Exercises In Archaeoastronomy - 3 - Keyhole Structures Of The Sahara

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Exercises in Archaeoastronomy - 3 - Keyhole structures of the Sahara

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Abstract

Here it is given the third work of a series proposing exercises in archaeoastronomy. The work contains a statistical study of the orientation of the prehistoric keyhole monuments that we can find in a large area of the Sahara.

In the previous discussions [1,2], we have introduced and proposed some exercises on ancient sites which are linked to the apparent motion of the sun. In particular we considered Stonehenge and Newgrange, the first aligned along the direction of sunrise on Summer Solstice, the second with the sunrise on Winter Solstice.

Since the azimuth of sunrise changes over the year, we can have the orientations of ancient sites which are spanning a quite large angle. In this case, a statistical analysis can help us in the evaluation of the relevance of any astronomical orientation we have evidenced. Here we will apply a statistical approach to the study of the orientation of the prehistoric keyhole structures that we can find in a large area of the Sahara. To measure their orientation we use satellite images and software suncalc.org. We will use this software as a pair of compasses.

Before the discussion of this case, and the exercises, let us note the following. When we have to apply a statistical analysis, it is necessary to have a high enough number of items in the considered data sample. It is also necessary that the data sample is statistically significant [3]. To explain this point, let us consider the following example. Suppose that we have a set of burials in an ancient necropolis. A study that we can do on this data sample is that concerning the distribution of the axes of the burials, to test the presence of a preferential orientation and, in the case it exists, whether this orientation is astronomically significant or not. To have an analysis which is statistically well-posed, the number of objects (tombs) must be at least 20 or 30, in order to have a frequency distribution which is providing some reliable indication [3]. Moreover, it is necessary that the data set of the considered objects is homogeneous. In the given example, even if the necropolis were composed of burials made by a single population, the chronological distribution of them could be quite large. In this case, it is necessary to study the different sections of the necropolis to determine the different periods, to verify the possibility that the burial criteria could have been changed over time. As a consequence, the necropolis as a whole is a data set lacking of statistical significance and the results obtained from it cannot be considered as significant [3].

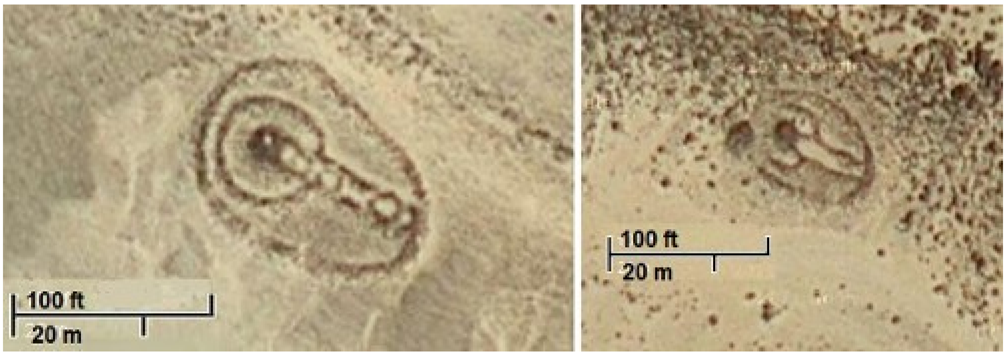

Figure 1: Two keyhole structures in the Sahara.

Let us consider the case of the keyhole monuments in Sahara and an analysis of their orientation.

The Sahara is rich of prehistoric stone funerary monuments, distributed in a huge geographic area. These monuments had been created in several different shapes. Some of them have the design that looks like a keyhole, and therefore are known as keyhole tombs (monuments en trou de serrure, in French). These tombs (Figure 1) consist of a mound surrounded by a circular stone enclosure having inside another stone circle, and a pathway crossing them. Since they are facing the sunrise, these tombs were also considered as places for the worship of the sun [4,5]. Let us observe that in them we can find a "symbolic" passage for the sun; in the passage tombs previously examined [2], it was solidly built and covered by a large mound.

The keyhole structures, and other stone structures in the Sahara, had been investigated rather extensively, also by means of satellite images and Google Earth [6,7]. Tuareg call these prehistoric funerary monuments, which can have different forms, with the general term of 'idenan' (sing. adebni, [8]). Actually, the earliest type of adebni is the 'keyhole' monument. Radiocarbon dates those in Niger from 3600 to 220 BCE [5]. As already observed by the early European visitors, a large number of idenan had their main distinctive elements facing the sunrise. According to the archaeologists that studied in 1966 the orientations of 158 keyhole monuments in the Fadnoun, Algeria [9], the monuments lie in the azimuth range of the sunrise. A similar result was obtained for the corridors of some keyhole monuments at Emi Lulu, Niger [5].

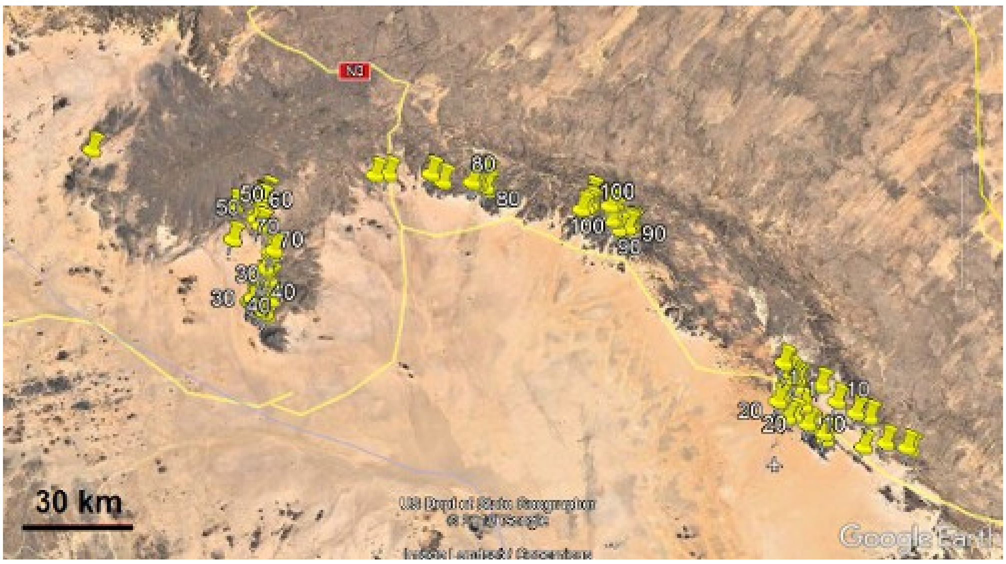

Figure 2: A region where we can find the prehistoric keyhole monuments (the satellite images have a resolution

which allows this search). The pins, more than a hundred, are indicating their positions. Probably, during the analysis, I have not found many monuments.

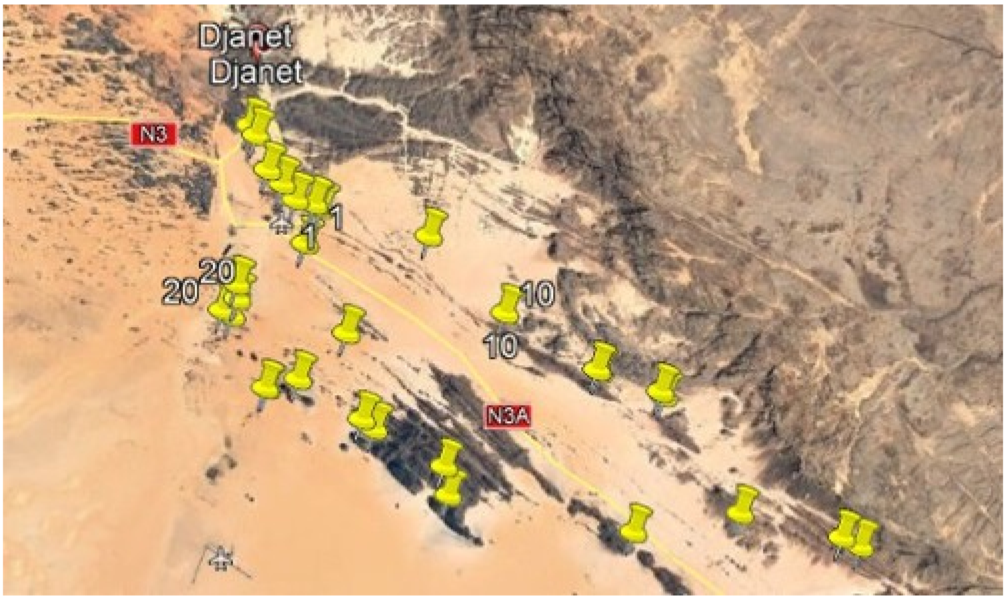

Figure 3: A detail of the region south of Djanet, Algeria.

Another relevant type of dry stone prehistoric burial place is the so-called V-shape monument, which is a tumulus having two lines or arms of stones – the antennae – that are some tens of meters long [5]. The earliest examples of this kind of stone structure are dated about 3200–2900 BCE. Again, the analysis of the V-shape idenan in Tassili is showing that their antennae are towards the rising sun. Several of these monuments are located in the middle of the wonderful landscape of Tassili: an Italian writer and explorer, who loved and visited several times this part of Sahara, Cino Boccazzi (1916 – 2009), defined them the “stone flying swallows” of the Amguid [10].

Other types of Saharan stone burials are the ‘crescent’ mounds, the ‘crater’ tumuli and the ‘mounds with an alignment’, which are ranging from 1900 BCE to the beginning of the local Islamic culture: inside them, the bodies have head or face oriented towards the rising sun [5]. In [11,12], we have studies the keyhole structures and found the position of a hundred of them (see the Figures 2 and 3). Other sites are given in [13-15].

Exercise 1: Using Google Earth, try to find al least ten keyhole tombs near Djanet. Solution: Use the features of the land that you can see close to the pins in the Figure 3 as reference points.

Exercise 2: Measure the apparent azimuth of the corridor of some of the keyhole structures. Solution: You can save the image of the keyhole structure from Google Earth and measure the azimuth by means of the “pair of compasses” of GIMP, the GNU Image Manipulation Program (see the Figure 4). As previously told, the researches on these structures have determines that their pathway is oriented towards the sunrise. Therefore, we can use the software suncalc.org, to determine the azimuth (see the Figure 5).

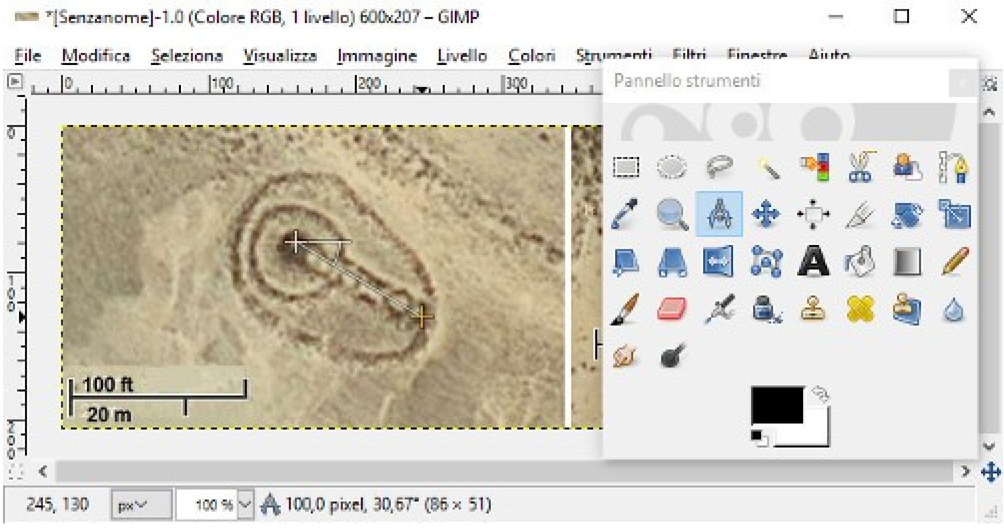

Figure 4: In GIMP, select the "pair of compasses" icon. You can measure the distance in pixels and the angle in degrees. In the case shown in the image, the angle given in the figure (30.67 degrees) is that between a horizontal line and the pathway of the keyhole structure. The azimuth, measured from north-south direction, is therefore of (90+30.67) degrees.

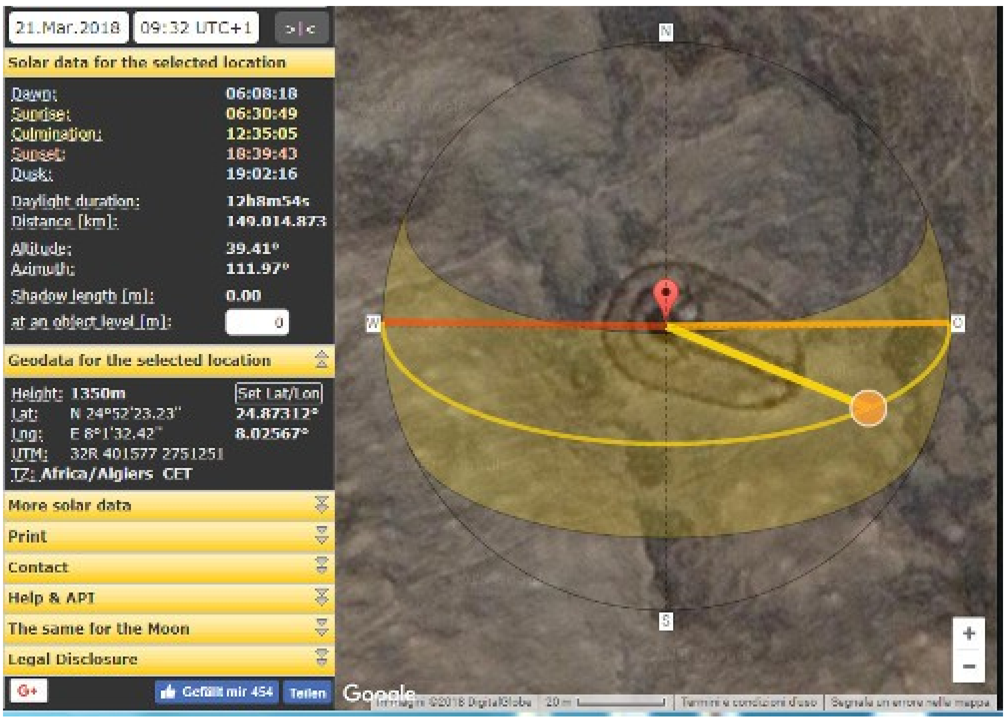

Figure 5: We can use software suncalc.org as a "pair of compasses". We can read directly the azimuth of the pathway. To measure, it is enough to align the solar azimuth along it, moving the cursor that we can find in the web page. In the case of the figure, the software panel gives an azimuth of 111.97 degrees. Using suncalc.org, it is not necessary to save the Google Earth image and use GIMP.

Exercise 3: What is the uncertainty of the value of the azimuth measured for the structure given in the Figure 5? Solution: We read in the panel of suncalc.org the value 111.97 degrees. However, if we slightly move the pair of compasses we see that the value changes. Therefore, let us use the following approach for giving the uncertainty of the value. Consider the Figure 6.

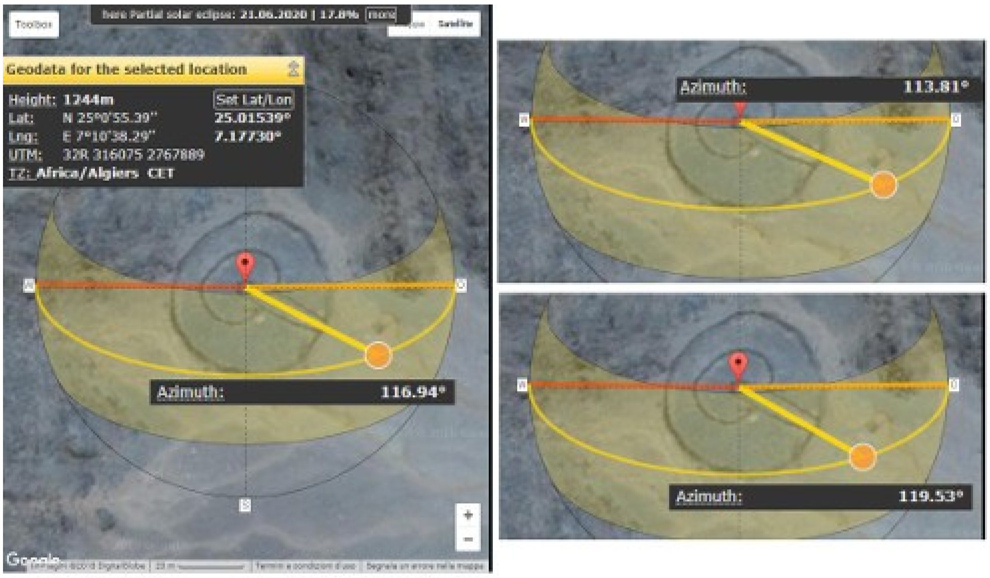

Figure 6: Let us maintain the compass fixed at the centre of the structure. One tips is the East (O, Osten in German). We can move the other tip, as given in the two panels on the right (from the end of one of the pathway lines to the end of the other line). The angle changes from 113.81 degrees to 119.53 degrees. Let us assume the uncertainty as (119.53-113.81)/2. degrees, that is, of about 3 degrees. Therefore, in the case of the monument given in the Figure, the pathway has an azimuth of (117 ± 3) degrees.

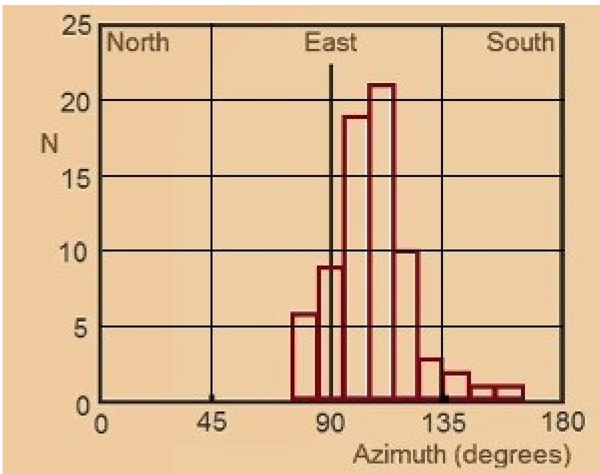

Figure 7: Distribution of the azimuths measured for the keyhole structures (Figure 2). The range from 0 to 180 degrees of the azimuth is divided in intervals of 10 degrees. N is the number of monuments in the corresponding interval. For instance, we have 10 monuments having an azimuth between 115 and 125 degrees.

Exercise 4: Using the sites you have found, determine the distribution of the azimuths of the keyhole structures. Solution: I used the sites identified by the pins in the Figure 2 (70 sites, because only the sites having a clearly visible pathway have been considered). The measured azimuths are between 75 and 165 degrees. The results are given in the Figure 7. The range of the azimuth, from 0 to 180 degrees, is divided in intervals of 10 degrees.

Exercise 5: Compare the results obtained in the Figure 7, to the sunrise azimuth on solstices. Solution: Use suncalc.org. The Figure 8 shows an image obtained by screenshots of the software.

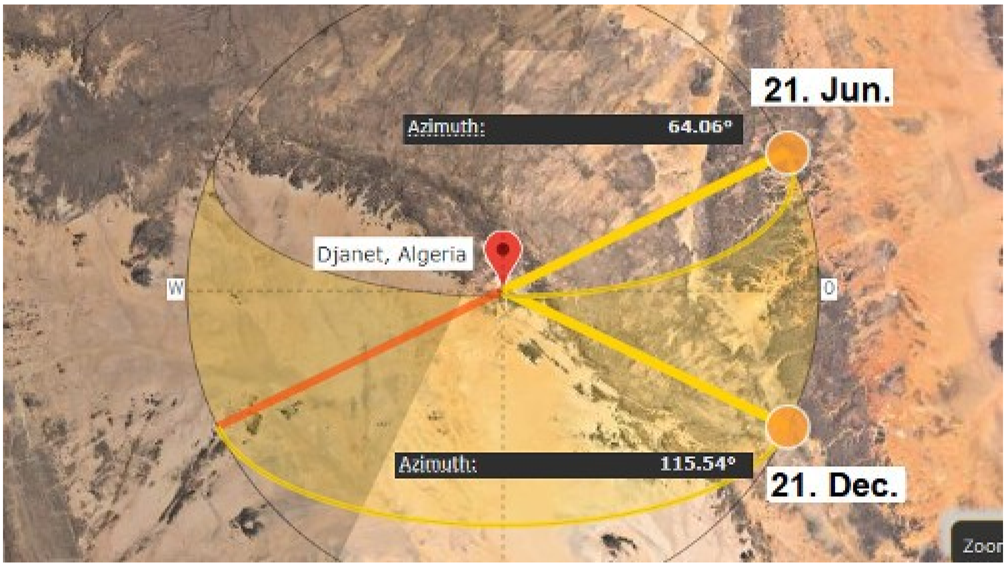

Figure 8: The image is obtained from two screenshots of software suncalc.org. The sunrise azimuth on the winter solstice is 116 degrees, that of the summer solstice is 64 degrees. These azimuths are given for an astronomical horizon.

The azimuths of the pathways of many of the keyhole structures, determined from satellite images, are between the extremal sunrise azimuths (about 72%). Let us note that in the analysis we have made by means of suncalc.org, we have considered the structures as located on flat surfaces. But it is possible that, for many of the sites, it is not so. Therefore, the results obtained by means of satellite images need refinement, and a control for each of the monuments of the slope on which they were built. Moreover, the software is considering an astronomical horizon, which can be different from the natural horizon [2]. Also in this case, a further control is necessary. We could control slope and natural horizon by means of Google Earth, but this is beyond the aim of this paper. Let us conclude the following. From Figures 7 and 8 we can tell that the 72% of the considered set of monuments is aligned along the sunrise azimuth. In any case, the remaining 28% of the sites has an azimuth equal to that of the sun, between 115 degrees and the noon.

As we have seen in the Figure 7, the distribution of the azimuths has a peak at about 105 degrees. The fact that the peak does not correspond to 90 degrees (East direction) is coming from the local constrains of the landscape (Figures 2 and 3).

Exercise 6: Let us consider another interesting area full of keyhole monuments. It is given in the Figure 9. This hill is like an island in the sea of the sands, and the coasts of this island is full of monuments. Evaluate the distribution of the azimuths.

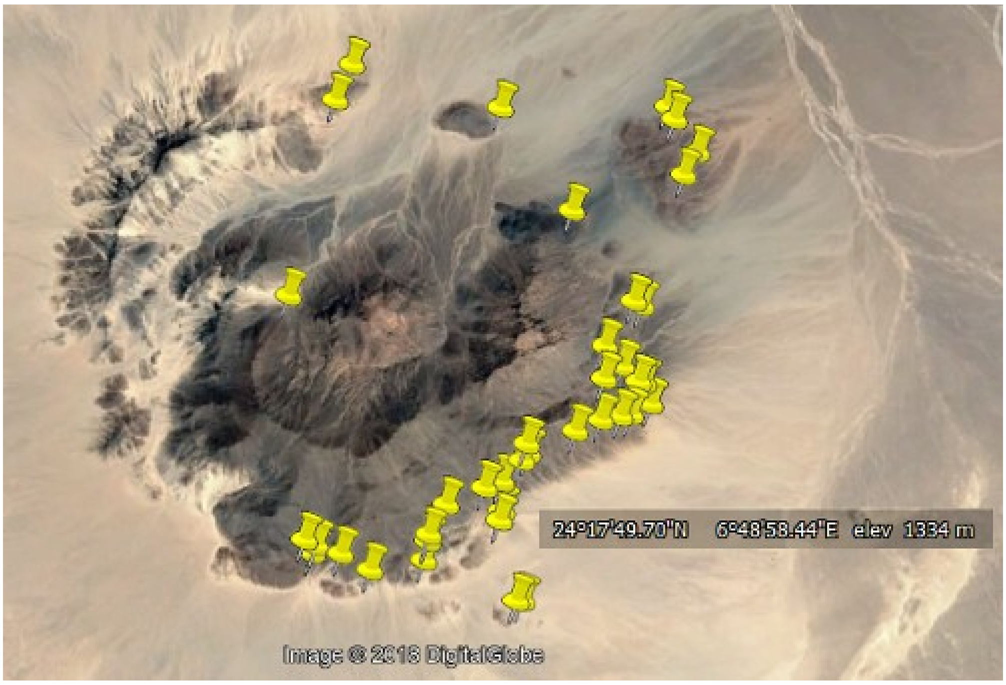

Figure 9: Interesting group of keyhole monuments (24 degrees 17’ 49’’,6 degrees 48’ 58’’).

Exercise 7: Consider the sites found by Gregory Fegel, the coordinates of which are (25 degrees 20’ 02.28’’,8 degrees 35’ 45.64’’), (25 degrees 20’ 05.04’’, 8 degrees 35’ 54.45’’), (25 degrees 19’ 58.11’’, 8 degrees 39’ 07.91’’), (25 degrees 18’ 06.00’’, 8 degrees 33’ 32.50’’), (25 degrees 21’ 04.54’’, 8 degrees 30’ 52.42’’). As Fegel observed in his e-mail via Academia.edu, April 2016, these five tombs have the keyhole design which is towards the rising sun. Measure the azimuth of the pathway of these sites.

Other statistical analyses of burial sites are given in [16-19]. These articles can help the reader in approaching the statical studies. For the examination of the orientation of monuments, we can use other approaches. We will illustrate one of them in the next work of the ‘Exercises in Archaeoastronomy’.

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