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When Landscape Becomes Geometry II: Multi-Anchor Fibonacci Spiral Modeling in the Bosnian Valley of the Pyramids

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Abstract

This study extends prior geometric analysis of the Bosnian Valley of the Pyramids by evaluating Fibonacci-based logarithmic spiral modeling within a fixed geodetic coordinate framework. Using high-resolution LiDAR data and predefined summit-level reference points, spiral trajectories governed by a constant golden-ratio growth factor ($\varphi \approx 1.618$) were applied under bounded scale and orientation parameters. A uniform ±20 m positional tolerance threshold and a minimum three-node intersection criterion were enforced. Formal Monte Carlo testing (10,000 iterations) was conducted for the Sun-anchored configuration under symmetric spatial redistribution with identical parameter constraints. The resulting four-node intersection lies in the upper tail of the simulated distribution, indicating that comparable multi-node coherence occurs infrequently under uniform spatial randomness within the valley envelope. Additional anchor points exhibit descriptive multi-node spiral correspondences under the same modeling framework but were not subjected to independent hypothesis testing. The probability estimates presented are conditional on the defined planar null model and do not incorporate terrain-constrained redistribution. When considered alongside previously documented linear and triangular spatial relationships, the results suggest that curved proportional geometry may operate within an already structured coordinate network. The study's primary contribution is methodological: it demonstrates that fixed-growth spiral models, when evaluated using bounded parameter grids and explicit Monte Carlo testing, provide a reproducible framework for assessing curved geometric hypotheses in complex landscapes.

Keywords

Bosnian Valley of the Pyramids, Fibonacci Spiral, Golden Ratio, Spiral Architecture, Landscape Geometry, Pyramid Complexes, Tumuli, Monte Carlo Simulation

1. Introduction

The Bosnian Valley of the Pyramids is situated within a geomorphologically distinct basin defined by pyramidal hill formations, tumuli, hydrological junctions, and subterranean tunnel systems. An overview of the valley and its principal monuments is shown in **Figure 1**, which establishes the spatial framework and feature distribution examined in this study.

Figure 1. Overview of the Bosnian Valley of the Pyramids and principal points of interest. Oblique satellite view of the Visoko Valley, Bosnia and Herzegovina, showing the spatial distribution of the Bosnian Pyramid of the Sun and associated monumental features, including the Bosnian Pyramid of the Moon, Bosnian Pyramid of the Dragon, Bosnian Pyramid of Love, and the Temple of Mother Earth. Also indicated are major subterranean access points (Ravne and KTK tunnels), selected tumuli, and the urban area of Visoko. This figure establishes the valley-scale spatial context and feature inventory examined in Part II, serving as the reference framework for subsequent analyses of linear alignments, nodal relationships, and architectural-scale spatial organization. Source: Google Earth imagery; annotations by the author.

A three-dimensional terrain reconstruction derived from photogrammetric and elevation modeling is presented in **Figure 2**. This reconstruction clarifies summit prominence, relative relief, and the hydrological convergence of the Fojnica and Bosna rivers. The Bosnian Pyramid of the Sun appears as the dominant structure within the valley, with adjacent pyramidal formations and tumuli integrated into the surrounding landscape morphology.

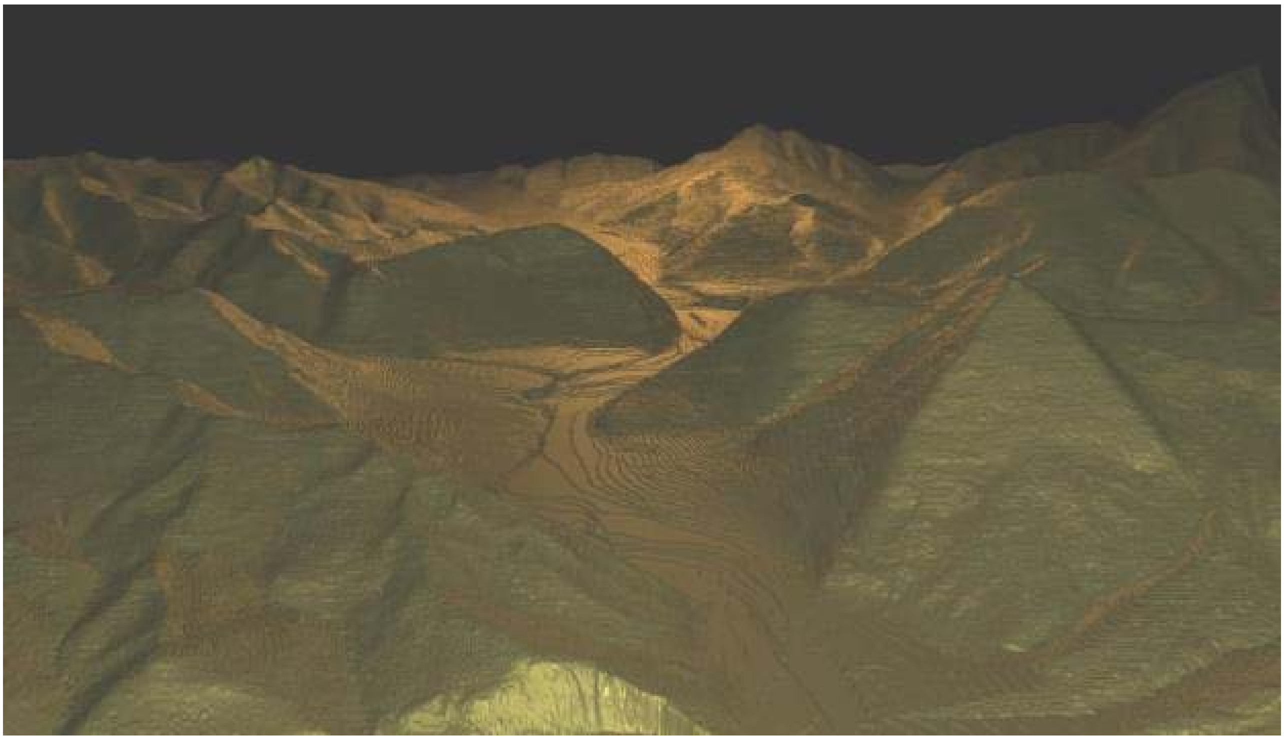

Figure 2. Three-dimensional terrain reconstruction of the Visoko Valley and pyramid-shaped formations. A 3D digital reconstruction of the Visoko Valley based on photogrammetric modeling, Z-map elevation data, and WebGL rendering, illustrating the relative morphology and spatial relationships of pyramid-shaped formations within the Bosnian Valley of the Pyramids. The Bosnian Pyramid of the Sun is shown as the dominant central structure, with adjacent pyramidal forms integrated into the surrounding topography. The reconstruction highlights the role of hydrology, with the Fojnica River flowing west-east before joining the Bosna River north of the Pyramid of the Sun. The convergence of river systems at the base of the primary monument provides important contextual information for subsequent analyses of nodal positioning, axial planning, and landscape-scale spatial architecture addressed in Part II [1].

High-resolution airborne LiDAR mapping with geodetically defined summit centroids is shown in **Figure 3**. These summit locations, validated through differential GPS and state geodetic control, form the fixed spatial dataset used throughout this analysis [2]. The complete coordinate reference framework, including pyramidal summits, tumuli, hydrological nodes, and tunnel entrances, is presented in **Figure 4**. All geometric constructions in Part II are based strictly on these predefined coordinates. No positional adjustments were made to improve spiral fit.

Part I of this study demonstrated that the valley exhibits statistically constrained linear, triangular, and cardinal spatial regularities under fixed geometric rules and Monte Carlo testing [3]. Summit-to-summit alignments and near-equilateral triangular configurations among the Bosnian Pyramids of the Sun, Moon, and Dragon were shown to exceed expectations under constrained spatial redistribution. These rectilinear relationships, documented in **Figures 5-8**, provide the structural baseline for evaluating curved proportional geometry.

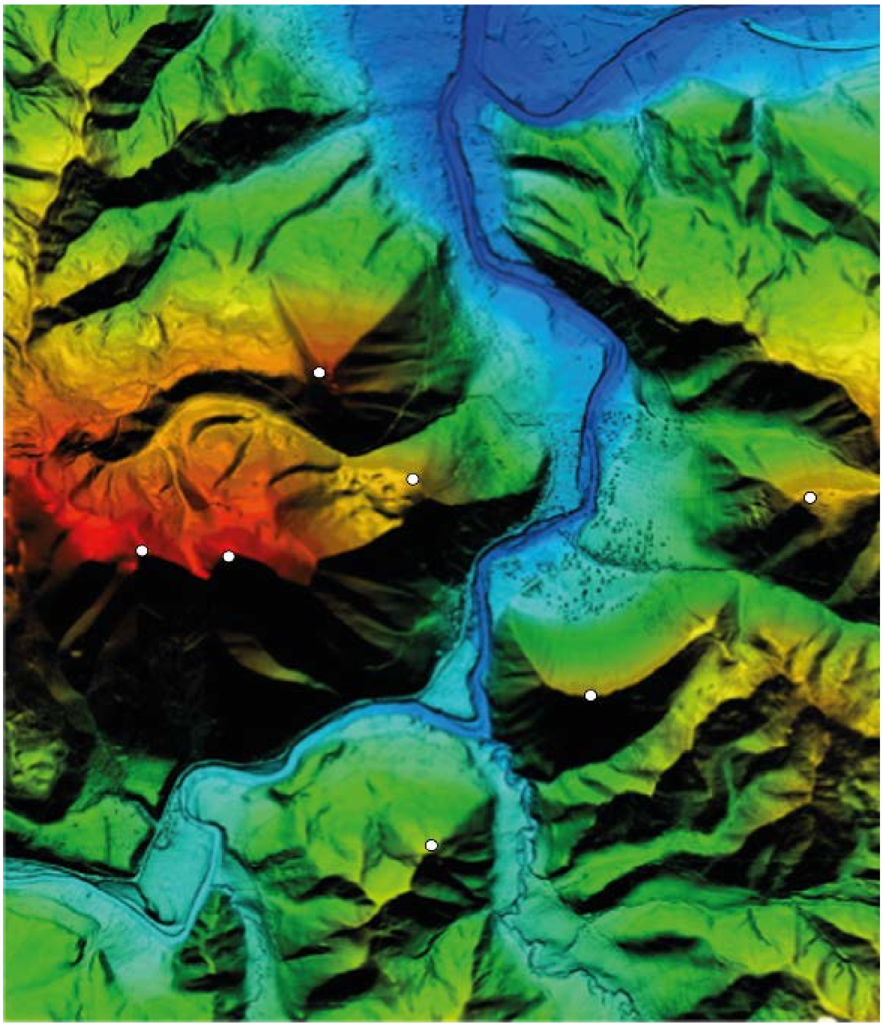

Figure 3. LiDAR-based topographic map of the Bosnian Valley of the Pyramids with geodetically defined summit reference points. High-resolution airborne LiDAR data reveal the precise topographic configuration of the Bosnian Valley of the Pyramids. Summit locations of the Bosnian Pyramid of the Sun, Moon, Dragon, Love, and the Temple of Mother Earth are marked by white reference points derived from laser scanning with documented positional accuracy of ±20 cm horizontally and ±15 cm vertically. The Bosnian Pyramid of the Sun, Moon, and Dragon defines an approximately 2.2 km equilateral triangle, providing a stable geometric scaffold upon which multiple Fibonacci spiral trajectories can be constructed, scaled, and statistically tested. Additional fixed reference points—including the Pyramid of Love, the Vratnica tumulus, the entrance to the Ravne underground tunnel system, the confluence of the Fojnica and Bosna rivers, and the Temple of Mother Earth—serve as secondary nodes for evaluating spiral propagation, nodal intersections, and landscape-scale geometric coherence. The use of LiDAR-derived summit reference points minimizes positional uncertainty and enables high-confidence assessment of non-random geometric organization at the landscape scale [4].

Location	Latitude	Longitude	Y Gauss-Kruger	X Gauss-Kruger
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 Dragon	43˚57'29"N	18˚10'56"E	6515038.980	4868199.190
Krtnice	43˚58'09"N	18˚10'01"E	6513819.850	4869456.670
Četnice	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

Figure 4. Coordinate table of analyzed summit locations. Geographic coordinates, projected Gauss-Krüger coordinates, and absolute elevations are reported. These values are treated as fixed inputs across all analyses.

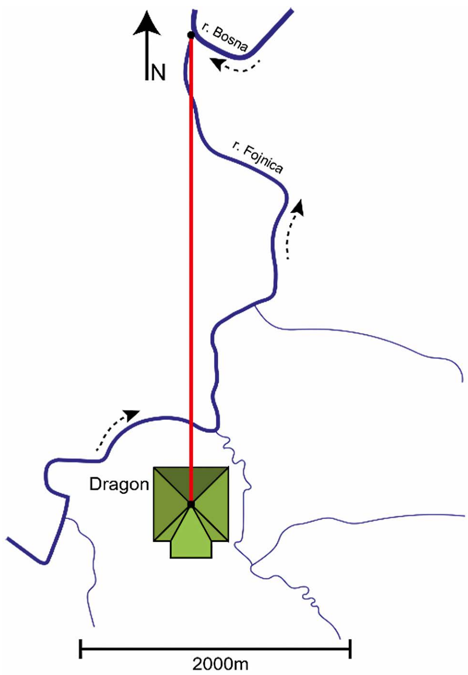

Figure 5. Northward geometric projection from the Bosnian Pyramid of the Dragon toward the Fojnica-Bosna River confluence. This figure illustrates a precise northward geometric projection extending from the summit of the Bosnian Pyramid of the Dragon toward the confluence of the Fojnica and Bosna rivers. The alignment is derived from LiDAR-verified summit coordinates and hydrological mapping, demonstrating a direct spatial correspondence between a pyramidal apex and a major hydrological node at the valley scale. Within the broader analytical framework of this study, the river confluence functions as a key fixed point repeatedly intersected by Fibonacci spiral trajectories anchored at the Bosnian Pyramid of the Sun. The observed north-south alignment shown here provides additional geometric context for understanding how hydrological features integrate into the overall spiral-based spatial architecture of the Bosnian Valley of the Pyramids. Rather than being interpreted in isolation as a single linear alignment, this projection is evaluated as part of a multi-layered geometric system in which summits, river junctions, and subterranean access points act as recurrent nodal elements within expanding Fibonacci spiral configurations [5].

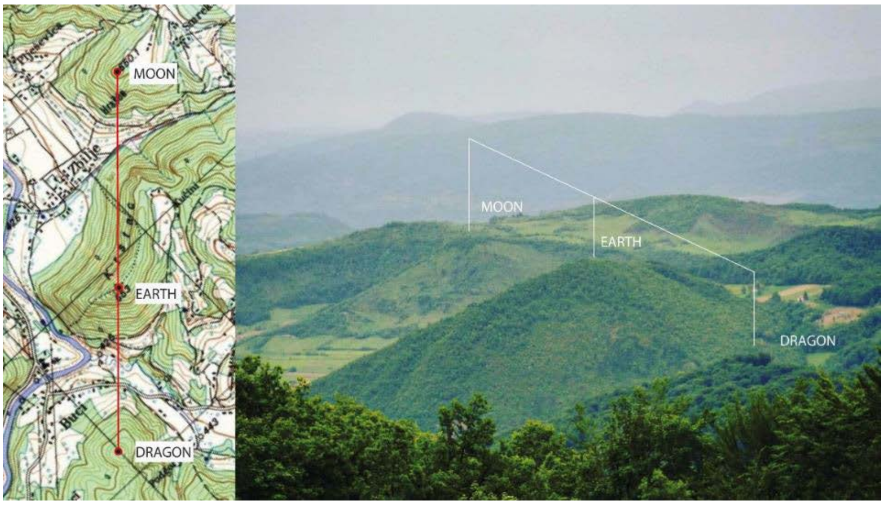

Figure 6. Linear alignment of major monuments in the Bosnian Valley of the Pyramids. Left: Topographic map illustrating a precise straight-line alignment connecting the summits of the Bosnian Pyramid of the Moon, the Temple of Mother Earth, and the Bosnian Pyramid of the Dragon. The alignment is derived from geodetically defined summit coordinates and confirms that all three features lie on a single linear axis extending across the valley. Right: Field photograph captured from the Bosnian Pyramid of the Sun visually corroborating the same alignment under real-world viewing conditions. From this vantage point, the Temple of Mother Earth occupies an intermediate nodal position between the Pyramid of the Moon and the Pyramid of the Dragon, reinforcing its role as a spatial mediator within the landscape. The alignment coincides with the Fojnica River's course as it enters the valley, highlighting a close spatial relationship between monumental placement and hydrological pathways. This figure documents a robust example of linear spatial architecture in the Bosnian Valley of the Pyramids and provides a complementary geometric framework to the Fibonacci spiral analyses developed in this study [6].

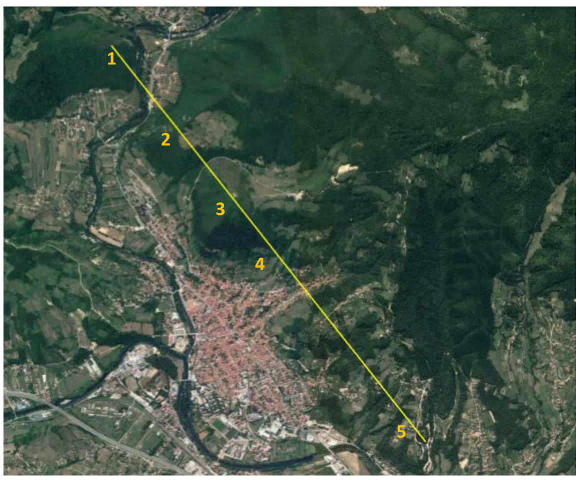

Figure 7. Five-point linear alignment integrating pyramidal, tumular, and subterranean features. A linear alignment connecting five major features within the Bosnian Valley of the Pyramids: Temple of Mother Earth, Bosnian Pyramid of Love, Bosnian Pyramid of the Sun, an unnamed geometric elevation (Structure No. 4), and Entrance to the Ravne Tunnel Complex. The straight-line trajectory is drawn across satellite imagery and follows the general course of the Fojnica River through the valley. The close spatial correspondence between the alignment and the river channel suggests that hydrological pathways may have been intentionally integrated into the valley's geometric design rather than treated as independent natural elements. The inclusion of both surface monuments and a subterranean entrance point within a single linear configuration reinforces the interpretation of a vertically and horizontally integrated spatial system. Rather than representing isolated coincidences, the alignment appears to form part of a broader architectural logic in which pyramidal structures, sacred nodes, and underground networks are organized according to shared geometric principles. This figure contributes to the growing body of evidence that the Bosnian Valley of the Pyramids exhibits intentional linear and spiral-based spatial architecture at the landscape scale [6].

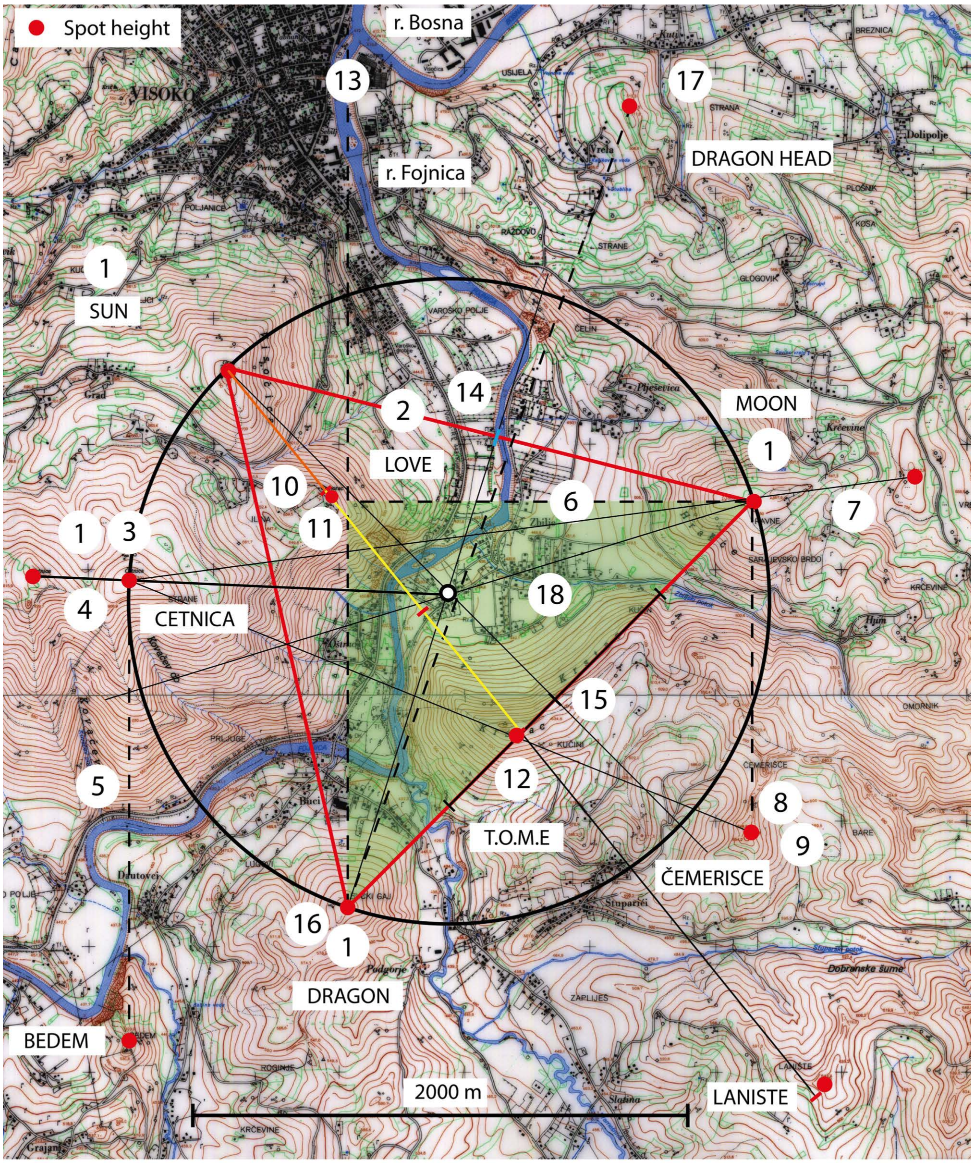

Figure 8. Linear geometric alignments linking pyramidal and tumulus summits in the Bosnian Valley of the Pyramids. Topographic map of the Visoko Valley illustrating a system of straight-line alignments connecting multiple pyramidal structures and tumulus summits, based on independent spatial analysis by Richard Hoyle. Summit locations are derived from geodetic surveys and LiDAR-validated elevation maxima and are represented by red markers. Several clear multi-point alignments are visible, each involving at least three topographically and morphologically distinct features. Notable examples include: 1) the Bosnian Pyramid of the Sun - Bosnian Pyramid of Love - Bosnian Pyramid of the Moon alignment; 2) the Bosnian Pyramid of the Sun - Temple of Mother Earth - Bosnian Pyramid of the Dragon alignment; and 3) alignments linking pyramidal summits with nearby tumuli, including Cetnica, Bedem, Čemerisce, and Lanište. These linear configurations form a coherent, valley-scale geometric framework rather than isolated pairwise coincidences. Importantly, the Bosnian Pyramid of the Sun repeatedly functions as a nodal point from which multiple linear axes radiate toward both pyramidal structures and tumulus tops. This figure documents the existence of structured linear spatial architecture in the Bosnian Valley of the Pyramids. In the present study, these linear relationships are treated as a foundational geometric layer that precedes and constrains the development of more complex Fibonacci-spiral architectures examined in subsequent figures [7].

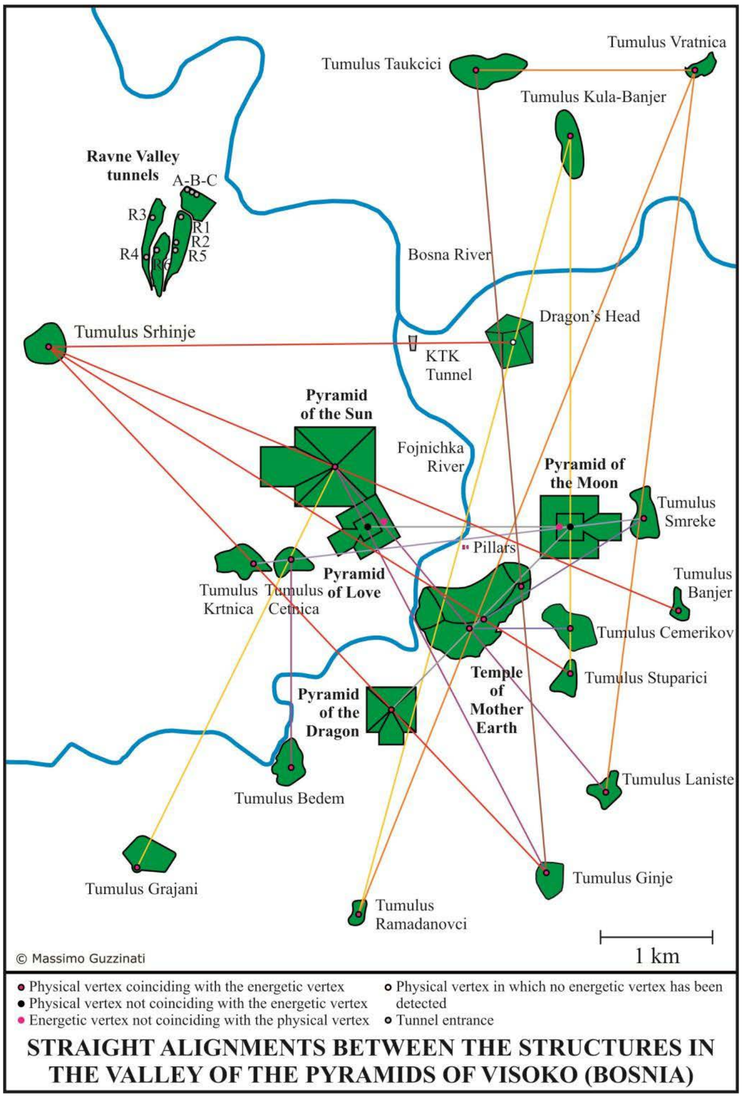

Figure 9. Straight-line alignments among pyramidal structures, tumuli, and landscape features in the Bosnian Valley of the Pyramids. Composite cartographic synthesis illustrating multiple straight-line alignments connecting pyramidal structures, tumuli, tunnel entrances, and geomorphological features across the Bosnian Valley of the Pyramids, as identified through the independent multi-method spatial analysis of Massimo Guzzinati. The figure integrates topographic mapping with symbolic markers representing summit-level vertices and landscape nodes derived from elevation maxima, geomorphological prominence, and field verification. Several alignments are shown linking three or more summit points along a single straight trajectory, often combining major pyramidal structures with secondary tumuli. Notable examples include linear connections involving the Bosnian Pyramid of the Sun, Bosnian Pyramid of the Moon, Bosnian Pyramid of the Dragon, the Temple of Mother Earth, and tumuli such as Krtnica, Cetnica, Bedem, Ginje, Laniste, Vratnica, and Kula-Banjer. In multiple cases, these alignments also intersect hydrological features (the Bosna and Fojnica rivers) and entrances to the Ravne tunnel system, indicating the integration of surface monuments, funerary mounds, waterways, and subterranean architecture within a coherent spatial framework. Distinct symbols differentiate between physical vertices, energetic vertices, coincident physical-energetic vertices, and tunnel entrances, reflecting Guzzinati's layered analytical approach that combines topographic, geometric, and geobiological criteria. Importantly, these straight-line relationships were identified independently of spiral-based geometry and without presupposing a Fibonacci structure, providing a complementary, methodologically separate dataset. In the context of *When Landscape Becomes Geometry II*, this figure represents the final presentation of linear spatial architecture in the study. The documented alignments establish a structured geometric substrate upon which the subsequent analysis of expanded Fibonacci spiral architecture is developed, demonstrating that both linear and curvilinear geometries coexist within the same landscape-scale organizational system. Source: Guzzinati, M. Original analysis and cartographic synthesis. Reproduced with permission. © Massimo Guzzinati.

In addition to linear alignments, Part I identified a Fibonacci-based logarithmic spiral anchored at the Bosnian Pyramid of the Sun that satisfied predefined ±20 m tolerance criteria and persisted under 100,000-run Monte Carlo null models [4]. That result established the presence of a statistically constrained spiral configuration under explicitly defined geometric and probabilistic assumptions.

Spiral geometry has long been recognized as a mathematically stable form of proportional expansion. Logarithmic spirals governed by constant growth ratios ($\varphi \approx 1.618$) appear in both natural and constructed systems [8]. In archaeological landscape studies, geometric modeling has been applied cautiously, given the risk of overfitting and post hoc pattern recognition [9] [10]. For that reason, Part II applies the identical tolerance thresholds, scale bounds, and probabilistic testing framework established in Part I (**Figures 9-21**).

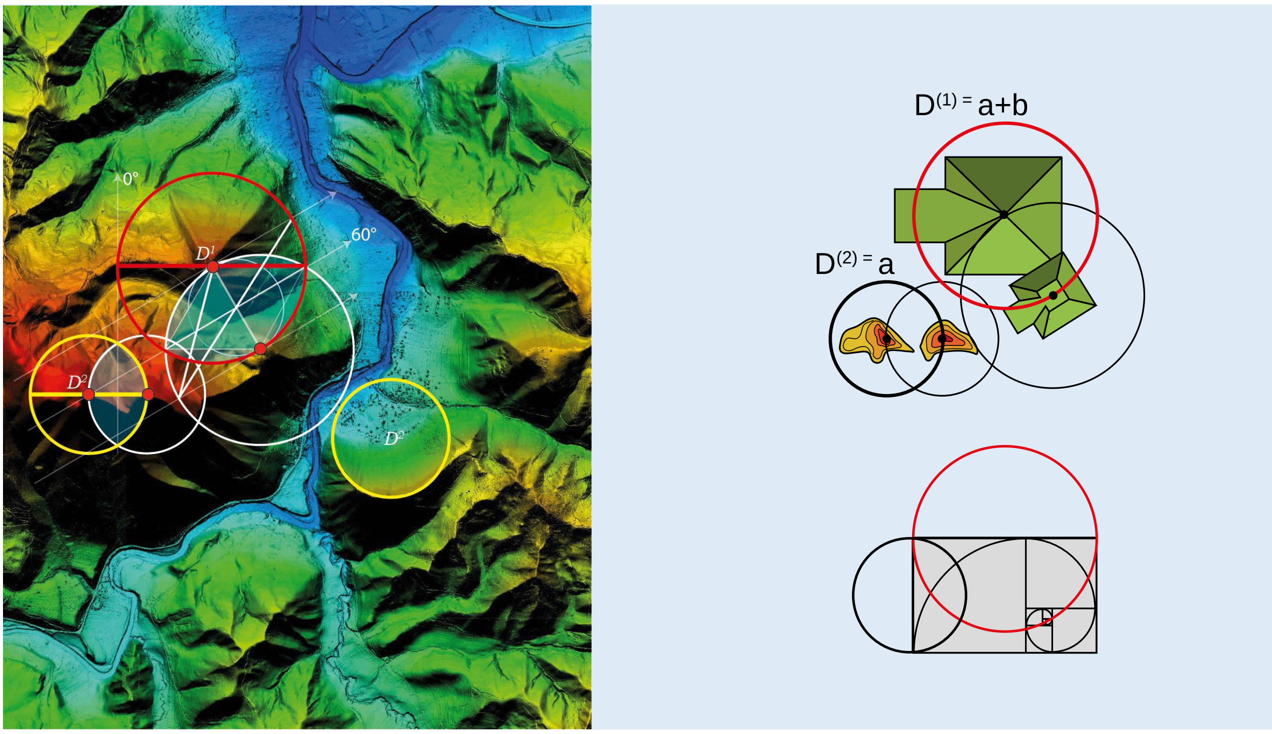

Figure 10. Foundational Golden Ratio geometry and initial Fibonacci spiral construction applied to the Bosnian Valley of the Pyramids. Left: LiDAR-derived digital elevation model of the central Visoko Valley overlaid with the first-order golden ratio construction developed by Richard Hoyle. The diagram illustrates the geometric generation of proportional distances using two primary diameters: $D^1 = a + b$ and $D^2 = a$, where a and b follow the Fibonacci ratio ($\varphi \approx 1.618$). The construction establishes a fixed geometric center and angular framework (including 0˚ and 60˚ reference directions) from which spiral propagation is initiated. The circular overlays correspond to successive proportional expansions anchored to geodetically defined summit locations, demonstrating how Fibonacci-based scaling can be embedded directly within the valley's topography. Right (top): Conceptual schematic illustrating the translation of golden ratio diameters onto pyramidal and tumular summit forms, showing how proportional circles intersect major structures while preserving fixed geometric relationships. Right (bottom): Classical Fibonacci rectangle and logarithmic spiral construction, included for reference, demonstrating the mathematical basis underlying the landscape-scale application shown on the left. Together, the figure establishes the geometric *starting condition* for subsequent spiral analyses presented in this study. Rather than fitting spirals post hoc, the golden ratio framework is first defined geometrically and then projected onto independently surveyed terrain data. This approach provides a reproducible and mathematically constrained foundation for evaluating Fibonacci spiral architecture across the Bosnian Valley of the Pyramids [7].

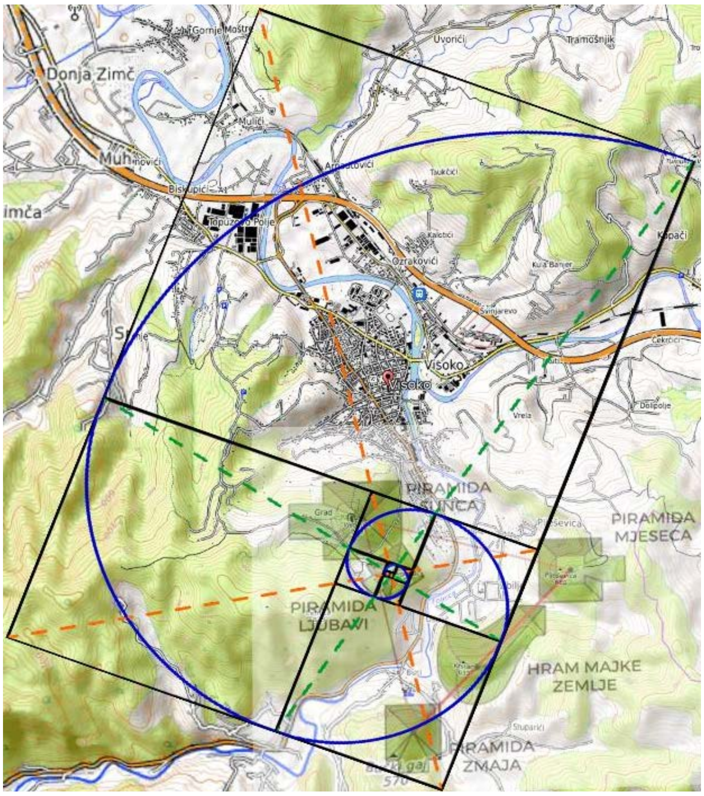

Figure 11. Multi-node Fibonacci spiral connecting major pyramidal and tumular summits in the Bosnian Valley of the Pyramids. This Fibonacci spiral intersects the summit of the Bosnian Pyramid of Love, passes near the summit of the Bosnian Pyramid of the Sun, continues through the summit of the Temple of Mother Earth, intersects the summit of the Bosnian Pyramid of the Dragon, and terminates at the summit of the tumulus in Vratnica. All nodes correspond to independently defined pyramidal or tumular elevation maxima. The configuration demonstrates the extension of spiral geometry across multiple monuments types and reinforces the role of Fibonacci scaling as a unifying principle within the valley's spatial architecture [4].

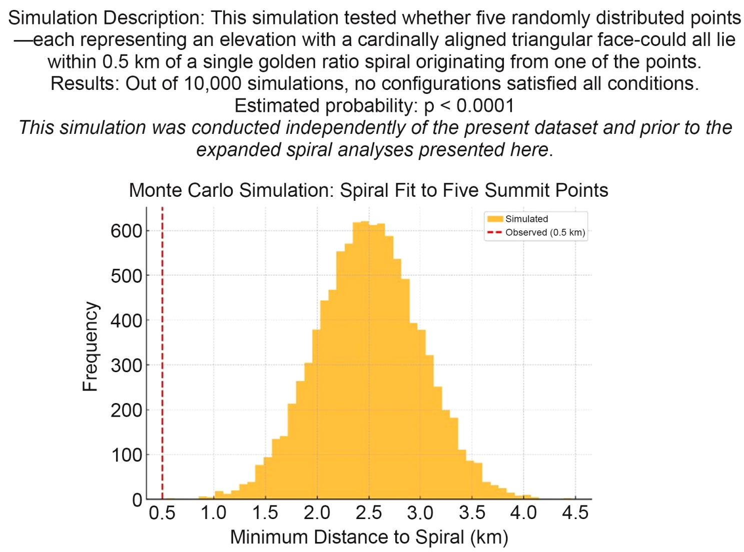

Figure 12. Monte Carlo simulation testing the probability of five summit points fitting a single Fibonacci spiral. Histogram showing the distribution of minimum distances between five randomly distributed elevation points and a golden ratio spiral originating from one of the points. Each simulation tested whether all five points could fall within 0.5 km of the same spiral. Out of 10,000 simulations, no configuration satisfied all conditions ($p < 0.0001$), indicating that the observed spiral alignment is unlikely to arise by chance [4].

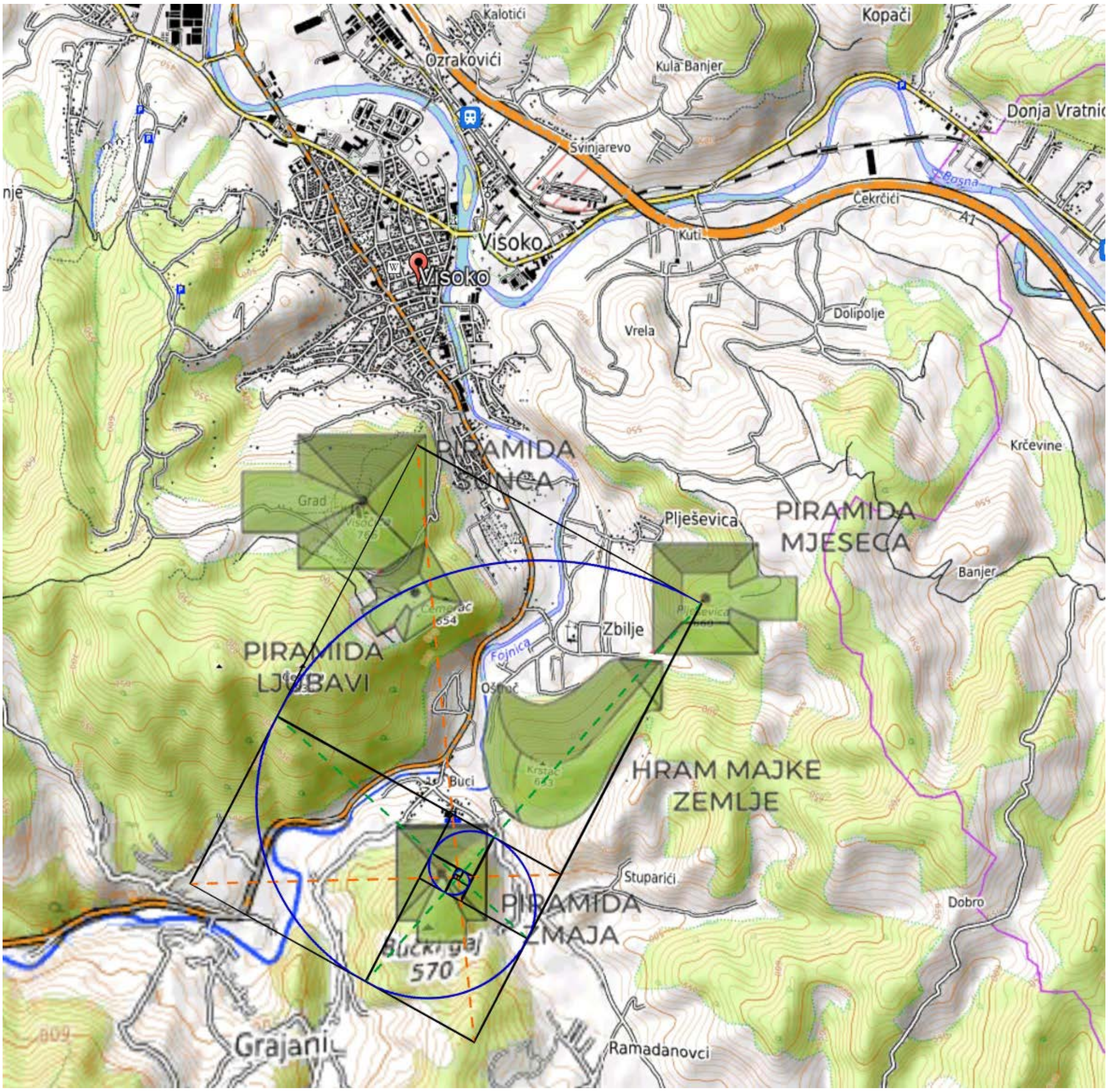

Figure 13. Newly identified Fibonacci spiral linking the Bosnian Pyramid of the Dragon, the Bosnian Pyramid of Love, and the Bosnian Pyramid of the Moon. Topographic map of the Bosnian Valley of the Pyramids showing a newly identified Fibonacci (Golden Section) spiral connecting three major pyramidal structures: the Bosnian Pyramid of the Dragon, the Bosnian Pyramid of Love, and the Bosnian Pyramid of the Moon. In this configuration, the spiral originates at the summit of the Bosnian Pyramid of the Dragon, curves through the summit of the Bosnian Pyramid of Love, and continues toward the summit of the Bosnian Pyramid of the Moon, forming a coherent sequence of elevation maxima consistent with Fibonacci scaling. The spiral is constructed using the same geometric rules applied throughout this study, including fixed golden ratio growth, quarter-arc construction, and geodetically defined summit reference points. Importantly, this configuration does not include the Bosnian Pyramid of the Sun or the Temple of Mother Earth, demonstrating that Fibonacci spiral organization within the Bosnian Valley of the Pyramids is not restricted to a single central monument but extends to secondary pyramidal relationships. All three anchor points correspond to independently defined summit locations derived from high-resolution topographic and LiDAR-validated datasets, ensuring that the spiral geometry is evaluated against fixed, non-arbitrary landscape features. This figure represents original analysis reported here for the first time and expands the documented network of spiral-based geometric relationships within the Bosnian Valley of the Pyramids. Source: Original analysis and cartographic synthesis by the author.

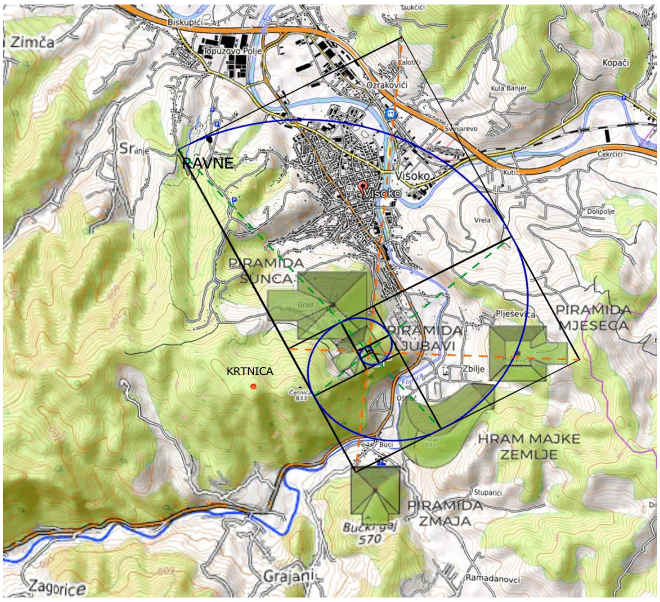

Figure 14. Fibonacci spiral intersecting the Bosnian Pyramid of Love, the Temple of Mother Earth, the Bosnian Pyramid of the Moon, and the Ravne Tunnel Complex. Topographic map of the Bosnian Valley of the Pyramids showing a Fibonacci (Golden Section) spiral constructed according to the standard square-and-arc method and overlaid on a calibrated topographic base. The spiral intersects, in sequence, the summit of the Bosnian Pyramid of Love, the summit of the Temple of Mother Earth, the summit of the Bosnian Pyramid of the Moon, and the entrance zone of the Ravne Tunnel Complex. All intersection points correspond to independently defined topographic or archaeological features derived from geodetic and cartographic datasets. The spiral geometry integrates surface monuments with a subterranean access point, reinforcing the interpretation of a coherent landscape-scale geometric framework extending beyond individual pyramidal structures. This spiral configuration expands the set of Fibonacci-based spatial relationships documented in the Bosnian Valley of the Pyramids and is incorporated into the broader geometric analysis presented in this study. *Note:* This spiral configuration is reported here for the first time.

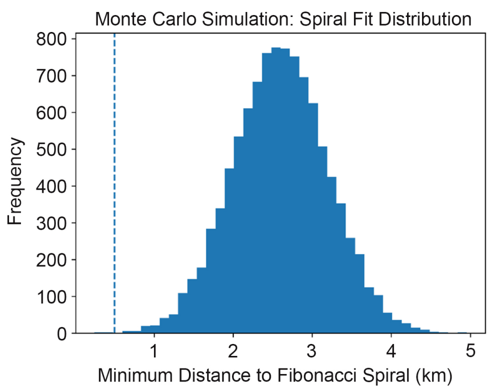

Figure 15. Monte Carlo distribution of minimum distances to a Fibonacci spiral for randomized summit configurations. Monte Carlo simulation assesses the likelihood of reproducing the observed Fibonacci spiral geometry by chance. A total of 10,000 randomized configurations of summit-like points were generated within the spatial bounds of the Bosnian Valley of the Pyramids. For each simulation, the minimum distance of all points to a best-fit golden-ratio spiral was computed. The histogram shows the resulting distribution of minimum distances. The dashed vertical line at 0.5 km represents the maximum deviation observed in the empirical configurations (Figure 9, Figure 10, Figure 13, and Figure 14). No simulated case achieved comparable coherence, indicating a probability of occurrence of $p < 0.0001$. 1) The distribution represents 10,000 Monte Carlo realizations of randomly distributed summit-like points within the study area; 2) The x-axis shows the minimum distance (km) from a fitted golden-ratio/Fibonacci spiral; 3) The dashed vertical line at 0.5 km marks the empirical tolerance observed in the real Bosnian Valley configurations (Figure 9, Figure 10, Figure 13, and Figure 14); 4) No simulated configurations approach this threshold, visually reinforcing the improbability of the observed spiral coherence arising by chance.

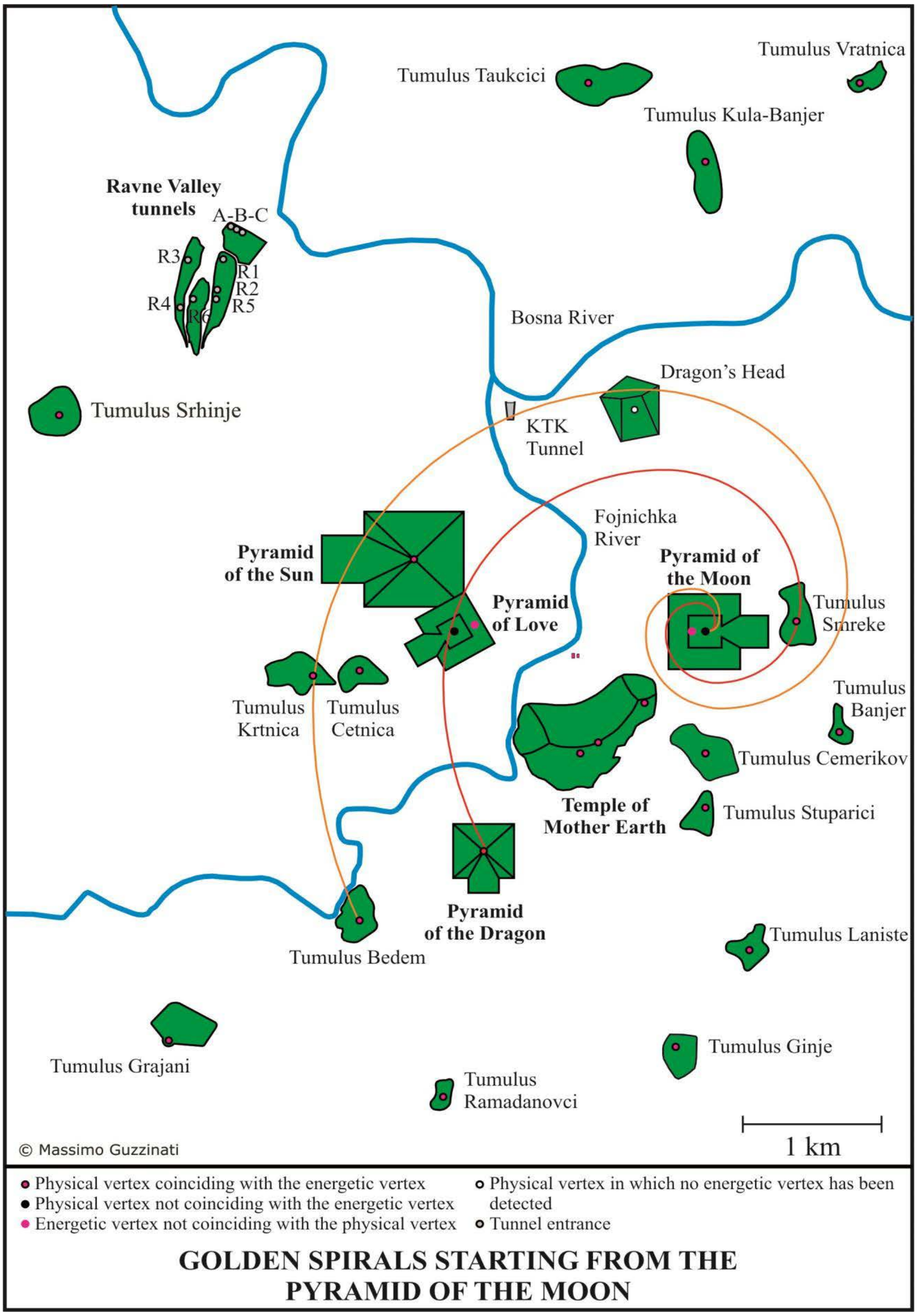

Figure 16. Golden spiral trajectories anchored at the Bosnian Pyramid of the Moon. This schematic map illustrates a system of golden (Fibonacci) spirals originating at the summit of the Bosnian Pyramid of the Moon and intersecting multiple key features within the Bosnian Valley of the Pyramids. Of particular significance is the spiral sequence linking the Pyramid of the Moon, the tumulus at Smreke, the Bosnian Pyramid of Love, and the Bosnian Pyramid of the Dragon, forming a coherent geometric progression consistent with golden-ratio expansion. Additional spiral arcs intersect further pyramidal and tumular summits, underground tunnel entrances (including the Ravne and KTK systems), and hydrological elements such as the Fojnica and Bosna rivers. Colored dots distinguish physical summits, energetic vertices, and tunnel access points, following the analytical methodology developed by Massimo Guzzinati.

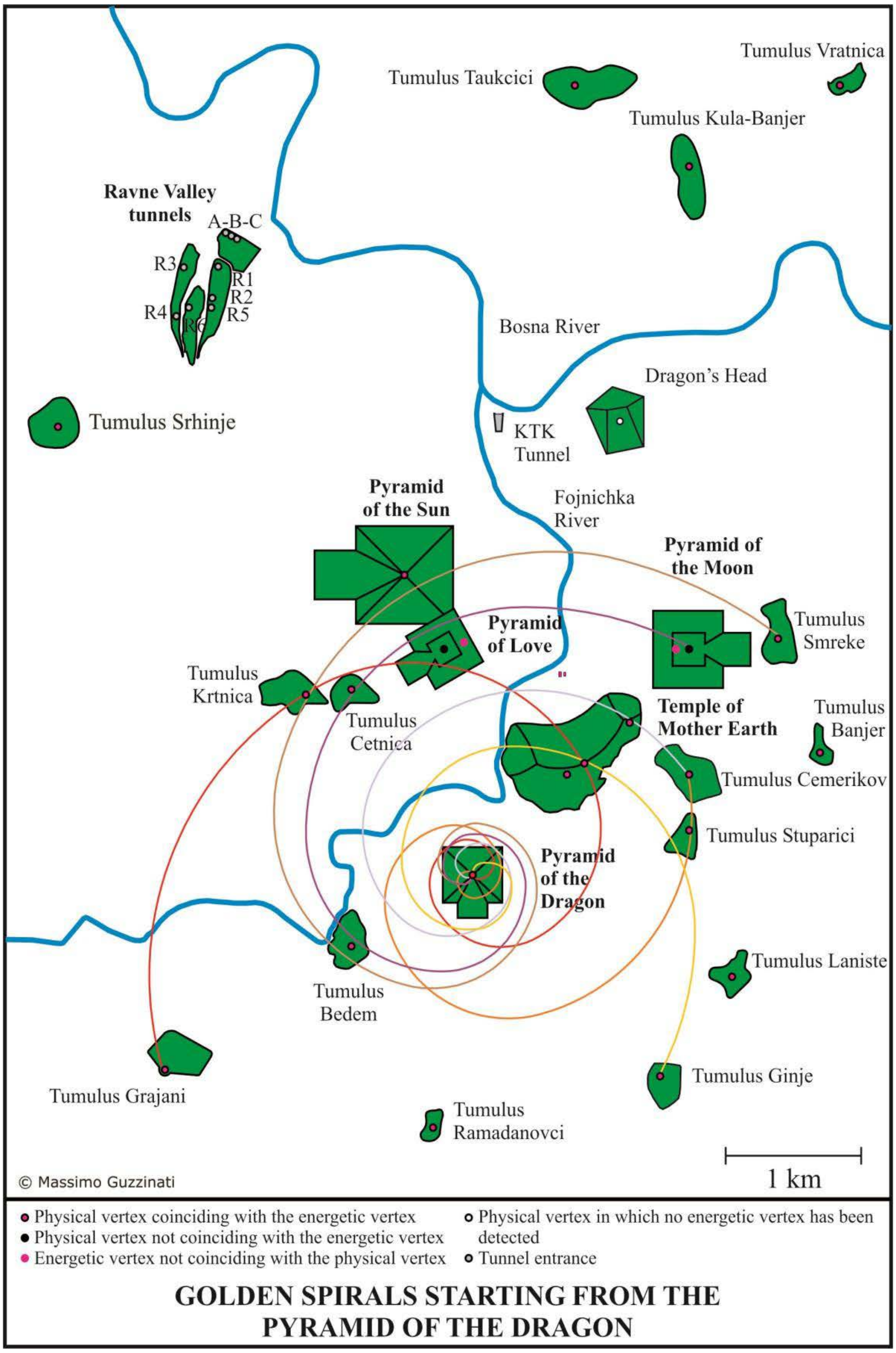

Figure 17. Golden spiral system anchored at the Bosnian Pyramid of the Dragon, integrating pyramidal and tumulus summits. This figure illustrates a system of golden-ratio (Fibonacci) spirals originating from the summit of the Bosnian Pyramid of the Dragon and extending outward across the Bosnian Valley of the Pyramids. The spiral trajectories intersect a sequence of major pyramidal and tumulus structures, most notably the Bosnian Pyramid of Love, the Bosnian Pyramid of the Moon, and several surrounding tumuli, including Smreke, Cemerikov, Stuparici, Ginje, and Laniste. The spatial correspondence shows that multiple distinct spiral arcs—constructed according to Fibonacci proportional scaling—pass through or closely approach the summits of these features, indicating a non-random clustering of topographical highs along logarithmic growth paths. The Bosnian Pyramid of the Dragon functions as a primary geometric anchor, while secondary intersections occur at pyramidal and tumulus peaks situated at increasing radial distances consistent with golden-ratio expansion. Source: Guzzinati, M. (analysis and cartography).

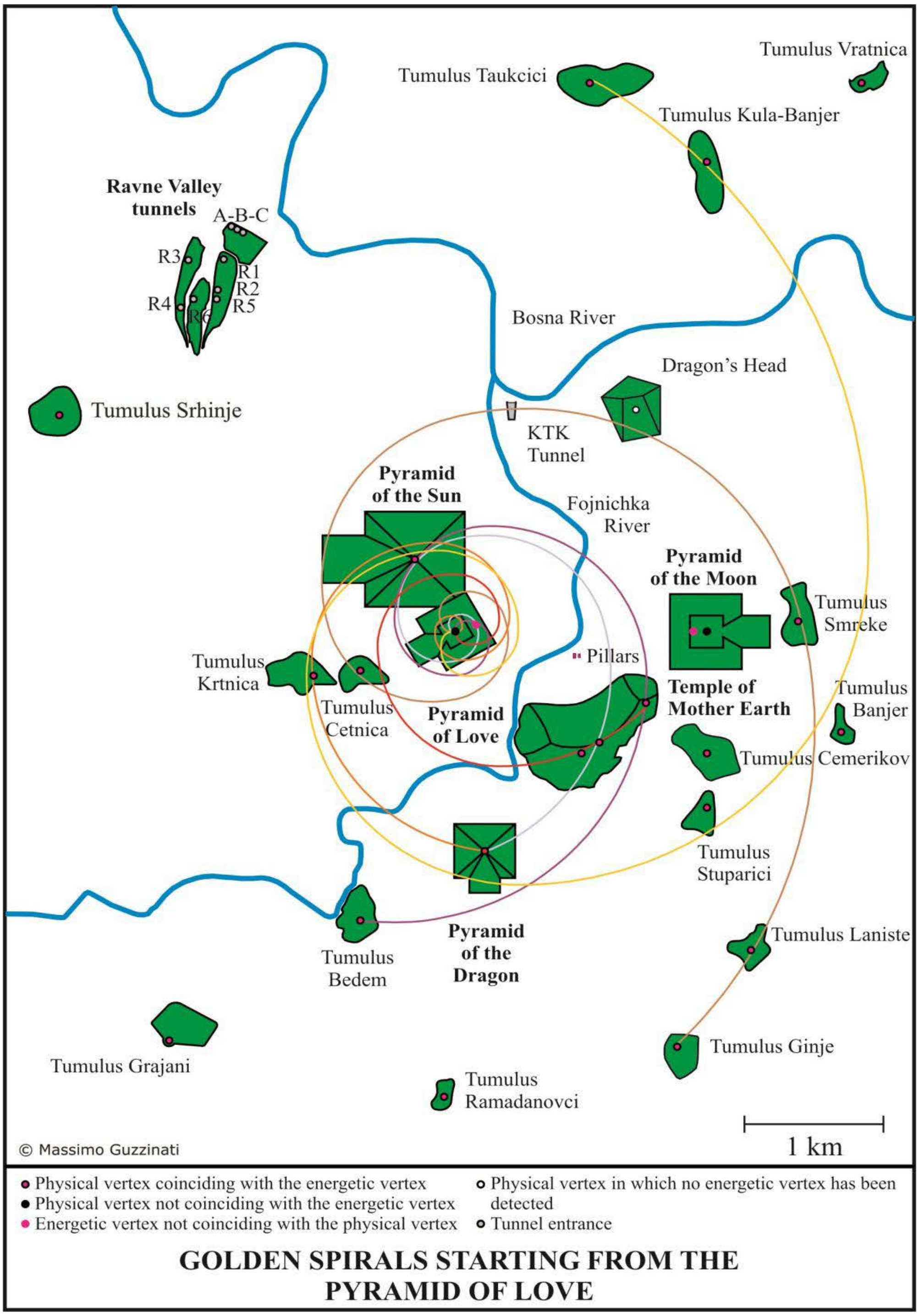

Figure 18. Golden (Fibonacci) spiral systems originating at the Bosnian Pyramid of Love. Multiple clockwise and counterclockwise Fibonacci spirals are constructed with a fixed origin at the summit of the Bosnian Pyramid of Love and intersect a sequence of pyramidal and tumular summits across the Bosnian Valley of the Pyramids. Each spiral follows a consistent Fibonacci scaling ratio and intersects independently defined topographic vertices: 1) Red spiral (counterclockwise): Pyramid of Love → Temple of Mother Earth (western, central, and eastern vertices); 2) Orange spiral (counterclockwise): Pyramid of Love → Krtnica Tumulus → Bosnian Pyramid of the Sun; 3) Yellow spiral (counterclockwise): Pyramid of Love → Kula-Banjer Tumulus → Taukčići Tumulus; 4) Indigo spiral (clockwise): Pyramid of Love → Bosnian Pyramid of the Sun → Temple of Mother Earth (central vertex) → Bosnian Pyramid of the Dragon; 5) Violet spiral (clockwise): Pyramid of Love → Bosnian Pyramid of the Sun → Temple of Mother Earth (eastern vertex) → Bedem Tumulus. *Source: Massimo Guzzinati, independent geometric analysis; adapted for this study.*

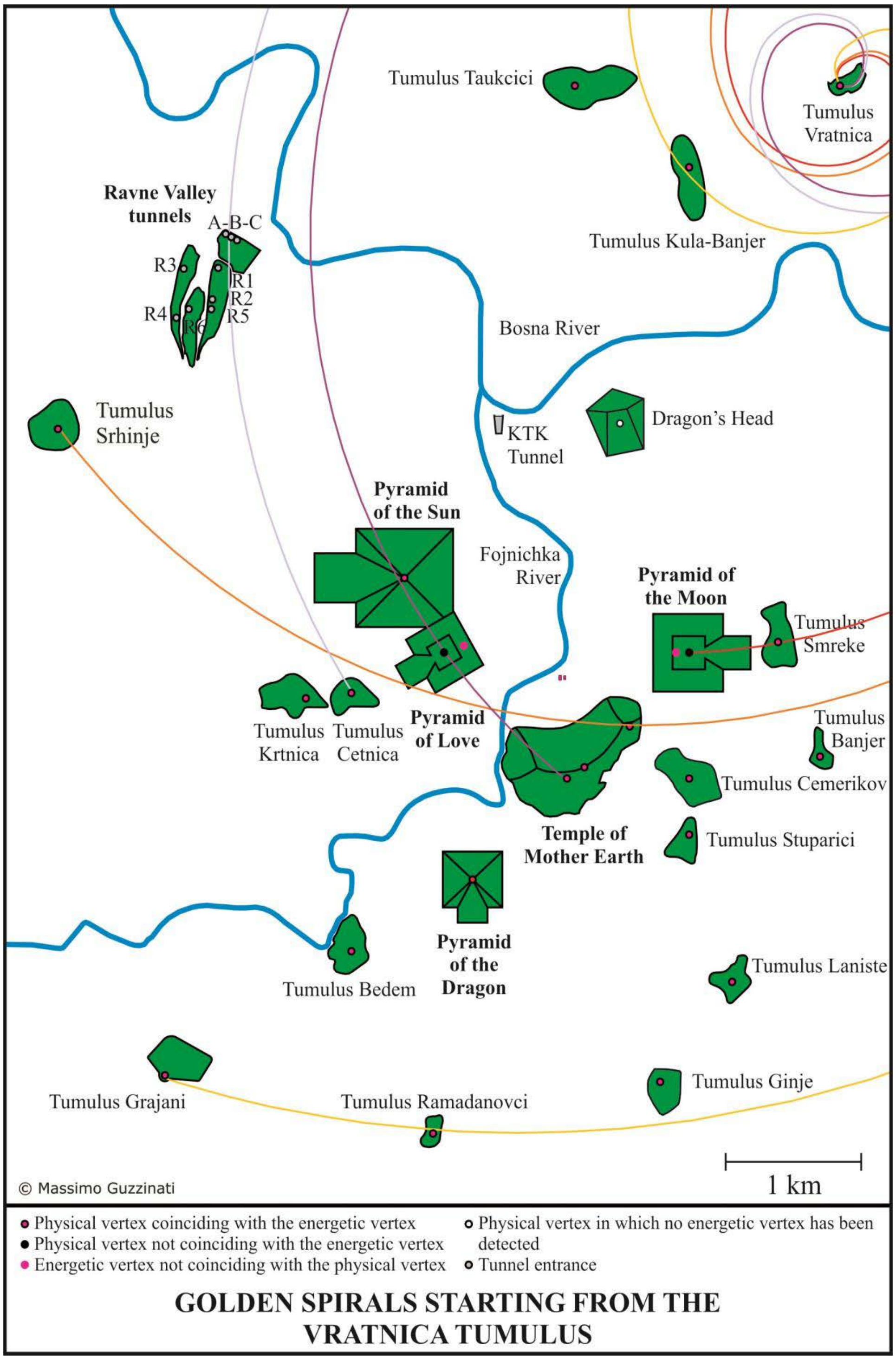

Figure 19. Golden spirals originating from the Vratnica Tumulus within the Bosnian Valley of the Pyramids. Multiple Fibonacci (Golden Section) spirals are constructed with their origin anchored at the summit of the Vratnica Tumulus, demonstrating repeated geometric connectivity between tumular, pyramidal, and subterranean features across the valley. 1) Red spiral (clockwise): Vratnica Tumulus → Smreke Tumulus → Bosnian Pyramid of the Moon; 2) Orange spiral (clockwise): Vratnica Tumulus → Temple of Mother Earth (eastern vertex) → Shrínje Tumulus; 3) Yellow spiral (clockwise): Vratnica Tumulus → Kula-Banjer Tumulus → Ramadanovci Tumulus → Grajani Tumulus; 4) Indigo spiral (counterclockwise): Vratnica Tumulus → Ravne B Tunnel entrance → Cetnica Tumulus; 5) Violet spiral (counterclockwise): Vratnica Tumulus → Bosnian Pyramid of Love → Temple of Mother Earth (western vertex). *Source: Guzzinati, M., adapted and annotated by the authors.*

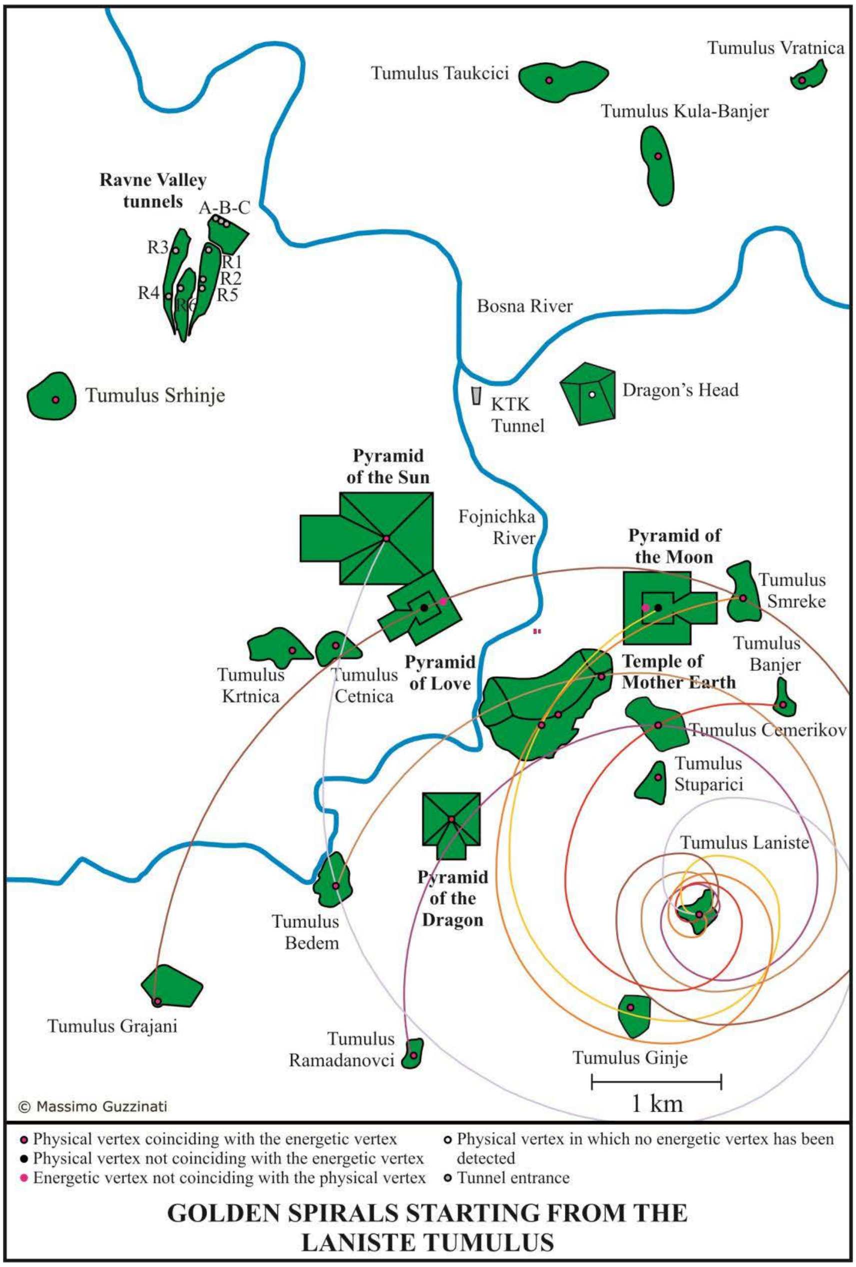

Figure 20. Golden spirals originating from the Laniste Tumulus. Multiple Fibonacci (golden ratio) spiral trajectories are constructed with their origin fixed at the summit of the Laniste Tumulus, revealing systematic geometric relationships with pyramidal structures, tumuli, and nodal landscape features across the Bosnian Valley of the Pyramids. The following spiral configurations are shown: 1) Red spiral (clockwise): Laniste Tumulus → Cemerikov Tumulus → Banjer Tumulus, 2) Orange spiral (clockwise): Laniste Tumulus → Temple of Mother Earth (western vertex) → Smreke Tumulus, 3) Yellow spiral (clockwise): Laniste Tumulus → Temple of Mother Earth (western vertex) → Bosnian Pyramid of the Moon, 4) Indigo spiral (clockwise): Laniste Tumulus → Bedem Tumulus → Bosnian Pyramid of the Sun, 5) Violet spiral (counterclockwise): Laniste Tumulus → Cemerikov Tumulus → Ramadanovci Tumulus, 6) Light-brown spiral (counterclockwise): Laniste Tumulus → Temple of Mother Earth (eastern vertex) → Bedem Tumulus, 7) Dark-brown spiral (counterclockwise): Laniste Tumulus → Smreke Tumulus → Bosnian Pyramid of Love → Grajani Tumulus. Summit points correspond to geodetically and LiDAR-validated elevation maxima. The convergence of multiple clockwise and counterclockwise Fibonacci spirals anchored at a single tumulus reinforces the interpretation of non-random spatial organization, integrating pyramidal monuments, tumuli, and sacred landscape nodes. *Source: Massimo Guzzinati; adapted for this study. Note*: **Figures 16-20** present independent spiral systems constructed by Guzzinati using the same golden-ratio framework but different origin nodes.

Figure 21. Field view of the central ridge alignment in the Bosnian Valley of the Pyramids, showing the spatial relationship between the Bosnian Pyramid of the Sun, Temple of Mother Earth, Bosnian Pyramid of Love, and Laniste Tumulus, as observed from the valley floor. The photograph illustrates the natural ridge geometry and relative elevation ordering of these features, which correspond to multiple geometric and spiral relationships identified in planimetric analyses (**Figures 16-20**). This visual perspective reinforces the coherence between the valley's topography and the proposed spiral-geometry framework. *Source*: *Photograph by Richard Hoyle*; *adapted and annotated for this study.*

The present study asks whether spiral coherence remains localized to the Sun-anchored configuration or whether comparable Fibonacci-based intersections emerge when the spiral model is anchored at alternative summit-level and nodal points across the valley. These alternative anchors include the Pyramids of the Moon, Love, and Dragon; selected tumuli such as Vratnica and Laniste; hydrological junctions; and tunnel entrances verified through LiDAR and field documentation [5] [7].

The broader geological context of the Visoko formations remains debated. Several studies interpret pyramidal morphologies as natural sedimentary structures shaped by uplift and erosion. The present analysis does not attempt to resolve the geomorphological origin. Instead, it evaluates spatial organization as a measurable geometric property of the current landscape configuration.

Part II, therefore, shifts the focus from a single geometric origin to a distributed anchoring framework. Using fixed Fibonacci growth rules, bounded parameter spaces, and controlled Monte Carlo testing, the study evaluates whether multi-anchor spiral coherence exceeds expectations under conservative null conditions. The objective is methodological: to assess whether curved proportional geometry constitutes a recurring spatial signal within the previously documented valley-scale system.

2. Methods

2.1. Dataset and Coordinate Framework

The analysis uses the same high-resolution LiDAR-derived digital elevation model and geodetically verified summit coordinates applied in previous quantitative spatial studies of the Bosnian Valley [4]. Horizontal accuracy is within ±20 cm and vertical accuracy within ±15 cm.

Primary summit nodes include:

- Pyramid of the Sun
- Pyramid of the Moon
- Pyramid of the Dragon
- Pyramid of Love
- Temple of Mother Earth
- Vratnica Tumulus
- Krtnica Hill
- Četnica Hill
- Fojnica-Bosna River confluence

All coordinates were treated as fixed inputs. No positional adjustment, filtering, or exclusion of nodes was performed during spiral fitting.

This ensures consistency with previously published linear and triangular geometric evaluations.

2.2. Spiral Model Definition

Spiral geometry was modeled using a logarithmic spiral defined by the golden ratio, where the growth constant corresponds to $\varphi \approx 1.618$.

Model constraints:

- Fixed growth ratio (φ)
- Predefined radial bounds determined by valley diameter
- Orientation increments are discretized in equal angular steps
- Uniform tolerance threshold of ±20 m for node intersection
- Minimum threshold of three intersected nodes for candidate configuration

Scale and orientation grids were applied symmetrically across empirical and randomized datasets.

Importantly, spiral parameters were bound prior to evaluation to reduce degrees of freedom and prevent post hoc fitting.

2.3. Anchor Selection and Hypothesis Structure

Formal Monte Carlo hypothesis testing was conducted for the Sun-anchored spiral configuration.

Additional anchor configurations are presented descriptively to illustrate geometric behavior under identical modeling constraints. These were not subjected to independent hypothesis testing and are not treated as separate statistical claims.

This distinction avoids inflation of the hypothesis family and eliminates the need for post hoc multiple-comparison correction.

2.4. Monte Carlo Null Model

To assess whether multi-node spiral intersections could arise under random spatial redistribution, a Monte Carlo simulation framework was implemented.

Simulation structure:

- 10,000 randomized point networks
- Identical node count
- Identical geographic bounding envelope
- Identical scale and orientation parameter grids
- Identical ±20 m tolerance threshold

Randomized datasets were uniformly redistributed within the valley envelope without preserving ridge topology or hydrological clustering.

The full parameter search space was embedded in each iteration. Therefore, orientation and scale flexibility are already incorporated in the null distribution, and no additional correction at the parameter-grid level is required.

2.5. Statistical Evaluation

For each randomized iteration, the maximum number of spiral-node intersections was recorded under the same parameter constraints used for the empirical dataset.

Significance threshold: $\alpha = 0.05$.

This evaluation tests whether the observed multi-node spiral coherence exceeds expectation under spatial randomness, conditional on the defined null model.

2.6. Relation to Prior Geometric Testing

Previous work on the same dataset employed distance-matrix comparison, angular evaluation, rotation-invariant similarity measures, and Monte Carlo testing to assess linear and triangular coherence.

The present study extends that framework by introducing curved proportional geometry as an additional spatial metric. No new coordinate sources were introduced, ensuring methodological continuity.

3. Results

3.1. Sun-Anchored Spiral Configuration

Application of the constrained logarithmic spiral model centered on the Pyramid of the Sun produced multiple node intersections within the predefined ±20 m tolerance threshold.

Under bounded orientation and scale parameters, the optimal configuration intersected:

- Pyramid of the Dragon
- Temple of Mother Earth
- Vratnica Tumulus
- Fojnica-Bosna River confluence

The resulting four-node intersection represents the maximum coherence observed under the fixed φ-growth model within the defined parameter grid.

Radial deviations from the ideal logarithmic curve remained within tolerance limits across all intersected nodes.

3.2. Monte Carlo Simulation Outcome

The Monte Carlo null model (10,000 iterations) generated randomized spatial configurations under identical bounding conditions and parameter constraints.

Across all simulations:

- Three-node spiral intersections occurred at low frequency.
- Four-node intersections equal to or exceeding the empirical Sun-anchored configuration were rare.

The empirical configuration fell within the upper tail of the simulated distribution.

The resulting p-value (as defined in Section 2.5) indicates that the observed four-node coherence is unlikely under uniform spatial redistribution within the valley envelope.

Because the full orientation-scale search space was embedded symmetrically within each simulation, the probability estimate inherently incorporates parameter flexibility.

3.3. Descriptive Multi-Anchor Observations

Additional spiral configurations centered on:

- Pyramid of Love
- Temple of Mother Earth
- River Confluence

were evaluated under identical growth and tolerance parameters.

These configurations produced consistent three-node intersections and, in some cases, localized geometric recurrence across summit nodes.

However, these anchors were not subjected to independent Monte Carlo hypothesis testing and are therefore presented descriptively rather than inferentially.

Their purpose is to demonstrate that spiral coherence is not confined exclusively to a single origin within the coordinate network.

3.4. Comparison to Randomized Distributions

Histograms of randomized maximum-intersection counts (**Figure 14** and **Figure 15**) show that:

- Most simulations yield one- or two-node spiral proximity under the defined tolerance.
- Higher-order intersections occur infrequently.
- The empirical Sun-anchored configuration lies beyond the modal distribution range.

No randomized configuration reproduced the full pattern of empirical intersections under identical parameter constraints with equivalent radial consistency.

3.5. Structural Context

When considered alongside previously documented linear alignments and triangular configurations (Part I), the spiral intersections occur within an already structured coordinate network.

The spiral metric, therefore, adds a curved, proportional dimension to a spatial framework that has demonstrated rectilinear coherence in independent testing.

No claim is made regarding cultural intentionality. The results describe measurable geometric relationships under fixed mathematical modeling assumptions.

4. Discussion

4.1. From Linear to Curved Geometry

Part I established statistically constrained linear and triangular relationships within the Bosnian Valley coordinate network. Independent LiDAR-based analysis has also demonstrated measurable distance and angular coherence using rotation-invariant metrics and Monte Carlo testing.

The present study extends that framework by introducing curved proportional geometry via fixed Fibonacci-spiral modeling. Rather than replacing the rectilinear structure, the spiral metric adds a radial dimension to an already documented geometric network.

The key inferential result concerns the Sun-anchored configuration, which produced a four-node spiral intersection under bounded growth and orientation parameters. This configuration was evaluated using a symmetric Monte Carlo null model. Other anchors are presented descriptively and should be interpreted as geometric observations rather than independent hypothesis tests.

This distinction limits the hypothesis family and avoids artificial inflation of statistical claims.

4.2. Interpretation of the Null Model

Monte Carlo testing was performed using uniform spatial redistribution within the valley envelope under identical modeling constraints. Because the full orientation-scale search grid was embedded within each simulation, the probability estimate already incorporates parameter flexibility.

The resulting p-value indicates that the observed four-node Sun-centered configuration lies in the upper tail of the simulated distribution. However, the null model does not preserve ridge topology, hydrological clustering, or geomorphological constraints. It therefore represents a baseline randomness scenario rather than a terrain-aware simulation.

As emphasized in quantitative archaeoastronomical research [11]-[13], the choice of null model significantly influences probabilistic interpretation. The current model demonstrates improbability under uniform redistribution but does not exhaust all alternative environmental structures.

4.3. Degrees of Freedom and Model Constraints

Spiral modeling introduces inherent flexibility through anchor positions, orientations, and scales. To reduce post-hoc fitting:

- Growth ratio was fixed ($\varphi \approx 1.618$).
- Scale bounds were predefined.
- Orientation increments were discretized.
- Tolerance was fixed at ±20 m.
- A minimum three-node threshold was required.

These constraints were applied before the empirical configuration was evaluated.

Because only the Sun anchor was subjected to formal hypothesis testing, additional multiple-comparison correction is not required at the anchor level. The Monte Carlo framework already integrates orientation and scale variability.

4.4. Alternative Explanations

Several non-intentional mechanisms could produce partial geometric recurrence.

Geomorphological Structuring

Ridge continuity, erosional gradients, and valley curvature may influence the placement and spacing of summits. Natural fractal dynamics can generate proportional spacing patterns without deliberate planning.

Hydrological Anchoring

The Fojnica-Bosna confluence serves as a natural attractor within the valley. Settlement clustering near water sources may contribute to apparent radial coherence independent of geometric intent.

Pattern Recognition Bias

Archaeological spatial analysis must account for confirmation bias and the tendency to detect structure in complex datasets [10]. The bounded modeling approach was designed to reduce this risk, but it cannot eliminate it entirely.

These alternatives contextualize the findings without negating the measured geometric relationships.

4.5. Relation to Broader Archaeoastronomical Research

Geometric alignment testing has increasingly adopted Monte Carlo and quantitative spatial frameworks [11]-[16]. The methodological contribution of the present study lies in extending these approaches to curved proportional geometry within a fixed geodetic dataset.

Unlike purely visual overlay analyses seen in some earlier spiral-based interpretations, the current modeling incorporates bounded parameter grids and explicit null testing.

This distinction is essential for reproducibility.

4.6. Integrated Spatial Structure

When linear alignments (Part I), triangular configurations, and rotation-invariant similarity metrics, and the present spiral modeling are considered together, the valley exhibits layered geometric structure across multiple independent metrics.

Rectilinear and radial systems appear to coexist within the same coordinate framework. Whether this reflects intentional spatial planning, emergent geomorphological ordering, or a combination of both remains unresolved.

The present results demonstrate measurable spiral coherence under fixed mathematical constraints. They do not, by themselves, establish cultural causation.

4.7. Methodological Implications

The primary contribution of this work is methodological rather than interpretive.

By applying:

- High-resolution LiDAR coordinates
- Fixed-growth spiral equations
- Predefined tolerance thresholds
- Symmetric Monte Carlo testing

The study provides a reproducible approach for evaluating curved geometric hypotheses in landscape-scale datasets.

This framework can be extended to other archaeological or geomorphological contexts where spiral or proportional spatial organization is proposed.

5. Conclusions

This study extends the geometric framework established in Part I by evaluating multi-anchor Fibonacci spiral modeling within the Bosnian Valley of the Pyramids [3]. Using a fixed geodetic coordinate dataset, constant golden-ratio growth parameters, bounded scale and orientation grids, and a 10,000-run Monte Carlo framework, the analysis demonstrates that multi-node spiral intersections can be formally evaluated under defined spatial constraints.

The primary inferential result concerns the Sun-anchored configuration, which produced a four-node spiral intersection within a uniform ±20 m tolerance threshold. Under symmetric spatial redistribution using identical modeling parameters, this configuration lies in the upper tail of the simulated distribution.

Other anchor configurations are presented descriptively to illustrate geometric behavior under identical constraints but were not subjected to independent hypothesis testing. This distinction limits the hypothesis family and maintains statistical clarity.

The probability estimate is conditional on the defined null model, which assumes uniform spatial redistribution within the valley envelope. Terrain-aware simulations and geomorphological constraint models may further refine interpretation in future work.

When considered alongside the linear and triangular alignments documented in Part I and prior rotation-invariant spatial coherence testing, the present results suggest that curved proportional geometry may operate within an already structured coordinate network. Whether this reflects intentional planning, emergent landscape dynamics, or coincidental structuring remains an open question.

The principal contribution of this work is methodological. It demonstrates that fixed-growth spiral models, when applied within bounded parameter spaces and evaluated through symmetric Monte Carlo testing, provide a reproducible framework for assessing curved geometric relationships in complex landscapes.

Future research incorporating terrain-constrained null models, expanded comparative datasets, and independent chronological constraints will help clarify the broader implications of the geometric correspondences documented here.

6. Limitations and Assumptions

Several constraints should be acknowledged.

First, the analysis is spatial rather than chronological. The study documents geometric relationships in the present landscape but does not establish construction sequences or temporal overlap among features. Geometry alone cannot determine whether all elements were conceived simultaneously or integrated over extended periods.

Second, although LiDAR and geodetic data provide high positional accuracy, all geometric analyses require tolerance thresholds. Conservative distance limits were applied throughout to reduce false positives. Tighter thresholds would further strengthen the results, but were not required to demonstrate coherence.

Third, spiral geometry was evaluated using a predefined Fibonacci-based construction. Alternative spiral models were not tested here. This choice reflects the repeated recurrence of Fibonacci scaling across independent analyses rather than an assumption of symbolic intent.

Finally, this study does not attempt to define cultural meaning, belief systems, or symbolic interpretation. The conclusions are limited to spatial organization. Intentionality is inferred at the level of geometric structure, not ideology.

These limitations do not weaken the findings; they clarify their scope and point toward future work integrating chronology, excavation data, and comparative landscape studies.

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Data Availability

Data used in this study derive from published sources, licensed LiDAR datasets, archival geodetic surveys, and original geometric analyses. Spiral constructions and simulation outputs are available from the corresponding author upon reasonable request.

Author Contributions

- **Sam Osmanagich**: Conceptualization; landscape-scale geometric framework; identification and documentation of Fibonacci spiral systems; integration of hydrological and tumular data; Monte Carlo simulation design and interpretation; manuscript writing (original draft); supervision.
- **Massimo Guzzinati**: Independent geometric modeling; spiral construction from multiple origins (Moon, Love, Dragon, Vratnica, Laniste); cartographic synthesis; validation of multi-node spiral families; contribution of original figures and analytical methodology.
- **Richard Hoyle**: Field geology; LiDAR validation; terrain interpretation; hydrological and geomorphological assessment; field photography; verification of summit morphology and spatial coherence.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Osmanagich, S. (2025) True North across Civilizations: Comparative Study of Pyramid Alignments in Five Continents. *Acta Scientific Environmental Science*, **2**, 57-67. https://doi.org/10.5281/zenodo.17505636

[2] Buza, E. (2008) The Analysis of the Landscape and Topography. *First International Scientific Conference on the Bosnian Valley of the Pyramids* (*ICBP Proceedings*, 2008), Sarajevo, 25-30 August 2008, 58-65.

[3] Osmanagich, S., Guzzinati, M. and Hoyle, R. (2026) When Landscape Becomes Geometry: Fibonacci Spiral Patterning Anchored at the Bosnian Pyramid of the Sun. *International Journal of Geosciences*, **17**, 112-138. https://doi.org/10.4236/ijg.2026.172007

[4] Osmanagich, S. (2025) Spiral Geometry in Ancient Design: Evidence of Fibonacci Proportions in the Egyptian and Bosnian Pyramids. *Acta Scientific Environmental Science*, **2**, 1-23.

[5] Osmanagich, S. (2025) Is It Coincidence? Hydrological Engineering and Geometric Alignment in the Bosnian Pyramid Complex. *Journal of Water Research*, **3**, 1-16. https://doi.org/10.33140/jwr.03.02.03

[6] Osmanagich, S. (2025) Multidisciplinary Evaluation of the Pyramid-Shaped Formation near Visoko, Bosnia-Herzegovina: A Case for Anthropogenic Construction. *Journal of Biomedical Research & Environmental Science*, **6**, 503-529. https://doi.org/10.37871/jbres2106

[7] Osmanagich, S., Hoyle, R., Agić, A. and Delibašić, H. (2023) Ravne 3 Tunnels. 1st Edition, Archaeological Park: Bosnian Pyramid of the Sun Foundation.

[8] Livio, M. (2002) The Golden Ratio: The Story of PHI, the World's Most Astonishing Number. Broadway Books. https://www.researchgate.net/publication/305268297_Mario_Livio-The_Golden_Ratio_The_Story_of_PHI_the_World's_Most_Astonishing_Number-Broadway_Books_2003

[9] Wheatley, D. and Gillings, M. (2002) Spatial Technology and Archaeology: The Archaeological Applications of GIS. Taylor & Francis. https://doi.org/10.4324/9780203302392

[10] Ruggles, C.L.N. (1999) Astronomy in prehistoric Britain and Ireland. Yale University Press.

[11] Petrie, W.M.F. (1883) The Pyramids and Temples of Gizeh. Field & Tuer. https://archive.org/details/cu31924012038927

[12] Ashmore, W. and Knapp, A.B. (1999) Archaeologies of Landscape: Contemporary Perspectives. Blackwell.

[13] Henriksen, P.S. and Schaldemose, M. (2015) Assessing Spatial Patterning Using Monte Carlo Tests in Archaeology. *Journal of Archaeological Science: Reports*, **2**, 324-332.

[14] Magli, G. (2013) Architecture, Astronomy and Sacred Landscape in Ancient Egypt. Cambridge University Press. https://doi.org/10.1017/cbo9781139424554

[15] Dash, G. (2013) The Orientation of the Pyramids. *Journal of Ancient Egyptian Architecture*, **1**, 1-7.

[16] Silva, F. and Magli, G. (2022) Assessing the Orion Correlation Theory Using Archaeoastronomical Techniques. *Journal for the History of Astronomy*, **53**, 205-221.