

The influence of altitude on the preservation of stećak tombstones in the Tuzla Canton

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INTRODUCTION

The subject of research in this paper is the influence of altitude on the preservation of stećak tombstones in the Tuzla Canton, located in the northeast of Bosnia and Herzegovina. Tuzla Canton has 13 municipalities out of a total of 143 in Bosnia and Herzegovina. The aim of the work is to determine whether, and to what extent, changes in altitude affect the preservation of stećak tombstones. The climate changes with increasing altitude. The law is that with increasing altitude, temperatures decrease. For every 100 meters of increase in altitude, temperatures decrease by an average of 0.56 °C. With increasing altitude, the air temperature decreases, air molecules expand, or the air density decreases, so the air is lighter and exerts less pressure on the surface. At the same time, the amount of precipitation increases. Lower temperatures at higher altitudes also affect the more frequent occurrence of snowfall and the longer retention of snow cover. The climate is harsher at higher altitudes, and the effect of rock erosion is increased. It is logical to assume that climatic conditions should also affect stećak tombstones that are carved in stone, where limestone predominates. Throughout Bosnia and Herzegovina, there are unique tombstones, special for their diverse and unusual shapes, decorations, and inscriptions. In general and quite simply, it can be said that stećci are stone tombstones that are characteristic of the area of the old Bosnian state (Bešliagić, 1982) (Figure 1).



Figure 1. The Bosnian state in the time of King Tvrtko (14. century)

Stećci were carved in the period from the 13th to the 16th century. Their age significantly affects their preservation. The largest number of stećak necropolises is located in Bosnia and Herzegovina, 2,687 necropolises or 84.97%. There are 59,593 stećak tombstones recorded there, which is 85.92% of the total number. The remaining stećak tombstones are located in the border areas of the neighboring countries of Croatia, Serbia and Montenegro, which were once part of the medieval Bosnian state (Bešliagić, 1982).

According to their shape, stećci are divided into: lying and standing. Lying shapes are further divided into types: slab, crate, crate with pedestal, gable and gable with pedestal. Standing forms include: column, cross and amorphous forms (Figure 2).



Figure 2. Basic shapes of stećak tombstones

A total of 1,517 stećaks in 177 necropolises, in all 13 municipalities, were analyzed in Tuzla Canton. The state of preservation of stećaks was first done for all 1,517 stećaks (1,388 stećaks whose shape was determined, as well as 129 amorphous stećaks). Badly or poorly preserved stećaks, which are the most eroded or damaged, are the least recorded (947 stećaks). The well-preserved stećak category is in second place (533 stećci). Very well-preserved stećaks are the least damaged and there are the least number of them (37 stećaks). There are no completely preserved stećaks due to the age of the stećaks themselves, daily and centuries-long exposure to the effects of atmospheric conditions.

As an example of a very well-preserved stećak, a stećak from the Mramorje necropolis in the Bulatovi settlement in the Kalesija municipality is shown (Figure 3). An example of a poorly preserved stećak can be found at the Djevojka necropolis in the settlement of Noćajevići in the municipality of Kladanj (Figure 4).



Figure 3. A very well-preserved stećak (Municipality of Kalesija, Mramorje necropolis in Bulatovi settlement)



Figure 4. Poorly preserved stećak (Municipality of Kladanj, Necropolis of Djevojka in the settlement of Noćajevići)

In order to obtain reliable results, necropolises where all stećak tombstones were moved from their original locations, necropolises with only one stećak tombstone, and stećak tombstones that were damaged, overturned, built over, etc. by people were eliminated from the analysis. For this analysis, 809 stećak tombstones located in 101 necropolises in 10 municipalities of the Tuzla Canton met the criteria. The lowest necropolis is located at 103 m above sea level, while the highest is located at 1010 m above sea level, which represents an altitude difference of 907 m.

MATERIAL AND METHODS

The Tuzla Canton is one of the ten cantons of the Federation of Bosnia and Herzegovina. It consists of 13 municipalities that together have an area of 2,649 km², which is about 5% of the total area of Bosnia and Herzegovina (Figure 5).

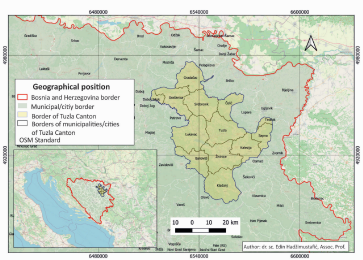


Figure 5. Geographical position of Tuzla Canton

The northernmost point of the Tuzla Canton (φ = 44° 55' N, λ = 18° 26' E) is in the settlement of Ledence Gornje in the municipality of Gradačac, while the southernmost point (φ = 44° 09' N, λ = 18° 41' E) lies in the settlement of Mala Kula in the municipality of Kladanj. The easternmost point is in the settlement of Turunovo Brdo, municipality of Teočak (φ = 44° 36' N, λ = 19° 02' E), while the westernmost point is in the municipality of Doboj Istok in the settlement of Stanici Rjeka (φ = 44° 44' E, λ = 18° 08' E).

The canton is mostly located in the northeastern foothills of the Dinaric mountain system, in the area between the river valleys of the Bosna, Drina, Sava and Krivaja (Hutnić et al., 2013). The lowest altitudes, slightly more than 100 m, are in the north of the canton, increasing towards the southern part. The highest peak of the canton is at 1,338 m, which is also the highest peak of Mount Konjuh. These areas are characterized by a temperate continental climate. The average annual temperature is about 10.1 °C, while the average annual precipitation is about 908.6 mm.

The preservation of stećak tombstones was carried out in situ at the necropolises of the Tuzla Canton. The stećak tombstones were observed, examined, and their degree of preservation was determined. Data on the necropolises were collected using the form "Record sheet of stećak necropolises in the Tuzla Canton". In the general part, data of the necropolis were entered: municipality, settlement, locality name, geographical coordinates, dimensions of the necropolis, aspect, geomorphological position, vegetation cover, degree of preservation, sketch of the necropolis, etc. Data of the stećak tombstones were recorded also: geographical coordinates of the stećak tombstone, orientation, dimensions, shape, degree of preservation, degree of sinking, ornaments and inscriptions. The data collected in this way were used to create a digital relational database "one-to-many", i.e. one necropolis to many stećak tombstones, in the Microsoft Access program. The database was integrated into geographic information systems.

The position of necropolises, as well as stećak tombstones, was determined using the global positioning system (GPS).

In order to provide a clearer picture of the geospatial distribution of necropolises, three geographic maps of the distribution of stećak necropolises in the Tuzla Canton area were created.

RESULTS AND DISCUSSION

In the area of Tuzla Canton, in all 13 municipalities, a total of 1,517 stećaks were found in 177 necropolises. The shape of 1,388 stećaks has been determined, and 129 are amorphous. In order to obtain more reliable results, this paper selected necropolises and stećak tombstones that meet certain criteria. This paper analyzed 809 stećak tombstones located in 101 necropolises in 10 municipalities of the Tuzla Canton. Necropolises where all stećak tombstones were moved from their original locations and necropolises with one stećak tombstone were excluded from the analysis. Stećak tombstones that were damaged by human activity (torn down, broken, half a stećak tombstone, buried, walled up) were also excluded from the analysis.

Of the total number of stećaks, the shape of 744 has been determined, while 65 are amorphous stećaks. Amorphous stećaks are the most damaged, they are so damaged that it is impossible to determine their shape. Stećaks that are in bad condition, more eroded, damaged by weathering were also selected. Of the stećaks analyzed in this paper, the most damaged slabs were 77.55%. They are followed by crates with 66.24%, pillars with 58.3%, crates with pedestals 51.35%, gables 51.08%. The least eroded are gables with a pedestals, 32.16%.

Shape of stećak tombstone	Slabs	Crates	Crates with pedestal	Gables	Gables with pedestal	Pillars	Total
Total	49	234	37	231	283	554	1,388
Analyzed	38	155	19	118	91	323	744
%	77.55	66.24	51.35	51.08	32.16	58.30	

Table 1. The total number of stećak tombstones compared with analyzed shape of stećak tombstone

Source: Data obtained by the author's field research

Geographical distribution of stećak necropolises

The analyzed necropolises of stećak tombstones were found in the area of 10 municipalities of the Tuzla Canton (Banovići, Čelić, Gračanica, Gradačac, Kalesija, Kladanj, Sapna, Teočak, Tuzla and Živinice). For clearer visualization, the geographical distribution of necropolises is represented with three maps, which partially show the Tuzla Canton.

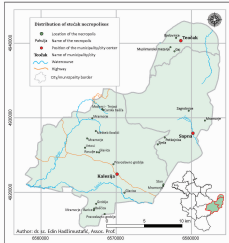


Figure 6. Geographical distribution of stećak necropolises in the municipalities: Čelić, Gradačac, Kalesija and Tuzla

Figure 7. Geographical distribution of stećak necropolises in the municipalities: Kladanj, Sapna and Teočak

Figure 8. Geographical distribution of stećak necropolises in the municipalities: Banovići, Kladanj, Živinice

Distribution of the stećak necropolis by altitude

At the lowest altitude of 103 m a.s.l. there is a necropolis in the municipality of Gradačac, in the settlement of Gornje Ledence, in the locality of Zelinkici - Razljevi. At 1010 m a.s.l. a necropolis was found (Municipality of Kladanj, settlement of Konjevići, locality of the same name), which is also at the highest altitude in the Tuzla Canton (Figure 9).

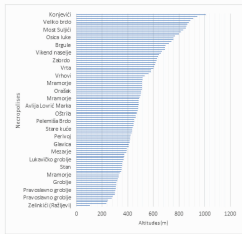


Figure 9. Distribution of the necropolis by altitude

The necropolises are distributed at altitudes ranging from 907 m. The average altitude at which the necropolises are located is 507 m. The standard deviation is 183.5 m. The most frequent altitude at which necropolises have been recorded is 300 m. At this altitude there are two necropolises (Živinice municipality, Gračanica settlement, Zajask site and also in the Živnice municipality, Podgajevi-Mujanovići settlement, Mekota site). In the hypsometric zone of 300-500 m, 453 (55.9%) stećak tombstones were recorded at 52 (51.5%) sites. The fewest stećak tombstones are at the lowest altitudes (100-300 m) and at the highest altitudes (900-1000 m) (Figure 10).

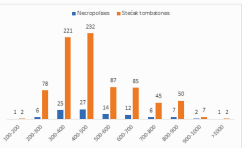


Figure 10. Distribution of the necropolis by hypsometric zones

Correlation of poorly preserved stećaks with altitudes

The distribution by altitude serves to familiarize us with necropolises in general and does not show the influence of altitudes on the state of preservation of necropolises. To obtain more reliable results, the total number of poorly preserved stećak tombstones at each necropolis must be taken into account. The assumption is that the number of poorly preserved stećak tombstones will increase with increasing altitude. It has already been said that 809 stećak tombstones are being analyzed, at 101 necropolises. The smallest necropolis has 3 poorly preserved stećak tombstones and the largest 31. The average number of stećak tombstones at a necropolis is 8. One quarter (25%) of necropolises have up to 3 stećak tombstones, half have up to 5, and 75% of necropolises have up to 10 stećak tombstones.

The number of stećaks should be put in relation to the altitudes, that is, the potential correlation between altitudes and poorly preserved stećaks should be calculated. Before the correlation is calculated, the data should be graphed to explore the data. The scatter plot diagram, illustratively shows the (dis)connection of the variables: altitude and poorly preserved stećci. It is clearly observed that the data are very scattered and that no connection between them can be observed (Figure 11). Therefore, the correlation between the variables cannot be calculated. This fact shows us that the preservation of the stećak is not affected by the increase in altitude of the stećak necropolis.

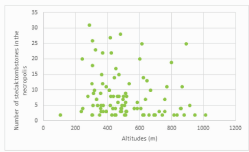


Figure 11. Distribution of poorly preserved stećak tombstones in relation to the altitudes of their necropolises

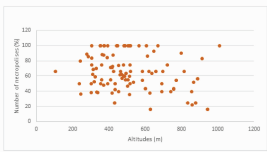


Figure 12. Distribution of the percentage of poorly preserved stećak tombstones in relation to altitudes

Instead of the total number of stećaks, the percentage of poorly preserved stećaks in necropolises is the most relevant indicator of their eventual preservation. Analyzing the data distribution on the scatter plot, we can again conclude that there is no correlation (Figure 12).

CONCLUSION

The analysis conducted in this paper has yielded results that show that the preservation of stećak tombstones does not fully fit into the climatic laws. Increases in altitudes at which necropolises are located do not directly affect the degree of preservation of stećak tombstones. It is undeniable that climate influences and is the primary factor in the degree of preservation of stećak tombstones. Centuries of exposure to the effects of climatic elements: solar energy, temperature changes, precipitation of various types, changes in cloudiness, air humidity, gradually erode the stone in which the stećak is carved.

This paper is an introduction to research of this kind. To obtain more detailed data on the preservation of stećak tombstones and the influence of climate, it is necessary to conduct additional research with adequate equipment. Until then, the results of this paper show a partially accurate state of preservation of stećak

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