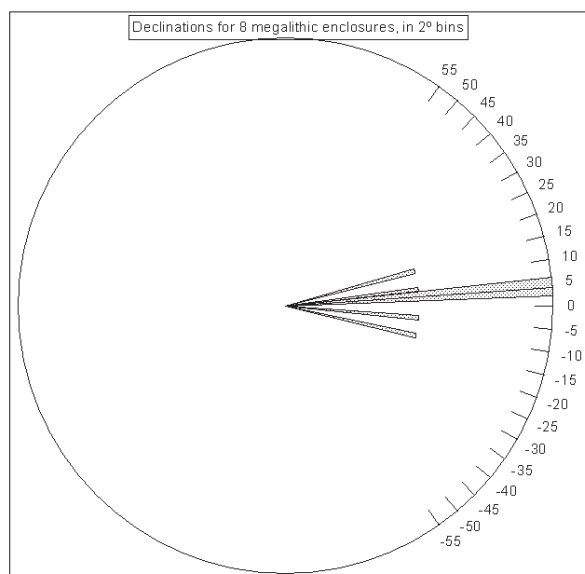


Fig. 6. Circular bar graph for the symmetry-axis declinations of 8 enclosures.

Curve fitting was done using LAB Fit<sup>4</sup> software that handles variables' uncertainties and produces the full resulting covariance matrix. This software also provides an error propagation calculation based on the standard expression for the absolute error. This function was used for the determination of the final uncertainties for  $\arctan(q)$  or  $\arctan(-1/q)$ , and also for the declinations. For the declination calculation the astronomical refraction effects were calculated using G. G. Bennett's formula (Meeus 1991, p.102) for a temperature of 15° and a pressure of 1010 mbar. We used an uncertainty of 0.5° for the horizon elevation, including the uncertainty in the refraction effects, and 1" for the latitude (measured by GPS).

## Discussion

As is clear from Figure 6, the orientations are all in a narrow range, close to the direction of due east. Since there is a very low probability of this happening by chance ( $\sim 7 \times 10^{-7}$ , using the expression<sup>5</sup>  $n * (\theta_{\text{range}} / 360)^{n-1}$  (6), with  $n=8$ ) and there are no common horizon features that could justify such a pattern, we believe that only two explanations are possible: either an astronomical target (Sun, Moon or planets) or a construction following the slope, and thus as a consequence facing the far horizon, since we verified that the azimuth of the symmetry axis and the azimuth of the steepest slope have a correlation coefficient of 0.7.

<sup>4</sup> da Silva, Wilton P. and Silva, Cleide M. D. P. S., LAB Fit Curve Fitting Software (Nonlinear Regression and Treatment of Data Program) V 7.2.36 (1999-2007), available from [www.labfit.net](http://www.labfit.net).

<sup>5</sup> See Ruggles 1999, p. 95.

If we consider the Sun or Moon to be the most probable astronomical targets, there is apparently an interest in declinations around that of the equinoxes. It is generally accepted that there are technical difficulties and no clear reasons for precise equinoctial orientations (Ruggles 1997). Nonetheless several natural signs from flora and fauna can be used together with astronomical events to mark seasonal changes. If for northern latitudes, the extreme limits of the solar and lunar azimuths can represent a strong motivation for special rituals, in lower latitudes where there is a more temperate climate, a similar motivation can occur at the beginning of spring and autumn.

The surveyed sites can be thought as a scenic/theatrical space facing the "stage" of the rising heavens.

## Conclusions

We can conclude from the data that the enclosures do not seem to have been built just following the slope, but instead probably pointed to an astronomical target. There seems to be an interest in declinations that correspond to the Sun at the beginning of spring or end of summer or to the Full Moon at the beginning of autumn or end of winter.

It is interesting to compare our results with the declination distribution for the dolmens in the Alentejo according to Michael Hoskin<sup>6</sup> (Hoskin 1998, 2001, 2002). While possible solar declinations are also possible lunar declinations, Occam's razor argues here in favour of a solar orientation, since there are no exceptions outside the declination range from -24° to +24°. Hoskin interpreted this distribution as an orientation towards the rising Sun at the end of winter or the beginning of autumn, and probably the latter, since agriculture demanded less attention at that time of year, leaving time available for the construction of communal tombs. It is possible that, through cultural continuity, ritualistic use of the enclosures around the beginning of autumn or the end of winter, and particularly at Full Moon at the beginning of autumn, could have led, later in the Neolithic, to the construction of dolmens oriented towards the rising eastern horizon and particularly to the Sun, mostly in the same period of the year.

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We wish to thank Nuno Crato, Carlos Daniel Paulino, Clive Ruggles and Manuel Calado for their helpful comments on early drafts of this paper. We wish also to express our gratitude to Andrew Smith from Adelaide University for the horizon elevation and distance-to-

<sup>6</sup> See Figure 9.

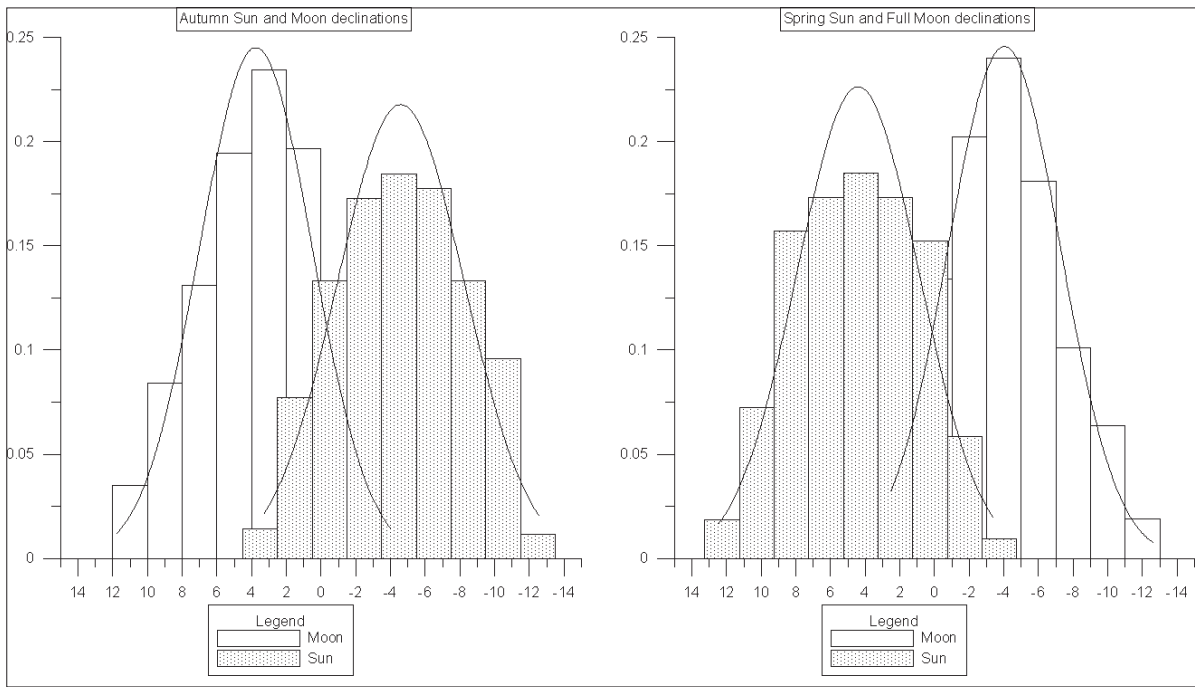


Fig. 7. 428-year simulation for Sun and Full Moon declinations (a) at “Autumn Full Moon equinox” and (b) at “Spring Full Moon equinox”.

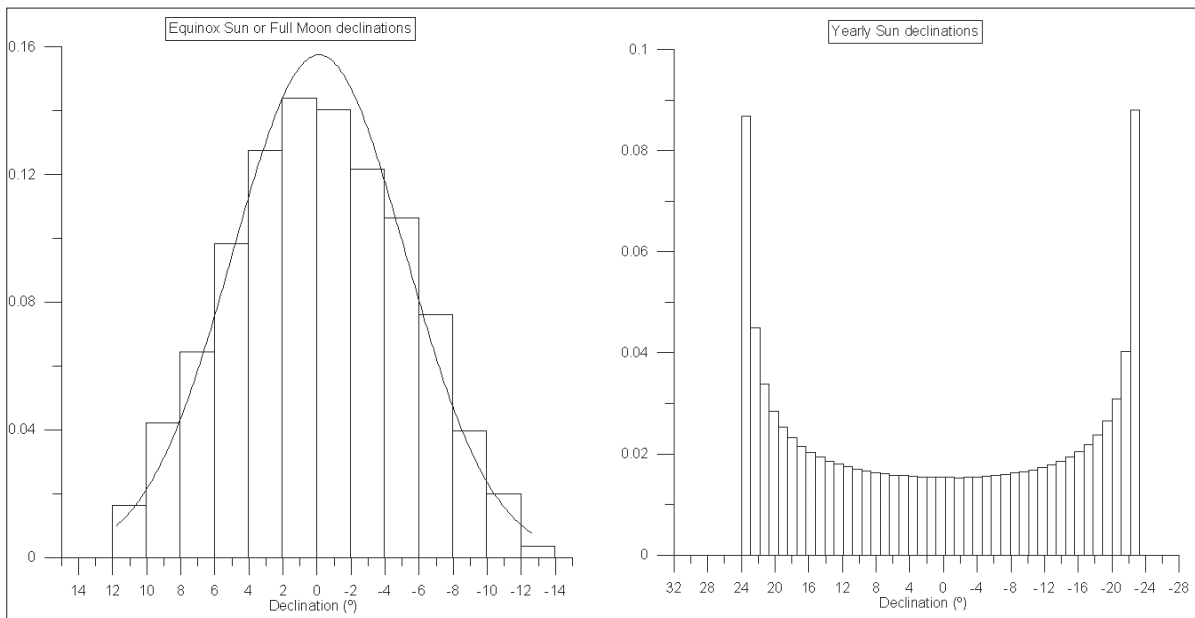


Fig. 8. (a) 428-year simulation for Sun and Full Moon declinations for both “Full Moon equinoxes”. (b) 93-year simulation for annual solar declinations.

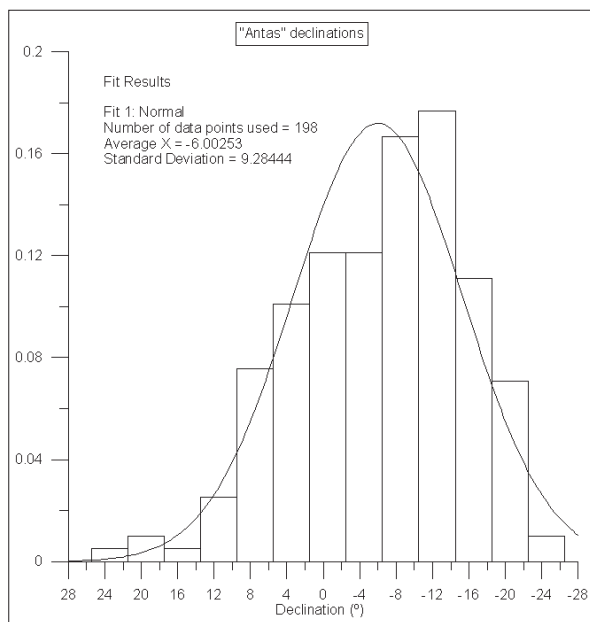


Fig. 9. Distribution of declinations of 198 Alentejo dolmens (or "Antas").

horizon profiles produced by the software that he is developing. Thanks are also due to Marta Freitas for her kind help on our last day of fieldwork.

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## CENTRINIO ALENTEŽO MEGALITINIŲ ĮTVIRTINIMŲ ORIENTAVIMAS

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#### Santrauka

Straipsnyje aptariamas Alentežo (Alentejo) provincijos (Pietų Portugalija) 12-os megalitinių aptvarų orientavimas. Nors būta įvairių bandymų nagrinėti šį klausimą (Alvim 1996–1997, 2004; Silva 2000), stigo visapusiško, visus aptvėrimus, įskaitant sugriautuosius, apimančio tyrimo (Cardoso 2002, p. 235).

Dalis šių objektų, datuojamų 6–5 tūkstantmečiais pr. m. e., yra vieni seniausių akmeninių aptvarų Europoje. Anot archeologo M. Calado (Calado 2004, p. 72, 82), dominuojanti šių aptvarų forma buvo pasagos pavidalo į rytų pusę atverta struktūra.

Tyrimas atskleidė orientavimo į rytus modelį: aptvėrimai statyti ne tik pagal reljefą, bet greičiausiai ir paisant astronominių objektų, ypač Saulės padėties pavasario pradžioje ar vasaros pabaigoje bei Mėnulio pilnaties padėties rudens pradžioje ar žiemos pabaigoje.

Šiuos rezultatus galima palyginti su Alentežo dolmenų deklinacijų pasiskirstymu (Hoskin 1998, 2001, 2002). Nors galimos Saulės deklinacijos yra kartu ir Mėnulio deklinacijos, remiantis Okamo skustuvo principu labiau tikėtinas orientavimas pagal Saulę, kadangi už deklinacijų ribų tarp  $-24^\circ$  ir  $+24^\circ$  nėra išimčių. M. Hoskin tokį pasiskirstymą aiškina kaip orientavimą į tekančią Saulę rudens pradžioje ar žiemos pabaigoje, kuomet mažiau pastangų skiriama žemdirbystei ir lieka laiko bendruomenės kapaviečių įrengimui.

Vertė Jurgita Žukauskaitė