Archaeoastronomical analysis of the Roman Colonia Marciana Ulpia Traiana Thamugadi (Timgad) , founded at the sunrise of Trajan's Birthday

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It was told that the Roman Colonia Marciana Ulpia Traiana Thamugadi (Timgad in Algeria), founded in 100 AD, had been oriented to the sunrise on the day of Trajan's birthday, given as September 18. This Gregorian date corresponds to September 17 of the Julian Calendar. Here we use software such as CalSKY and Stellarium to investigate the sunrise azimuth and compare it to the direction of the decumanus of the Roman town. After the archaeoastronomical analysis we can conclude that the assertion concerning the orientation of Timgad to the sunrise of the day of Trajan's birthday could be true.

In 2012, I wrote an article concerning the orientation of Trajan's town of Timgad [1]. Timgad was a Roman colonial town founded by the Emperor Trajan in AD 100. The Roman full name was "Colonia Marciana Ulpia Traiana Thamugadi": in this name we find the names of emperor's mother Marcia, his father Marcus Ulpius Traianus and his eldest sister Ulpia Marciana. The ruins of the Trajan's Timgad are in Algeria. It the book entitled "Ancient Town-Planning", written by F. Haverfield and published in 1913 [2], Timgad is proposed as a noteworthy site for being one of the best examples of the Roman city planning. When the author wrote the book, about Trajan's Timgad there were only purely archaeological remains. Haverfield reports that the ruins are on "the northern skirts of Mount Aurès, halfway between Constantine and Biskra and about a hundred miles from the Mediterranean coast. Here the emperor Trajan founded in A.D. 100 a 'colonia' on ground then wholly uninhabited, and peopled it with time-expired soldiers from the Third Legion which garrisoned the neighbouring fortress of Lambaesis ... The 'colonia' of Trajan appears to have been some 29 or 30 acres in extent within the walls and almost square in outline (360 x 390 yds.). It was entered by four principal gates, three of which can still be traced clearly, and which stood in the middle of their respective sides; the position of the south gate is doubtful. According to Dr. Barthel, the street [decumanus] which joins the east and west gates was laid out to point to the sunrise of September 18, the birthday of Trajan." [2,3].
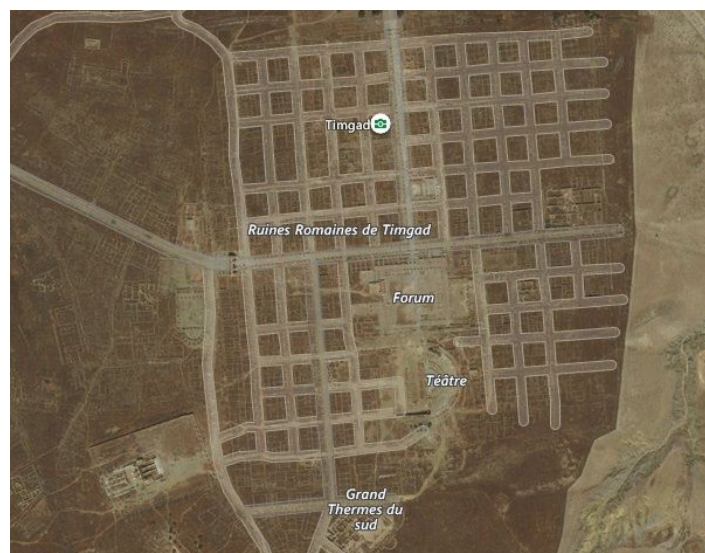

Figure 1: Timgad seen from space with streets evidenced (Courtesy: Bing Maps).

From the Figure 1, it is clear the reason for proposing in [2] this town as an example of the layout of Roman colonies. It seems that the Roman colonies were founded according to an ancient ritual [3]. An augur (a religious official), after inspecting good omens from skies, decided the place of the future town and the orientation of the main street, the decumanus. After the augur's decision, surveyors were deputed to transfer the plan devised by the augur on the land, by means of a surveying method which is known as "centuriation". This is the same method that the Romans used to subdivide the land for agriculture. If the assertion that we find in [2] is true, it means that Timgad has the decumanus oriented to the sunrise on September 18. So let us start our analysis.

Using CalSKY
In [1] I used an approach based on satellite images and on a rather simple equation, to discuss what Haverfield is telling about Timgad [2]. Instead of using the equation given in [1], we can use software CalSKY. Actually, detailed discussion and tables are given in [4], so we do not repeat them here. Summarising: let us consider the day of 18 September of 2019 and 100 AD at Timgad. We have that sunrise azimuth on September 18 (without considering the local natural horizon and the effect of the atmospheric refraction), it was of 86.4° in 100 AD; it is of 87.0° in 2019. The altitude of the sun is 56.4° in 2019; it was 56.9° in 100 AD. So, a difference of half a degree exists for the altitude of the sun due to the fact that the tilt of the Earth's axis slightly changed in two thousand years.

Let us consider the azimuth 86.4° and compare to the direction of the decumanus. Here we use satellite images. From a Bing Map we have the following Screenshot 1.
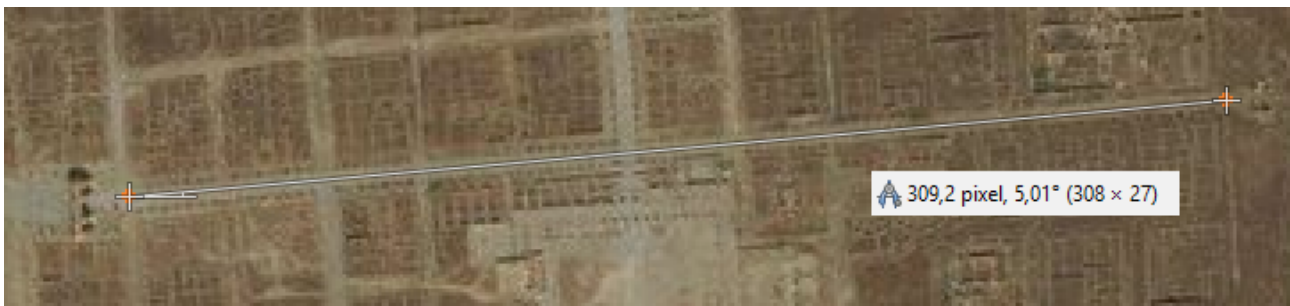
Screenshot 1: Satellite image courtesy Bing Maps. The azimuth of the decumanus is of 85°.

In the screenshot you can see the measurement of the angle made by means of GIMP pair of compasses. The azimuth of the decumanus, from true North, is of 85°. As a conclusion, using CalSKY, we have that it is possible that Timgad had been founded on 18 September 100 AD, if we consider that a difference of about 1.5° can be due to the used surveying method and the fact that the atmospheric refraction had been not considered.

Actually it is possible to reduce the difference including the effect of atmospheric refraction. Let us assume, roughly, that the atmospheric refraction could affect the azimuth of 0.5°, then the sunrise azimuth could be estimated as 86°, and the difference reduced to a degree. This is a result which is far better than that given in [1]. Of course, the result here proposed is given for an astronomical horizon.

The natural horizon
Of course, it would be better to have a local survey. But, in the case that this is not possible, we can use Google Earth, to investigate the horizon. We can use a long straight line, along the Timgad decumanus, in the direction of the sunrise. Google Earth provides the elevation profile along this line (see the Figure 1).
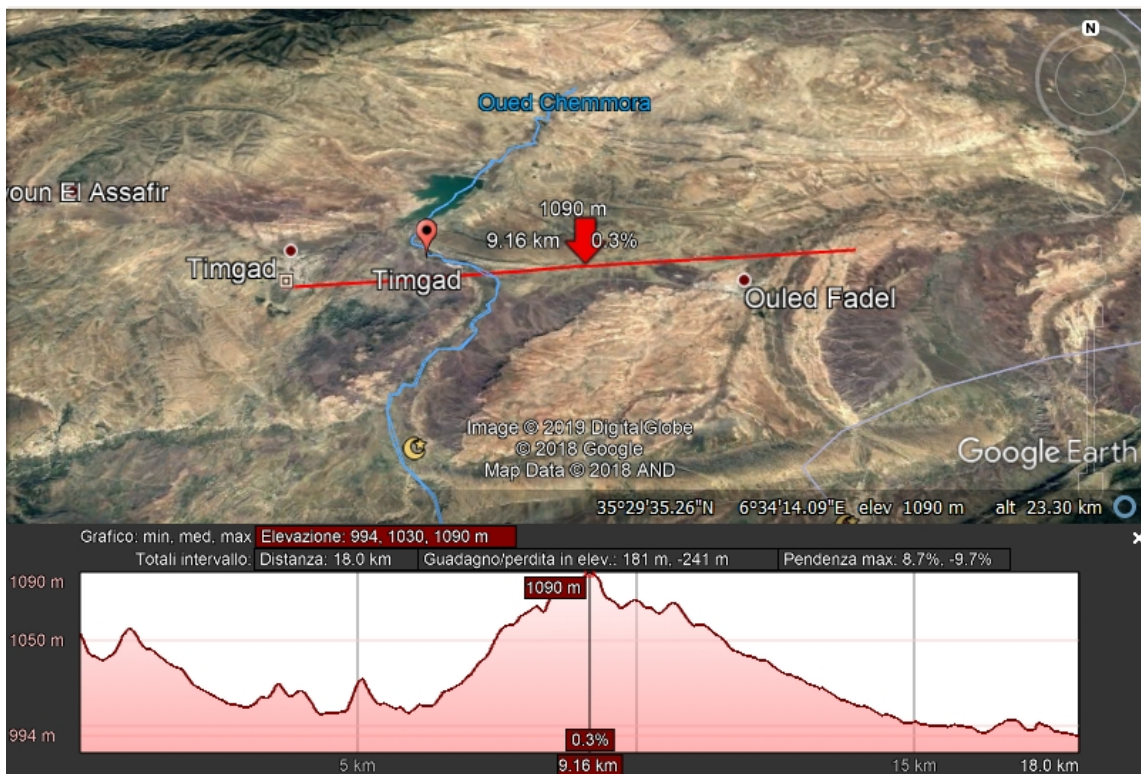
Figure 1: The elevation profile is a courtesy of Google Earth. Using the peak marked in the figure, we find that the natural horizon is 0.21° (that is 13', in the further analysis we will round it to 15') above the astronomical horizon.
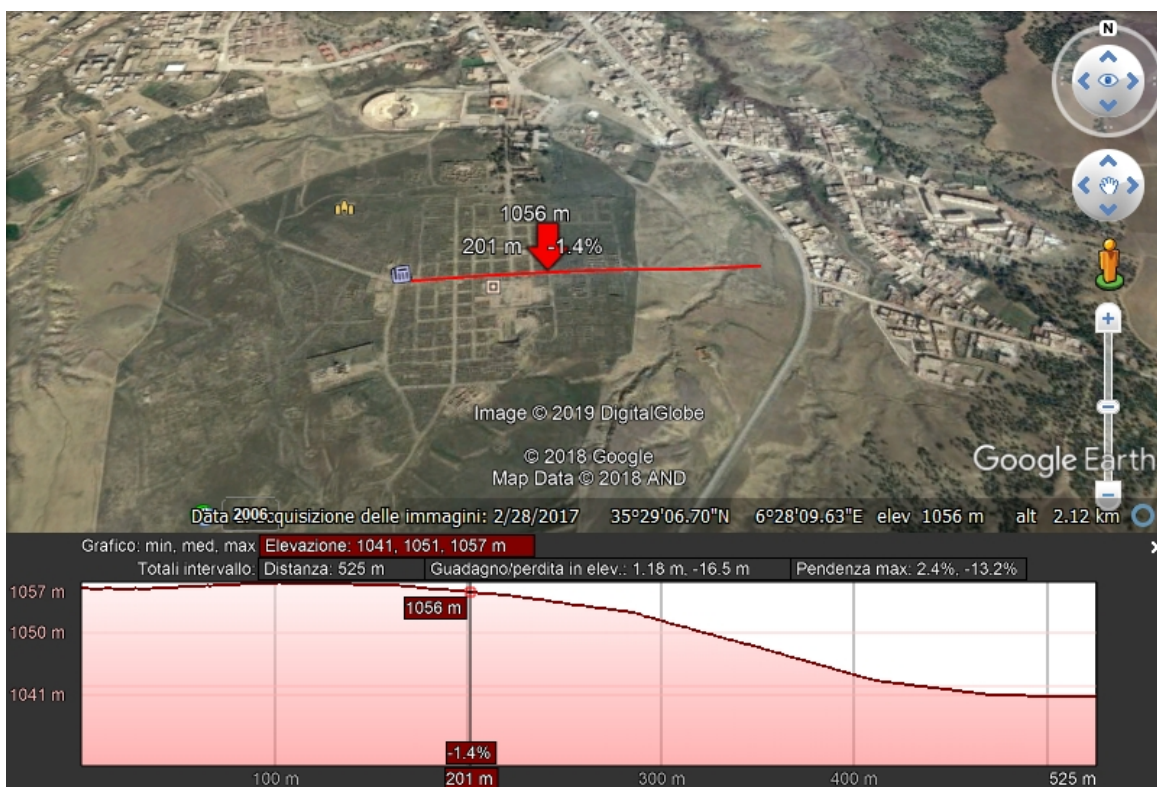

Figure 2: Detail of the elevation profile of the decumanus. Actually, the town is not flat. So we will consider two parts of the decumanus, one from the West Gate to the forum, the other near the East Gate.

Using the peak marked in the Figure 1, we find that the natural horizon is 0.21° (that is 13', in the further analysis we will round it to 15') above the astronomical horizon.

Let us consider the profile of the decumanus too. In the Figure 2 we see that the town is not flat. So we will consider the decumanus in two parts. First, we consider the part of the decumanus from the West Gate to the forum. Again, Google Earth can help us to find the azimuth of this part of the street.
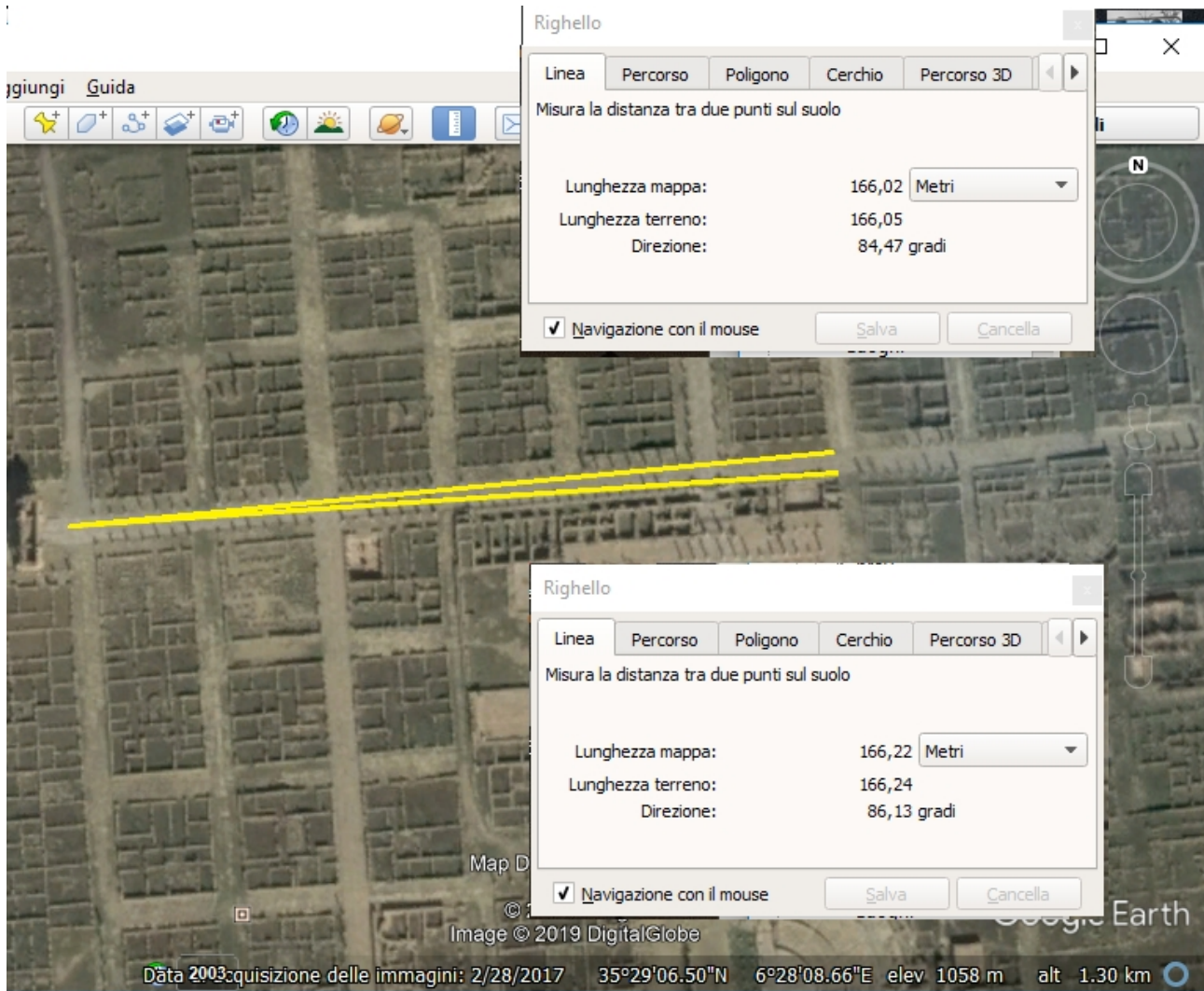

Figure 3.

In the Figure 3 we can see the screenshots of the results we obtain by means of Google Earth. We can see that the street is quite broad. If we consider the upper yellow line, we find an azimuth of 84.5°. For the lower yellow line we find an azimuth of 86.10°. The average is about 85°.

Then let us consider the part of the decumanus near the East gate. The result is given in the Figure 4. In the figure we see that the direction is of about 86°. This is a very interesting result, because it is, within half a degree, close to the sunrise azimuth of 18 September 100 AD given by means of the analysis made through the use of CalSKY.

Actually, this analysis shows an important fact, that we have not to consider the decumani of the Roman towns as a perfect straight line. The decumanus was an engineered line, studied to give the best result according to the local environment. Of course, better results can be obtained by means of a local survey.
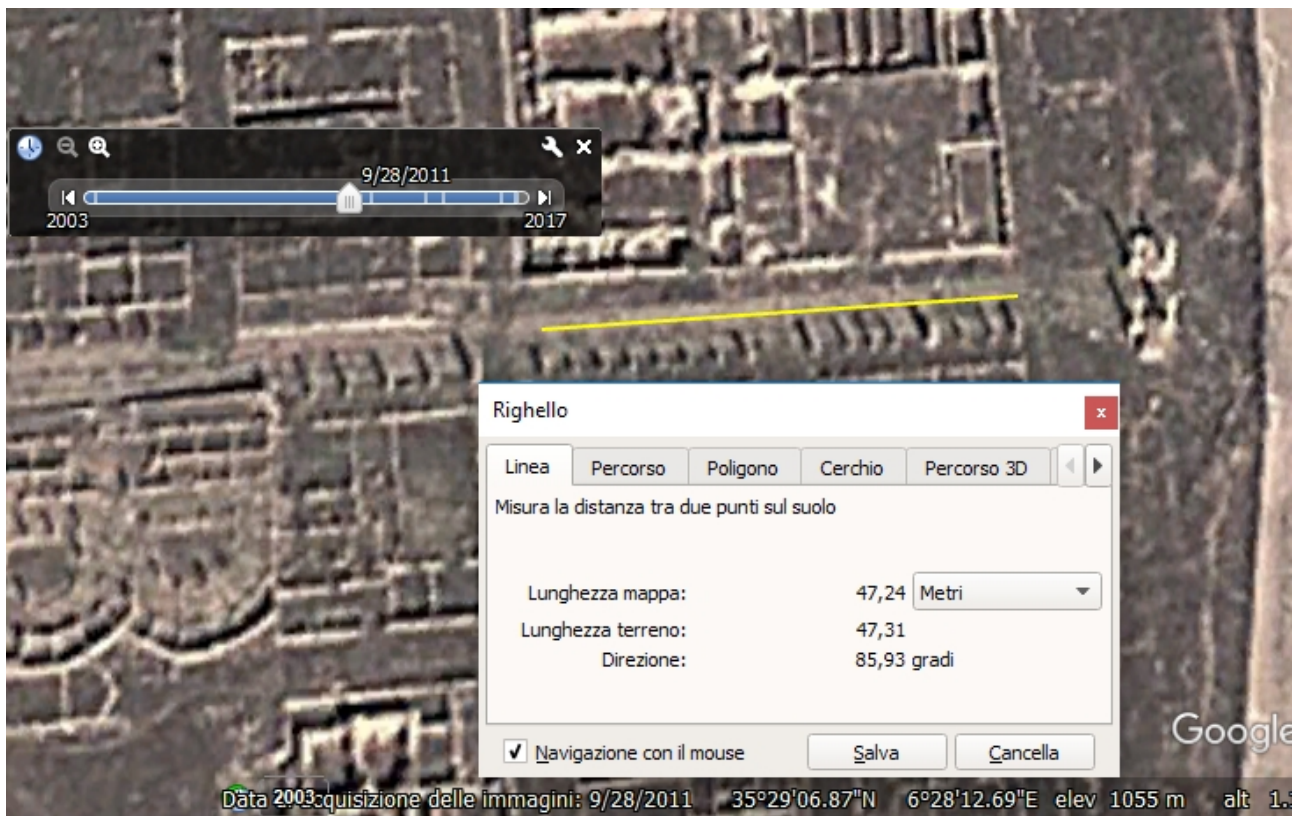
Figure 4.

Using Stellarium
CalSKY gave us very good results concerning the astronomical horizon, that is the line which is the intersection of a horizontal plane and the vault of the sky. But, as we have seen from the Figure 1, the natural horizon cannot be assumed as flat. Therefore the sun must be about 15' above the astronomical horizon to be seen from Timgad. However, we have to consider the role of the atmospheric refraction. Let us assume an effect of 35': we can reduce the sun altitude to -20'. Furthermore, we could imagine that the augur, or the surveyor, could had observed the first ray of the sun at the sunrise. So we can further reduce of 16', that is half the angular diameter of the sun.
We arrive to an altitude of the sun of -36' (the sun is below the astronomical horizon but is can be seen due to atmospheric refraction).
Let us use this altitude in software Stellarium. Please note that Stellarium automatically uses the Julian date for events which happened before the introduction of the Gregorian Calendar [5]. If we use Stellarium for 18 September 100 AD, we find, in the conditions given above, that the azimuth was of 86° 33'. However the Julian date of 18 September corresponds to the Gregorian date of 19 September (this is what we find if the use the conversion of the calendars as given by https://www.galileo.fr.it/marc/varie/calendario/indice.htm). Is Haverfield in [2] giving a Julian or a Gregorian date? We have to investigate. We know that the birthday of Trajan is mentioned in a letter written by Pliny the Younger.

Pliny the Younger (A.D. 62?–c.A.D. 113). Letters. The Harvard Classics. 1909–14. Here the Letter XVI to the Emperor Trajan (Courtesy: https://www.bartleby.com/9/4/2016.html).
"AS I had a very favourable voyage to Ephesus, so in travelling by post-chaise from thence I was extremely troubled by the heats, and also by some slight feverish attacks, which kept me some time at Pergamus. From there, Sir, I got on board a coasting vessel, but, being again detained by contrary winds, did not arrive at Bithynia so soon as I had hoped. However, I have no reason to complain of this delay, since (which indeed was the most auspicious circumstance that could attend me) **I reached the province in time to celebrate your birthday.** I am at present engaged in examining the finances of the Prusenses, their expenses, revenues, and credits; and the farther I proceed in this

work, the more I am convinced of the necessity of my enquiry. Several large sums of money are owing to the city from private persons, which they neglect to pay upon various pretences; as, on the other hand, I find the public funds are, in some instances, very unwarrantably applied. This, Sir, I write to you immediately on my arrival. **I entered this province on the 17th of September**, and found in it that obedience and loyalty towards yourself which you justly merit from all mankind. You will consider, Sir, whether it would not be proper to send a surveyor here; for I am inclined to think much might be deducted from what is charged by those who have the conduct of the public works if a faithful admeasurement were to be taken: at least I am of that opinion from what I have already seen of the accounts of this city, which I am now going into as fully as is possible."

From this letter we see that it was September 17 of Julian Calendar. So let us repeat the analysis by means of Stellarium using 17 September. Here the result in Screenshot 2.

Screenshot 2: Stellarium results. Below the detail.

We find that the sunrise azimuth, according to the previously given conditions, on September 17, was of 85°35', that is 85.58°. Then, the difference between the average azimuth of the Timgad decumanus and the sunrise azimuth on 17 September 100 AD was of about half a degree.

Sunrise on September 17, Julian date, had been a quite remarkable astronomical show, framed by the East Gate of the town built in the name of Trajan.

Discussion

As we have seen using Google Earth, the decumanus was designed to adjust itself on the local surface of the ground. So let us assume its azimuth given as 85°±1°. If we assume the sunrise azimuth determined in the conditions mentioned above, we find a value of 85.58°. This value is within the uncertainty range of the decumanus, that is, it is between 84 and 86 degrees. In this framework, we can conclude that the town of Timgad could had been oriented to the sunrise of the day of Trajan's birthday.

Let me add a further observation concerning the year of the foundation. It seems to me that it is impossible to determine the specific year of the foundation by comparing the azimuth of the decumanus to the sunrise azimuth. And this is clearly shown by the CalSKY results. To change the difference of half a degree of the sunrise azimuth, we need two thousand years. Therefore, we cannot determine the year of foundation from any comparison of decumani and sunrise azimuths.

References

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[2] Haverfield, F. (1913). Ancient town - planning, Oxford, The Clarendon Press, 1913, available at http://www.gutenberg.org/files/14189/14189-h/14189-h.htm

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[4] Sparavigna, A. C. (2019, February 1). The Roman Colonia Marciana Ulpia Traiana Thamugadi (Timgad) and Trajan's Birthday. Zenodo. http://doi.org/10.5281/zenodo.2555082

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