Comparative Analysis of the Earth Pyramids near Konopishte with Similar Structures in the Balkans

[1]Dejan Nakovski
Angela Milenkovska Klimovska

Abstract
The earth pyramids near Konopishte represent unique denudation structures with multidisciplinary significance. This study analyzes their morphogenetic processes, lithological composition, archaeological interpretation, and comparative examples from the Balkans and beyond. The research utilizes field data, literature, and geographic information to highlight the ecological, geographical, and touristic value of the pyramids. Results show that local geological conditions and human interventions define the unique form and function of the pyramids, while comparative analysis confirms the universality of denudational pyramid forms.
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JEL classification: Q01, Q23, Z32, R11, N50

Introduction

Earth pyramids, or vertical denudational columns, are formed by selective erosion of tuffs, sands, and volcanic layers. The site near Konopishte, within the catchment areas of the Lisachka River and Boshava River, represents a unique example of this phenomenon (Lazarević, 1975). The aim of this study is to investigate the morphogenetic processes, lithological composition, archaeological interpretation, and to conduct a comparative analysis with other regions in the Balkans and beyond. Additionally, the ecological, geographical, and touristic values of the pyramids are analyzed.

Methodology

The research is based on:

1. Literature review and theoretical background – an overview of scientific studies from the Balkans and beyond.
2. Geographical and geological data – maps of the watershed, sediment composition, and volcanogenic blocks.
3. Comparative approach – comparison with similar denudational columns in Serbia, Albania, Montenegro, Romania, Greece, Italy, and France.

Earth Pyramids (Columns)

The Earth pyramids (columns) represent a unique phenomenon among denudational forms in the Tikveš region, particularly within the catchment areas of the Lisachka and Boshava Rivers, on the territory of the villages Konopishte and Gorna Boshava. Their occurrence and localization are not random but result from specific geological and morphological conditions in the area. Along the Konopishte–Gorna Boshava stretch, the Boshava River has deeply incised its valley into fossilized brecciated tuffs of the Kožuf–Vitachevo volcanogenic area, forming a canyon with a depth of up to 300 meters. Downstream of Konopishte, the valley also intersects previously deposited Neogene sedimentary material from the Pliocene lacustrine phase.

An additional factor influencing the morphogenesis of the earth pyramids is the canyon dissection and formation of deep ravines from surrounding tributaries, which flow toward the main river course. A second prerequisite is the presence of abundant andesite blocks in the area. These act as natural protection for the softer underlying layers against

[1]**Dejan Nakovski, PhD.,** Full Professor, **Angela Milenkovska Klimovska, PhD.,** assistent Professor, University Skopje in Skopje, Republic of Macedonia

surface and linear erosion, while the surrounding soft material, especially tuffs, is denuded and removed (Lazarević 1975).

In terms of genesis, appearance, and characteristics, these formations are similar to the "Kuklica" formations. This is understandable, as both occurrences developed in volcanic rocks of similar composition: andesites, andesitic tuffs, and breccias (Milevski, Stone Columns ("Tsutski") in the "Valley of Fertility" near Konopishte, Geoportal).

Lithological Composition and Morphogenesis

The earth pyramids near Konopishte are composed of heterogeneous material, primarily sand, clay, and volcanic tuffs, with a smaller proportion of organic matter. This composition provides relative stability to the pyramids, with the presence of harder andesite blocks functioning as a protective layer, preventing rapid erosion of the softer layers.

The morphogenesis of the pyramids results from the synergistic action of natural geological processes and long-term denudation. The primary mechanism is the erosive activity of the Boshava and Lisachka Rivers, which deepen the valleys and form canyon-like configurations. The surrounding relief, consisting of lower ravines and side tributaries, also contributes to gradual selective erosion, where the harder andesite blocks remain as columns while the softer tuffs and sediments are gradually removed.

An additional factor determining the morphology of the pyramids is the uneven erosive resistance of the various lithological layers. Since the tuffs are more exposed to atmospheric effects, their removal leads to the formation of elongated, vertically elevated structures typical of this region. The presence of andesite blocks not only protects the base but also defines the shape of the pyramids, creating the impression of independent vertical columns dominating the landscape (Lazarević 1975).

In a comparative context, similar morphogenetic processes are observed in other parts of the Balkans, where denudation and local geological structure form pronounced vertical configurations of earth or stone columns. Similarities can be found, for example, in areas with volcanogenic material and insufficient vegetation cover, which enhances water erosion and the formation of isolated columns.

Archaeological Interpretation and Function

The earth pyramids near Konopishte are not only geomorphological phenomena but also significant archaeological sites that suggest possible human interventions or adaptations. Although the exact function of these structures has not been fully documented, several theories exist based on field observations and comparative studies with similar constructions in the Balkans.

The first and most common interpretation is defensive. The earth pyramids may have served as natural or artificially enhanced outposts for monitoring the surrounding terrain and protecting settlements. The height of the pyramids, protection from erosion, and their elevated forms create natural vantage points for observing movement through the valley.

The second interpretation is symbolic or ritualistic, where the pyramids could have marked territorial boundaries or held religious–cultural significance for the local population. This type of use is often similar to phenomena observed in neighboring Balkan regions, where tuff columns and other denudational materials were integrated into local rituals and territorial markers (Ivkovska, *Ritual and Territorial Significance of Denudational Columns in the Balkan, 45–62*).

The third possibility is practical or functional use, such as storage of materials or selective use of the pyramids for construction purposes. This interpretation is based on

analysis of layers and the presence of local materials indicating human intervention for stabilization and preservation of the columns.

Comparative analyses with other regions in the Balkans reveal similar morphological and archaeological characteristics, supporting the thesis of interaction between natural geological processes and human activities in shaping the pyramids. In this way, the earth pyramids near Konopishte reflect a combination of natural and cultural factors in shaping the local landscape.

Comparative Analysis with Other Balkan Regions

The earth pyramids near Konopishte have analogs in several parts of the Balkan Peninsula, where natural geological conditions and human activities have resulted in the formation of vertical columns and pyramids from denudational materials.

1. **Montenegro – Đurište and the surroundings of Pljevlja**
   In northwestern Montenegro, isolated tuff and sand columns occur, formed by erosive processes in river valleys. The tall vertical forms were sometimes used as natural landmarks or for local territorial markers. The material is similar to Konopishte: a mixture of volcanic tuffs and sand, with protective stone blocks on the top.
2. **Southern Serbia – near Pirot**
   In southern Serbia, near Pirot, isolated denudational columns composed of tuff and sand layers can be found. These structures, similar to those at Konopishte, are the result of the synergistic action of erosive processes in river valleys and side streams, which selectively remove the softer material while the consolidated blocks remain as vertical columns. The structures in Pirot were sometimes used as natural landmarks and territorial markers, and their morphology indicates an interaction between the geological composition of the terrain and hydrological erosion. Similar to the Konopishte pyramids, the presence of consolidated stone blocks ensures the stability of the columns and prevents their complete denudation (Cvičić 1918).
3. **Bosnia and Herzegovina – Neretva Valley**
   In the Neretva Valley, denudational processes result in isolated tuff and sand columns similar in morphology to those at Konopishte. Although the vertical forms are less pronounced, local erosive and hydrological conditions define their height and shape, while harder blocks maintain structural stability. While not as prominent as at Konopishte, the local pyramids reflect the role of hydrological erosion and the local lithological composition.
4. **Albania – the highlands around Shkodër**
   In northern Albania, on the highlands around Shkodër, natural elevations of tuffs and andesite blocks occur, sometimes serving as foundations or additional protection for traditional "kulla" stone houses. These structures, although partially adapted by humans, demonstrate similarity with the morphogenetic processes at Konopishte: erosive selection of softer sediments and preservation of consolidated blocks (Jerliu 2024).
5. **North Macedonia – the surroundings of Kožuf**
   Apart from the Konopishte site, vertical tuff and sand columns are observed in the western part of Kožuf. The morphology of these forms results from local hydrological erosion and geological structure, with consolidated blocks protecting the base while softer layers are denuded. These forms reflect the

interaction between natural processes and possible human interventions, similar to those at Konopishte.

6. **Slovenia – the surroundings of Kranjska Gora**
   In smaller mountain valleys, volcanic tuffs and sediments form vertical denudational columns. Although the terrain and climate differ, the process of selective erosion is similar, with harder blocks preserved at the tops.

These examples indicate that the phenomenon of vertical columns and pyramids from denudational materials is present throughout the Balkans. Comparative analysis shows that, although morphogenetic processes are similar across the region, local geological conditions, type of denudational material, and human intervention create variations that define the character and function of the pyramids in different parts of the Balkans.

Earth Pyramid Forms as a Globally Present Phenomenon

1. **Romania – Dobruja and Transylvania**
   In northern Transylvania and the Dobruja region, denudational columns of sand and tuff sediments can be observed, formed by erosive processes of rivers and streams. These columns are sometimes referred to as "Earth Pyramids" and are characterized by harder stone caps that protect them from complete erosion.
2. **Bulgaria – the surroundings of Strumica and the Rhodope Mountains**
   In the mountainous areas of the Rhodope Mountains and the Strumica watersheds, natural earth pyramid forms are found, resulting from selective erosion of tuff and sand layers. Similar to Konopishte, harder blocks or stone caps maintain the vertical form while the surrounding softer sediments are removed.
3. **Greece – Meteora and Thessaly**
   Although the columns in Meteora are primarily stone and used for monasteries, their geomorphology is the result of erosion of soft sedimentary and volcanic layers, representing a natural analogue of denudational pyramid forms. The processes of selective erosion and vertical column formation are similar to the phenomenon at Konopishte, differing mainly in material and human use.
4. **Italy – Val d'Orcia and the surroundings of Siena**
   In Tuscany, especially in the Val d'Orcia region, erosive sand and tuff columns can be observed, sometimes referred to as "Calanchi." These forms result from selective erosion by rainfall and streams, where harder layers protect the column bases while softer layers are removed.
5. **France – Provence and the Verdon area**
   In the Verdon canyons, denudational columns of sand and tuff form vertical "earth pillars." These forms result from natural erosive processes and illustrate the universality of morphogenetic mechanisms, similar to the Balkan sites.

These examples from the broader region highlight that the morphogenesis of earth pyramid forms is a globally present phenomenon, where local lithological composition, erosive processes, and human intervention define the specific shape and function of the columns.

Location / Country	Material	Height (m)	Protective Blocks	Erosion / Denudation	Feature / Note	Source
Konopishte, North Macedonia	tuff, sand, andesite	5–12	present	60%	Local natural pyramid form, potential archaeological use	Lazarević, 1975; Pavlov et al., 2014
Pirot, Southern Serbia	tuff, sand	4–10	present	55%	Denudational columns, natural landmarks	Cvičić, 1918
Shkodër, Albania	tuff, andesite	3–8	partial	50%	Partially human-adapted “kulla” houses	Jerliu, 2024
Kožuf, Northwestern North Macedonia	tuff, sand, andesite	4–10	present	58%	Sometimes used for defensive purposes	Ivkovska, 2019
Pljevlja, Montenegro	tuff, sand	3–9	present	52%	Denudational forms, natural landmarks	Ivkovska, 2019
Dobruja, Romania	sand, tuff	3–7	partial	48%	“Earth Pyramids,” natural denudational columns	Panin, 2005
Rhodope Mountains, Bulgaria	tuff, sand	3–8	present	50%	Vertical denudational columns	Dimitrov, 2010
Meteora, Greece	sand, tuff, rock	10–20	present	45%	Stone columns used for monasteries,	Vagenas, 2003

Location / Country	Material	Height (m)	Protective Blocks	Erosion / Denudation	Feature / Note	Source
					natural analogs	
Val d'Orcia, Italy	tuff, sand	3–9	present	50%	"Calanchi," erosive columns, natural tourist attractions	Guerr

Table 1. Examples of Denudational and Earth Pyramid Forms

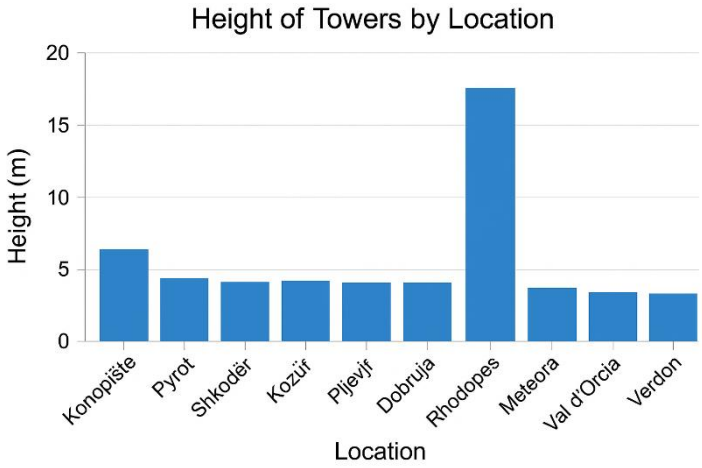

Figure 1. Height of Earth Pyramid Forms

Values and Significance of the Earth Pyramids near Konopishte

The earth pyramids near Konopishte represent a significant natural phenomenon with multiple values – ecological, geographical, and touristic – highlighting their role in the local landscape and cultural-historical context.

Ecological Values

The ecological role of the pyramids is multi-layered. They create specific microhabitats for local biodiversity. The soft tuff and sand layers, protected by harder stone blocks, allow for the growth of endemic and rare flora, rarely found on surrounding horizontal terrains. Within the columns and at their bases, insects, birds, and small

mammals find shelter, nesting sites, or safe resting areas, increasing the biological value of the region (Ivkovska, 2019).

Additionally, the pyramids reduce surface erosion on the surrounding terrain. The harder blocks stabilize the structures, which helps preserve the soil and regulate rainwater drainage. This natural erosion control mechanism enhances the stability of the local landscape and preserves the natural environment.

Geographical Values

The geographical values of the pyramids are particularly expressed through their morphology and role in the local relief. The earth pyramids define the topography of the Lisachka River and Boshava River watersheds, creating striking vertical accents that enhance the landscape. The lithological composition of tuff, sand, and andesite blocks makes the pyramids natural laboratories for geological and geomorphological research, providing insight into volcanic and sedimentary processes in the region (Lazarević, 1975).

The pyramids also modify the hydrology of the watershed. They channel the flow of side streams, influencing erosion processes and sediment transport throughout the valley. In this way, the pyramids have a functional significance in preserving the geomorphological stability of the terrain.

Touristic Values

From a tourism perspective, the earth pyramids represent a significant attraction. The tall, vertically elevated forms create a visually striking landscape, attracting tourists, photographers, and recreational visitors. Their educational value is also significant – visitors can learn about the geological composition, denudation processes, and potential archaeological functions of the pyramids, creating opportunities for educational and scientific tourism.

The pyramids can be integrated into eco-trails and thematic tourist routes in the Tikveš region, enabling the development of sustainable tourism. Hiking tours, field visits, and promotion of the natural landscape raise awareness of the pyramids' importance and support the local economy without negatively impacting nature.

Recommendations for Protection

Erosion control: Construction of minimal barriers, stabilization of blocks, erosion monitoring.

Ecological protection: Preservation of microhabitats, protection of biodiversity, visitor education.

Touristic and cultural protection: Sustainable trails, educational programs, regulation of visitor numbers.

Research and monitoring: Scientific studies, digital documentation, partnerships with universities and institutes.

Legal and administrative measures: Legal protection, awareness campaigns, control of agricultural and construction activities.

Discussion

The earth pyramids near Konopishte represent a unique geomorphological and archaeological phenomenon, resulting from the complex interaction between natural and anthropogenic factors. Local erosional processes, primarily the activity of the Boshava River and its tributaries, selectively remove softer tuff and sand layers, while the harder andesite blocks remain as stable vertical columns. The lithological composition and presence of organic components further define the morphology of the pyramids, providing long-term stability (Lazarević, 1975).

Archaeological interpretations suggest that the pyramids may have served defensive purposes, territorial markers, or ritual activities. Similar examples from the Balkans, such as in Southern Serbia (Pirot), Northwestern North Macedonia (Kožuf), Albania (Shkodër), and Montenegro (Pljevlja), indicate that the synergistic effect of erosion, geological composition, and human activities is universal, with local variations in form and function (Ivkovska, 2019; Jerliu, 2024).

Expanding the comparative analysis to other countries, including Romania, Bulgaria, Greece, Italy, and France, it is evident that denudational columns of sand, tuff, and volcanic materials are a globally present phenomenon. The similarity in selective erosion processes, preservation of consolidated blocks, and formation of vertical structures confirms the universal principle of the morphogenesis of denudational pyramidal forms, with variations driven by local geology and climate (Cvičić, 1918).

The comparative approach also highlights the uniqueness of the Konopishte earth pyramids, resulting from a specific combination of:

- local lithological composition (tuff, sand, andesite),
- high canyon dissection and erosional processes,
- presence of consolidated blocks stabilizing the structure, and
- possible human interventions for preservation and use of the pyramids.

This multidisciplinary approach demonstrates the interaction between nature and human activity and emphasizes the importance of integrating geological, morphological, and archaeological data for a comprehensive understanding of the phenomenon.

Conclusion

The earth pyramids near Konopishte are significant as a local geomorphological and cultural-archaeological phenomenon. They reflect the interaction between natural erosional processes and human activity, and their morphology and lithological composition allow for long-term stability and a unique visual effect.

Comparative analysis with other regions of the Balkans and beyond confirms the universality of denudational pyramidal forms while highlighting the uniqueness of the local context at Konopishte. The presence of consolidated andesite blocks, the canyon dissection of the Boshava River, and possible human interventions define the shape and function of the pyramids, making them important for geomorphological, archaeological, and cultural research.

The earth pyramids at Konopishte illustrate the interaction between natural erosional processes and human intervention. They are significant from ecological, geographical, and touristic perspectives and can be integrated into sustainable local development strategies. The implementation of recommended measures will ensure long-term protection and sustainable tourism.

For further research, it is recommended to:

1. Conduct detailed field and laboratory analyses of the lithological composition.
2. Undertake geoarchaeological studies to assess human intervention.
3. Study erosional processes and their impact on the long-term stability of the pyramids.

These activities will provide a comprehensive understanding of the morphogenesis, function, and significance of the Konopishte earth pyramids within a broader geographical and historical context.

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