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COMPUTATIONAL ANALYSIS OF THE SPATIAL DISTRIBUTION OF PRE-CHRISTIAN SLAVIC SACRED SITES

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ABSTRACT

This paper proposes a method to find out the units of length used by the Slavs prior to their Christianization. The method relies on a previous research of the tripartite structure of pre-Christian Slavic sacred sites discovered by Andrej Pleterski. Such spatial structures represent myth in space and are in correlation with the central Slavic myth of the divine battle between Perun and Veles as presented by Radoslav Katičić. By measuring the angles which Sun takes through the year cycle and comparing them with the angles between the sacred sites, the pagan priests had means to accurately determine the days of religious festivals and the calendar in general. The angles likely had an important role, but this article tries to examine weather the absolute values of the distance between the sacred sites were also important. The method relies on the mathematical properties of arithmetic and geometric sequences. If for some of the inital parameters of the sequences the probability function for a given distribution of sacred sites in some area shows to be significantly smaller than the average, then it is an indication that the respective distribution is not random. The parameters in such case may point to the system of measures used during the creation of the structure. The proposed method really detected some common modules, but in this phase it is only experimental and still can not be used as a proof of common Pan-Slavic system of units.

KEY WORDS

myth in space, metrology, archeoastronomy, spatial analysis, probability distribution

CLASSIFICATION

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INTRODUCTION

The pagan Slavs positioned their sacred shrines in such a way that the chosen positions formed a tripartite structure, a triangle as discovered by Andrej Pleterski [1]. Such structures represented myth in space and were related to the central Slavic myth of the divine battle between Perun and Veles as presented by Radoslav Katičić [2-4]. The Perun's sanctuary was usually placed on some high place, the Veles' sanctuary accross the local river on a usually lower place, and the Mokos' sanctuary somewhere between them, close to the river or some other watering place. Measuring the angles which Sun takes through the year cycle and comparing them with the angles between the sacred sites, the pagan priests had means to accurately determine the days of religious festivals and the calendar in general. This means that the major holidays were held at each solstice and each equinox, probably with some correction regarding the lunar phases.

The number of sacred triangles have already been described on several Croatian sites mostly by Vitomir Belaj. These are located in the area of Ivančica, Mošćenica [5], Žrnovnica [5, 6], West Papuk [7], Zagreb [7], on the island of Pag [5, 8, 9] and in some other areas. It can be concluded that the most important features of those triangles are the angle of about 23,5° and the ratio between the two sides of the triangle which often amounted to 1: $\sqrt{2}$. The angle of 23,4° corresponds to the axial tilt of Earth which could be measured looking the Sun's zenith position from an equinox to the the consecutive solstice as was discovered by Andrej Pleterski.

An important feature of a sacred landscape system which I described in the lower course of the river Krapina [10, 11] is a fact that from the centre of the area at Babožnica (Mokos' sanctuary) 8 sacred points[1] are located at intervals mutually related as 1: $\sqrt{2}$. At the same time of those 8 points, 5 of them form 3 sacred triangles together with Babožnica. The two of them are identical in lengths and angles (the angles 23.5° and 34°). The ratio of the two shorter sides of a triangle with angles 23,5°, 34° and 122,5° is also the ratio 1: $\sqrt{2}$. I discovered that the angle of 34° at the position of Babožnica corresponds to the sunset/sunrise angle distance from an equinox to the the consecutive solstice. In contrast to the angle of 23,5° this second angle changes with the latitude, which consequently means that the ratio of the two shorter sides of such triangle also changes with latitude. But despite that, the ratio 1: $\sqrt{2}$ probably had a special meaning to the pagan Slavic priests regardless of the latitude and the Sun angles. This ratio is easy to construct in any landscape and it could be used to indirectly measure the distance between any two vertices of an isosceles, rectangle triangle (the triangle with angles 45°, 45° and 90°).

According to my research, the third angle of 15,5° (2/3 of 23,4°) also had an important role because it served as a tool for determining four midseason holidays which were celebrated between equinoxes and solstices, roughly at the dates: May 2, August 12, November 3 and February 8.

The angles likely had an important role, but there is the question weather the absolute values of the distances between the sacred points were also important. This gave me the impetus to build a mathematical apparatus by which it should be possible to examine whether the space distribution of sacred sites also accounts the absolute values of the distance between them.

This paper is divided into three main sections. Section one describes mathematical algorithm used to calculate the common modules between sacred sites in some individual landscape. Section two tries to assess the effects of random and non-random distribution of points on the proposed algorithm. Section three applies the algorithm to several real spatial distributions of sacred sites.

METHOD

The probability distribution of points around some central position will be calculated using the properties of a geometric and arithmetic sequence depending on the values of the initial term, the difference and the quotient of the progression respectively. If for some of the inital parameters of the sequences the probability function for a given distribution of sacred sites in some landscape shows to be significantly smaller than average, then it is an indication that the respective distribution is not random.

By comparing the resulting modules for various Slavic regions it should be possible to determine if among them there is a correlation. In that case it would be an indication of the existence of the old Pan-Slavic units of length.

The general case is defined as a sequence of distances (D_1, D_2, D_3, ..., D_k) measured from the central point (S_0) with the associated limits of tolerance (T_1, T_2, T_3, ..., T_k) (Fig. 1).

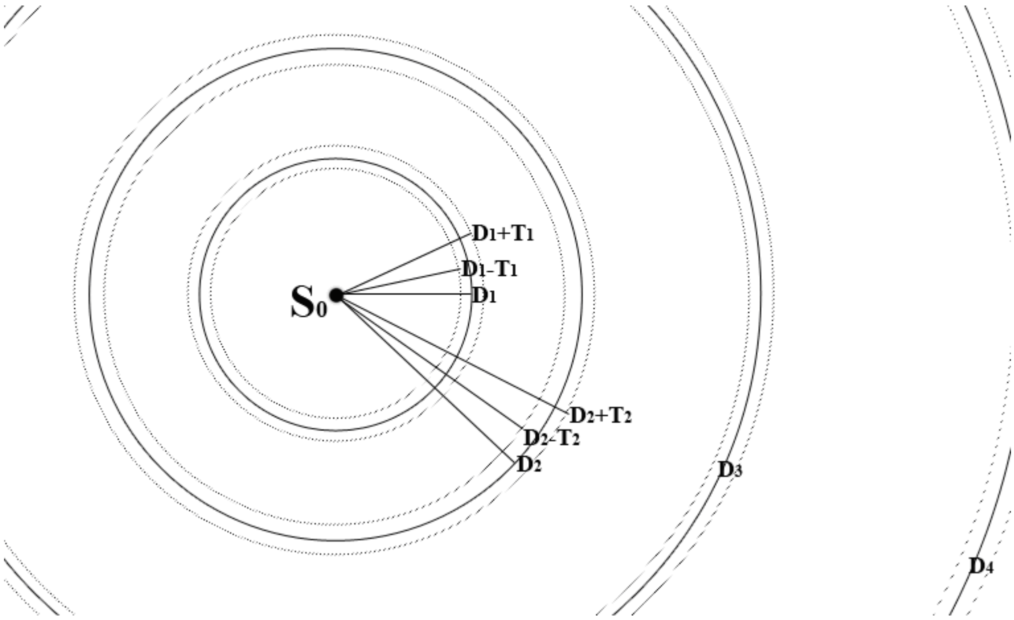

Figure 1. Graphic representation of a sequence of distances D_1, D_2, D_3, D_4, ... from the central point S_0 with the associated limits of tolerance T_1, T_2, T_3, T_4, ...

The probability to find a sacred site within the n-th member of the sequence is equivalent that its distance from S_0 is greater than $D_n - T_n$ and less than $D_n + T_n$. It can be expressed as a ratio of n-th 'ring' surface to the total surface area observed (D_{max} represents maximal radius from S_0):

$$P_n = \frac{P_n}{P_{tot}} = \frac{(D_n + T_n)^2\pi - (D_n - T_n)^2\pi}{D_{max}^2\pi} = \frac{4D_nT_n}{D_{max}^2}. \quad (1)$$

Since it does not matter in which of the rings a sacred point is located, we will calculate the probability to find it within any of the rings.

This probability can be expressed through the relationship of the total surface area of all rings whose radius is smaller than D_{max}, to the total surface area observed:

$$p = \frac{4}{D_{max}^2}\sum_{n=1}^{k} D_nT_n . \quad (2)$$

uz $D_k \le D_{max} < D_{k+1}$, k = 0, 1, 2, ...

The likelihood P of any distribution of sacred sites in respect to such sequence may be expressed with the formula for the binomial distribution:

$$p = q^{N-n} p^{n} \frac{N!}{n!(N-n)!}. \tag{3}$$

where p is the probability that a sancred point satisfies the conditions of belonging to any member of the sequence, $q = 1 - p$ the probability that a sacred point does not satisfy these conditions, N the total number of sacred points, k the total number of sequence members $D_k \leq D_{max} < D_{k+1}$, k = 0, 1, 2, ..., and n the total number of sacred points which meet the conditions.

In order to simplify the calculation, we express D_{max} using a real number s,

$$s = D_{max}/D. \tag{4}$$

GEOMETRIC SEQUENCE

A geometric sequence is a sequence of numbers where each term after the first is found by multiplying the previous one by a fixed non-zero number, called the common ratio or quotient. In the case of a geometric sequence with the initial element D, quotient Q, and tolerance factor T (we assume that tolerance grows linearly with the sequence members), the following equations for the n-th member of a sequence are valid:

$$D_n = Q^{n-1}D, \tag{5}$$

$$T_n = TD_n = TQ^{n-1}D. \tag{6}$$

The probability p_n that sacred site satisfies the conditions for the n-th member of a sequence in this case is:

$$p_n = \frac{4D_nT_n}{D_{max}^2} = \frac{4Q^{n-1}DTQ^{n-1}D}{s^2D^2} = \frac{4T}{s^2}Q^{2(n-1)}. \tag{7}$$

The probability p that sacred site satisfies the conditions of any member of a sequence is:

$$p = \frac{4T}{s^2}\sum_{n=1}^{k} Q^{2(n-1)} = \frac{4T}{s^2}\frac{Q^{2k}-1}{Q^2-1}. \tag{8}$$

The total number of the sequence members k is obtained from the expression:

$$Q^{k-1}D \leq D_{max} < Q^kD, \tag{9}$$

$$\log_Q(s) < k \leq \log_Q(s)+1. \tag{10}$$

ARITHMETIC SEQUENCE

Arithmetic sequence is a sequence of numbers such that the difference between the consecutive terms is constant. If the initial term of an arithmetic progression is D_0 and the common difference of successive members is D, then the n-th term of the sequence is given by formula:

$$D_n = D_0 + (n-1)D. \tag{11}$$

In case of an arithmetic sequence with initial value D, difference D, and tolerance factor T (tolerance depends only on D), the following equations for the n-th member of a sequence are valid:

$$D_n = nD, \tag{12}$$

$$T_n = TD = \text{const}. \tag{13}$$

The tolerance value for all members of a sequence is always the same since it depends only on the difference value D. If we take a tolerance T_n to be dependent on the value of the n-th member of a sequence (D_n), then the limit of tolerance after some number of members may become larger than the spacing of adjacent members of the sequence, and such a calculation would not make any sense.

The probability p_n that sacred site satisfies the conditions for the n-th member of a sequence in this case is:

$$p_n = \frac{4D_n T_n}{D_{max}^2} = \frac{4nDTD}{s^2 D^2} = \frac{4T}{s^2} n. \tag{14}$$

The probability p that sacred site satisfies the conditions of any member of a sequence is

$$p = \frac{4T}{s^2} \sum_{n=1}^{k} n = \frac{2T}{s^2} k(k+1). \tag{15}$$

The total number of the sequence members k is obtained from the expression:

$$Q^{k-1} D \le D_{max} < kD, \tag{16}$$

$$s - 1 < k \le s. \tag{17}$$

ASSUMPTIONS

In all the calculations the elevation is not taken into account, since it would significantly complicate the algorithm, and would not significantly contribute to the final result.

Also, the analysis accounts all the mutually visible locations that have some tradition of worship, whatever their actual age, which in most cases is impossible to determine.

After receiving Christianity all of the newly established sacred points certainly did not take into account the distances between them, so they should obey a random distribution and therefore their influence on the final result, on average, should not have a significant impact.

PERFORMED TESTS

To assess the effects of random distributions on the result of the algorithm we will make several tests. The behavior of the algorithm will be examined on random and non-random distribution of points.

ARITHMETIC SEQUENCE – NON RANDOM DISTRIBUTION

Around central point, at intervals 500 m, 10 points are distributed[2] (Fig. 2).

The bar graph in Fig. 3 shows on the ordinate the logarithm of the reciprocal values of the probability of the arithmetic sequences for every difference value D ranging from 100 m to 1499 m for the central point (0) from Figure 2. The probabilities are calculated using (3) with $T = 0{,}02D$ and $D_{max} = 10\,000$ m. The tolerance is taken to be 2 % of D as a reasonable degree of accuracy in measurement, which for $D = 500$ m gives the absolute value of tolerance to be 10 m. Resolution of the abscissa is 1 m. The probability values are recalculated into the logarithm of their reciprocal values, because that is most practical for the visualisation of the result. The more improbable sequences get the higher values on the bar graph[3] (Fig. 3).

From the graph it can be seen that the function of probability gives four major values of probability which belong to the arithmetic sequences which have difference values D equal to 100 m, 125 m, 250 m and 500 m. It could be observed that the most improbable arithmetic sequences belong to the modules which are subharmonics and harmonics of 500 m (Table 1).

If we calculate the probability distribution for the chosen center point in Fig. 2, its graphical representation is as in Fig. 3. If we furthermore calculate the probability distributions for every point in Fig. 2 and aggregate[4] the results in a single graph, then such graph (Fig. 4) will actually represent overall probability distribution for all points. If there is any common module among any of them, such graph surely will reveal it. As we can see in Figure 4, among all the points from Figure 2 there are no other significant common modules than those shown in Figure 3.

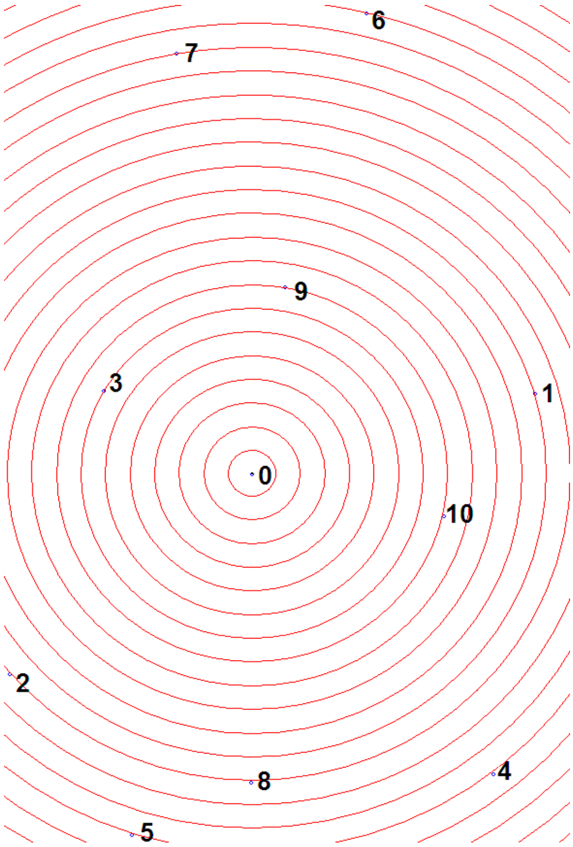

Figure 2. Ten points distributed at intervals 500 m apart. The distance between consequtive circles is 500 m, D_{max} = 10 000 m.

Table 1. The least probable arithmetic sequences, from data in Fig. 4. For four major values of D/D_0 the probabilities are bolded. Here D_0 = 500 m.

***D*, m**	**log(1/*p*)**	***D*/*D*₀**
100	**13,936**	1/5
125	**13,925**	1/4
200	7,700	2/5
250	**13,872**	1/2
400	6,037	4/5
500	**13,768**	1
666	5,978	4/3
1000	7,475	2

ARITHMETIC SEQUENCE – COMBINATION OF RANDOM AND NON RANDOM DISTRIBUTIONS

Around central point, at intervals of 500 m apart, 10 points are distributed (the same points as in Fig. 2) along with the 10 randomly distributed points[5].

As can be seen from the graph in Fig. 5, the most improbable modules are not changed, except that they become moderately more probable (the bars on the graph are lower) than in the previous case (Fig. 3) in which there were only 10 non-random points on the same area.

The aggregate result (Fig. 6) for all the points generated (and shown in Fig. 7) also shows no significant changes. The points do not conform to any other yet unknown module, although ten random points were added.

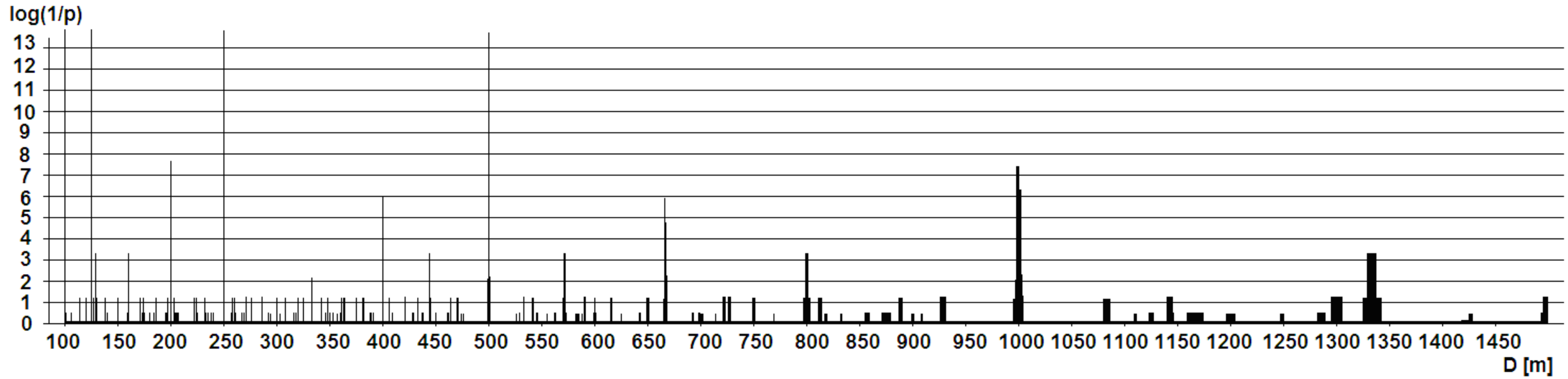

Figure 3. Bar graph of probability of arithmetic sequences (the logarithm of the reciprocal values) for the central point (0) from Figure 2 with $T = 0{,}02\,D$, $D_{max} = 10\,000$ m and resolution 1 m.

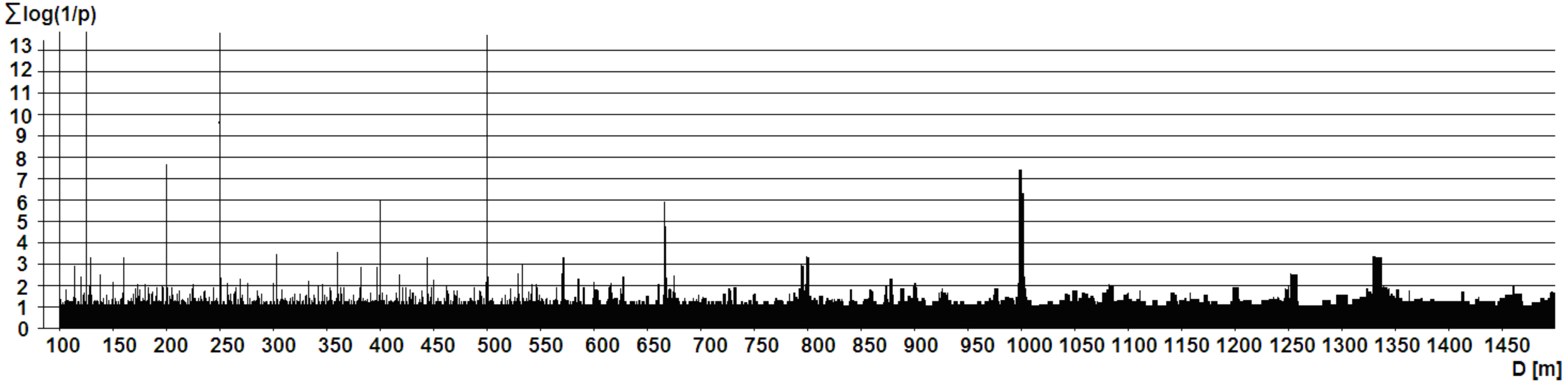

Figure 4. Bar graph of aggregate values of probability of arithmetic sequences (the logarithm of the reciprocal values) for all the points from Figure 2 with $T = 0{,}02\,D$, $D_{max} = 10\,000$ m and resolution 1 m.

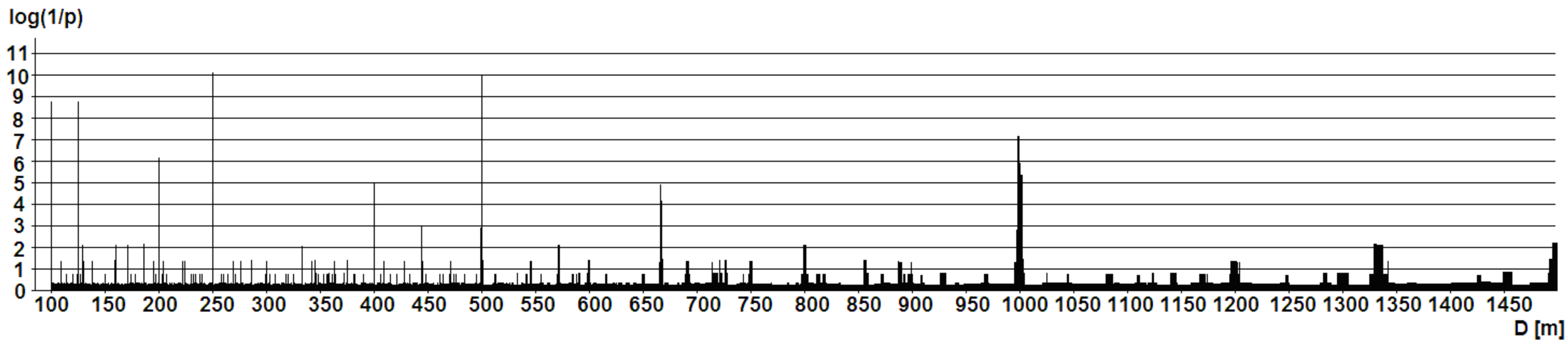

Figure 5. Bar graph of probability of arithmetic sequences (the logarithm of the reciprocal values) for the central point (0) from Figure 5 with $T = 0,02\ D$, $D_{max} = 10\ 000$ m and resolution 1 m.

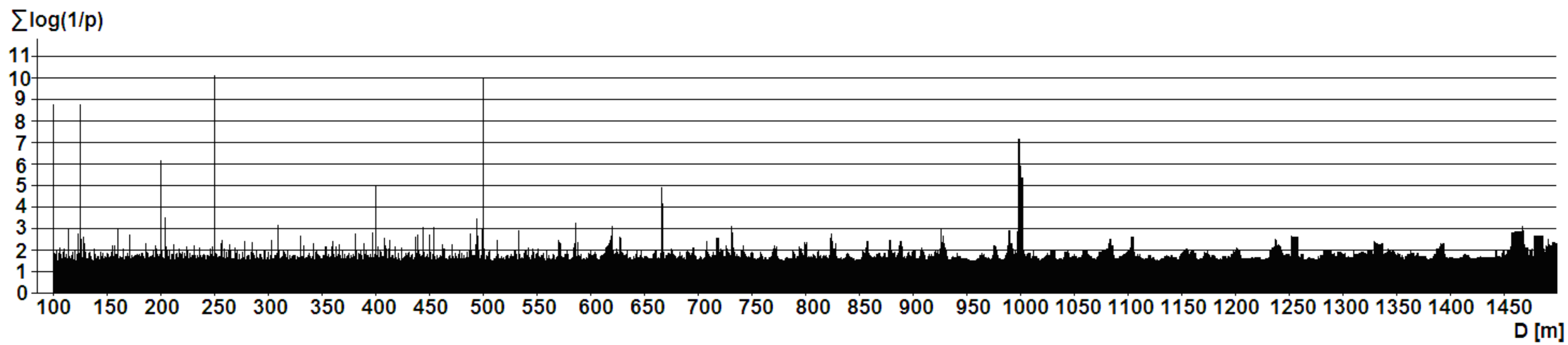

Figure 6. Bar graph of aggregate values of probability of arithmetic sequences (the logarithm of the reciprocal values) for all the points from Figure 5 with $T = 0,02\ D$, $D_{max} = 10\ 000$ m and resolution 1 m.

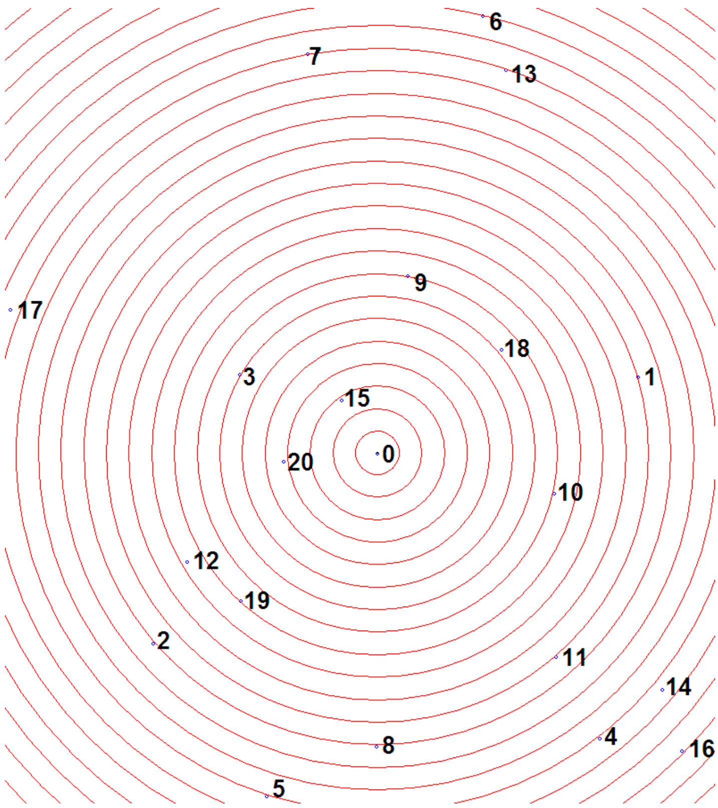

Figure 7. Ten points from Fig. 2 with the addition of another ten randomly generated points. The distance between circles is 500 meters as shown in the figure, D_{max} = 10 000 m.

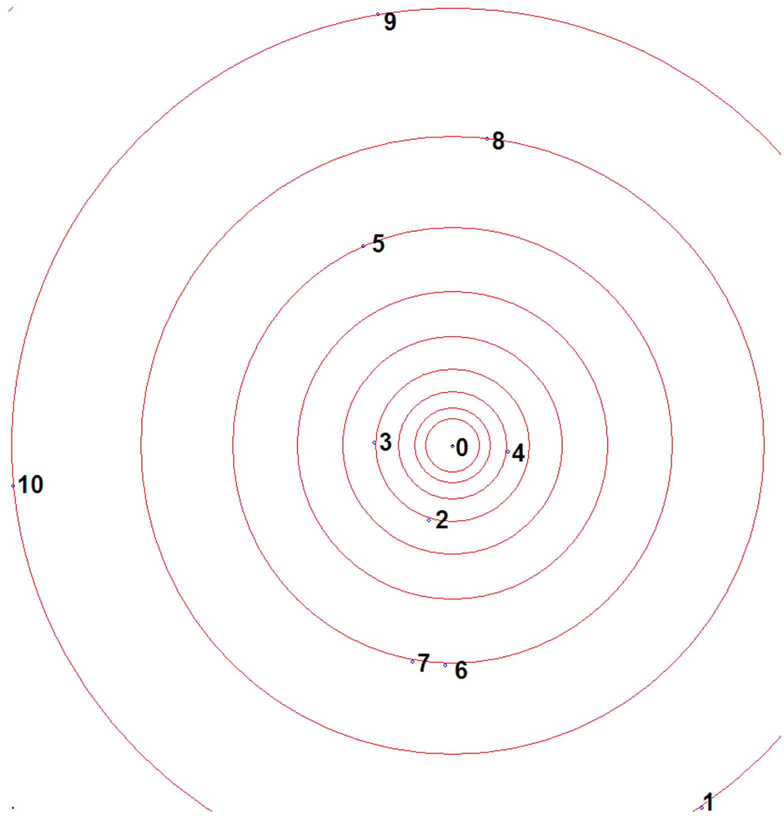

Figure 8. Ten points distributed according to the geometric sequence with quotient $Q = \sqrt{2}$ and initial value D = 500 m. Geometric sequence is shown in the figure as a sequence of circles. In this case D_{max} = 10 000 m.

GEOMETRIC SEQUENCE – NON RANDOM DISTRIBUTION

Around central point at geometric sequence intervals, with quotient $Q = \sqrt{2}$ and initial value $D = 500$ m, ten points are added[6] (Fig. 8, to be differentiated from Fig. 9).

From the graph in Fig. 10 it can be seen that the function of probability gives a number of major values which are positioned exactly at the members of the geometric sequence

$$D_n = 500\sqrt{2^{n-1}} \text{ m} \tag{18}$$

for n equal to –3, –2, –1, 0, 1, 2, 3 and 4, and D_n = 125 m, 177 m, 250 m, 354 m, 500 m, 707 m, 1000 m and 1414 m, respectively.

The aggregated probability function for every point in Fig. 8 as we can see in Fig. 11 does not reveal any other significant common module.

GEOMETRIC SEQUENCE – COMBINATION OF RANDOM AND NON RANDOM DISTRIBUTION

Around central point at geometric sequence intervals with quotient $Q = \sqrt{2}$ and initial value $D = 500$ m, ten points are taken from Figure 8, and additional ten points are randomly generated[7].

As we can see from the graph in Fig. 12, the most improbable geometric sequence did not change, except that its members become moderately lower on the graph than in the previous case when there on the same area were only 10 non-random points.

But, the aggregate probability function for every point in Figure 11 as we can see in Fig. 13 does, besides already known geometric sequence $D_n = 500\sqrt{2^{n-1}}$ m, reveal one additional moderately improbable significant geometric sequence with $D_n = 456\sqrt{2^{n-1}}$ m. This secondary geometric sequence appeared despite random distribution of additional 10 points. So we can conclude that such case is not so improbable.

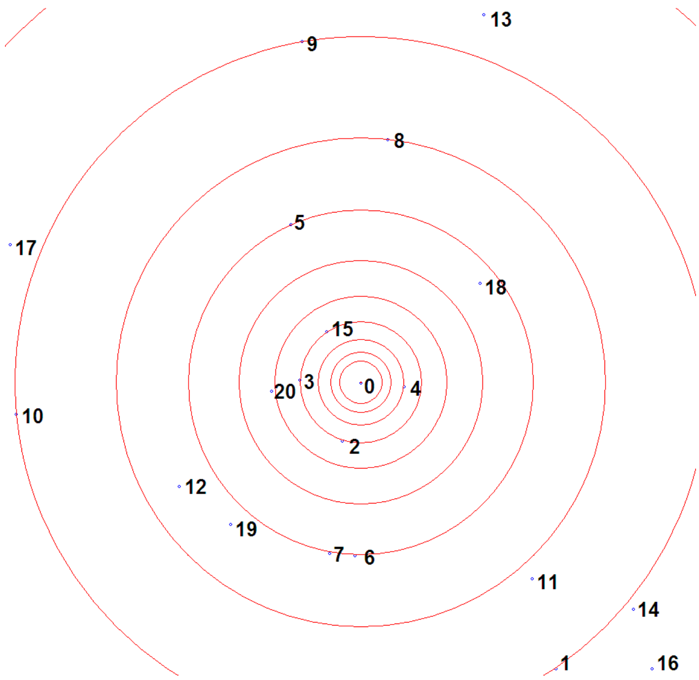

Figure 9. Ten points from Fig. 8 with the addition of 10 completely random points. Diameters of circles shown are distributed according to the geometric sequence quotient $Q = \sqrt{2}$ with initial value $D = 500$ m and $D_{max} = 10\,000$ m.

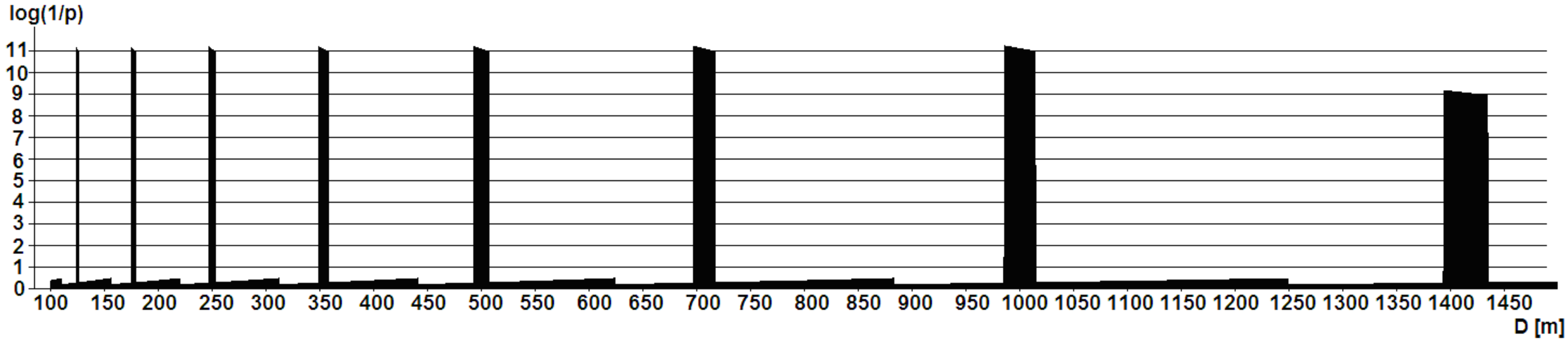

Figure 10. Bar graph of probability of geometric sequences (the logarithm of the reciprocal values) for the central point (0) from Figure 8. Parameters are $Q = \sqrt{2}$, $D = 500$ m, $T_n = 0{,}015D_n$, $D_{max} = 10\ 000$ m and resolution is1 m.

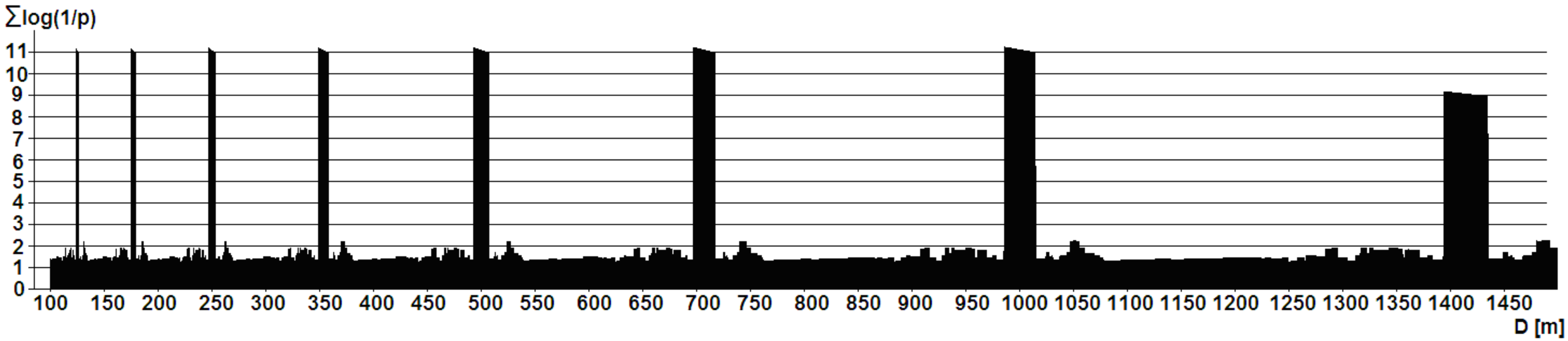

Figure 11. Bar graph of aggregated values of probability of geometric sequences (the logarithm of the reciprocal values) for the central point (0) from Figure 8. Parameters are $Q = \sqrt{2}$, $D = 500$ m, $T_n = 0{,}015D_n$, $D_{max} = 10\ 000$ m and resolution is1 m.

RANDOM DISTRIBUTION

Inside the area of 20 000 × 20 000 m^2 it is distributed 10 points using the generator of random numbers[8]. Fig. 14 shows probability function bar graph for geometric sequences of every such point, and at the end the aggregate result. As we can see, there appear for most of the points some not so probable geometric sequences, but generally nothing significant.

Fig. 15 shows probability function bar graph for arithmetic sequences of every randomly generated points, and the aggregate result. As we can see, there appear for most of the points some not so probable arithmetic sequences, but generally nothing significant.

CONCLUSION BASED ON THE PERFORMED TESTS

From the aforementioned test cases we can conclude that any arithmetic or geometric sequence which is not a result of randomness and which is part of some intended system, will appear with its subharmonics and harmonics in the bar graph of the probability function despite any reasonable number of added points which are not part of the system. But, on the other side, some moderately improbable arithmetic or geometric sequences can appear as a result of completely random distribution of points.

So, if a real distribution of sacred points in some area really is a result of intention, we surely will detect the used modules, but we will not be sure if they are a result of coincidence. On the other side, comparing the resulting modules from various Slavic regions it should be possible to determine if among them there is a correlation. Only then we could be reasonably sure that the given modules are not the result of a coincidence.

THE REAL SPATIAL DISTRIBUTIONS

BABOŽNICA

Babožnica here in a broader sense references a system of 13 sacred points in the lower course of the river Krapina in the northwestern part of Croatia very close to Zagreb, Fig. 16. The central point of the system is located 170 m from the old meanders of the river Krapina and 40 m from the old course of the stream Bistra which is the major stream on the left bank of Krapina in its lower course. That area is known as Babožnica[9] or more precisely Vučinka ('the wolf's place') and in the tradition the area is connected with the famous semi-legendary mill[10]. The precise location of Babožnica is taken to be the place which forms three sacred triangles of which the two are identical in lengths and angles. Two triangles are with angles 23°, 34° and 123° while one triangle has angles 15,5°, 34° and 130,5° [10, 11].

This is the system which gave me the inspiration for the method, because around Babožnica I detected geometric sequence which obeys the rule $D_\mathrm{n} \approx 2500\sqrt{2^{\mathrm{n}-1}}$ m [11]. Conversion of the geographic coordinates into the Cartesian rectangular coordinate system in this paper is performed according to the formulas for the orthographic projection given in Appendix.

In Figs. 17, 18 and 19 locations of sacred points are shown for Babožnica and two other sacred places, while corresponding bar graphs are shown in Figs. 20, 21 and 22.

Fig. 17 shows the bar graph for the geometric sequences around Babožnica. Initial values with the most improbable sequences are presented in Table 2. From that table it could be seen that this point really is a centre for the geometric sequence $D_\mathrm{n} \approx 109{,}6\sqrt{2^{\mathrm{n}-1}}$ m (n = 1, 2, 3, 4, 5, 6, 7 and 8), which is equivalent to the sequence $D_\mathrm{n} \approx 620\sqrt{2^{\mathrm{n}-1}}$ m (n = –4, –3, –2, –1, 0, 1, 2).

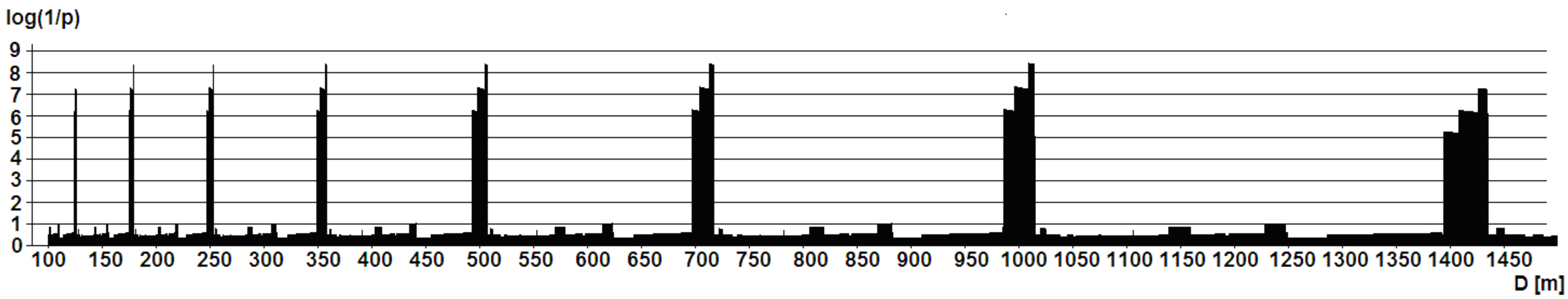

Figure 12. Bar graph of probability of geometric sequences (the logarithm of the reciprocal values) for the central point (0) from Figure 8. Parameters are $Q = \sqrt{2}$, $D = 500$ m, $T_n = 0{,}015D_n$, $D_{max} = 10\ 000$ m and resolution is1 m.

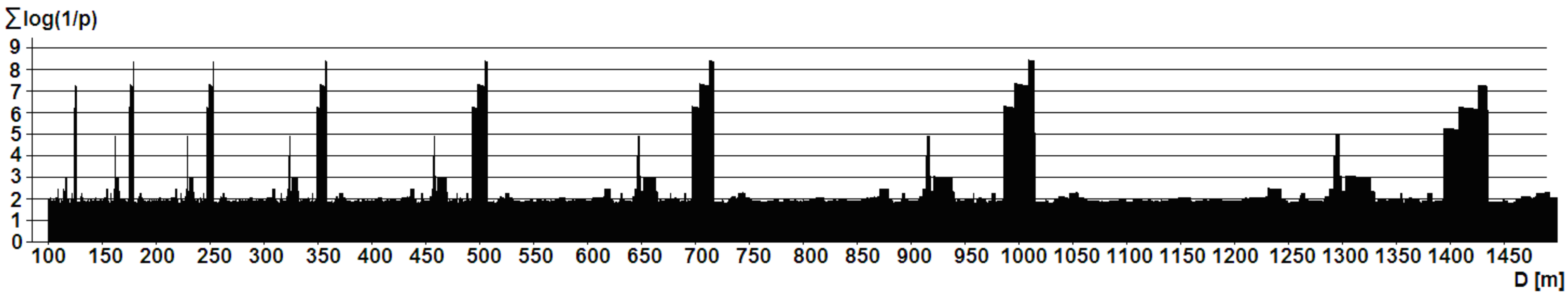

Figure 13. Bar graph of aggregated values of probability of geometric sequences (the logarithm of the reciprocal values) for the central point (0) from Figure 8. Parameters are $Q = \sqrt{2}$, $D = 500$ m, $T_n = 0{,}015D_n$, $D_{max} = 10\ 000$ m and resolution is1 m.

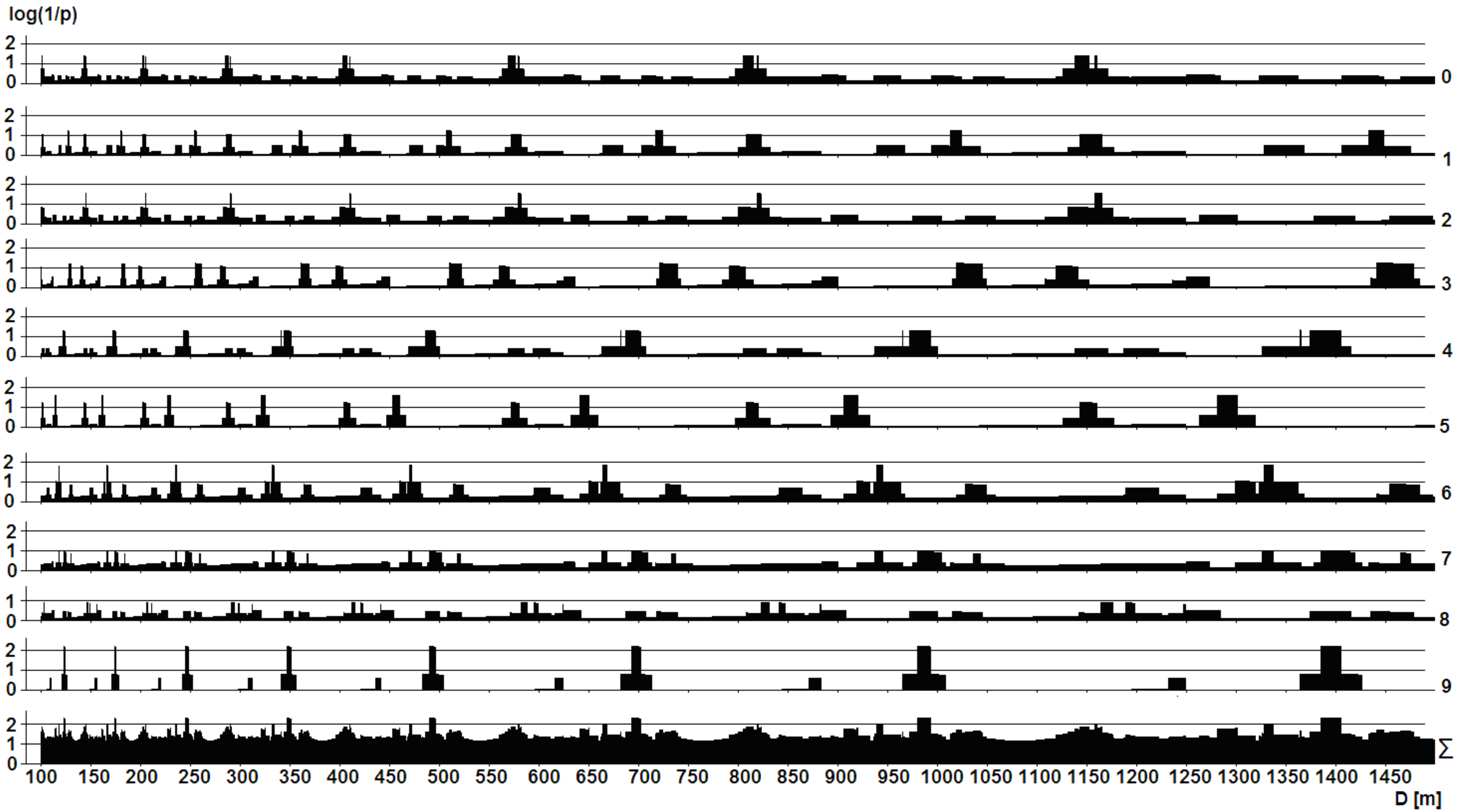

Figure 14. The bar graphs of values of probability of geometric sequences (the logarithm of the reciprocal values) separately for all randomly generated points and aggregate result (marked with Σ). Here $T_n = 0,15\ D_n$ and $D_{max} = 10\ 000$ m.

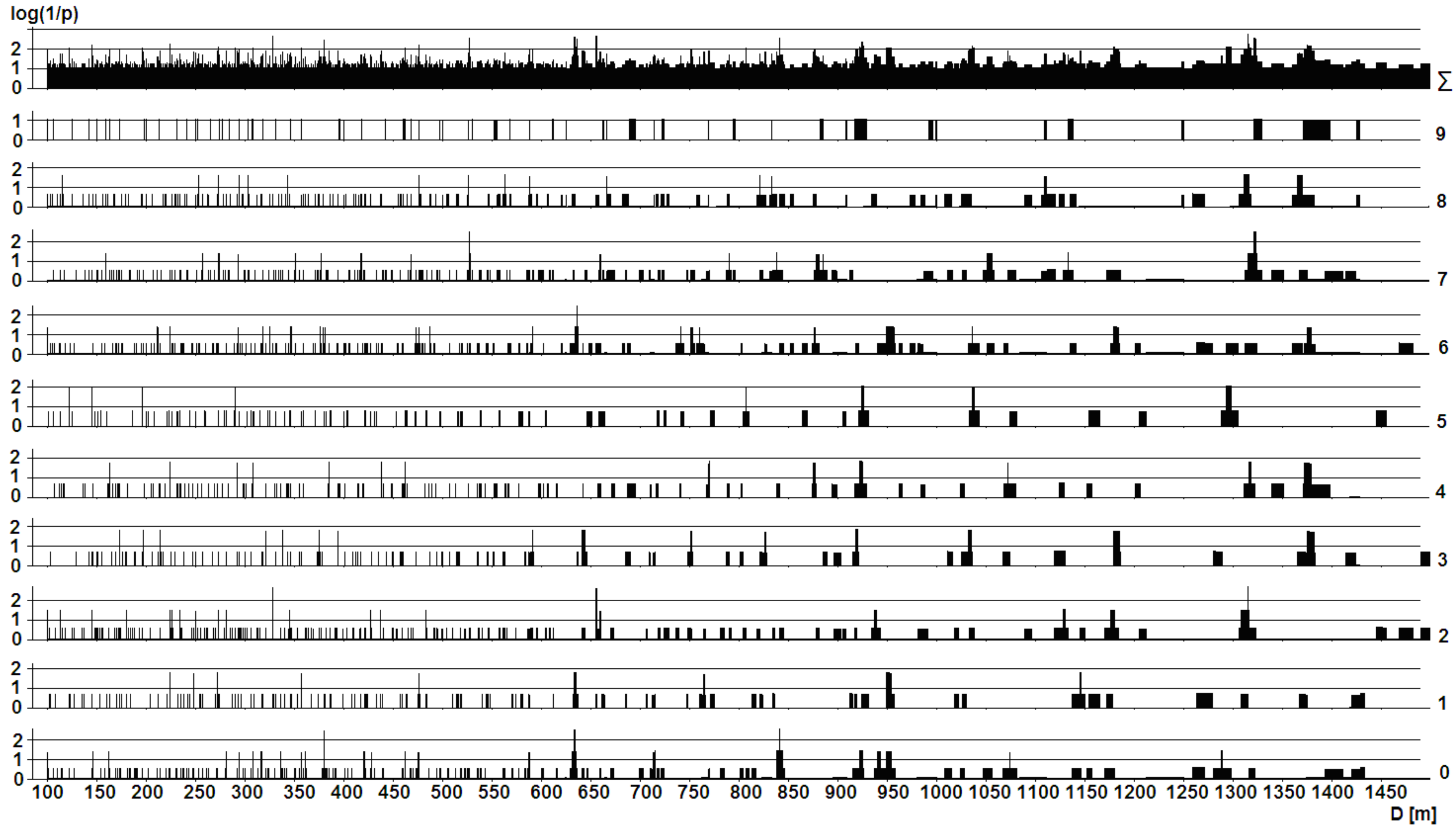

Figure 15. The bar graphs of values of probability of arithmetic sequences (the logarithm of the reciprocal values) separately for all randomly generated points and aggregate result (marked with Σ). Here $T_n = 0{,}02\, D$ and $D_{max} = 10\ 000$ m.

Table 2. Minimal values of probability of geometric sequences around Babožnica, D_0 = 620 m.

***D*, m**	**log(1/*p*)**	***D*/*D*₀**
109	4,62	$\sqrt{2}/4$
155	5,72	1/4
219	5,72	$\sqrt{2}/2$
310	5,72	1/2
438	5,72	$1/\sqrt{2}$
620	5,72	1
877	5,73	$\sqrt{2}$
1240	5,74	2

Table 3. Minimal values of probability of geometric sequences around St. Vitus in Javorje, D_0 = 620 m.

***D*, m**	**log(1/*p*)**	***D*/D_0**
109	2,45	$1/(4\sqrt{2})$
154	2,45	1/4
217	2,47	$1/(2\sqrt{2})$
309	3,18	1/2
437	3,18	$1/\sqrt{2}$
618	3,18	1
873	3,19	$\sqrt{2}$
1235	3,20	2

Table 4. The minimal values of probability of arithmetic sequences around St. Anthony in Gradna depending on start value/difference D, with D_0 = 620 m.

***D*, m**	**log(1/*p*)**	***D*/D_0**
414	2,363	2/3
620	4,399	1
827	2,312	4/3
1238	4,553	2

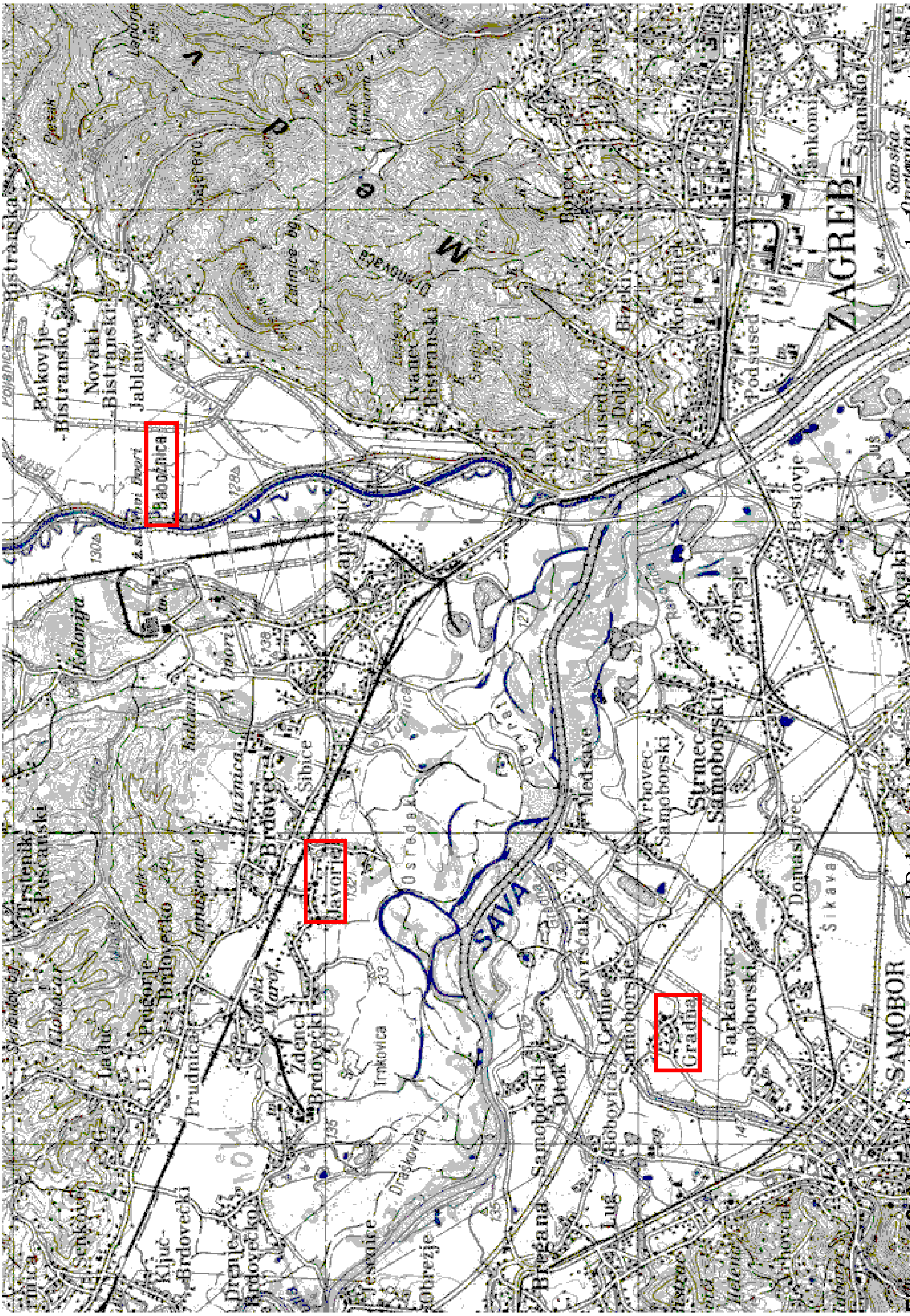

Figure 16: Map of the study area around Babožnica. The positions of three central, sacred points are marked with the rectangles. Starting from the left these are St. Anthony in Gradna, St. Vitus in Javorje and Babožnica.

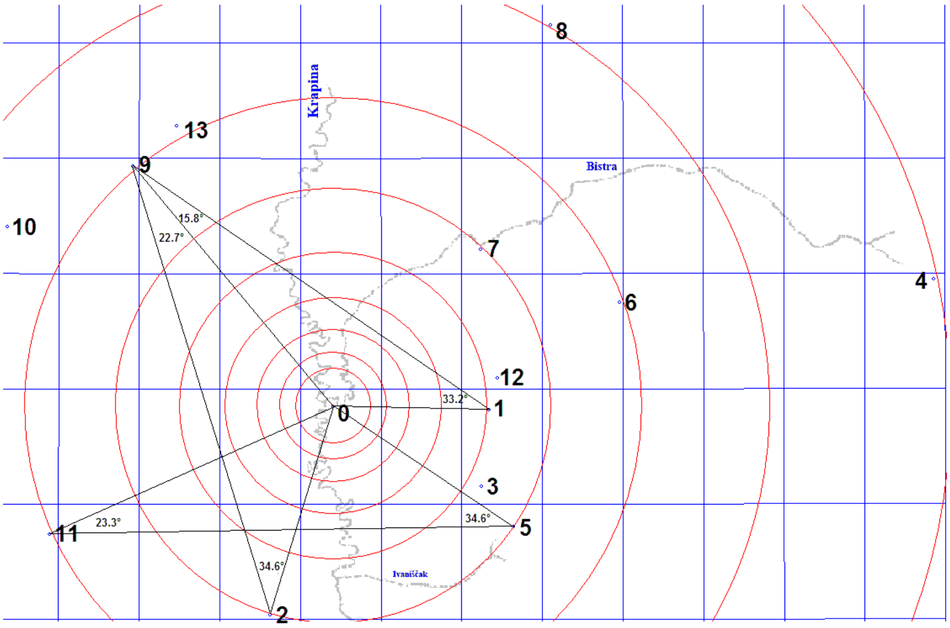

Figure 17. Geometric sequence $D_n = 620\sqrt{2^{n-1}}$ m around Babožnica (with aproximation of the old courses of Krapina and Bistra). The circles shown are distributed according to the geometric sequence with $Q = \sqrt{2}$ and start value $D = 620$ m; Three sacred triangles around Babožnica are emphasised. Sacred sites are denoted as follows[11]: 0. Babožnica, 1. St. John Jablanovec, 2. St. Peter Zaprešić, 3. Kameni svati, 4. Sljeme, 5. Zlatinice, 6. St. Nicholas Poljanica B., 7. St. Vendelin Donja Bistra, 8. St. Dorothea Jakovlje, 9. St. Mary Donja Pušća, 10. St. Catherine Hrebine, 11. St. Vitus Javorje, 12. St. Roch Novaki B and 13. St. Andrew Bregovljani.

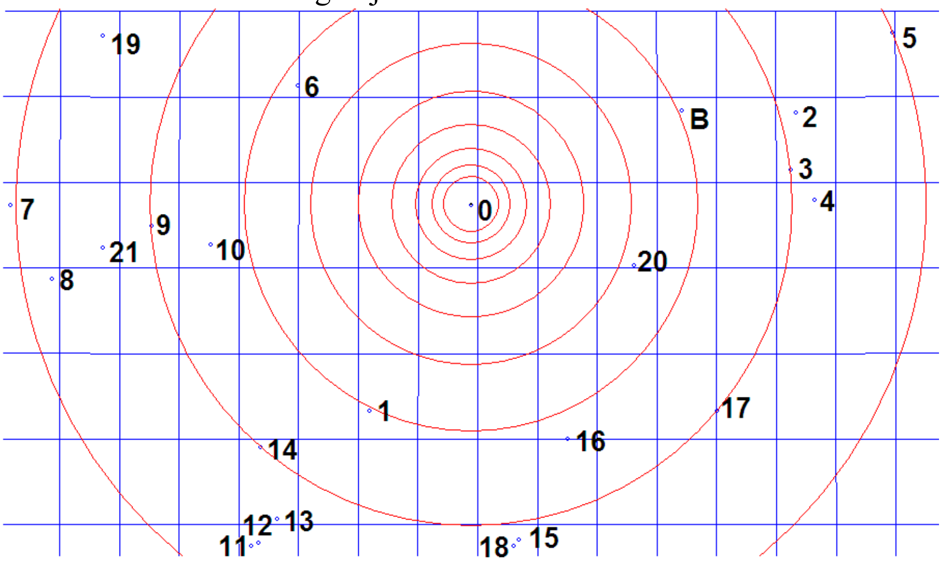

Figure 18. Geometric sequence $D_n = 618\sqrt{2}^{n-1}$ m around St. Vitus in Javorje. Circles shown in the figure are distributed according to the geometric sequence with $Q = \sqrt{2}$ and the initial value $D = 618$ m. Sacred sites are denoted as follows: 0. St. Vitus Javorje, 1. St. Anthony Gradna, 3. Kameni svati, 4. Zlatinice, 5. St. Nicholas Poljanica B., 6. St. Leonard Laduč, 7. St. Crux Cirnik, 8. St. Jacob Ponikve, 9. The Mokrice castle, 10. St. Mary Magdalene Jesenice, 11. St. George Samobor, 12. St. Anne Samobor, 13. St. Anastasia Samobor, 14. St. Helen Samobor, 15. St. Trinity Sveta Nedelja, 16. St. Nicholas Strmec Samoborski, 17. St. Martin Podsused, 18. St. Roch Sveta Nedelja, 19. St. Mary Dobova, 20. St. Peter Zaprešić and 21. St. Mary V. Dolina, while letter B denotes site Babožnica.

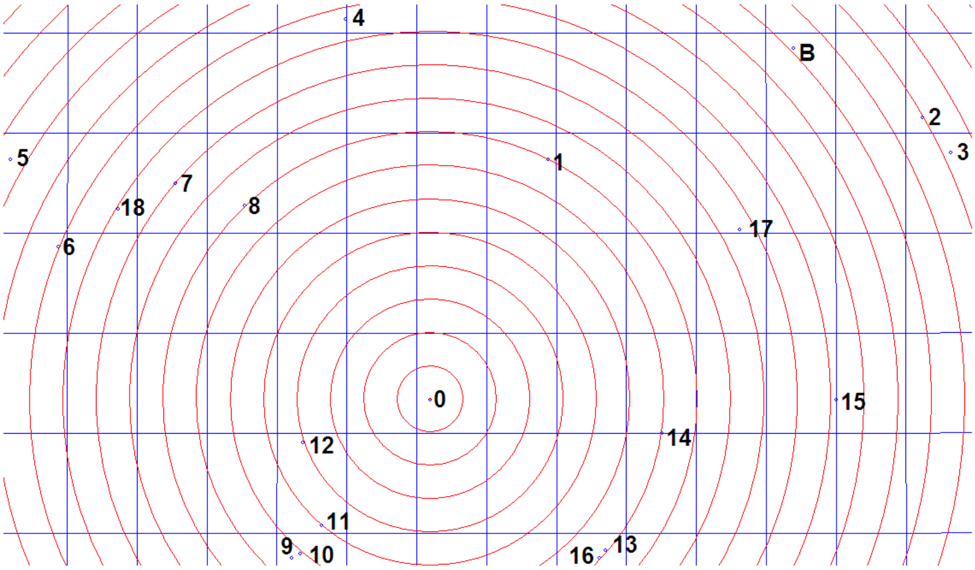

Figure 19. Arithmetic sequence D_n = n·620 m around St. Anthony in Gradna. Circles shown in the figure are distributed according to the arithemetic sequence with distance value D = 620 m. Sacred sites are denoted as follows: 0. St. Anthony Gradna, 1. St. Vitus Javorje, 2. Kameni svati, 3. Zlatinice, 4. St. Leonard Laduč, 5. St. Crux Cirnik, 6. St. Mary V. Dolina, 7. The Mokrice castle, 8. St. Mary Magdalene Jesenice, 9. St. George Samobor, 10. St. Anne Samobor, 12. St. Helen Samobor, 13. St. Trinity Sveta Nedelja, 14. St. Nicholas Strmec Samoborski, 15. St. Martin Podsused, 16. St. Roch Sveta Nedelja, 17. St. Peter Zaprešić and 18. St. Jacob Ponikve while letter B denots site Babožnica. Points 3., 4., 5. 9. and 17. do not lie on the concentric circles.

Babožnica is special but it is only a reconstruction, more or less probable. So we will also make the calculations for some other important points around Babožnica which are more confirmed.

The Church of St. Vitus in Javorje is mentioned already in 1334 [14]. The visible points (excluding Babožnica) around that church make the bar graph of geometric sequences in Fig. 21. The bar shows the minimal values of probability at approximately the same values of length (Table 3) as in the case of Babožnica, although the minimums are not so distinct because of a noise which is mainly the result of much more visible sacred points.

From Fig. 18 we will further take the most closest point from St. Vitus which lays on a concentric circle of the geometric sequence $D_n = 619\sqrt{2}^{n-1}$ m. This is the point number 1 in Fig. 18, a rather small chapel of St. Anthony in Gradna, across the Sava river. The distance of this chapel from St. Vitus is the same as is the distance between Babožnica and St. Vitus. The bar graph in Figure 22 shows the probability of arithmetic sequences around Gradna. It gives the minimal values on the lengths which overlap with the lengths of the geometric sequences around Babožnica and St. Vitus (Table 4). This is a rather interesting coincidence. It is important to note that, along with that. St. Vitus in Javorje, St. Anthony in Gradna and Kameni svati form the triangle with angles 23,3°, 34,0° and 122,7° whose sides are almost exactly √2 times larger than the sides of the two identical triangles around Babožnica.

We can conclude that if there is any common module in the area of Babožnica then this module surely has 620 meters in length.

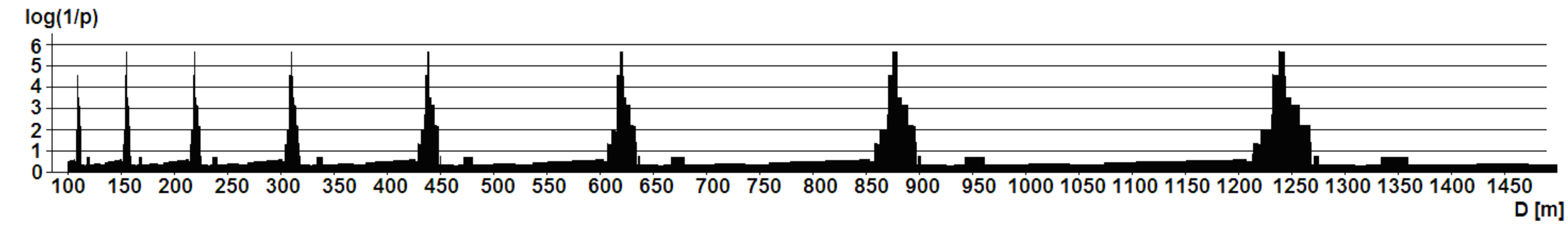

Figure 20. The bar graph of probability of geometric sequences around Babožnica, $D_n = D\sqrt{2}^{n-1}$ with $Q = \sqrt{2}$, $T_n = 0{,}015\,D_n$ and D_{max} =10 000 m.

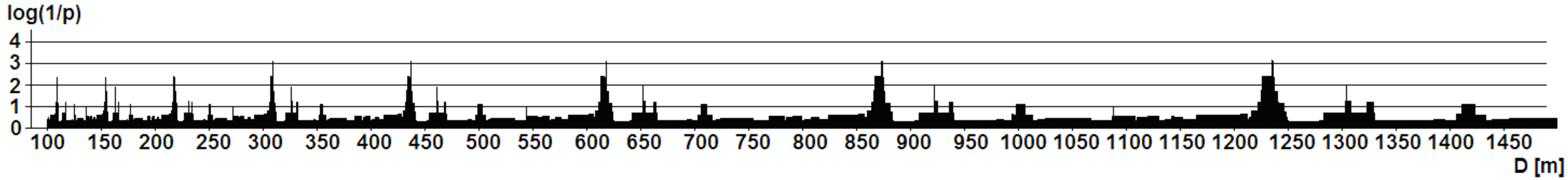

Figure 21. The bar graph of probability of geometric sequences around St. Vitus in Javorje, $D_n = D\sqrt{2}^{n-1}$ with $T_n = 0{,}01D_n$ and D_{max} = 10 000 m (Babožnica excluded).

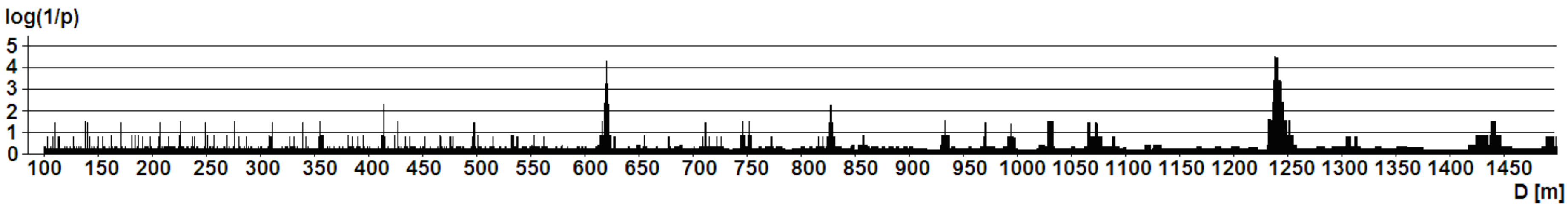

Figure 22. The bar graph of probability of arithmetic sequences around St. Anthony in Gradna; $D_n = nD$ with $T_n = 0{,}02D$ and D_{max} = 10 000 m (Babožnica excluded).

RÜGEN

On the island of Rügen in Germany it is possible to detect several sacred places from 9-13th century. In that time the area was under pagan Slavic control. The exact locations of sites are taken from the GoogleEarth map[12]. If some site covers a larger area, then the sacred point is taken to be at the geometric centre (Fig. 23).

In the recent articles I detected there a sacred triangle Arkona-Venzer Burgwall-Rugard with the angles 23°, 42° and 115° [10, 11]. The island of Rügen is located much further north than Babožnica, so the angle which depends on latitude there is approximately 42,5°. The sacred triangle gives the ratio of its smaller sides which is in no way related to the ratio 1: √2, but is very close to the ratio 1: √3. Geometric sequence bar graph with $Q = \sqrt{3}$ around Venzer Burgwall gives the probability mimimums at 150 m, 260 m, 450 m, 780 m and 1350 m (Fig. 25).

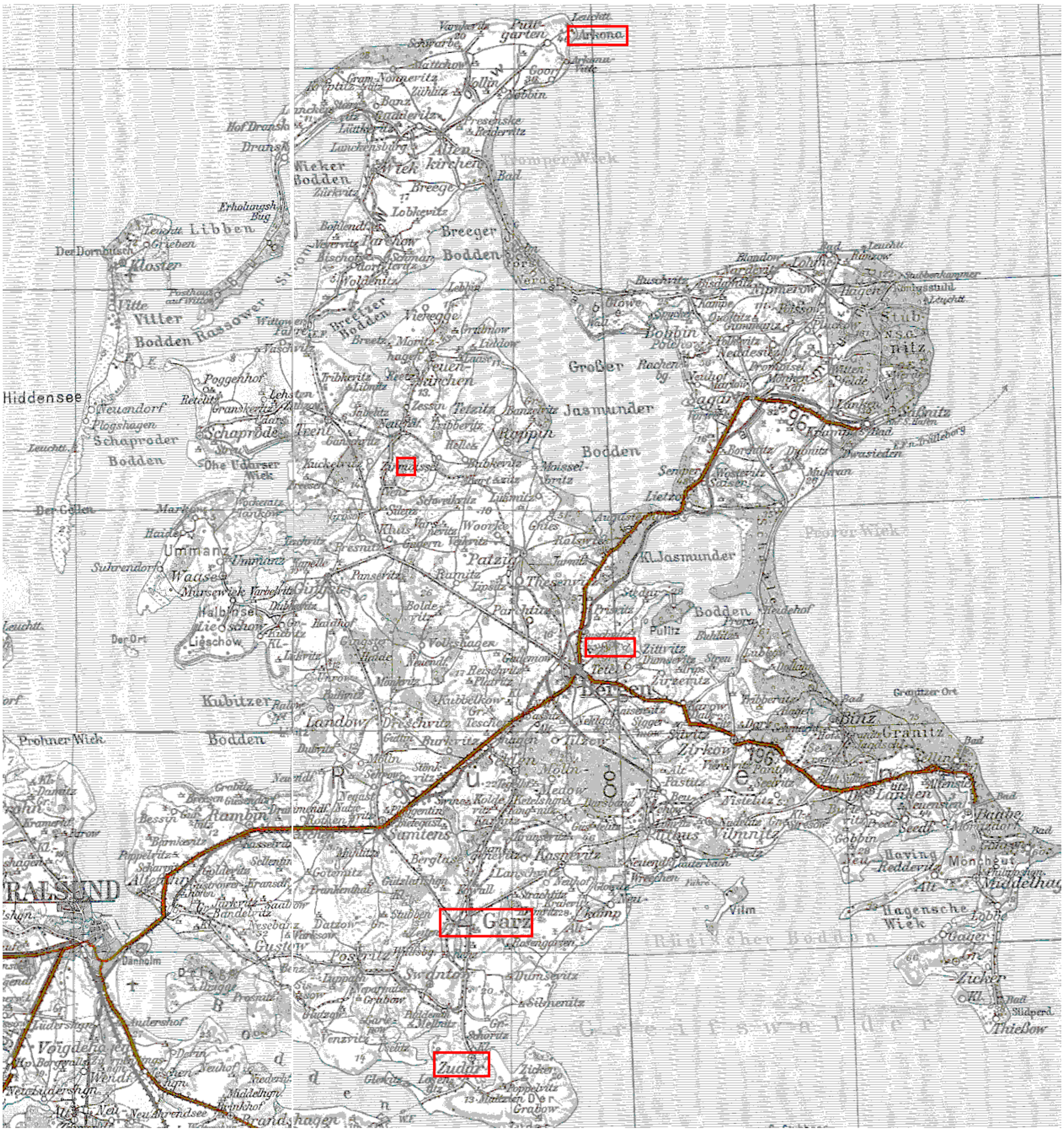

Figure 23. Map of the island of Rügen. The positions of sacred sites are marked with rectangles.

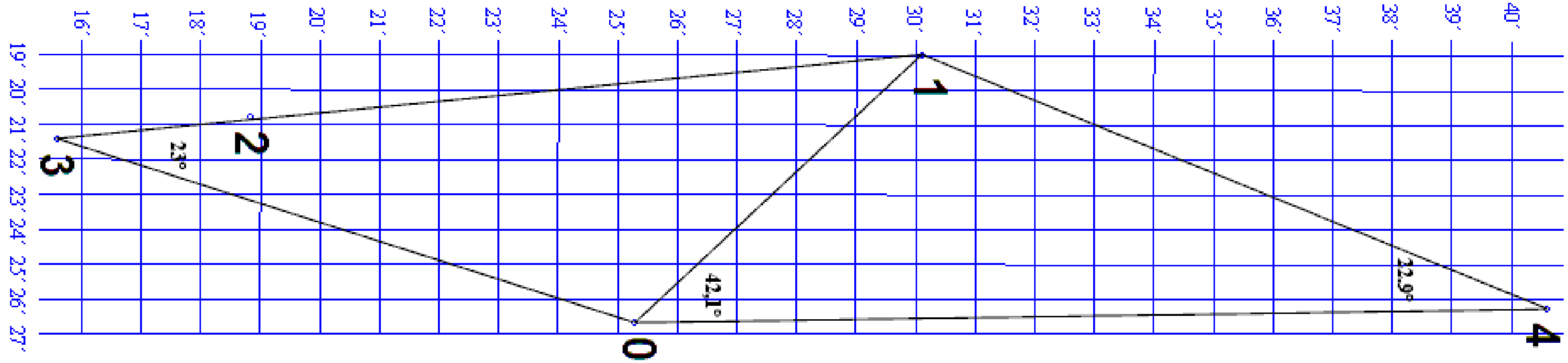

Figure 24. The locations of sacred sites on the island of Rügen. Longitude is 13° x E with x the number of angular minutes written for abscissa. Latitude is 54° y W with y the number of angular minutes written on ordinate axis.

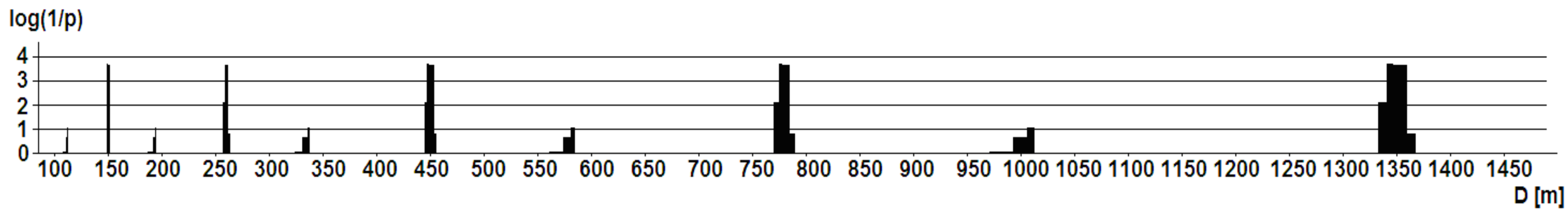

Figure 25. The bar graph of values of probability of geometric sequences around Venzer Burgwall. Here $Q = \sqrt{3}$, $T = 0{,}01D_n$ and $D_{max} = 47\ 000$ m.

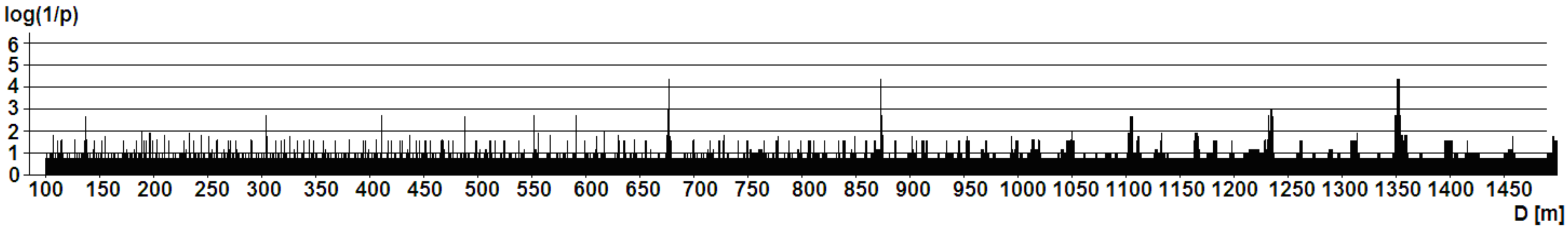

Figure 26. Bar graph of aggregate values of probability of arithmetic sequences (the logarithm of the reciprocal values) for all four points shown in Figure 24. Here $T = 0{,}04D$ and $D_{max} = 47\ 000$ m.

It is also possible to build an aggregate bar graph of arithmetic sequences of all detected sacred points which have some relation with the sacred angles. The result is given on the bar graph in Fig. 26. The bar graph from Fig. 26 show the most improbable arithmetic sequences at difference lengths in Table 5.

The bar graphs for all four points in Fig. 24. are given in Fig. 27.

Table 5. The minimal aggregate values of probability function of arithmetic sequences from the bar graphs in Figure 25 and Figure 26.

***D*, m**	**Relation**	**log(∑(1/*p*))**
591		2,777
677		**4,404**
873	$\sqrt{2}\cdot 617$	**4,411**
1234	2·617	3,024
1352	2·676	**4,416**

Table 6. The distances between the points in Fig. 24 and their correlation with the least probable arithmetic sequences from Table 5.

Pair of points	**0, 1**	**1, 4**	**0, 4**	**1, 2**	**0, 2**	**2, 3**	**0, 3**	**3, 4**	**1, 3**	**2, 4**
Distance, m	12 188	20 976	28 370	20 978	13 559	6091	18 907	46 688	27 068	40 768
Multiple		17	23	17	11					33
***D*, m**		1234	1234	1234	1233					1235
Multiple			48		23		32	79		69
***D*, m**			591		590		591	591		591
Multiple	14	24		24		7			31	
***D*, m**	871	874		874		870			873	
Multiple	18	31	42	31	20	9	28	69	40	60
***D*, m**	677	676	676	678	678	677	675	677	677	679

From Table 6 and from Fig. 27 it could be seen that the arithmetic sequence with the difference value approximately 677 m gives the minimum of probability for almost every point from Fig. 24. There also could be seen a minimum at 1234 m which is approximately the double of 617 m which is very close to the module at Babožnica. While this may be a mere coincidence, the appearance of minimum at 873 m which is equal to $617\cdot\sqrt{2}$ gives some credence to this observation. The fact that all the distances between the points from Fig. 24 are multiples of length of approximately 677 m is rather interesting.

For the island of Rügen we can conclude that if there is any common module, then that module rather probably is related to 677 m, and possibly also to 617·2 = 1234 m and $617\cdot\sqrt{2}$ = 873 m.

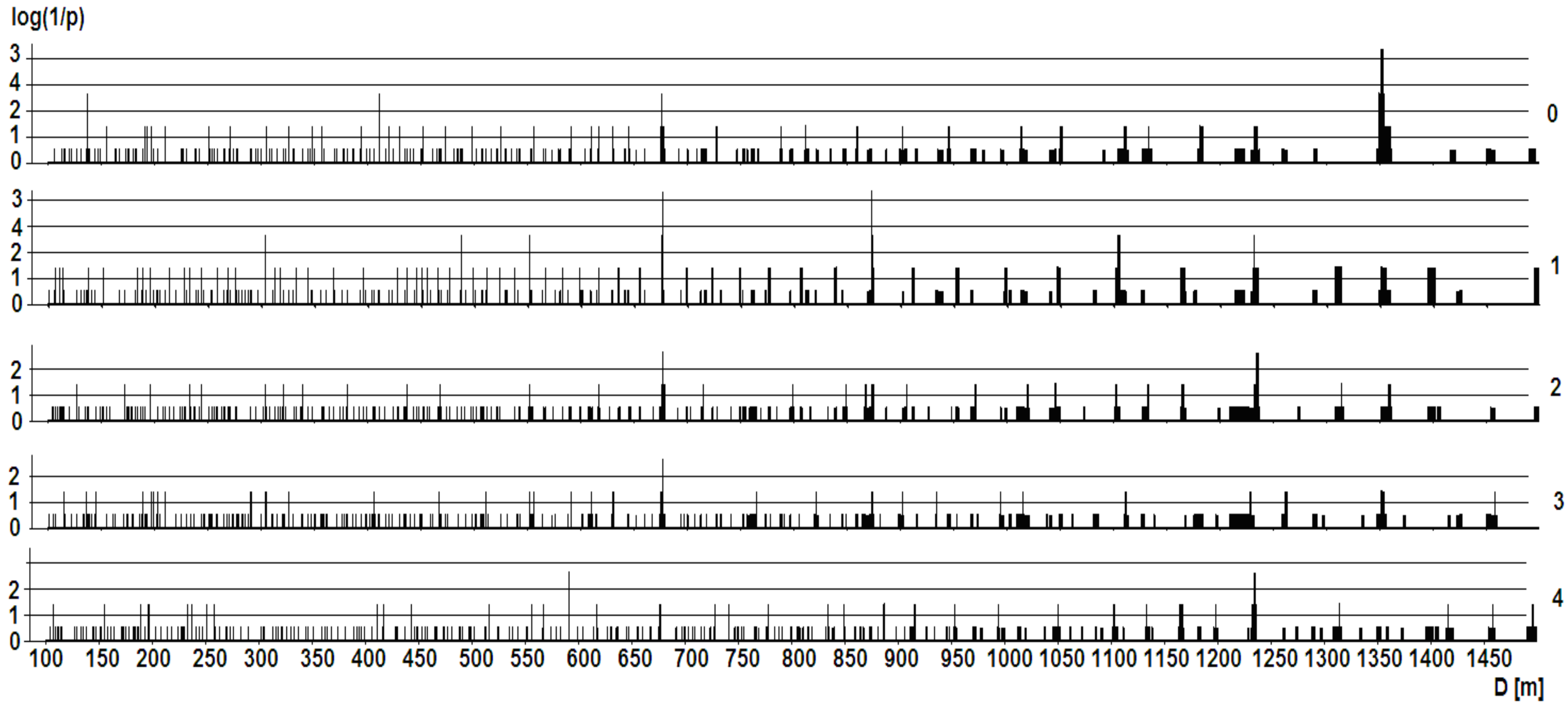

Figure 27. The bar graphs of values of probability of arithmetic sequences (the logarithm of the reciprocal values) separately for all the points from Fig. 24. Here $T = 0{,}04D$ and $D_{\max} = 47\ 000$ m.

PAG

The locations of the sacred points of „the Pag’s sacred triangle“[5, 8, 9] on island Pag in Adriatic sea in Croatia (Fig. 28) are given on the excerpt from orthophotographic map[13] (Fig. 29).

The precise location of the former Church of St. George is located with the help of the plan of the ancient byzantine fort [12] which stood on the same hill previously (Fig. 30). Deviation of the line St. Mary-St. George from the north is 1,17°, while the line St. Vitus-St. George forms the angle of 23,2° with the east-west line. The bar graphs in Fig. 31 show the probability minimums at the lengths listed in Table 7.

From Table 7 we can see that the modules of the sides of the Pag’s triangle are some multiple of approximately 208 m and 167 m.

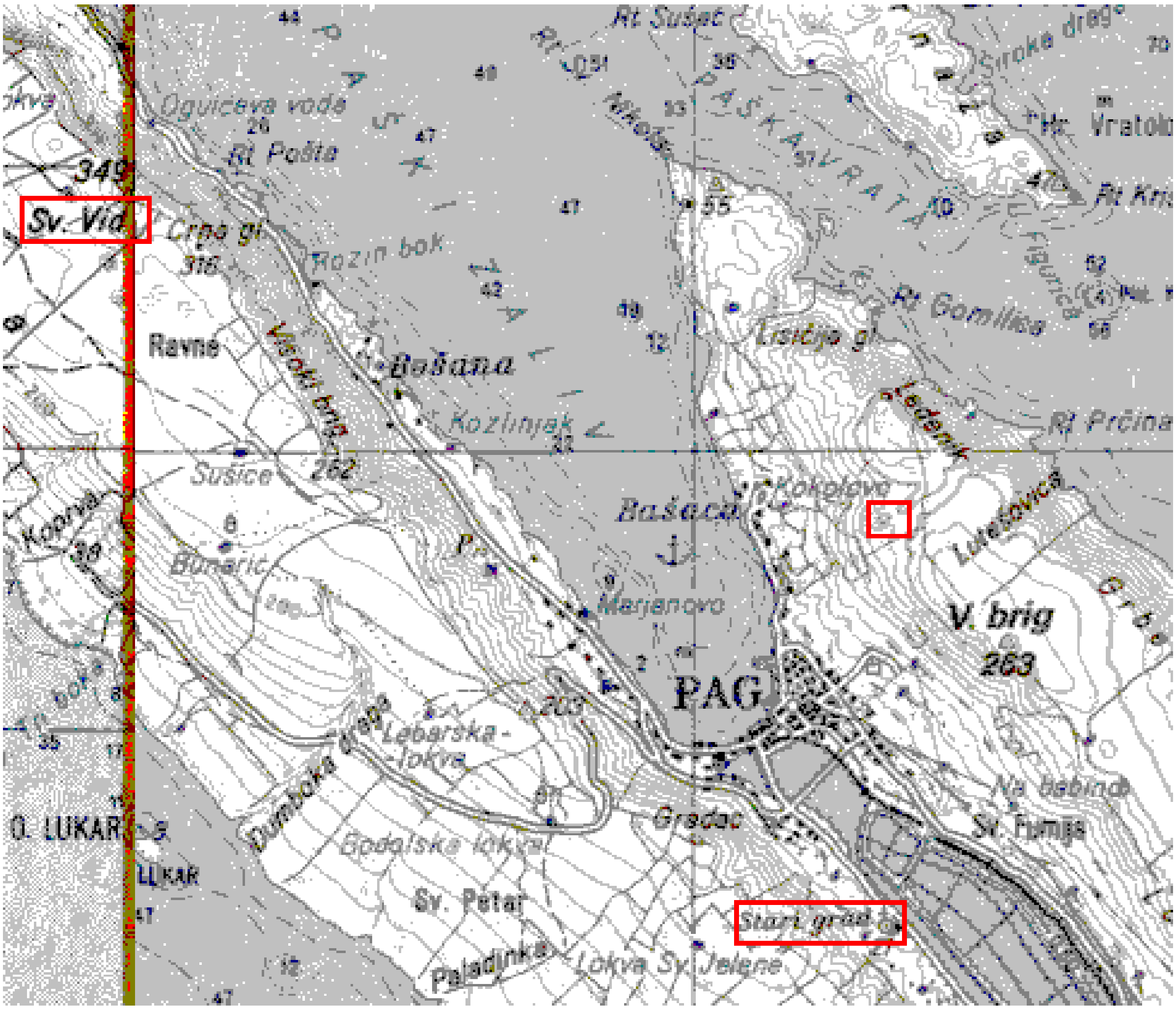

Figure 28. Map of the area where is located Pag’s sacred triangle. The positions of sacred sites are marked with the rectangles.

Table 7. The minimums of probability function from the bar graphs in Figure 31.

D, m	Relation	log(∑(1/*p*))
1456	208·7	2,91
834	208·4, or 167·5	2,89
578	167·2√3	2,80
417	208·2	2,85
289	167·√3	2,82
167		2,83

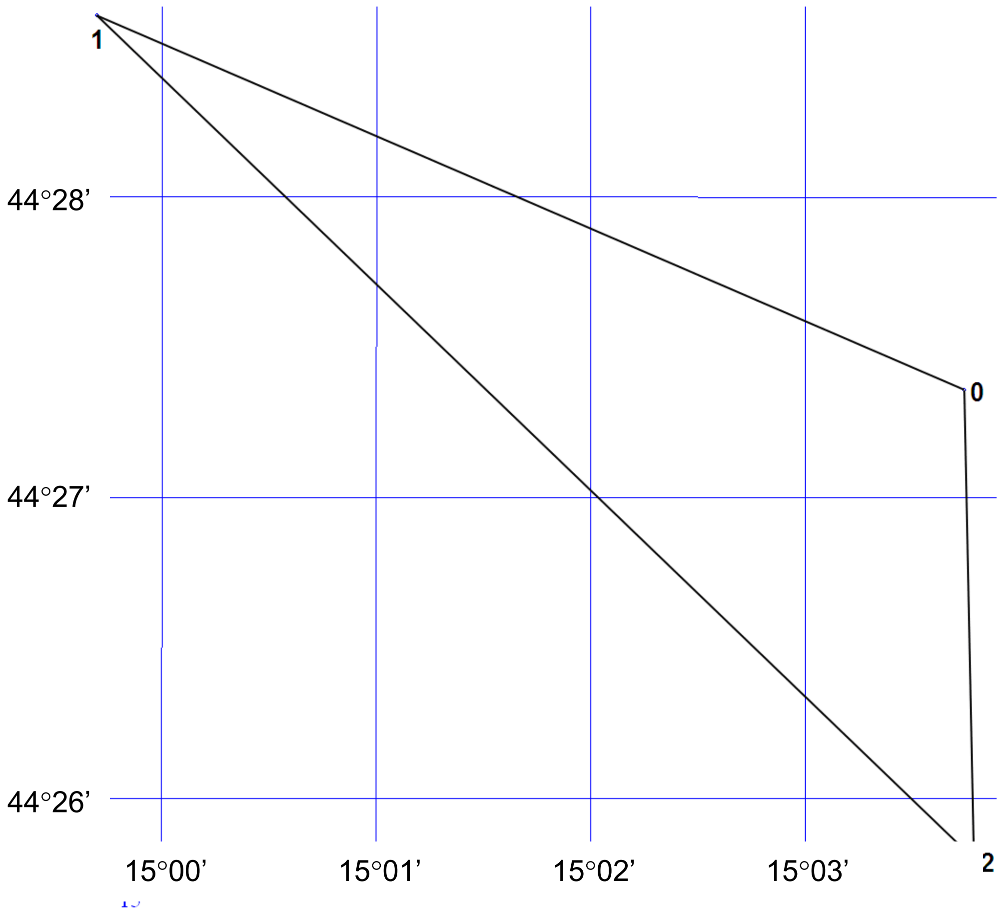

Figure 29. „Pag’s sacred triangle“. Numbers denote the following sacred sites: 0. St. George, 1. St. Vitus and 2. St. Mary.

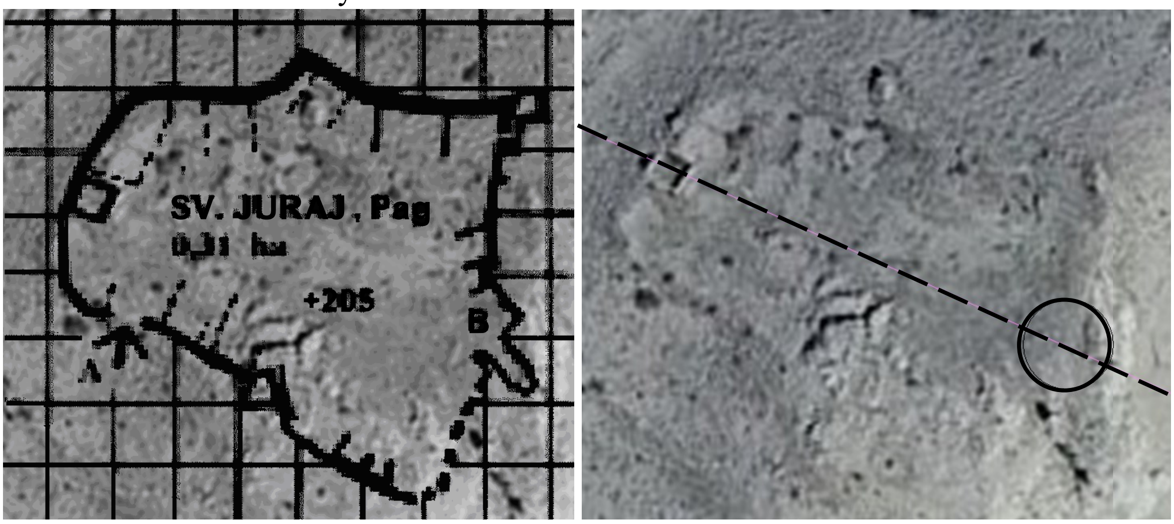

Figure 30. The hill of St George, Pag. Left: the plan of the byzantine fort superposed on the orthophotographic map. Letter B denotes the position of the church. Right: dashed line represents the line St. Vitus–St. George. That line crosses the diagonal of the Church of St. George. The Church of St. George is denoted by the circle.

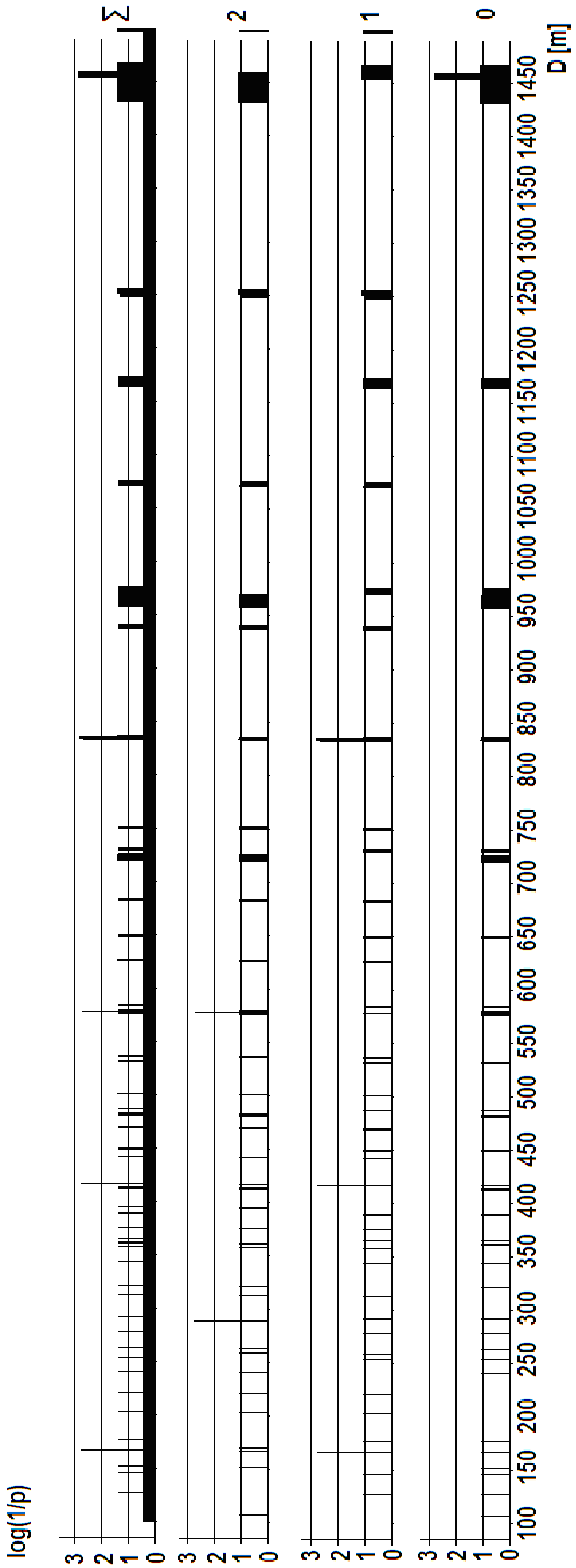

Figure 31. The bar graphs of values of probability of arithmetic sequences (the logarithm of the reciprocal values) separately for all three points from Figure 29 and in aggregation. Here $T_{\mathrm{n}} = 0{,}02\ D$ and $D_{\max}$=10 000 m.

INTERPRETATION

The absolute values of modules from Babožnica, Rügen and Pag are not the same, but some of them can be mutually related as is shown in Table 8.

The module of approximately 620 m is very probably some multiple of the basic unit which likely was in length less than a meter. To get a basic unit one needs to divide the module with a divisor which is some round number, or a number with some significant meaning like the number of months or the number of days in a year. The interesting resultant basic unit is the one which is equal to 620/1200 = 0,517 m. This basic unite is practically the same with the length of the Dubrovnik cubit (the cubit from Orlando's forearm is 51,2 cm), Sumerian Nippur cubit (51,84 cm) and Egyptian royal cubit (52,4 cm). Again, to be sure that this is not only a coincidence, further data from more regions needs to be analysed.

The modules of 677 m from Rügen, and 167 m from Pag look very different. A possible relationship between 677 m and aproximatelly 620 m is the formula $620 \approx 1000 \cdot 677/(3 \cdot 365)$.

One may argue that the locations of sacred points are often predetermined by natural landscape and its features (e.g. mountain peaks) and not by some assumed common Slavic modules. This objection can be opposed in two ways. First, the pagan priests were able to adjust the other sacred points according to the given fixed points. Secondly, the natural confirmation of modules in some landscape might lead the pagan priests to interpret that coincidence as a divine providence. Such landscape structures could become a place of pilgrimage from distant areas. This was very probably true for the island of Rügen. The sacred sites on that island surely were known far and wide. Also, the coincidence that the line which connects the two natural peaks on the island of Pag (St. Vitus and St. George) is laid at an angle of 23,2° from the east-west line, probably was a big motivation for the pagan priests to choose those two locations for the sanctuaries. Babožnica might also gain some fame in pagan time. It is placed within the boundaries of the old parish of St. Nicholas which was first mentioned already in 1209 and is better known under the name Bistra. It is indicative that the population of the neighboring parishes calls it 'Stara Bistra' ('the old Bistra') to distinguish it from Marija Bistrica ('the little Bistra'). Since Marija Bistrica is the largest Croatian pilgrimage site, such a prominent epithet for a place which is today with respect to the pilgrimage much inferior is indicative. In the town of Samobor there exists a belief that the statue of black Madonna which is today placed in Marija Bistrica was before placed in the Church of St. Nicholas in 'Stara Bistra' (to Marija Bistrica they reffer just as 'Bistra') [13]. The original location of the Church of St. Nicholas is uncertain and it is even possible that it was located at the site of the present Church of St. John in Jablanovec, which is only 2,5 km east of Babožnica [14]. The line which connects St. John and St. Mary in Pušća is laid at an angle of 34° from the east-west line causing the sun looking from St. John to set on the summer solstice in the direction of St. Mary. In the case of the Church of St. Mary in Pušća it is preserved a legend which says something just in accordance with the aforementioned assumption. The legend says that the builder chose the hill on which the Church of St. Mary was built because of God's providence[14] [10]. The rods errected in the ground and the measures of the church are mentioned as something very important. Perhaps it is no coincidence that measuring rod and a coiled measuring cord were among the main insignia of the Sumerian sun god Shamash and the godess Inanna.

Table 8. Relations between some of the modules from Babožnica, Rügen and Pag.

Babožnica	Rügen	Pag
620 m	1234/2 = 617m $873/\sqrt{2}$ = 617m	$208 \cdot 3$ = 624 m

CONCLUSION

From the above analysis we can conclude that the proposed method gives indicative results. We detected some common modules which certainly apply to a limited area. It is even possible to make some correlation between the modules from three different regions.

It is also true that the proposed method is still in development phase and any result which it gives must be simultaneously analysed and proved by means of other methods which take into account also the time axis and cultural context. The method should be also further tested on the other already recognized pagan landscape structures. Definite conclusions would require extended analysis and only after that may be proved as a valuable auxiliary tool.

APPENDIX

Conversion of the geographic coordinates into the Cartesian rectangular coordinate system is performed according to the formulas for the orthographic projection (EPSG dataset coordinate operation method code 9840) [15]:

$$E = FE + \nu \cos\varphi \sin(\lambda - \lambda_0)$$

$$N = FN + \nu[\sin\varphi \cos\varphi_0 - \cos\varphi \sin\varphi_0 \cos(\lambda - \lambda_0)] + e^2(\nu_0 \sin\varphi_0 - \nu \sin\varphi)\cos\varphi_0$$

$$\nu = \frac{a}{\sqrt{1 - e^2 \sin^2 \varphi}}, \nu_0 = \frac{a}{\sqrt{1 - e^2 \sin^2 \varphi_0}}$$

$$a = 6378137 m$$

$$e = 0.081819191$$

with the following notation utilised: FE – false easting (a constant used to avoid negative values on the x coordinate), FN – false northing (a constant used to avoid negative values on the y coordinate), E – x coordinate (easting), N – y coordinate (northing), λ – geographic longitude, φ – geographic latitude, ν – prime vertical radius of curvature, λ_0 –longitude of origin and ν_0 – prime vertical radius of curvature at latitude of origin.

Geographic coordinates of sacred sites in Croatia are taken from the orthophotographic maps of ARCOD system, which is the project for the identification of land parcels in Croatia, http://www.preglednik.arkod.hr. In the case of churches, precise location of the sacred points is taken to be the main altar positions. Sacred points outside of Croatia are taken from GoogleEarth maps.

REMARKS

[1]A sacred point or sacred site in this article refers to any precise location which has some worship tradition. This could be a church, a mountain peak, or any place associated with folk story or legend with the mythological background. Every old church is assumed potentially to be located at the site of a previous pagan shrine.

[2]Coordinates of points: 0. (0, 0), 1. (5756, 1690), 2. (–4942, –4221), 3. (–3029, 1752), 4. (4903, –6320), 5. (–2443, –7617), 6. (2318, 9727), 7. (–1543, 8866), 8. (–16, -6499), 9. (675, 3942) and 10. (3899, –892). The points are distributed on the concentric circles by using the pseudorandom function rand() initialized with srand(1). These functions are defined in a computer programming language C. The circumferences of all concentric circles are summed together giving the total length. Then the result of rand() << 16 + rand() function which is less than the total length gives the position of a point on circumference of some concentric circle counting the length from smaller to the bigger concentric circles.

[3]The graph is ploted using the results of C++ function.

[4]The reciprocal values of probability for a certain value *D* for every point are summed together and on the bar graph the logarithm of that summed value is ploted.

[5]The points are distributed using random number generator at http://t.co/mriPYy8C. From the list, only the points with the distance from the central point less than 10 000 m are taken. The coordinates of randomly generated points are: 11. (3945, –4516), 12. (–4201, –2397), 13. (2830, 8515), 14. (6293, –5236), 15. (–793, 1188), 16. (6714, –6599), 17. (–8111, 3197), 18. (2741, 2307), 19. (–3010, –3276) and 20. (–2062, –185).

[6]Coordinates of points: 0. (0, 0), 1. (4502, –6612), 2. (–436, –1344), 3. (–1412, 70), 4: (995, –92), 5. (–1622, 3656), 6. (–135, –3997), 7. (–731, –3932), 8. (617, 5622), 9. (–1360, 7883) and 10. (–7967, –724). The points are distributed on the concentric circles by using the pseudorandom function rand() initialized with srand(2).

[7]The same ten random points as in the case of arithmetic sequence, with coordinates given in Remark 5.

[8]The points are distributed using random number generator generated at http://t.co/M3aPqM8s. Coordinates of the randomly generated points are: 0. (–3338, 3751), 1. (–7641, 2), 2. (–3955, 8410), 3. (517, 8888), 4. (3150, –2820), 5. (–9793, 4110), 6. (–4828, 2575), 7. (385, 1795), 8. (1587, 4910) and 9. (5491, –4298).

[9]Possible etymology is: Babo-: ‘the old woman’; -božnica: ‘the god’s place’, ‘sanctuary’. Babožnica begins at the point where ends the narrow strip of land between the old curses of Krapina and Bistra which is called Maškunjka (possible etymology is ‘the male area’). So there is maybe some space oposition between male and female principles, especially beacuse of the phallic shape of Maškunjka. However, on the other side the name may derive from aristocratic familiy Moscon.

[10]According to the legend this mill was the place where the leaders of the Croatian-Slovenian large peasant revolt of 1573 held secret meetings. The revolt and torture of the revolt leader Gubec acquired legendary status. At that time the mill at Krapina in the area of Babožnica really existed, but its precise location is not known.

[11]Cult places in the vicinity of Babožnica with their coordinates are: Babožnica (45525105 15492430), St. John Jablanovec (45524922 15512019), St. Peter Zaprešić (45510236 15483769), Kameni Svati (‘Petrified Wedding Guests’) (45520953 15511482), Zlatinice brijeg (‘Golden Mount’) (45514850 15513854), St. Nicholas Poljanica B. (45534548 15525792), St. Vendelin Donja Bistra (45541311 15511398), St. Mary Donja Pušća (45545629 15465555), St. Catherine Hrebine (45542477 15452161), St. Vitus Javorje (45514448 15455325), St Roch Novaki B. (45530576 15512670), Sljeme (45535740 15565084), St. Leonard Laduč (45530870 15425922), St. Crux Cirnik (SLO) (45514447 15381082), St. Mary V. Dolina (SLO) (45511488 15394339), St. Jacob Ponikve (SLO) (45505247 15385230), The Mokrice castle (45513007 15403289), St. Mary Magdalene Jesenice (SLO) (45511689 15413214), St. George Samobor-Giznik (45474538 15421322), St. Anne Samobor-Giznik (45474818 15422040), St. Anastasia Samobor (45480490 15423892), St. Helen Samobor (45485506 15422243), St. Anthony Gradna (45492070 15441162), St. Roch S. Nedelja (45474531 15463674), St. Trinity S.Nedjelja (45475038 15464181), St. Nicholas Strmec Samoborski (45490044 15473068), St. Martin Podsused (45492028 15500024), St. Dorothea Jakovlje (45560998 15520663), St. Andrew Bregovljani (45551709 15472809), St. Roch Luka (45573854 15491237) and St. Mary Dobova (SLO) (45534336 15394289).

[12]with the following geographic coordinates: Rugard (54°25’18,38” N, 13°26’41,34” E), Venzer Burgwall (54°30’06,54” N, 13°18’59,72” E), Garz Burgwall (54°18’51,11” N,

13°20'49,01" E), Wallberg Zudar (54°15'35,30" N, 13°21'26,05" E) and Arkona Jaromarsburg (54°40'35,77" N, 13°26'16,33"E).

[13]with the following geographic coordinates: St. George Pag (44°27'21,70" N, 15°03'44,65" E), St. Vitus Pag (44°28'36,27" N, 14°59'41,73" E) and St. Mary Pag (44°25'48,08" N, 15°03'47,34" E).

[14]The legend says: „While the lord of the land, Mato Bužan was in the hunt on the hill where today is the chapel of the Mother of God, he fell asleep under some trees. He dreamed a dream that he sleeps in the Church of the Mother of God. And when he woke he decided to build a chapel there leaving erected stakes in the ground in the form of the future chapel. But when he left the place, a shepherd called Dorčić who was keeping a cattle there, pulled out the stakes and moved it back into the ground in the same form but now occupying a larger area. When the lord reached the hill the second time he saw that his plan was extended, so he believed that this was God's providence and that he should build a bigger church there than he initially intended..."

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RAČUNALNA ANALIZA PROSTORNOG RASPOREDA SVETIŠTĀ PREDKRŠĆANSKIH SLAVENA

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Jablanovec, Hrvatska

SAŽETAK

U ovom radu predlaže se metoda za izračunavanje mjernih jedinica koje su koristili Slaveni prije prihvaćanja kršćanstva. Metoda se oslanja na istraživanja o trodjelnoj strukturi slavenskih predkršćanskih svetih prostora koju je otkrio Andrej Pleterski i koja ima pozadinu u središnjem slavenskom mitu o božanskoj borbi između Peruna i Velesa. Mjereći kutove koje Sunce napravi kroz godišnji ciklus i uspoređujući ih s kutovima između svetišta, poganski svećenici su mogli točno odrediti dane vjerskih svetkovina, ali i kalendar u cjelini. Ovaj članak istražuje da li su osim kutova i apsolutne vrijednost udaljenosti između svetišta također bile važne. Uporabljena metoda koristi matematička svojstva aritmetičkog i geometrijskog niza, ovisno o vrijednosti početnog člana, razlike odnosno kvocijenta niza. Ako za neke od ovih parametara vjerojatnost prostorne raspodjele svetišta na nekom području pokazuje vrijednost znatno manju od prosjeka, onda je to znak da dotični raspored nije slučajan. Parametri niza u tom slučaju mogu ukazati na sustav mjera koje su korištene u izgradnji svetog krajobraza. Predložena metoda u ovoj fazi je samo ilustracija, te se još uvijek ne može koristiti kao dokaz zajedničkih panslavenskih jedinica duljine. Indicije dobivene ovom metodom potrebno je dokazati i pomoću drugih metoda koje uzimaju u obzir vremensku os i kulturni kontekst. Metodu je potrebno dodatno testirati i na drugim već poznatim poganskim krajobraznim strukturama. Tek nakon toga postoji mogućnost da se dokaže kao vrijedna i korisna s mogućom primjenom u arheologiji, mitologiji i etnologiji.

KLJUČNE RIJEČI

mitovi u prostoru, metrologija, arheoastronomija, prostorna analiza, raspodjela vjerojatnosti