GIS ANALYSIS OF LINEAR AND SPIRAL GEOMETRIES IN THE BOSNIAN VALLEY OF THE PYRAMIDS

Implications for Prehistoric Civil Engineering

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Abstract

Spatial relationships among major geomorphological and archaeological features in the Bosnian Valley of the Pyramids were examined using GIS-based methods. The analysis focused on linear alignments and spiral geometries linking pyramid summits, tumuli, and underground tunnel systems. High-resolution LiDAR data, digital elevation models (DEM), satellite imagery, and GPS-derived coordinates were processed using spatial statistics, regression analysis, and Monte Carlo simulations to determine whether the observed configurations exceed random landscape distributions. The results identify statistically significant linear alignments and a strong correspondence with a Fibonacci-based spiral geometry, with correlation coefficients exceeding $R^2 = 0.99$ and probability values below $p < 0.01$. These geometric patterns were further examined in relation to terrain optimization, slope stability, hydrological flow, and geotechnical constraints. The findings demonstrate that GIS-supported geometric analysis provides a robust framework for investigating large-scale landscape organization and its potential relevance to prehistoric civil engineering and spatial planning.

Keywords: *GIS, Fibonacci spiral, linear alignment, prehistoric engineering, Bosnian Valley of the Pyramids*

1. Introduction

The Bosnian Valley of the Pyramids, located in Visoko, Bosnia-Herzegovina, encompasses a cluster of large geomorphological structures—including the Bosnian Pyramid of the Sun, the Bosnian Pyramid of the Moon, the Pyramid of the Earth, the Pyramid of Love, and the Dragon Pyramid—alongside extensive subterranean tunnel systems such as Ravne. Since its initial identification in 2005, the site has been systematically surveyed through archaeological excavation, geophysical assessments, engineering analyses, and geospatial modeling. The cumulative evidence suggests that the spatial organization of the complex was not arbitrary; rather, it reflects the application of advanced geometric and astronomical planning principles.(1)

Sacred geometry—specifically equilateral triangles, hexagons, the Flower of Life pattern, and Fibonacci-based spirals—has emerged as a key interpretive framework for understanding the layout of prehistoric structures globally. (2) The Bosnian Valley of the Pyramids appears to conform to several of these geometric archetypes, making it a unique case study for evaluating intentional design within a large-scale anthropogenic landscape. (3,4) Prior research by Osmanagich and collaborators has demonstrated geometric consistencies across multiple features within the valley, including repeating angular ratios, harmonic distances, and geometric centers. (5)

In parallel, several linear alignments have been documented, such as the Moon–Earth–Dragon axis and the Earth–Love–Sun–Ravne Tunnels orientation. These lines, when modeled geospatially, exhibit angular coherency and positional precision that exceed typical random alignment distributions. This raises the question of whether the prehistoric constructors possessed a systematic method for landscape planning, and whether such methods may align with engineering logics still relevant today.(2)

This paper aims to investigate whether linear and spiral spatial geometries present in the Bosnian Valley of the Pyramids can be quantitatively validated using modern GIS tools, and what implications such intentional ordering may have for understanding prehistoric civil engineering, water management, and site-wide functional design. (6-10)

The primary objective of this paper is to evaluate whether the spatial configuration of major geomorphological and archaeological features in the Bosnian Valley of the Pyramids exhibits measurable geometric order that exceeds what would be expected from random terrain formation. Using GIS-based spatial analysis, the study aims to test the presence and statistical significance of linear alignments and spiral geometries linking pyramid summits, tumuli, and subterranean tunnel systems.

A second objective is to assess whether these spatial patterns can be quantified using standard tools applied in civil engineering and urban planning, including LiDAR-derived terrain modeling, spatial statistics, and Monte Carlo simulations. By applying methods commonly used in infrastructure planning and geotechnical assessment, the study seeks to determine whether the observed landscape organization is compatible with deliberate large-scale planning.

Finally, the paper aims to position the Bosnian Valley of the Pyramids within a broader methodological framework, demonstrating how GIS and statistical geometry can be used to evaluate prehistoric landscapes without relying on speculative cultural interpretations. The emphasis is placed on reproducible measurement, probability testing, and engineering-relevant spatial logic.

2. Methodology

The methodological approach follows a sequential workflow commonly used in geospatial engineering studies, progressing from data acquisition and coordinate normalization to geometric modeling and probabilistic validation.

The methodological approach integrates geomatics, spatial statistics, and comparative archaeo-engineering to examine geometric relationships within the Bosnian Valley of the Pyramids. The analytical workflow combined high-resolution terrain data, geodetic measurements, and statistical testing to evaluate whether observed spatial patterns exceed what would be expected from random landscape formation.

Spatial datasets were compiled from multiple independently verified sources. These included LiDAR-derived digital elevation models with spatial resolution better than 1 m, GPS-based geodetic coordinates of pyramid summits, tumuli, tunnel entrances, and prominent hilltops such as Krtnica, Četnica, Smreka, Čemerika, and Bedem. Additional datasets included satellite imagery from Sentinel-2 and Google Earth Pro, as well as previously published GIS datasets from peer-reviewed studies addressing geometric characteristics of the site. All spatial data were projected in the WGS84 coordinate system to ensure consistency across analyses. (2,4)

Linear alignment analysis was conducted to evaluate major directional relationships among key features. Two primary alignments were examined: the Moon–Earth–Dragon pyramid axis and the Earth–Love–Sun–Ravne Tunnels axis. For each alignment, angular deviations between summit coordinates were calculated,

along with linear regression coefficients (R^2) and azimuth values referenced to true north. To assess whether these alignments could arise by chance, Monte Carlo simulations were performed using 10,000 randomized point distributions constrained within the valley boundaries. A probability threshold of $p < 0.05$ was adopted to distinguish non-random spatial organization.

Spiral geometry was evaluated using a Fibonacci-based model constructed around the summit of the Bosnian Pyramid of the Sun, incorporating auxiliary nodes representing pyramid corners and additional major landscape features. The golden ratio ($\varphi \approx 1.618$) was used as the governing growth parameter. Spiral correspondence was assessed at two spatial scales: a local scale encompassing the central pyramid cluster and a valley-wide scale incorporating tumuli and surrounding hilltops. Quantitative metrics included deviations of observed points from the modeled spiral, root mean square error (RMSE), and consistency of angular growth between spiral segments.

Additional geometric frameworks were examined to evaluate broader spatial coherence. These included equilateral triangular configurations formed by pyramid summits, hexagonal overlays, Flower-of-Life constructions, and harmonic distance ratios derived from the golden ratio. Each pattern was assessed for geometric fit using defined deviation thresholds appropriate for landscape-scale analysis.

To place the geometric findings within an engineering context, supplementary analyses were conducted on slope gradients, terrain aspect, bedrock stability, and hydrological behavior. (3) Water flow modeling and geotechnical information from previously published core samples were used to evaluate whether geometric placements correspond with favorable engineering conditions, such as stable substrates, controlled runoff, and reduced seismic exposure.

The final stage integrated geometric and engineering datasets to examine the potential relationship between spatial organization and prehistoric civil engineering practices. (6, 10) Emphasis was placed on landscape-level planning, water infrastructure, connectivity between surface and subsurface features, and the possibility that geometric principles informed both functional and symbolic aspects of the valley's layout.

The use of high-resolution LiDAR and GIS-based spatial analysis allows terrain-scale geometric relationships to be evaluated independently of surface vegetation, excavation extent, or subjective visual interpretation.

3. Results

This section presents the results of the GIS-based spatial, geometric, and statistical analyses applied to the Bosnian Valley of the Pyramids. The findings are reported descriptively and focus on measured linear alignments, spiral geometries, and associated probability estimates derived from Monte Carlo simulations, without interpretive conclusions.

For example, the Fibonacci spiral centered on the Bosnian Pyramid of the Sun intersects the Temple of Mother Earth, the Pyramid of the Dragon, and the Vratnica Tumulus within positional deviations below 70 m, a tolerance consistent with landscape-scale engineering geometry (Figures 5–8).

GIS line-fitting applied to summit coordinates revealed a highly coherent linear alignment linking the Bosnian Pyramid of the Moon, the Pyramid of the Earth, and the Pyramid of the Dragon (Figure 2). The calculated coefficient of determination reached $R^2 = 0.997$, indicating a near-linear correspondence among the three points. The measured azimuth of this alignment was $43.2° \pm 0.3°$ relative to true north. Monte

Carlo simulations (n = 10,000) demonstrated that randomly distributed point sets produced a comparable alignment in only 0.8% of trials ($p = 0.008$).

A second linear configuration was identified connecting the Pyramid of the Earth, the Pyramid of Love, the Bosnian Pyramid of the Sun, and the Ravne Tunnel complex (Figure 3). A four-point regression produced an R^2 value of 0.992, with a corresponding azimuth of 153.4° ± 0.4°. Monte Carlo testing indicated a probability of random occurrence of $p = 0.014$. Notably, this alignment incorporates both surface and subsurface features, with the Ravne Tunnel system representing the only underground element included in the dataset.

Spiral geometry modeling was conducted using Fibonacci-based parameters, with the Bosnian Pyramid of the Sun selected as the primary reference point. Within a central radius of approximately 1.5 km, eight of eleven analyzed features—including pyramid summits, tumuli, and tunnel entrances—fell within a root mean square error (RMSE) of less than 42 m relative to the modeled spiral curve (Figure 4). Angular growth ratios along the spiral approximated the golden ratio ($\varphi \approx 1.618$), with deviations ranging from 2.8% to 4.7%.

When the analysis was expanded to a valley-wide scale of approximately 5 km, fourteen spatial correspondences were identified between the Fibonacci spiral and prominent topographic features, including pyramid edges and nearby hilltops such as Krtnica, Četnica, Smreka, Čemerika, and Bedem (Figure 5). At this scale, RMSE values increased to a range of 67–110 m, consistent with expectations for landscape-scale geometric modeling.

Additional geometric relationships were observed in the form of equilateral and near-equilateral triangular configurations among key summit points. In particular, the Sun–Moon–Dragon configuration exhibited internal angular deviations from the ideal 60° ranging between 1.3° and 2.1° (Figure 6). Geospatial overlays further revealed hexagonal grid patterns whose vertices corresponded with pyramid summits and hilltops, with positional deviations below 60 m. Flower-of-Life–type circular constructions applied to the central cluster showed that 9 of 12 nodal intersections coincided with identifiable geomorphological features (Figure 7).

Engineering-related contextual analyses were also performed. Slope stability modeling indicated that major pyramid placements coincide with terrain gradients between 12° and 18°, a range favorable for runoff control and structural stability. Subsurface hydrological mapping within the Ravne Tunnel complex revealed water channels that follow pathways parallel to surface alignments identified in the linear and spiral analyses (Figure 8). In addition, bedrock density assessments showed that several major features are located within low seismic-risk microzones, as indicated by regional geophysical datasets.

4. Discussion

The results presented in this study point toward a landscape that appears to have been organized according to clear geometric principles rather than shaped solely by natural terrain processes. The consistency of several long linear alignments, combined with their directional coherence, suggests that the placement of major structures within the Bosnian Valley of the Pyramids followed a deliberate spatial logic. Similar directional planning is well documented in ancient cultures worldwide, where landscapes were organized using cardinal references, solar paths, and horizon observations long before the development of modern surveying instruments.

Unlike traditional archaeoastronomical studies that rely primarily on visual alignment or symbolic interpretation, the present approach applies quantitative spatial statistics and Monte Carlo simulations commonly used in civil engineering and urban planning to test non-random pattern formation.

Equally striking is the repeated appearance of spiral geometry across the valley. The successful application of Fibonacci-based spirals at both local and regional scales indicates that curved, expanding forms played a role in organizing space across the terrain. (2) Spiral patterns are widely recognized in ancient architecture and engineering, from pyramid complexes in Egypt to ceremonial centers in Mesoamerica and megalithic sites in Europe. In practical terms, spiral layouts offer advantages related to structural balance, movement of water, and the positioning of underground spaces. At the same time, spirals have deep symbolic meaning, often associated with cycles, growth, and the relationship between the sky and the Earth. (4,5,7,9) Within the Bosnian Valley, the coexistence of spiral geometry with linear alignments suggests that functional engineering needs and symbolic or cosmological concepts may have been addressed simultaneously. (5)

The inclusion of underground tunnel systems within these geometric frameworks further strengthens the impression of an integrated landscape design. The alignment of surface features with subsurface passages implies coordinated planning rather than independent construction phases. Such integration would have allowed ancient builders to manage water flow, movement through the landscape, visual connections between monuments, and possibly acoustic or energetic effects. Similar multifunctional planning approaches have been identified at other prehistoric sites, where monuments, pathways, and underground features form interconnected systems rather than isolated elements.

From a civil engineering perspective, the locations of the pyramidal structures correspond well with stable terrain conditions. (1) Favorable slope angles, solid geological substrates, and areas of reduced seismic risk appear repeatedly at key sites. These choices suggest careful observation of the natural environment and an understanding of how terrain behaves over long periods. The alignment of surface geometry with natural water pathways beneath the Ravne tunnel complex further indicates that hydrology was an important factor in site organization. While ancient builders did not possess modern analytical tools, their results reflect practical knowledge gained through experience, experimentation, and long-term interaction with the landscape.

Several limitations remain. Natural landforms can sometimes produce geometric patterns that resemble intentional design, although the statistical analysis used here reduces the likelihood of coincidence. In addition, much of the underground architecture remains unexplored, limiting a complete understanding of the system as a whole. Future work using deeper geophysical scanning and targeted subsurface investigation would help clarify the extent, function, and chronology of the underground structures and their relationship to surface geometry.

Taken together, the findings suggest that the Bosnian Valley of the Pyramids may represent a carefully planned monumental landscape in which geometry, engineering practice, and cultural worldview were closely intertwined. The application of GIS-based analysis provides a valuable tool for examining such large-scale spatial organization and opens new possibilities for interpreting prehistoric engineering achievements within complex natural environments.

5. Conclusion

This study applied GIS-based spatial analysis, LiDAR-derived terrain data, and statistical modeling to examine geometric relationships within the Bosnian Valley of the Pyramids. The results demonstrate that multiple linear alignments and spiral configurations linking pyramid summits, tumuli, tunnel systems, and natural features exceed what would reasonably be expected from random landscape formation. Monte Carlo

simulations consistently showed low probabilities for chance occurrence, supporting the conclusion that the observed spatial patterns reflect structured organization rather than coincidental arrangement.

The identification of coherent linear axes and Fibonacci-based spiral geometries across both local and valley-wide scales suggests that large portions of the landscape were planned according to shared geometric principles. These patterns integrate surface and subsurface features, indicating that underground tunnels and hydrological elements were likely considered alongside above-ground structures as part of a unified spatial system. From an engineering perspective, the placement of major features within zones of favorable slope, geological stability, and water flow further supports the interpretation of informed site selection and practical landscape management.

Beyond technical considerations, the findings also point to a broader cultural dimension in which geometry served not only functional purposes but also symbolic and cosmological roles. The recurring use of linear and spiral forms echoes patterns documented in other ancient monumental landscapes, where geometry was used to connect terrestrial construction with celestial observation and conceptual order. In this sense, the Bosnian Valley of the Pyramids may represent a synthesis of engineering knowledge and worldview, expressed through large-scale spatial planning.

The study demonstrates the value of GIS and quantitative spatial methods in re-examining prehistoric landscapes, particularly those that combine natural terrain with monumental construction. While further geophysical investigation and excavation are required to refine structural and chronological interpretations, the analytical framework presented here provides a reproducible approach for evaluating geometric coherence in complex environments. As such, this work contributes to ongoing discussions in civil engineering, urban planning, and landscape archaeology regarding how ancient societies organized space, managed terrain, and embedded meaning within the built environment.

Acknowledgments

The author expresses gratitude to the interdisciplinary scientific teams of the Archaeological Park: Bosnian Pyramid of the Sun Foundation for their long-term contributions to geophysical surveying, geodesy, archaeoastronomy, structural analysis, and environmental studies in the Bosnian Valley of the Pyramids. Special thanks are extended to international collaborators whose independent measurements and GIS modeling have strengthened the analytical framework used in this study. The author also acknowledges the local community of Visoko for their continued support of research and conservation efforts.

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Dr. Sam Osmanagich, Ph.D., is a scientist and author best known for discovering and investigating the Bosnian Pyramid Complex—Europe's largest and oldest known pyramid structure. With a doctorate in social sciences focused on ancient civilizations, he has spent over 40 years researching pyramid cultures, megalithic sites, sacred geometry, and the healing properties of ancient spaces.
He has published 36 peer-reviewed research articles and 22 books translated into 17 languages. His work challenges mainstream history and promotes interdisciplinary exploration. As Founder of the Bosnian Pyramid Foundation, he leads excavations, shares research, hosts conferences, and attracts thousands of global visitors annually.

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Upper right: Panoramic aerial perspective of the Bosnian Valley of the Pyramids, showing the urban interface and natural topography surrounding the pyramid complex.
Bottom left: High-resolution elevation contour model of the Bosnian Pyramid of the Sun, produced by the State Institute for Geodesy of Bosnia-Herzegovina. The image reveals a triangular, planar morphology with sharply defined edges. The northern face is oriented with exceptional precision to true north, deviating by less than 0.2°, a feature central to investigations of astronomical alignment.
Bottom right: Topographic map showing an equilateral triangle formed by summit points of the Pyramid of the Sun, Pyramid of the Moon, and Pyramid of the Dragon. Side lengths average approximately 2.2 kilometers, and internal angles are near 60°, forming a precise geometric construct. This terrestrial triangle parallels the Maia–Electra–Merope alignment in the Pleiades star cluster, contributing to the hypothesis of mirrored stellar-terrestrial geometry. (1)

Figure 2. Composite geomatic and photographic evidence illustrating linear and radial alignments within the Bosnian Valley of the Pyramids.

Upper right: Photographic and cartographic documentation of the linear Moon–Earth–Dragon alignment. The left panel shows a topographic map highlighting the straight-line connection among the summits of the Pyramid of the Moon, the Temple of Mother Earth, and the Pyramid of the Dragon. The right panel presents a field photograph taken near the Pyramid of the Sun, visually confirming the linear configuration of these features. This alignment closely resembles angular and proportional arrangements observed in the Pleiades star cluster.
Upper left and bottom: Geometric construction of Vesica Piscis forms derived from the summit points of the Pyramid of the Sun and Pyramid of Love (upper left), and the peaks of Krtnica and Četnica (bottom). These formations establish overlapping intersection zones that underlie Fibonacci spiral constructions. The geometry is defined by consistent angular divisions—60°, and proportions corresponding to $\sqrt{2}$, $\sqrt{3}$, and $\sqrt{5}$. This spatial logic expands the interpretive framework to include Krtnica and Četnica as potential analogues to outer Pleiades stars, specifically Pleione and Atlas. (2)

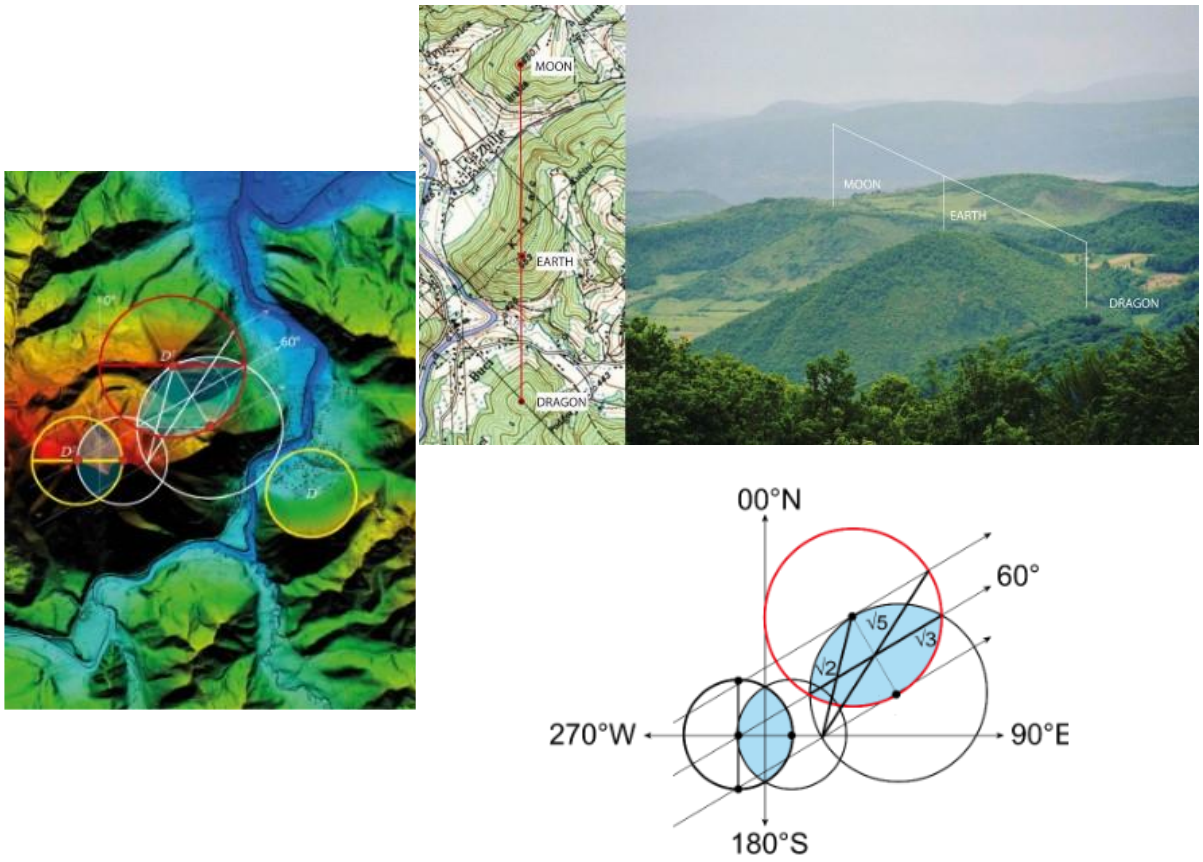

Figure 3. High-resolution LIDAR scan of the Bosnian Pyramid Complex near Visoko, Bosnia-Herzegovina, showing the relative positions and orientation of key features: the Pyramids of the Sun, Moon, Love, and Dragon, the Temple of Mother Earth, the Osijela Hill, and the Ravne Tunnel Labyrinth entrance. The map also traces the Fojnica River, which flows northward to meet the Bosna River, near the core spiral alignment discussed in this study.

Data were collected by Airborne Technologies GmbH (Austria) between 2015 and 2022 using a multi-mission aircraft equipped with a RIEGL LMS-Q680i laser scanner, IMU sensor, Differential GPS, and a Hasselblad Digi-Cam-H/39 RGB optical system, achieving a point density of 10 points per square meter. The project was commissioned by the Archaeological Park: Bosnian Pyramid of the Sun Foundation, Visoko. (2)

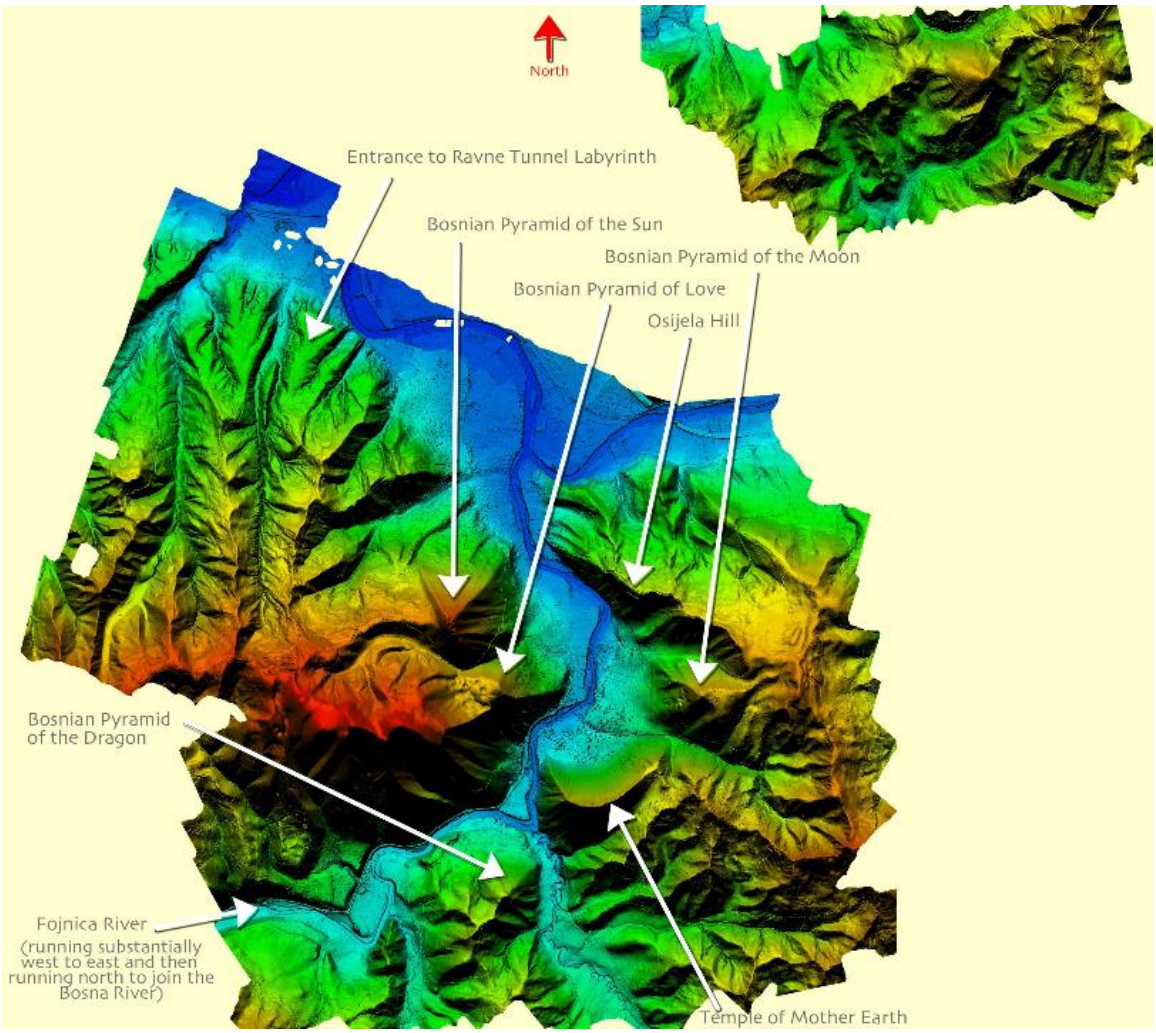

Figure 4. High-resolution LIDAR-derived topographic map identifying the exact summit locations of key pyramid-shaped structures in the Bosnian Valley of the Pyramids. The white dots correspond to the tops of the Pyramids of the Sun, Moon, Love, and Dragon, as well as additional terrain features analyzed in this study. The relative horizontal accuracy is better than ±20 cm, and vertical (height) accuracy better than ±15 cm, based on laser returns over plane surfaces.

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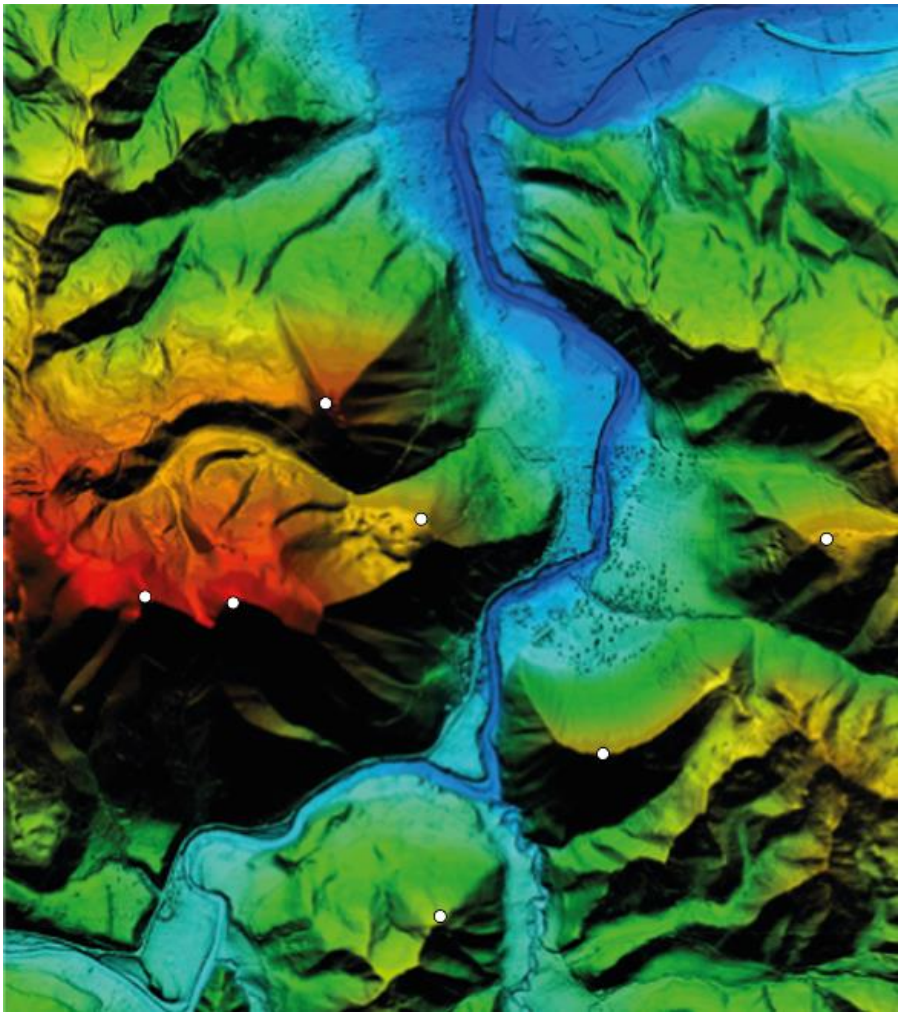


Figure 5. Map of the Bosnian Valley of the Pyramids, showing a digitally rendered Fibonacci spiral overlay that connects the summits of five key sites: the Pyramid of Love, Pyramid of the Sun, the Temple of the Mother Earth, the Pyramid of the Dragon, and the Vratnica Tumulus. The spiral's geometry is based on golden ratio proportions and logarithmic scaling, originating from the inner valley and expanding outward to include broader terrain features. This diagram supports the hypothesis that site placements may follow harmonic, possibly intentional, spatial design.(4)

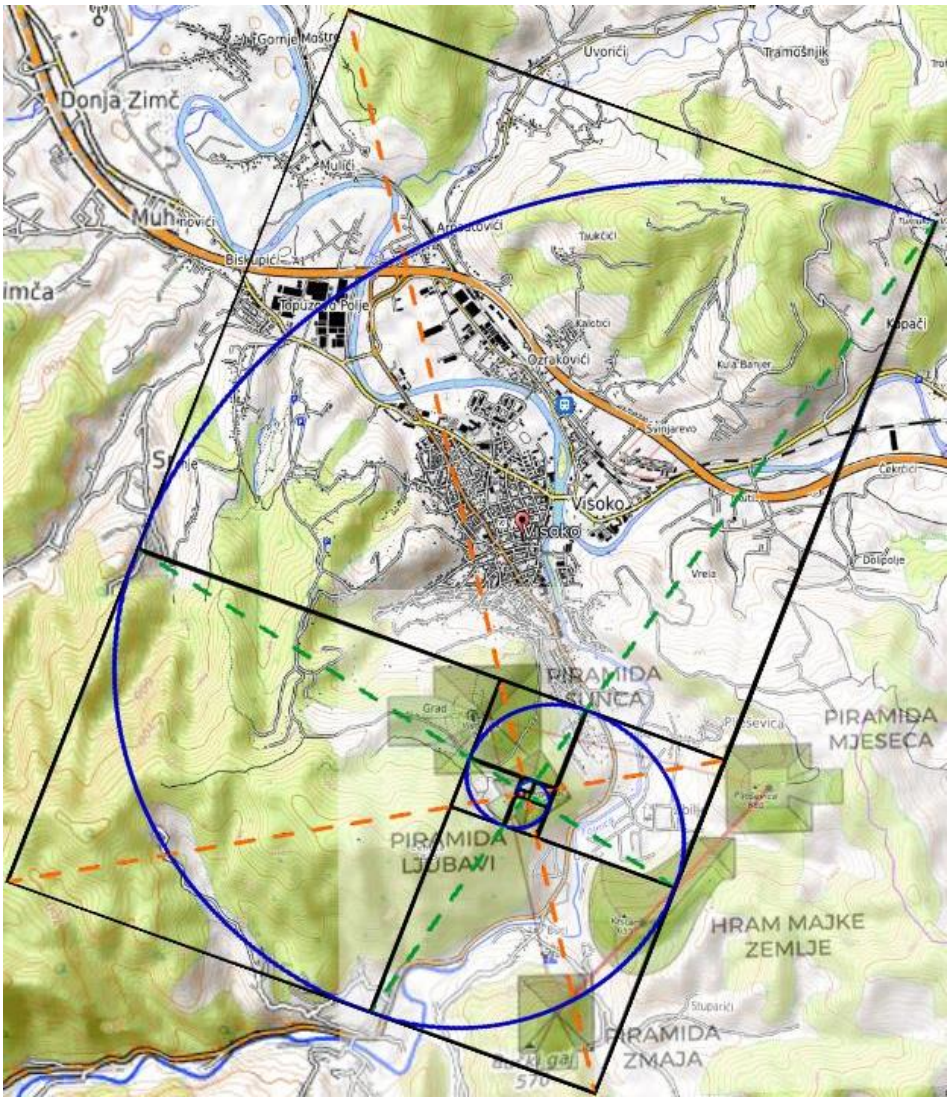


Figure 6. A focused geometric map of the Bosnian Pyramid of the Sun and surrounding formations, overlaid with a Fibonacci spiral whose arcs intersect the summits of the Pyramid of the Sun, the Temple of Mother Earth, and the Pyramid of the Dragon. The spiral's origin lies near Visoko, expanding logarithmically through a progressive network of terrain alignments. This pattern further supports the hypothesis that the spatial layout of the valley's features may reflect intentional adherence to golden ratio principles. (4)

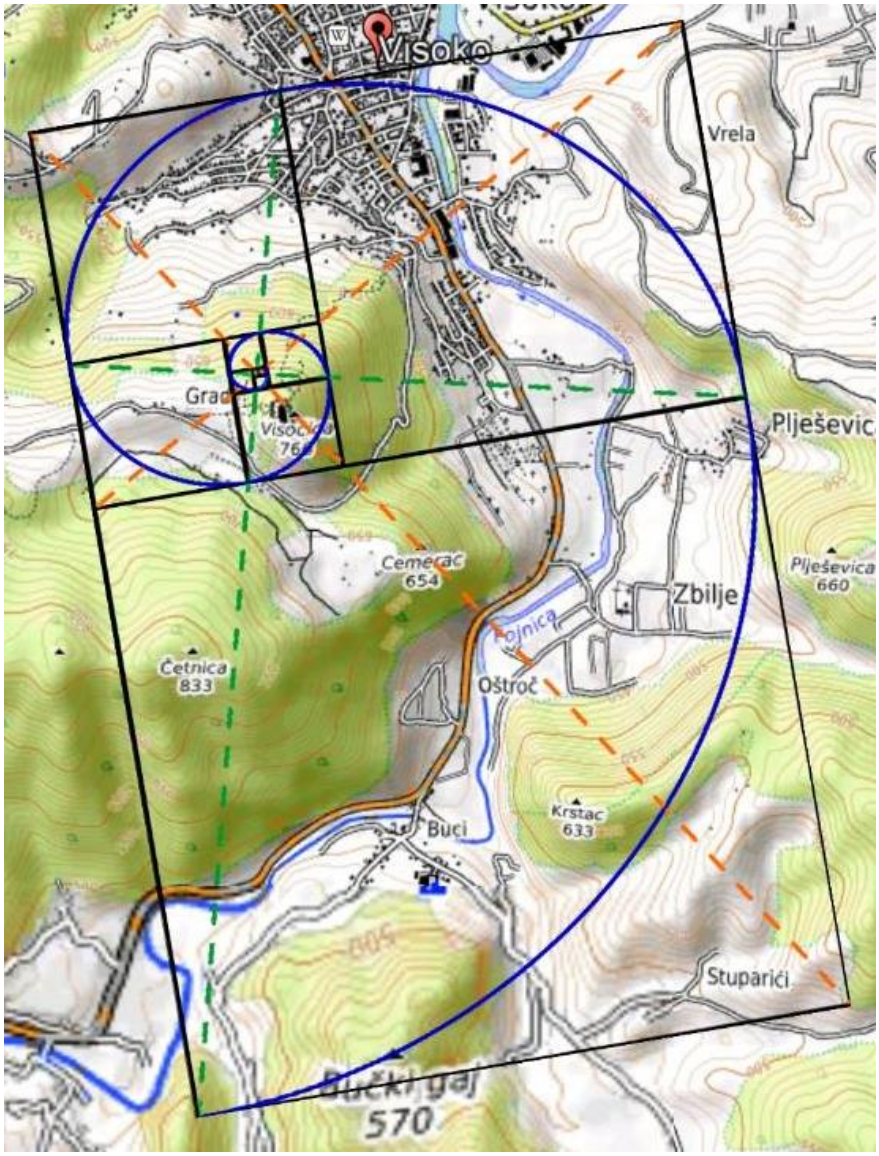


Figure 7. Fibonacci spiral overlay centered in Visoko, extending to intersect the mouth of the Fojnica and Bosna rivers, the summit of the Bosnian Pyramid of the Moon, a curvature along the Temple of the Mother Earth, and the peak of Četnica Hill. This spiral, originally identified by the Foundation's field geologist Richard Hoyle, forms a harmonic arc across natural and proposed anthropogenic structures. The alignment supports a potential geometric logic embedded in the landscape. (2)

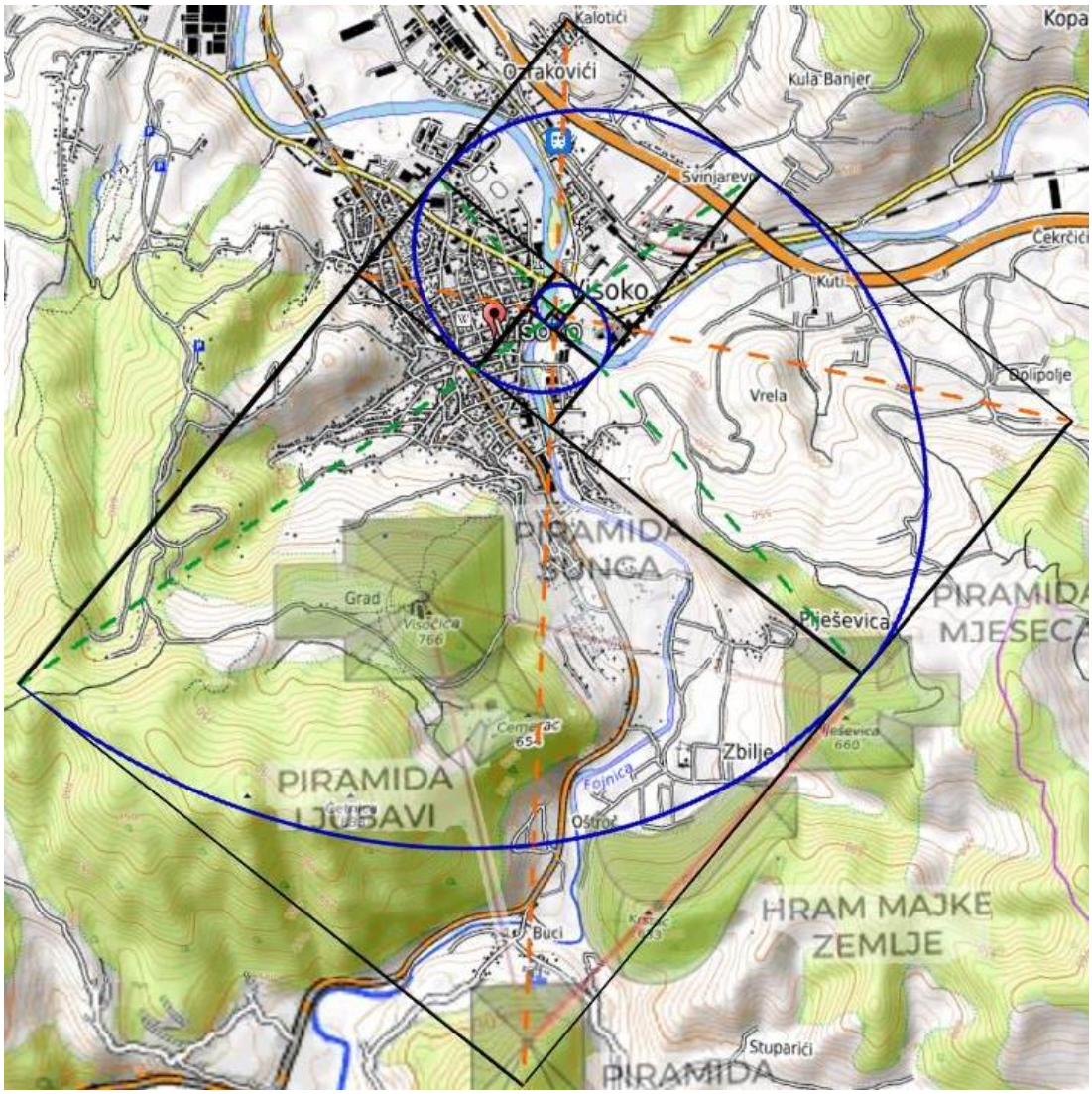
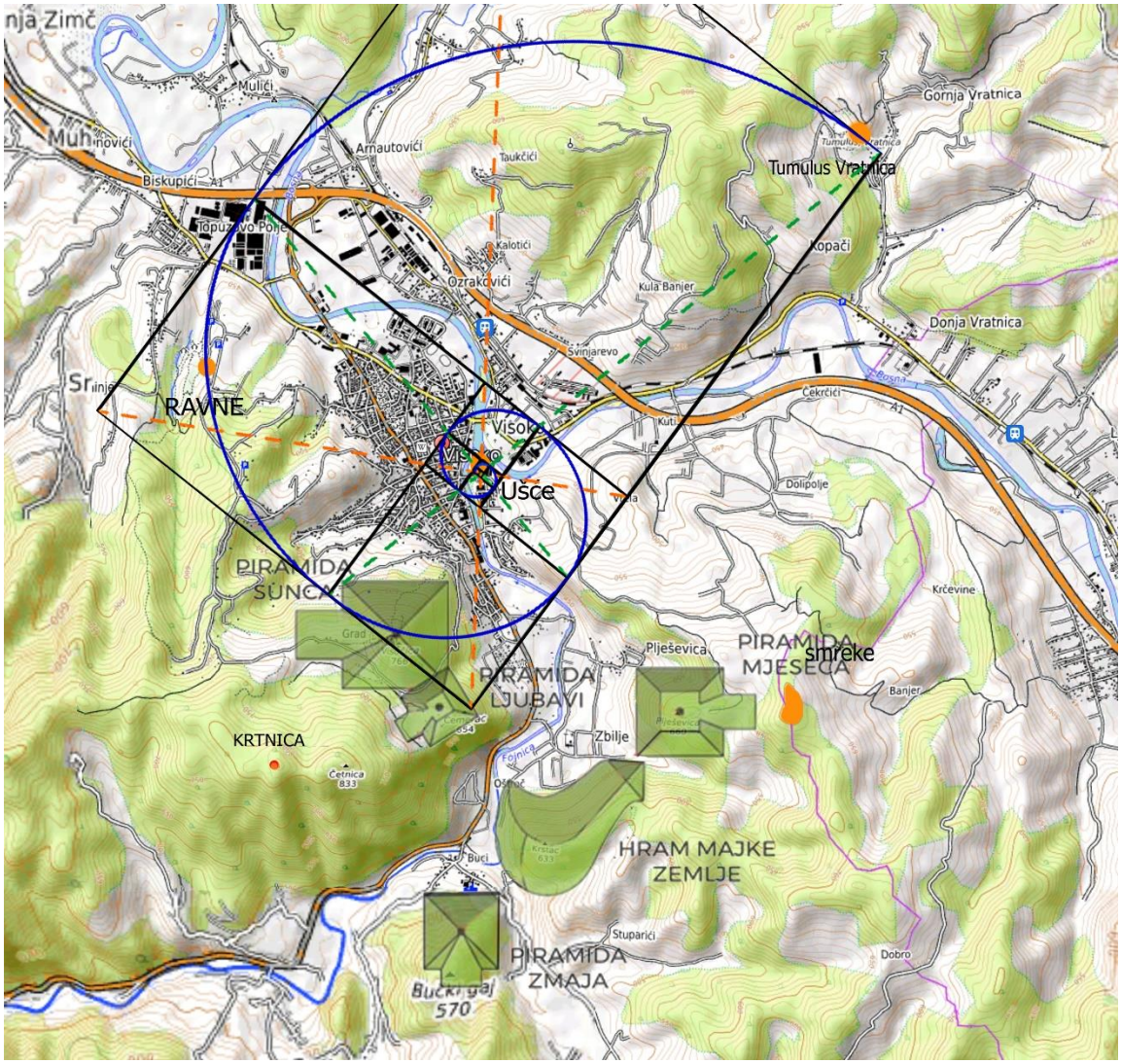


Figure 8. Geometric diagram connecting the mouth of the rivers Fojnica and Bosna, the Bosnian Pyramid of the Sun, the Ravne tunnel complex, and the Vratnica Tumulus through a Fibonacci spiral and an overlaid isosceles triangle whose sides reflect Golden Ratio proportions (1 : 1.618). The spatial relationships among these features exhibit consistent harmonic distances and angular symmetries, reinforcing the hypothesis of intentional spatial planning or selection based on sacred geometry. (3)


Tumulus Vratnica
RAVNE
Ušće
PIRAMIDA SUNCA
PIRAMIDA LJUBAVI
PIRAMIDA MJESECA
HRAM MAJKE ZEMLJE
PIRAMIDA ZMAJA
KRTNICA
smreke
Gornja Vratnica
Donja Vratnica
Višoka
Biskupići
Arnautovići
Kopači
Kula Banjer
Svinjarevo
Čekrčići
Dolipolje
Krčevine
Plješevica
Banjer
Zbilje
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