

The Bosnian Pyramid of the Dragon: A GIS-Based Spatial Analysis of Alignments, Triangular Configurations, Fibonacci Structures, and Network Centrality

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Abstract

The Bosnian Pyramid of the Dragon represents one of the principal topographic features within the Bosnian Valley of the Pyramids near Visoko, Bosnia and Herzegovina. While previous studies have examined individual geometric relationships among major features of the valley, the present study investigates whether the Bosnian Pyramid of the Dragon occupies a central position within the broader spatial geometry of a predefined landscape dataset. Using geodetic coordinates, LiDAR-derived digital elevation models, topographic datasets, and Geographic Information System (GIS) analyses, eleven summit and landscape locations selected prior to geometric evaluation were analyzed. The investigation included linear alignments, triangular configurations, logarithmic geometric models based on Fibonacci proportions, geometric centrality measures, combinatorial ranking analyses, predictive geometry assessments, and network robustness tests. Particular attention was given to the role of the Bosnian Pyramid of the Dragon within recurrent geometric structures identified across the study area. The results reveal that the Bosnian Pyramid of the Dragon participates in the principal linear alignment connecting the Bosnian Pyramid of the Moon and the Temple of Mother Earth, forms one vertex of a highly regular Sun-Moon-Dragon triangle, and serves as a defining node in multiple logarithmic geometric models. Combinatorial analyses indicate that these relationships rank among the strongest geometric configurations identified within the selected summit network. Motif participation and peak-removal robustness analyses further indicate that the Bosnian Pyramid of the Dragon serves as the most connected geometric node in the analyzed network, resulting in the greatest reduction in network connectivity when removed from the dataset. The ob-

served convergence of linear, triangular, and logarithmic geometries on the Bosnian Pyramid of the Dragon suggests that this location occupies a distinctive structural position within the spatial organization of the analyzed landscape dataset. The study demonstrates how GIS-based geometric network analysis can be applied to investigate complex spatial relationships among prominent landscape features and provides a quantitative framework for evaluating large-scale geometric patterns in cultural landscapes. The results should be interpreted as spatial observations derived from a predefined analytical dataset and do not, by themselves, establish intentional design, chronology, cultural agency, or anthropogenic origin.

Keywords

Bosnian Pyramid of the Dragon, Bosnian Valley of the Pyramids, GIS, LiDAR, Spatial Analysis, Geometric Alignment, Triangular Geometry, Fibonacci Geometry, Network Centrality, Robustness Analysis, Cultural Landscape

1. Introduction

1.1. Cultural Landscapes and Spatial Organization

Cultural landscapes frequently contain spatial relationships that are not immediately apparent through field observation alone. The development of Geographic Information Systems (GIS), high-resolution digital elevation models (DEMs), airborne LiDAR surveys, and spatial analytical methods has transformed the study of archaeological and topographic landscapes by enabling researchers to investigate large-scale spatial organization quantitatively [1] [2]. These technologies facilitate the analysis of settlement distributions, monument placement, visibility networks, transportation corridors, and relationships among prominent natural and cultural features.

Over the past three decades, GIS has become an essential methodological framework within landscape archaeology. Researchers have increasingly applied geospatial techniques to evaluate spatial patterning, topographic organization, and landscape connectivity in archaeological contexts [3] [4]. Digital terrain analysis, predictive spatial modeling, and network-based approaches have expanded investigators' ability to identify recurring spatial structures and assess whether observed configurations differ from those expected under random distributions [1] [5].

The growing availability of LiDAR datasets has further advanced archaeological landscape research by providing highly accurate representations of terrain morphology, often revealing features obscured by vegetation or modern land use [6] [7]. Combined with GIS-based spatial analysis, these datasets enable the systematic examination of relationships among topographic features across entire landscapes rather than isolated sites. As a result, archaeological investigations increas-

ingly integrate terrain modeling, remote sensing, spatial statistics, and network analysis to evaluate complex landscape organization [8] [9].

1.2. GIS and Geometric Analysis in Archaeology

The application of GIS to archaeological and landscape studies increasingly involves evaluating geometric relationships among prominent landscape features. Such analyses may involve linear alignments, geometric configurations, spatial clustering, network centrality, and predictive spatial models [2] [4]. The objective is not merely to identify visually appealing patterns but to determine whether measurable spatial relationships exist and whether they can be evaluated quantitatively using reproducible methods.

Previous studies have demonstrated that GIS provides an effective framework for testing geometric hypotheses through coordinate-based measurements, spatial statistics, and computational modeling [3] [5]. Recent developments in digital archaeology have emphasized the integration of geometric analysis, terrain modeling, and spatial networks as complementary approaches for understanding landscape organization [9]. These methods are particularly valuable when investigating landscapes characterized by multiple prominent topographic features whose spatial relationships may operate across different scales.

Within this context, geometric relationships may be evaluated through a variety of approaches, including alignment analysis, triangular configurations, geometric centrality measures, combinatorial ranking procedures, and network robustness assessments. Such methods allow researchers to compare observed spatial structures with alternative configurations, thereby reducing reliance on subjective visual interpretation. Consequently, GIS-based geometric analysis has become an increasingly important tool for evaluating the organization of archaeological and cultural landscapes.

1.3. The Bosnian Valley of the Pyramids

The Bosnian Valley of the Pyramids is located near the town of Visoko in central Bosnia and Herzegovina and contains several prominent topographic features that have been the subject of geomorphological, archaeological, and geospatial investigation during the last two decades. The study area includes the Bosnian Pyramid of the Sun, Bosnian Pyramid of the Moon, Bosnian Pyramid of Love, Bosnian Pyramid of the Dragon, the Temple of Mother Earth, the Vratnica Tumulus, and the Ravne Tunnel Complex.

The regional setting of the study area is presented in **Figure 1**. **Figure 2** shows a LiDAR-derived digital elevation model highlighting the principal topographic structures and their relative elevations. **Figure 3** presents the summit framework and spatial relationships among the analyzed locations, while **Figure 4** illustrates a three-dimensional LiDAR reconstruction of the central portion of the valley. Together, these datasets establish the geographic and geomorphological framework used throughout the present investigation.



Figure 1. Regional view of the Bosnian Valley of the Pyramids near Visoko, Bosnia-Herzegovina. The figure shows the locations of the Bosnian Pyramid of the Sun, Bosnian Pyramid of the Moon, Bosnian Pyramid of Love, Bosnian Pyramid of the Dragon, Temple of Mother Earth, Ravne Tunnel Complex, and the Vratnica Tumulus, which were analyzed in this study.

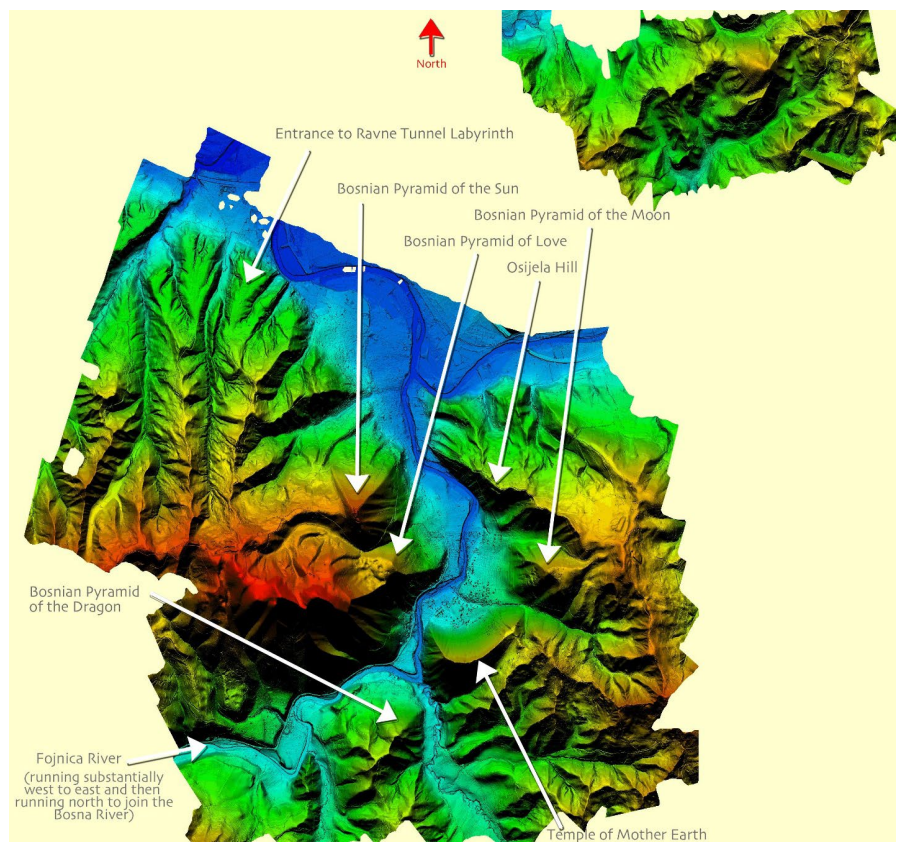


Figure 2. LiDAR-derived digital elevation model of the Bosnian Valley of the Pyramids showing the relative positions and elevations of the principal structures included in the spatial analysis.

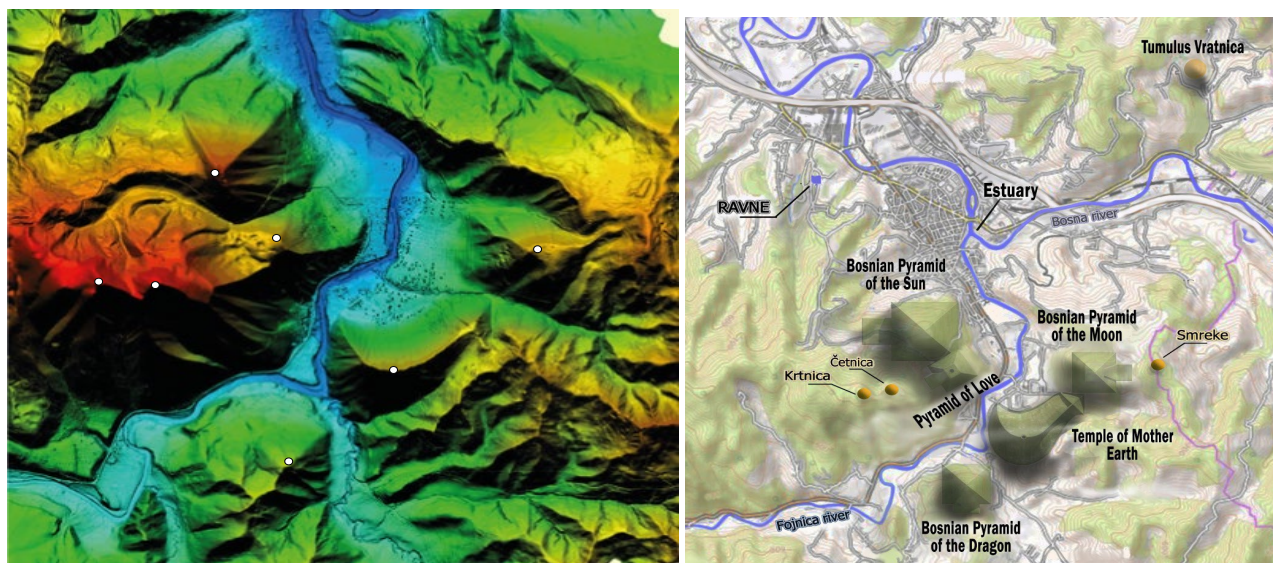


Figure 3. Spatial framework of analyzed locations within the Bosnian Valley of the Pyramids. Left: LiDAR-derived digital elevation model showing summit control points used in spatial analyses. Right: topographic representation of the principal structures, hydrographic features, and auxiliary locations included in the study.

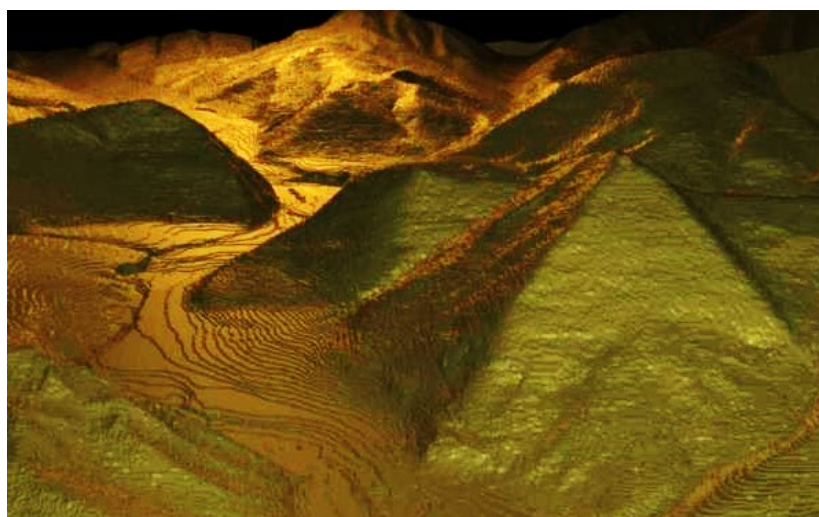


Figure 4. Three-dimensional LiDAR reconstruction of the central Bosnian Valley of the Pyramids. Visible structures include the Bosnian Pyramid of the Sun (foreground right), Bosnian Pyramid of Love (center foreground), Temple of Mother Earth (foreground left), and Bosnian Pyramid of the Dragon (background center).

The terminology used throughout this paper follows the geographic designations established in previous publications and field investigations conducted within the Bosnian Valley of the Pyramids. Names such as Bosnian Pyramid of the Sun, Bosnian Pyramid of the Moon, Bosnian Pyramid of the Dragon, Bosnian Pyramid of Love, and Temple of Mother Earth are employed as place identifiers for specific topographic features. Their use within the present study does not presuppose any particular interpretation regarding anthropogenic origin and serves solely to maintain consistency with the existing body of published literature.

1.4. Previous Research in the Bosnian Valley of the Pyramids

Previous investigations of the Bosnian Valley of the Pyramids have examined terrain morphology, cardinal orientations, summit relationships, shadow interactions, LiDAR-derived landscape models, and GIS-based evaluations of spatial geometry [10]-[16]. Several studies have focused on the Bosnian Pyramid of the Sun and its spatial relationships with neighboring structures, while others have investigated the Bosnian Pyramid of the Moon, Bosnian Pyramid of Love, the Vratnica Tumulus, and the Ravne Tunnel Complex. Collectively, these studies have identified recurring geometric relationships within the valley and have demonstrated the utility of GIS methods for evaluating large-scale spatial patterns.

The results of previous investigations suggest that the principal structures of the valley cannot be fully understood as isolated topographic entities. Rather, they form part of a broader spatial system characterized by alignments, geometric relationships, and recurring landscape-scale patterns. However, most analyses have focused on individual structures or specific geometric configurations, leaving several aspects of the broader summit network underexplored.

1.5. Knowledge Gap

Despite numerous spatial investigations conducted within the Bosnian Valley of the Pyramids, the Bosnian Pyramid of the Dragon has received comparatively limited attention as an independent spatial entity. Preliminary observations indicate that the Dragon structure repeatedly appears in linear alignments, triangular configurations, logarithmic-spiral constructions, and other recurring geometric relationships among neighboring summit locations. Nevertheless, its role within the overall spatial organization of the valley has not been evaluated previously using an integrated GIS framework that combines geometric, network, and robustness analyses.

Consequently, it remains unclear whether the Bosnian Pyramid of the Dragon merely participates in isolated geometric relationships or whether it occupies a structurally significant position within the broader summit network.

Previous studies have primarily focused on individual geometric relationships, specific alignments, or isolated logarithmic constructions. A comprehensive evaluation of the Bosnian Pyramid of the Dragon as a node within a broader geometric network has not previously been undertaken. Furthermore, few investigations have attempted to compare observed geometric relationships against the full set of alternative summit combinations available within a predefined landscape dataset. This study addresses that gap through an integrated analysis of alignments, triangular configurations, geometric participation, predictive relationships, and network robustness.

1.6. Objectives of the Present Study

Unlike previous studies that focused primarily on individual geometric constructions, the present investigation evaluates the Dragon Pyramid using an integrated

framework that combines geometry, topology, and network analysis.

To address this objective, geodetic coordinates, LiDAR-derived terrain models, topographic datasets, and GIS-based analytical methods are integrated into a unified spatial framework.

The analyses include linear alignment evaluation, triangular geometry assessment, logarithmic Fibonacci constructions, combinatorial ranking procedures, predictive geometry models, geographic and geometric centrality measures, and network robustness testing. Particular attention is given to identifying recurring geometric relationships involving the Bosnian Pyramid of the Dragon and comparing those relationships with alternative summit configurations present within the study area.

1.7. Hypothesis

The working hypothesis of this study is that the Bosnian Pyramid of the Dragon functions as a recurrent geometric node within the predefined summit dataset. If the Dragon location consistently exhibits higher participation across independent geometric frameworks than other analyzed locations, it may be interpreted as a dominant geometric hub within the spatial network. The analyses presented below evaluate this hypothesis using reproducible GIS-based methods, geometric metrics, and network robustness procedures.

2. Materials and Methods

2.1. Study Area

The Bosnian Valley of the Pyramids is located near the town of Visoko in central Bosnia and Herzegovina, approximately 30 km northwest of Sarajevo. The study area occupies a strategic position between the Bosna and Fojnica valleys and comprises a series of prominent hills, ridges, and elevated landforms that dominate the surrounding landscape. Several of these topographic features have been the subject of archaeological, geomorphological, and geospatial investigations during the last two decades [10]–[16].

The terminology used throughout this paper follows the geographic designations established in previous publications and field investigations conducted within the Bosnian Valley of the Pyramids. Names such as Bosnian Pyramid of the Sun, Bosnian Pyramid of the Moon, Bosnian Pyramid of the Dragon, Bosnian Pyramid of Love, and Temple of Mother Earth are employed as place identifiers for specific topographic features. Their use within the present study does not imply any assumption regarding anthropogenic origin and serves solely to maintain consistency with the existing body of published literature.

The present study focuses on eleven summit and landscape locations distributed throughout the valley. These include the Bosnian Pyramid of the Sun, Bosnian Pyramid of the Moon, Bosnian Pyramid of Love, the Bosnian Pyramid of the Dragon, the Temple of Mother Earth, the Vratnica Tumulus, the Ravne Tunnel Entrance, Krtnica, Četnica, Bedem, and Smreke. Together, these locations form a spatial

framework suitable for evaluating geometric relationships at the landscape scale.

The regional setting of the study area is illustrated in **Figure 1**. A LiDAR-derived digital elevation model showing the principal structures and their relative elevations is presented in **Figure 2**. **Figure 3** provides the spatial framework used throughout the analysis, including summit control points and auxiliary locations, while **Figure 4** presents a three-dimensional LiDAR reconstruction of the central portion of the valley. The geographic coordinates, projected coordinates, and elevations of all analyzed locations are summarized in **Table 1**.

Table 1. Coordinate table of analyzed summit locations.

Location	Latitude	Longitude	Y Gauss-Krüger	X Gauss-Krüger
Bosnian Pyramid of the Sun	43°58'36"N	18°10'35"E	6514549.010	4870258.900
Temple of Mother Earth	43°57'51"N	18°11'24"E	6515656.180	4868887.120
Tumulus in Vratnica	44°00'28"N	18°12'56"E	6517695.090	4873744.790
Bosnian Pyramid of the Moon	43°58'20"N	18°12'03"E	6516518.910	4869793.150
Tunnel Ravne Entrance	43°59'44"N	18°09'39"E	6513311.590	4872362.840
Bosnian Pyramid of Love	43°58'21"N	18°10'51"E	6514934.430	4869818.840
Bosnian Pyramid of the Dragon	43°57'29"N	18°10'56"E	6515038.980	4868199.190
Krtnica	43°58'09"N	18°10'01"E	6513819.850	4869456.670
Četnica	43°58'11"N	18°10'17"E	6514157.130	4869489.700
Bedem	43°57'13"N	18°10'14"E	6514109.610	4867713.720
Smreke	43°58'19"N	18°12'23"E	6516557.900	4869745.780

Geographic coordinates, projected Gauss-Krüger coordinates, and absolute elevations are reported. These values are treated as fixed inputs across all analyses.

2.2. Coordinate Dataset

The analytical dataset consisted of eleven summit and landscape locations situated within the Bosna-Fojnica river confluence region and its immediately surrounding uplands (**Table 2**). The study area was defined prior to geometric analysis and encompasses the principal topographic features that have been the subject of previous archaeological, topographic, LiDAR, and GIS investigations. The analytical dataset was intentionally restricted to locations previously documented through archaeological, topographic, LiDAR, or GIS investigations conducted between 2005 and 2026. The objective was not to evaluate all summits within the region but to compare spatial relationships among locations that already possessed independent topographic or archaeological significance prior to the present geometric analysis.

Table 2. Pairwise distances between principal structures.

From	To	Distance (m)
Bosnian Pyramid of the Sun	Bosnian Pyramid of the Moon	2,024.21
Bosnian Pyramid of the Sun	Bosnian Pyramid of the Dragon	2,117.19

Continued

Bosnian Pyramid of the Moon	Bosnian Pyramid of the Dragon	2,175.06
Bosnian Pyramid of Love	Bosnian Pyramid of the Dragon	1,623.02
Bosnian Pyramid of Love	Temple of Mother Earth	1,178.57
Bosnian Pyramid of the Moon	Temple of Mother Earth	1,251.08
Bosnian Pyramid of the Dragon	Temple of Mother Earth	924.22
Bosnian Pyramid of the Sun	Bosnian Pyramid of Love	584.98

Pairwise Euclidean distances between principal summit locations derived from projected Gauss-Krüger coordinates. Distances provide the geometric basis for alignment, triangle, and network analyses presented in subsequent sections.

The present study does not claim that these locations represent all summit points within the study area. Rather, they constitute a predefined analytical sample selected before geometric evaluation. The purpose of the analysis is therefore comparative, assessing the relative geometric behavior of locations within the same coordinate framework rather than demonstrating the existence of geometry across all possible topographic points.

Projected coordinates were used for all distance and geometric calculations because they provide a consistent planar reference system suitable for GIS analysis. Elevation values were included to support terrain interpretation and LiDAR-based visualization.

The selected locations represent the principal topographic features that repeatedly appear in previous spatial analyses of the valley [10]-[16]. In addition to the major pyramid structures, several auxiliary locations were included for their topographic prominence and participation in previously identified geometric relationships. Smreke, Krtnica, Četnica, and Bedem were incorporated into the dataset to permit broader combinatorial evaluation of alignments, triangular configurations, and network relationships across the summit system.

2.3. GIS and LiDAR Data

Spatial analyses were performed using GIS software integrating LiDAR-derived digital elevation models, orthophotographic imagery, topographic maps, and geodetic coordinate datasets. LiDAR data provided detailed representations of terrain morphology and summit structure, while orthophotos and topographic maps were used for positional verification and spatial interpretation.

All datasets were imported into a common GIS environment and examined using a consistent coordinate reference system. Spatial processing included coordinate verification, distance calculations, topographic visualization, summit identification, and geometric construction.

LiDAR-derived terrain models were used to generate the visualizations presented in **Figures 2-4** and provided the topographic framework for subsequent alignment, triangulation, and geometric analyses.

LiDAR data used in this study were acquired through airborne laser scanning

campaigns conducted by Airborne Technologies GmbH (Austria) between 2015 and 2022. Data collection employed a RIEGL LMS-Q680i laser scanner integrated with differential GPS and inertial navigation systems. The resulting digital elevation models provide an average point density of approximately 10 points per square metre, with horizontal positional accuracy of approximately ± 20 cm and vertical accuracy of approximately ± 15 cm under optimal terrain conditions.

All spatial analyses were performed using georeferenced coordinate datasets referenced to the Gauss-Krüger coordinate system. The positional uncertainty of the LiDAR and geodetic datasets is substantially smaller than the spatial offsets reported in the predictive geometry analyses, indicating that observed deviations cannot be attributed solely to measurement uncertainty.

2.4. Linear Alignment Analysis

Linear alignment analysis was conducted to evaluate the degree of collinearity among selected summit locations. Particular attention was given to the spatial relationship between the Bosnian Pyramid of the Moon, the Temple of Mother Earth, and the Bosnian Pyramid of the Dragon.

The analysis compared the perpendicular displacement of intermediate locations relative to the baseline defined by the outer summit points. Alignment quality was evaluated using a relative alignment error metric that normalizes positional deviations by baseline length. Smaller values indicate stronger linearity.

The resulting alignment model is illustrated in **Figure 5**, while quantitative measurements are presented in **Table 3**.

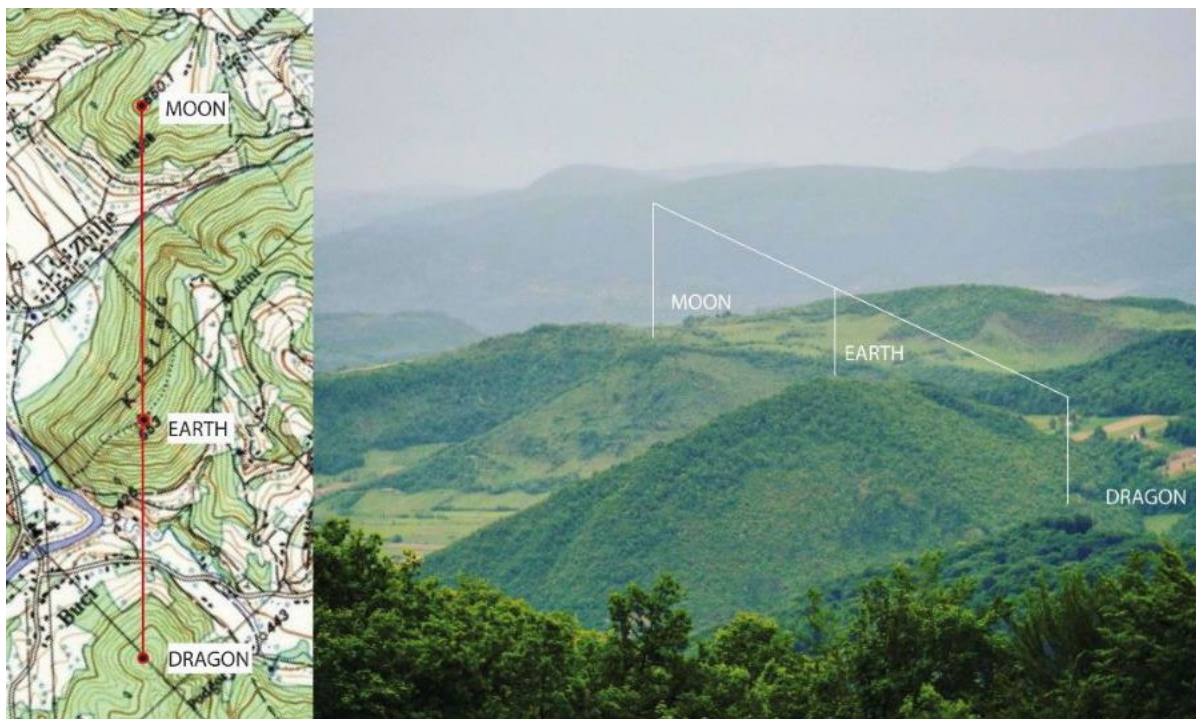


Figure 5. Linear alignment of the Bosnian Pyramid of the Moon, Temple of Mother Earth, and the Bosnian Pyramid of the Dragon.

Table 3. Alignment analysis of the Moon-Mother Earth-Dragon Axis.

Parameter	Value
Moon-Dragon distance	2,175.06 m
Mother Earth offset from axis	15.77 m
Relative deviation	0.73%
Axis azimuth (Moon→Dragon)	227.12°
Reverse azimuth	47.12°
Deviation from ideal NE-SW axis	2.12°

Quantitative evaluation of the Moon-Mother Earth-Dragon alignment. Metrics include baseline length, perpendicular offset, relative deviation, and azimuthal orientation.

2.5. Triangular Geometry Analysis

Triangular geometry analysis was performed to evaluate geometric relationships among summit locations using GIS-derived coordinate data. The principal focus was the triangular configuration formed by the Bosnian Pyramid of the Sun, the Bosnian Pyramid of the Moon, and the Bosnian Pyramid of the Dragon.

For each triangle, side lengths, interior angles, and enclosed area were calculated. To evaluate similarity to an equilateral triangle, an Equilateral Similarity Index (ESI) was applied. This metric measures the degree of uniformity among the three sides and provides a standardized basis for comparing different summit triangles.

The analyzed configuration is illustrated in **Figure 6**, and the resulting geometric parameters are summarized in **Table 4**.

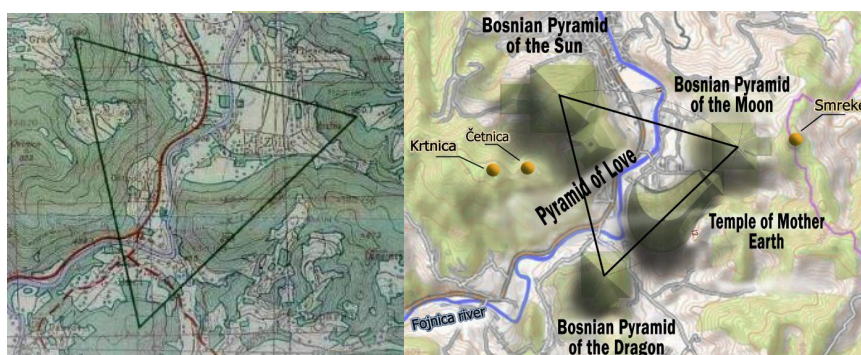


Figure 6. Topographic and GIS representations of the triangular spatial relationship between the Bosnian Pyramid of the Sun, Bosnian Pyramid of the Moon, and the Bosnian Pyramid of the Dragon. The triangle is defined using summit coordinates derived from geodetic and LiDAR datasets.

Table 4. Sun-Moon-Dragon Triangle Geometry.

Parameter	Value
Sun-Moon side	2,024.21 m
Sun-Dragon side	2,117.19 m
Moon-Dragon side	2,175.06 m

Continued

Area	1.915 km ²
Sun angle	63.32°
Moon angle	60.43°
Dragon angle	56.26°
Maximum deviation from equilateral	3.74°

Geometric characteristics of the Sun-Moon-Dragon triangle derived from summit coordinates. Side lengths, interior angles, and area are reported together with deviation from an ideal equilateral triangle.

2.6. Fibonacci Geometry Analysis

The logarithmic geometric constructions evaluated in this study should be regarded as exploratory geometric models rather than confirmatory statistical tests. The models were derived from previously published investigations that proposed logarithmic geometric relationships among selected summit locations. The present study examines whether candidate locations identified independently from those investigations also occupy positions consistent with the resulting geometric framework.

Spiral origin points were selected from locations that had previously emerged in alignment and triangular analyses and were not adjusted to improve correspondence with candidate sites. Candidate locations were evaluated only after the geometric constructions had been established.

The analyses involved selecting spiral origin points, constructing logarithmic curves, generating golden-ratio rectangles, and evaluating the intersections of summits. Multiple geometric models were examined to determine whether recurrent spatial relationships emerged across independent constructions.

The resulting geometric frameworks are illustrated in **Figures 7-10**. These analyses were conducted as geometric models intended to evaluate spatial correspondence rather than to imply causation or intentional design.

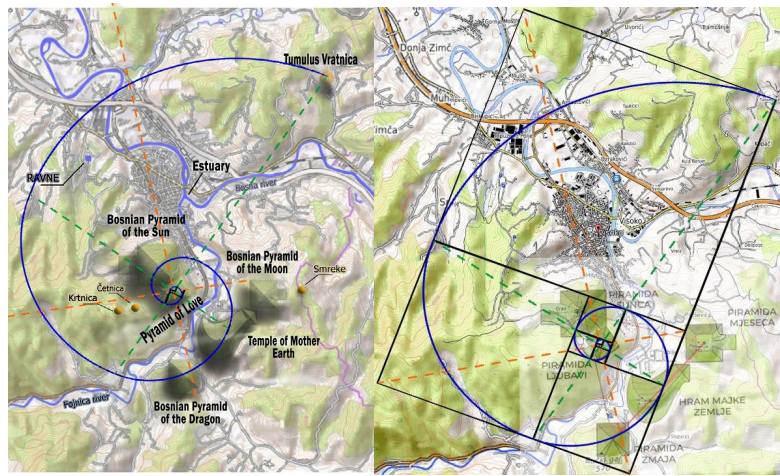


Figure 7. Logarithmic Fibonacci spiral originating at the summit of the Bosnian Pyramid of Love and passing through the summits of the Bosnian Pyramid of the Sun, Temple of Mother Earth, Bosnian Pyramid of the Dragon, and the Vratnica Tumulus.

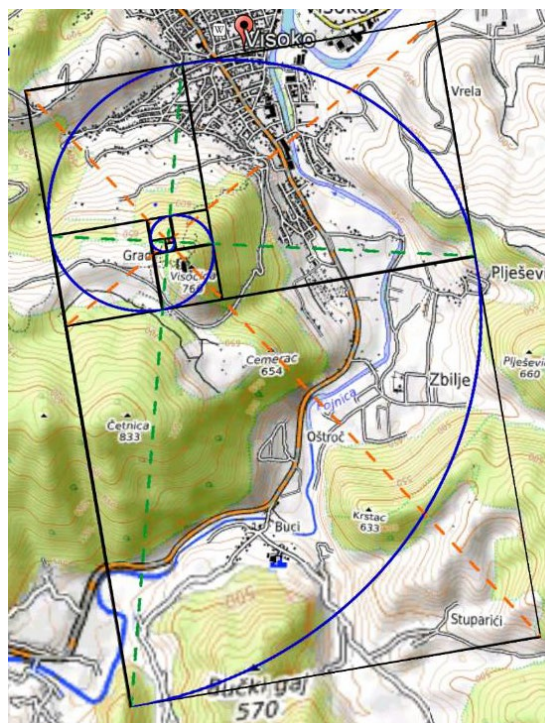


Figure 8. Logarithmic Fibonacci spiral originating at the Bosnian Pyramid of the Sun and intersecting the Temple of Mother Earth, the Bosnian Pyramid of the Dragon, and the Bedem elevation.

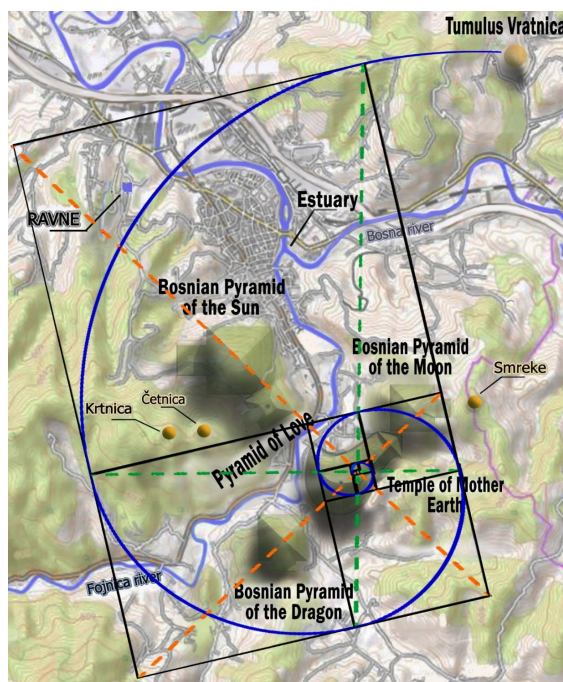


Figure 9. Integrated geometric model centered on the Temple of Mother Earth. A Fibonacci spiral connects the Temple of Mother Earth, the Bosnian Pyramid of the Moon, and the Vratnica Tumulus. The figure also illustrates the intersection of the Sun-Mother Earth and Dragon-Mother Earth-Moon axes, highlighting the Temple of Mother Earth's role as a central geometric node within the Bosnian Valley of the Pyramids.

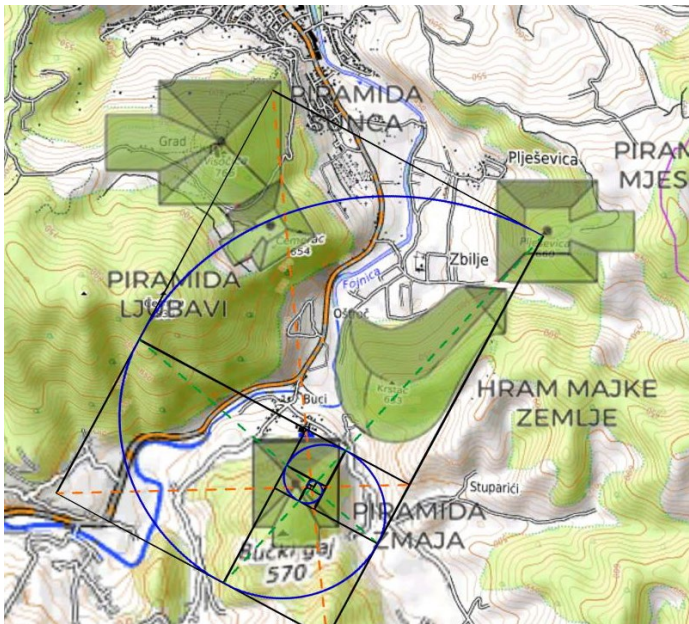


Figure 10. Dragon-centered Fibonacci spiral geometry. The summit of the Bosnian Pyramid of the Dragon serves as the origin of a logarithmic spiral and nested golden-ratio rectangles. The geometric construction links the Bosnian Pyramid of the Dragon with the Bosnian Pyramid of Love and the Bosnian Pyramid of the Moon, while the diagonals of the golden-ratio rectangles intersect at the summit of the Dragon Pyramid, forming a secondary geometric framework within the Bosnian Valley of the Pyramids.

2.7. Geographic Centrality Analysis

Geographic centrality was evaluated by calculating the geometric centroid of the summit dataset and measuring the distance between each analyzed location and the resulting center point.

Locations situated closer to the centroid were interpreted as exhibiting greater geographic centrality within the summit network. This analysis provides an objective measure of spatial position independent of geometric constructions or motif participation.

The resulting centrality values and rankings are presented in **Table 5**.

Table 5. Geographic centrality analysis.

Location	Distance from Dataset Centroid (m)	Rank
Bosnian Pyramid of Love	230.46	1
Bosnian Pyramid of the Sun	650.60	2
Četnica	1,070.40	3
Temple of Mother Earth	1,190.97	4
Krtnica	1,393.70	5
Bosnian Pyramid of the Moon	1,405.30	6
Smreke	1,450.01	7
Bosnian Pyramid of the Dragon	1,754.69	8

Continued

Bedem	2,456.73	9
Tunnel Ravne Entrance	3,015.38	10
Tumulus in Vratnica	4,582.99	11

Geographic centrality analysis based on Euclidean distance from the centroid of the summit dataset. Lower values indicate greater geographic centrality.

2.8. Geometric Motif Participation Analysis

To evaluate the relative importance of individual locations within the geometric framework, a geometric motif participation analysis was performed.

A motif was defined as an independently identified geometric relationship involving one or more summit locations. The motifs considered in this study included linear alignments, triangular configurations, logarithmic spiral relationships, and nodal geometric intersections.

Each location received a motif participation score corresponding to the number of independent geometric relationships in which it appeared. This approach provided a simple and reproducible measure of geometric connectivity within the summit network.

The resulting motif participation scores are summarized in **Table 6**.

Table 6. Geometric motif participation analysis.

Location	Linear Alignment	Triangular Configuration	Logarithmic Geometry	Geometric Intersection	Additional Geometric Relationship	Total
Bosnian Pyramid of the Dragon	1	1	1	1	1	5
Bosnian Pyramid of the Moon	1	1	0	1	1	4
Temple of Mother Earth	1	0	1	1	1	4
Bosnian Pyramid of the Sun	0	1	1	1	0	3
Bosnian Pyramid of Love	0	0	1	1	0	2
Tumulus in Vratnica	0	0	1	0	1	2
Bedem	0	0	1	0	0	1
Krtnica	0	0	0	0	0	0
Četnica	0	0	0	0	0	0
Smreke	0	0	0	0	0	0
Tunnel Ravne Entrance	0	0	0	0	0	0

Total motif participation = 21; Geometric motif participation analysis of the eleven analyzed locations. Motifs were grouped into five categories: (1) participation in a principal linear alignment, (2) participation in a principal triangular configuration, (3) participation in a logarithmic geometric model, (4) occurrence at a geometric intersection between independent constructions, and (5) participation in an additional independent geometric relationship identified within the analyzed network. Multiple occurrences of the same location within a single construction were counted only once. The Bosnian Pyramid of the Dragon exhibits the highest motif participation score (5), followed by the Bosnian Pyramid of the Moon and the Temple of Mother Earth (4 each). The total motif participation count for the network is 21, which serves as the baseline for the leave-one-out robustness analysis presented in **Table 10**. For the purposes of motif analysis, each independent geometric construction contributed to a maximum value of one participation point per location, regardless of the number of times that location appeared within the same construction.

Motif participation was calculated by counting the number of independent geometric constructions in which a given location appeared. Linear alignments, triangular configurations, logarithmic geometric models, and nodal intersections were treated as separate motif classes. Multiple occurrences of the same location within a single geometric construction were counted only once in order to avoid inflating participation scores through overlapping relationships.

2.9. Predictive Geometry Analysis

Predictive geometry analysis was conducted to assess whether geometric constructions based on known summit locations could successfully identify additional locations within the study area.

Several geometric models were constructed using alignments, intersecting axes, and triangular relationships. Predicted locations derived from these constructions were subsequently compared with observed summit positions, and positional discrepancies were recorded.

The resulting predictive relationships are summarized in **Table 7**.

Table 7. Predictive geometry analysis.

Constructed Axes	Predicted Location	Actual Location	Error (m)
Moon-Dragon × Sun-Love	Temple of Mother Earth	Temple of Mother Earth	71
Moon-Dragon alignment model	Temple of Mother Earth	Temple of Mother Earth	15.77
Sun-Moon-Dragon triangular model	Near-equilateral triangle geometry	Observed triangle	Max angular deviation 3.74°

Predictive geometry analysis evaluating the correspondence between geometrically predicted locations and observed summit locations.

For the purposes of this study, a predictive result was considered successful when the predicted location occurred within 100 m of a candidate summit position. Predictions between 100 m and 250 m were classified as moderate correspondences, while larger deviations were considered weak correspondences. These thresholds were selected because they substantially exceed the positional uncertainty of the underlying geodetic and LiDAR datasets while remaining small relative to the study area's overall dimensions.

2.10. Combinatorial Ranking Analyses

To place observed geometric relationships within the broader context of the summit dataset, combinatorial ranking procedures were applied.

All possible three-point triangular configurations and all possible three-point alignment configurations generated from the eleven analyzed locations were evaluated. The resulting combinations were ranked according to their respective geometric quality metrics.

Triangular configurations were assessed using the Equilateral Similarity Index, and alignments were ranked by relative alignment error. These procedures enabled direct comparison between the principal geometric relationships highlighted in the study and alternative configurations present within the dataset.

The resulting rankings are presented in **Tables 8 and 9**.

Table 8. Combinatorial triangle ranking analysis.

Rank	Triangle Configuration	Equilateral Similarity Index (ESI)
1	Bosnian Pyramid of the Sun - Bosnian Pyramid of the Dragon - Smreke	0.9818
2	Bosnian Pyramid of the Sun - Bosnian Pyramid of the Moon - Bosnian Pyramid of the Dragon	0.9705
3	Temple of Mother Earth - Krtnica - Bedem	0.9583
4	Tumulus in Vratnica - Tunnel Ravne Entrance - Smreke	0.9527
5	Tumulus in Vratnica - Bosnian Pyramid of the Moon - Tunnel Ravne Entrance	0.9471

Combinatorial ranking of summit triangles within the Bosnian Valley of the Pyramids. A total of 165 possible triangles were generated from the 11 analyzed locations and evaluated using an Equilateral Similarity Index (ESI), defined as one minus the coefficient of variation of side lengths. Higher values indicate greater similarity to an equilateral triangle. The Bosnian Pyramid of the Sun-Bosnian Pyramid of the Moon-Bosnian Pyramid of the Dragon triangle ranks second among all possible summit triangles and is among the most geometrically regular configurations identified in the dataset.

Table 9. Combinatorial alignment ranking analysis.

Rank	Alignment Configuration	Relative Alignment Error
1	Bosnian Pyramid of the Sun - Tumulus in Vratnica - Krtnica	0.00054
2	Krtnica - Četnica - Smreke	0.00093
3	Tunnel Ravne Entrance - Krtnica - Bedem	0.00197
4	Bosnian Pyramid of the Moon - Tunnel Ravne Entrance - Smreke	0.00298
5	Bosnian Pyramid of the Moon - Krtnica - Četnica	0.00329
6	Bosnian Pyramid of the Moon - Temple of Mother Earth - Bosnian Pyramid of the Dragon	0.00725

Combinatorial ranking of three-point summit alignments within the Bosnian Valley of the Pyramids. A total of 165 possible summit alignments were evaluated using a relative alignment error metric defined as the ratio of perpendicular deviation to baseline length. Smaller values indicate stronger linearity. The Bosnian Pyramid of the Moon-Temple of Mother Earth-Bosnian Pyramid of the Dragon alignment ranks sixth among all possible summit alignments and represents one of the strongest linear spatial relationships identified in the analyzed summit network.

2.11. Network Robustness Analysis

A leave-one-out robustness procedure was implemented to evaluate the contribution of individual locations to the overall geometric framework.

Each location was sequentially removed from the summit network, after which geometric motif participation was recalculated. The resulting reduction in network connectivity provided a measure of the relative importance of each location within the overall spatial system.

This procedure also allowed identification of locations functioning as geometric hubs whose removal produced disproportionately large effects on network structure.

The robustness analysis and geometric centrality results are presented in **Tables 10-12**.

Table 10. Leave-one-out robustness analysis of summit network geometry.

Removed Location	Motif Score Removed	Network Loss (%)
Bosnian Pyramid of the Dragon	5	23.81
Bosnian Pyramid of the Moon	4	19.05
Temple of Mother Earth	4	19.05
Bosnian Pyramid of the Sun	3	14.29
Bosnian Pyramid of Love	2	9.52
Tumulus in Vratnica	2	9.52
Bedem	1	4.76

Peak-removal robustness analysis of the geometric summit network. Network loss is calculated as the percentage reduction in total geometric motif participation resulting from the removal of an individual location. The Bosnian Pyramid of the Dragon produces the greatest reduction in network connectivity, indicating that it functions as the most influential geometric node within the analyzed summit system.

Table 11. Geometric centrality analysis of principal summit locations.

Location	Geometric Motif Score	Normalized Motif Index
Bosnian Pyramid of the Dragon	5	1.00
Bosnian Pyramid of the Moon	4	0.80
Temple of Mother Earth	4	0.80
Bosnian Pyramid of the Sun	3	0.60
Bosnian Pyramid of Love	2	0.40
Tumulus in Vratnica	2	0.40

The geometric motif score represents the number of independent geometric relationships in which each location participates, including linear alignments, triangular configurations, logarithmic spiral constructions, and nodal geometric intersections. The Bosnian Pyramid of the Dragon exhibits the highest motif participation score and therefore functions as the dominant geometric hub within the analyzed network.

Table 12. Geographic center versus geometric center.

Location	Distance from Dataset Centroid (m)	Geometric Motif Score
Bosnian Pyramid of Love	230.46	2
Bosnian Pyramid of the Sun	650.60	3
Temple of Mother Earth	1,190.97	4
Bosnian Pyramid of the Moon	1,405.30	4
Bosnian Pyramid of the Dragon	1,754.69	5
Tumulus in Vratnica	4,582.99	2

Comparison between geographic centrality and geometric centrality within the Bosnian Valley of the Pyramids. Geographic centrality is represented by distance from the dataset centroid, whereas geometric centrality is represented by motif participation. The Bosnian Pyramid of Love occupies the geographic center of the analyzed summit network, whereas the Bosnian Pyramid of the Dragon exhibits the highest level of geometric participation.

2.12. Integrated Spatial Metrics

The final stage of the analysis integrated geographic, geometric, and topographic variables into a unified spatial framework.

For each location, projected coordinates, elevation, geographic centrality, geometric motif participation, and normalized motif indices were compiled and evaluated collectively. This synthesis enabled direct comparison among locations and provided an overall assessment of their relative positions within the summit network.

The integrated spatial metrics are presented in **Table 13** and form the basis for the interpretations discussed in the Results and Discussion sections.

Table 13. Integrated spatial metrics for analyzed locations.

Location	Y Gauss-Krüger	X Gauss-Krüger	Elevation (m)	Distance from Dataset Centroid (m)	Geometric Motif Score	Normalized Motif Index
Bosnian Pyramid of Love	6514934.430	4869818.840	668.310	230.46	2	0.40
Bosnian Pyramid of the Sun	6514549.010	4870258.900	764.856	650.60	3	0.60
Četnica	6514157.130	4869489.700	836.340	1,070.40	0	0.00
Temple of Mother Earth	6515656.180	4868887.120	659.695	1,190.97	4	0.80
Krtnica	6513819.850	4869456.670	844.000	1,393.70	0	0.00
Bosnian Pyramid of the Moon	6516518.910	4869793.150	666.060	1,405.30	4	0.80
Smreke	6516557.900	4869745.780	637.000	1,450.01	0	0.00
Bosnian Pyramid of the Dragon	6515038.980	4868199.190	595.530	1,754.69	5	1.00

Continued

Bedem	6514109.610	4867713.720	527.510	2,456.73	1	0.20
Tunnel Ravne Entrance	6513311.590	4872362.840	496.650	3,015.38	0	0.00
Tumulus in Vratnica	6517695.090	4873744.790	506.710	4,582.99	2	0.40

Integrated spatial metrics for analyzed locations within the Bosnian Valley of the Pyramids. The table summarizes projected coordinates, elevation, distance from the geometric centroid of the dataset, geometric motif participation score, and normalized motif index. The motif score represents the number of independent geometric relationships in which each location participates, including alignments, triangular configurations, logarithmic spiral constructions, and nodal geometric intersections. The normalized motif index is calculated by dividing the motif score by the maximum observed score (5), allowing direct comparison among locations.

3. Results

3.1. Topographic Framework of the Bosnian Valley of the Pyramids

The Bosnian Valley of the Pyramids contains several prominent topographic structures situated within the confluence zone of the Bosna and Fojnica river valleys (Figure 1). The LiDAR-derived digital elevation model reveals a concentration of elevated landforms distributed around the central Visoko basin (Figure 2). The principal structures include the Bosnian Pyramids of the Sun, Moon, Love, and Dragon, the Temple of Mother Earth, the Vratnica Tumulus, and several surrounding elevations.

The summit framework shown in Figure 3 demonstrates that the analyzed locations form a compact spatial network occupying approximately 7 km². Three-dimensional LiDAR reconstruction further illustrates the relative elevations and spatial relationships among the major structures (Figure 4).

The coordinate dataset used throughout the analyses is presented in Table 1.

3.2. Linear Geometric Relationships

One of the most prominent linear relationships identified in the study area is formed by the Bosnian Pyramid of the Moon, the Temple of Mother Earth, and the Bosnian Pyramid of the Dragon (Figure 5).

Quantitative alignment metrics are summarized in Table 3. The Moon–Mother Earth–Dragon alignment extends across the central portion of the valley and exhibits a perpendicular deviation of 15.77 m over a baseline length of 2,175.06 m, corresponding to a relative alignment error of 0.73%.

Combinatorial ranking analysis further indicates that the Moon–Mother Earth–Dragon alignment ranks sixth among the 165 possible three-point summit alignments evaluated within the dataset (Table 9).

3.3. Triangular Configurations

The Bosnian Pyramids of the Sun, Moon, and Dragon form a near-equilateral triangular configuration (Figure 6).

Geometric measurements for the principal triangle are presented in **Table 4**. Side lengths range from 2,024.21 m to 2,175.06 m, while the interior angles exhibit a maximum deviation of 3.74° from an ideal equilateral triangle. The enclosed area of the triangle is 1.915 km².

Combinatorial ranking analysis identified the Sun-Moon-Dragon triangle as one of the most regular triangular configurations within the summit network. Among the 165 possible triangles generated from the eleven analyzed locations, the Sun-Moon-Dragon configuration ranks second according to the Equilateral Similarity Index (**Table 8**).

3.4. Logarithmic Fibonacci Structures

Several logarithmic Fibonacci spiral constructions were identified within the analyzed summit network.

The first configuration originates at the Bosnian Pyramid of Love and intersects the Bosnian Pyramid of the Sun, the Temple of Mother Earth, the Bosnian Pyramid of the Dragon, and the Vratnica Tumulus (**Figure 7**).

A second configuration originates at the Bosnian Pyramid of the Sun and intersects the Temple of Mother Earth, the Bosnian Pyramid of the Dragon, and the Bedem elevation (**Figure 8**).

A third configuration places the Temple of Mother Earth at the center of the logarithmic construction and incorporates the Bosnian Pyramid of the Moon, the Bosnian Pyramid of the Dragon, and the Vratnica Tumulus (**Figure 9**).

The fourth configuration highlights geometric relationships among the Bosnian Pyramid of the Dragon, the Bosnian Pyramid of Love, the Bosnian Pyramid of the Moon, and associated summit locations through a Dragon-centered logarithmic spiral and nested golden-ratio framework (**Figure 10**).

Collectively, these constructions demonstrate the recurrence of logarithmic geometric relationships among the principal structures of the valley.

3.5. Geographic and Geometric Centrality

Geographic centrality analysis was performed using the centroid of the summit dataset. Distances from the centroid to each analyzed location are summarized in **Table 5**.

The Bosnian Pyramid of Love exhibits the smallest centroid distance and therefore occupies the most geographically central position within the summit network. The Bosnian Pyramid of the Sun ranks second, while the Bosnian Pyramid of the Dragon ranks eighth among the analyzed locations.

A different pattern emerges from the geometric motif participation analysis (**Table 6**). The Bosnian Pyramid of the Dragon participates in the greatest number of geometric structures, including alignments, triangular configurations, logarithmic spiral models, and nodal geometric relationships. The Bosnian Pyramid of the Moon and the Temple of Mother Earth exhibit the next highest motif participation scores.

In total, 21 independent geometric motifs were identified within the analyzed network. The Bosnian Pyramid of the Dragon participates in five motifs, representing the highest motif participation score observed among all analyzed locations.

3.6. Predictive Geometry Analysis

Predictive geometric testing was conducted to evaluate whether summit locations could be reconstructed from previously identified geometric relationships.

Results are summarized in **Table 7**. Several summit positions were successfully approximated through combinations of alignments, triangular constructions, and logarithmic geometric models. The intersection of the Moon-Dragon and Sun-Love axes predict the location of the Temple of Mother Earth with a positional discrepancy of 71 m, while the Moon-Dragon alignment predicts the Temple of Mother Earth with an offset of 15.77 m.

These results demonstrate measurable geometric redundancy within the analyzed summit network.

3.7. Combinatorial Ranking Analyses

All possible summit combinations were evaluated to determine the relative ranking of observed geometric configurations.

The triangular ranking analysis is summarized in **Table 8**. Although the Sun-Dragon-Smreke triangle achieved the highest Equilateral Similarity Index, it was not identified independently through alignments, logarithmic constructions, or predictive geometry analyses. For this reason, the Sun-Moon-Dragon configuration remains of greater interest within the integrated network framework examined in this study.

Alignment ranking results are presented in **Table 9**. The highest-ranked alignment comprises the Bosnian Pyramid of the Sun, the Vratnica Tumulus, and Krt-nica. The Moon-Mother Earth-Dragon alignment ranks sixth among all evaluated three-point summit alignments.

These rankings place the principal geometric relationships identified in the study among the strongest configurations present within the complete summit dataset.

3.8. Network Robustness

Network robustness analysis was performed by sequentially removing individual summit locations and recalculating geometric connectivity metrics (**Table 10**).

The removal of the Bosnian Pyramid of the Dragon resulted in the largest reduction in network connectivity (23.81%). Removal of the Bosnian Pyramid of the Moon and the Temple of Mother Earth each resulted in a 19.05% reduction, while removal of the Bosnian Pyramid of the Sun resulted in a 14.29% reduction.

The remaining locations generated progressively smaller reductions in overall network connectivity.

Geometric centrality values derived from motif participation are presented in **Table 11**. The Bosnian Pyramid of the Dragon exhibits the highest normalized motif index, followed by the Bosnian Pyramid of the Moon and the Temple of Mother Earth.

3.9. Integrated Spatial Metrics

The combined results of geographic centrality, geometric participation, combinatorial ranking, predictive geometry, and network robustness analyses are summarized in **Tables 12 and 13**.

The Bosnian Pyramid of Love occupies the geographic center of the summit network, whereas the Bosnian Pyramid of the Dragon exhibits the highest geometric participation score and the largest influence on network connectivity. Intermediate values are observed for the Bosnian Pyramid of the Moon, the Temple of Mother Earth, and the Bosnian Pyramid of the Sun.

Taken together, the analyses indicate that the Bosnian Pyramid of the Dragon exhibits the highest geometric participation scores and the largest network influence values among the analyzed locations.

The predictive correspondences reported in this study should be regarded as spatial observations requiring independent archaeological verification.

4. Discussion

4.1. The Bosnian Pyramid of the Dragon within the Spatial Geometry of the Valley

The results indicate that the Bosnian Pyramid of the Dragon occupies a distinctive position within the geometric organization of the Bosnian Valley of the Pyramids. Unlike several other analyzed locations that participate in only one or two geometric relationships, the Dragon Pyramid repeatedly appears in linear alignments, triangular configurations, and logarithmic Fibonacci structures. This recurrence across multiple independent geometric frameworks suggests that its role within the analyzed landscape extends beyond that of an isolated topographic feature.

The most prominent linear relationship identified in this study is formed by the Bosnian Pyramid of the Moon, the Temple of Mother Earth, and the Bosnian Pyramid of the Dragon. Likewise, the Dragon Pyramid forms one vertex of the highly regular Sun-Moon-Dragon triangle and appears in several logarithmic-spiral constructions involving neighboring summit locations. The simultaneous occurrence of these relationships indicates a degree of geometric integration not observed at most other nodes analyzed.

The repeated appearance of the Bosnian Pyramid of the Dragon across independent geometric models is particularly noteworthy because each analytical approach was developed separately and evaluated using different criteria. Consequently, the recurrence of the Dragon Pyramid cannot be attributed to a single analytical procedure; rather, it emerges consistently throughout the study.

4.2. Geographic Center versus Geometric Center

One of the most significant findings of this investigation is the distinction between geographic centrality and geometric centrality.

Geographic centrality analysis identified the Bosnian Pyramid of Love as the location nearest to the centroid of the summit network. In purely geographic terms, Love therefore occupies the most central position within the study area.

However, geometric participation analyses produced a different result. The Bosnian Pyramid of the Dragon exhibited the highest motif participation score, the highest normalized geometric centrality index, and the strongest influence on network connectivity. This distinction demonstrates that the geographic center of a landscape does not necessarily coincide with its geometric center.

The concept of a geometric center may be defined as the location exhibiting the greatest participation within a network of spatial relationships. Under this definition, the Bosnian Pyramid of the Dragon emerges as the most connected geometric node of the analyzed summit system. The contrast between the geographic position of the Bosnian Pyramid of Love and the geometric prominence of the Bosnian Pyramid of the Dragon represents one of the most distinctive outcomes of the present study.

4.3. Robustness of the Geometric Network

Network robustness analysis further supports the importance of the Bosnian Pyramid of the Dragon within the broader spatial framework.

The removal of individual locations had varying effects on overall network connectivity. The largest reduction occurred when the Bosnian Pyramid of the Dragon was removed from the network. Removal of the Bosnian Pyramid of the Moon and the Temple of Mother Earth also produced measurable reductions, whereas removal of several peripheral locations generated comparatively small effects.

These results indicate that a substantial proportion of the identified geometric relationships depend directly upon the Dragon node. The robustness analysis, therefore, independently corroborates the conclusions obtained from motif participation and geometric centrality measurements.

Taken together, the centrality and robustness analyses indicate that the Bosnian Pyramid of the Dragon occupies a structurally influential position within the geometric network under analysis.

4.4. Significance of the Combinatorial Rankings

A common criticism of geometric landscape studies is that visually compelling patterns may emerge from large collections of spatial points simply by chance. To address this issue, the present study evaluated all possible triangular configurations and all possible three-point alignments generated from the eleven-location summit dataset.

The resulting rankings place the principal geometric relationships involving the

Bosnian Pyramid of the Dragon among the strongest configurations identified within the complete set of possible summit combinations. The Sun-Moon-Dragon triangle ranked second among all evaluated summit triangles, while the Moon-Mother Earth-Dragon alignment ranked sixth among all evaluated three-point alignments.

These rankings do not demonstrate causation, intentionality, or cultural significance. However, they provide an objective measure of relative geometric prominence and indicate that the highlighted configurations are not arbitrary selections from a much larger set of possible relationships. From a methodological perspective, combinatorial evaluation strengthens geometric analysis by placing individual observations within the context of all available alternatives.

4.5. Relationship with Previous Investigations

Previous studies of the Bosnian Valley of the Pyramids have documented a variety of geometric relationships involving the Bosnian Pyramid of the Sun, the Bosnian Pyramid of the Moon, the Bosnian Pyramid of Love, the Vratnica Tumulus, and other landscape features [10]-[16]. These investigations demonstrated that the valley contains recurring alignments, triangular configurations, and logarithmic geometric constructions.

The present study extends those investigations by focusing specifically on the Bosnian Pyramid of the Dragon and evaluating its position within the broader summit network. Rather than examining individual geometric structures in isolation, the current analysis integrates multiple classes of spatial relationships into a single GIS-based framework.

The resulting pattern consistently identifies the Bosnian Pyramid of the Dragon as one of the most influential nodes within the analyzed landscape. In this respect, the study complements earlier investigations while providing a more comprehensive evaluation of the Dragon Pyramid's spatial role within the valley.

4.6. Implications for Landscape Geometry

The coexistence of linear alignments, near-equilateral triangular configurations, logarithmic geometric structures, and network-level connectivity patterns suggests that the Bosnian Valley of the Pyramids can be examined as an integrated geometric system rather than as a collection of independent landforms.

The integrated spatial metrics presented in **Tables 12 and 13** demonstrate that these geometric relationships are not independent but interconnected through a small number of recurring summit locations, most notably the Bosnian Pyramid of the Dragon.

Whether these relationships result from cultural design, geomorphological processes, observational bias, or a combination of factors remains beyond the scope of the present study. The objective of this investigation was not to determine the origin of the observed configurations but rather to evaluate their spatial properties using reproducible GIS methods.

From this perspective, the principal finding is that the Bosnian Pyramid of the Dragon serves as a recurring geometric node that links multiple classes of spatial relationships throughout the valley.

4.7. Limitations and Future Research

Several limitations should be acknowledged. First, the analyses were conducted using a finite summit and landscape locations selected based on topographic prominence and prior investigations. Additional LiDAR-derived peak inventories may reveal further geometric relationships not considered in the present study.

Second, although geometric rankings, centrality measures, and robustness metrics provide quantitative measures of spatial organization, they do not, by themselves, establish the causal mechanisms responsible for the observed configurations.

Third, the logarithmic geometric models presented in this study represent one possible class of geometric interpretation. Alternative spatial models and statistical approaches may reveal additional patterns within the same landscape.

Future research should incorporate expanded LiDAR datasets, automated peak-detection procedures, large-scale combinatorial analyses, spatial null models, and Monte Carlo simulations to evaluate the probability that comparable geometric structures arise in randomly generated landscape networks. Such investigations may provide a more comprehensive understanding of the spatial organization of the Bosnian Valley of the Pyramids and the role of the Bosnian Pyramid of the Dragon within that system.

The study evaluates relative geometric prominence within a predefined dataset of summits and does not address questions of chronology, cultural agency, or intentional construction.

5. Conclusions

This study employed GIS-based spatial analysis, LiDAR-derived elevation models, geodetic coordinate datasets, and geometric network evaluation to investigate the role of the Bosnian Pyramid of the Dragon within the Bosnian Valley of the Pyramids. Eleven summit and landscape locations were analyzed through a combination of alignment measurements, triangular geometry, logarithmic Fibonacci structures, geographic centrality metrics, geometric participation analysis, combinatorial ranking procedures, and network robustness testing.

Several principal findings emerged from the investigation.

First, the Bosnian Pyramid of the Dragon forms part of one of the highest-ranked linear relationships identified within the study area, namely the Moon-Mother Earth-Dragon alignment. Combinatorial analysis demonstrated that this configuration ranks among the strongest alignments within the summit network analyzed.

Second, the Dragon Pyramid constitutes one vertex of the Sun-Moon-Dragon triangle, a highly regular geometric configuration that ranked second among the

165 possible triangular relationships generated from the summit dataset. The persistence of this triangular geometry across independent analyses demonstrates its importance within the broader spatial framework of the valley.

Third, the Bosnian Pyramid of the Dragon repeatedly appeared in logarithmic Fibonacci constructions involving the Bosnian Pyramid of the Sun, Bosnian Pyramid of the Moon, Bosnian Pyramid of Love, the Temple of Mother Earth, the Vratnica Tumulus, and several surrounding elevations. The recurrence of the Dragon node across multiple independent spiral configurations distinguishes it from most other locations analyzed.

Fourth, geographic and geometric centrality analyses produced different outcomes. While the Bosnian Pyramid of Love occupies the geographic center of the summit network, the Bosnian Pyramid of the Dragon exhibits the highest level of geometric participation. This distinction demonstrates that geographic centrality and geometric influence represent separate spatial properties within complex landscape systems.

Fifth, network robustness testing identified the Bosnian Pyramid of the Dragon as the location whose removal produced the greatest reduction in geometric connectivity. This result indicates that a substantial proportion of the observed geometric relationships depend directly upon the Dragon node and confirms its importance within the overall network structure.

Collectively, the analyses reveal a consistent pattern. Linear alignments, triangular configurations, logarithmic Fibonacci structures, geometric participation scores, combinatorial rankings, and robustness metrics independently identify the Bosnian Pyramid of the Dragon as a recurrent and influential component of the spatial organization of the Bosnian Valley of the Pyramids.

The principal contribution of this study is therefore both methodological and geographic. By integrating GIS analysis, LiDAR terrain modeling, geometric ranking procedures, and network-based evaluation within a single analytical framework, the research demonstrates how complex spatial relationships among prominent landscape features can be investigated quantitatively and reproducibly.

Within the limits of the analyzed dataset, the Bosnian Pyramid of the Dragon exhibits the highest level of geometric participation among the evaluated locations.

Future investigations incorporating expanded LiDAR inventories, automated peak detection, predictive archaeological field verification, spatial null models, and large-scale Monte Carlo simulations may further refine understanding of the processes responsible for the observed spatial organization.

Data Availability Statement

The coordinate dataset analyzed in this study is included within the manuscript. Additional GIS layers, LiDAR-derived visualizations, and supporting spatial data are available from the author upon reasonable request.

Author Contributions

Sam Osmanagich conceived the study, compiled the datasets, performed the GIS analyses, interpreted the results, and wrote the manuscript.

Artificial Intelligence Use Statement

Artificial intelligence tools were used solely for editorial assistance, language refinement, organizational review, and support for manuscript development. All scientific concepts, hypotheses, analytical procedures, calculations, figures, tables, interpretations, and conclusions were developed, verified, and approved by the author. The author assumes full responsibility for the content and accuracy of the manuscript.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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