# Navigating the Intersection of Geology and Architecture

## The conceptualization of the cave churches in Pustec as the convergence of geo-morphic agents

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**Abstract -** *The research examines the intersection between geology and architecture in the Pustec and Prespa region, where ancient geological formations converge with rich cultural heritage. Central to this study is Prespa Lake, whose geology significantly influences the surrounding landscape and human-built structures. The interplay between geological forms and cultural monuments creates a unique dualism, where natural landscapes and human activities coalesce seamlessly. Historically, figures like Ruskin and Charles Smith have explored the potential of geology to inform architecture beyond mere engineering concerns, suggesting a deeper, creative integration. Ruskin viewed geology as more than a technical science, proposing that it could inspire architectural design through its intrinsic understanding of the earth's history and processes. Charles Smith, a Victorian geologist and stonemason, furthered this idea by positing that geological formations narrate the earth's past. Building on these historical insights, the research employs a multidisciplinary approach, combining geological mapping together with cultural heritage mapping. This methodology includes both qualitative analyses (such as visual interpretations of layered maps) and quantitative methods using Geographic Information Systems (GIS) to analyze spatial relationships. By superimposing cultural heritage maps onto enhanced geological maps, the study reveals significant patterns, particularly the concentration of heritage sites on ancient geological layers. This suggests that older geological formations provided stable and strategic locations for human settlement and construction, highlighting the importance of geological context in cultural heritage preservation. A detailed case study of the Maligrad cave church exemplifies the integration of natural and built environments. Located within a karst landscape on Maligrad Island, the church embodies Alonso's "Material-Event," where architecture and geology converge. The karst formations, characterized by limestone and natural caves, create a dynamic backdrop for the church, which has been meticulously adapted to fit the natural contours of the cave. This integration reflects a deliberate effort to harmonize human design with geological features, showcasing architecture as a mediator between human creativity and geological forces. The findings advocate for a broader acknowledgment of geology's role in architectural and cultural heritage studies, suggesting that an integrated perspective enriches our understanding of historical human-environment interactions and guides future conservation efforts. This approach, embracing both scientific and humanistic dimensions, underscores the deep symbiosis between the earth's physical history and the cultural legacy it supports.*

*Keywords -* *Architecture, Geology, Cultural Heritage, Deep-Time*

## Introduction

Pustec and the Prespa region present a very particular context where division happens between the geopolitical borders, however the interconnectedness of the natural landscape is very apparent when emphasized by its geological identity. At the core of this expansive region lies Prespa Lake which together with its adjacent lake Ohrid comprise two of Europe's most ancient lakes [1]. This ancient and intricate geological formation plays a pivotal role in shaping, informing and influencing the surrounding landscape. This geological foundation serves as the bedrock upon which both the vast and diverse natural environment and the human-built infrastructure coexist. Cultural heritage monuments from different time periods are scattered around the area in a way that seamlessly

blends with the natural one. It is this dualism between the geological forms and the cultural ones which gives rise to the intersection between the two. In this context we can observe Architecture and Geology as two wide notions with a relation quite apparent at first glance, yet very ambiguous if inspected. Their connection is likely contrived from the immediate link between the building and the earth, the latter being always geologically complex. This complexity is more often than not, dealt with in engineering terms and appears to rarely go beyond it. The necessary acknowledgment of its broader dimension is often trampled by the inherent disregard as a superfluous science that belongs to another discipline altogether. It is its perception as a foundational science that informs our understanding of the earth's history and processes that brings a disregard in favor of more utilitarian perspectives. However, when extended beyond mere pragmatism, it has the potential to reveal a deeper understanding of the interconnectedness between the natural and the built environment.

## Literature Review

### Ruskin and Charles Smith

Ever since Ruskin, there has been a conscious effort to dissect the potential of this science as a means for one to influence the other. Through his lens, geology was a source of insight that transcended mere economic or technical considerations and opted for the creative processes of design and construction it could delve into, insisting on the understanding geology could provide. Often considered a theological geologist, his interpretation even bordered the poetic when he elaborated that the Gothic churches are a sum of parts in the same way the chemical composition of minerals suggested a union of elements [2]. Beyond the literal interpretation and the untenable reach of this statement, his insight contributed to broadening the perspective from which geology can be viewed and recognizing its architectural potential. In this sense, beyond serving as a catalyst for expanding the discourse, this statement can be viewed as a much larger base for claiming that the geological composition of the material can be used to instruct the way in which matter can take shape.

An initial idea for this was put forth by the British geologist Charles Smith, who extensively elaborated on the novel way architecture could be informed by geology, which even preceded Ruskin, during the Victorian times. This wasn't coincidental because as Gillin states [3], the chain reaction of industrialization and its economic interests brought forth a fascination with geology that was unprecedented. Charles Smith being a geologist as well as a stonemason and builder can be considered to be the figure where these fields intersected to produce the first research on the matter. Gillin examines works of the Victorian period where this influence is first noticed, however, most of it is rendered to the study and use of particular stones to envelop the facades. This merely aesthetic action pales in comparison to the articulated ideas that were written down and put forward at the time. In his writings, Smith introduces the idea that the solid earth was once in a fluid state because of heat and that every geological formation was a narrator of the past and its form [3]:

*"The entire materials of the great globe we inhabit, were at one time in a fluid state; and that the cause of this fluidity was heat."*

Geology became a way of reconceptualizing Earth's history [4] and this was done through the notions of perpetual movement and erosion.

### Flowing Matter

What Charles Smith claimed during the 19th century would be more than a century later solidified not only in the studies of geology but also into a proper branch of physics that studies the flow of matter, namely "rheology". Despite the fact that he is never cited, the term itself describes the same concepts presented by Smith, although of course in a much more specific sense than he intended. Marcus Reiner who coined the term, used Heraclitus' "Panta Rhei " to express the idea that matter constantly flows, even if to an observer it may seem the opposite. This pivots around one particular constant called the Deborah number [5], which beyond the scientific technicalities in studying the properties of fluids with industrial applications, actually serves as a philosophical inquiry into the perception of time and matter. What this conundrum addresses

is the limited human perception in contrast to the vast temporal scale where the universe operates. This disparity leads to a constrained temporal perspective and as a result a static interpretation of it. Whereas mountains appear robust and unmoving when posited against a short time span, they appear liquid when the movement of matter is observed on a much wider time span. In this case, this can very well be applied into the geological perception, being that when opposed to the human perception, the geological time spans can be very extended. The latter consists of billions of years, as research shows the oldest geological strata on Earth to be 4.4 million years old [6]. The same can be said for the built environment. Latour and Yaneva [7] stated that architecture is by no means static but rather dynamic because its past and future act as agents that continuously shape a building beyond its construction. In their influential article "Give Me a Gun and I Will Make All Buildings Move" they express the need for a method of representation that would be the quintessential opposite of Etienne Jules Marey's photographic gun which through freeze-framing each second of a rapid movement succeeded in dissecting the latter into fixed and static images. Latour and Yaneva proposed the reversal of this process to achieve a flowing image of architecture that would do justice to its fluctuating nature. However, as Harman deduces, the very act of joining single instances and fixed frames of a building through time, goes against the very principle of continuous flux as understood by Aristotle and later Bergson who claim that movement and time is indivisible [8]. This very sharp swerve in attempting to ontologically analyze the object of architecture is what illuminates the conundrum it tries to solve. Contrary to their claim "we too need an artificial device (a theory in this case) in order to be able to transform the static view of a building into one among many successive freeze-frames that could at last document the continuous flow that a building always is", Latour and Yaneva's proposal is very much distanced from purely theoretical devices and conceptions while it actually strives for a reproductive device in the milieu of architectural representation. This reproduction of the image would become the device itself which produces furthere.

## Geomorphic agents

In architecture theory and practice there have been various attempts, such as the one exemplified by



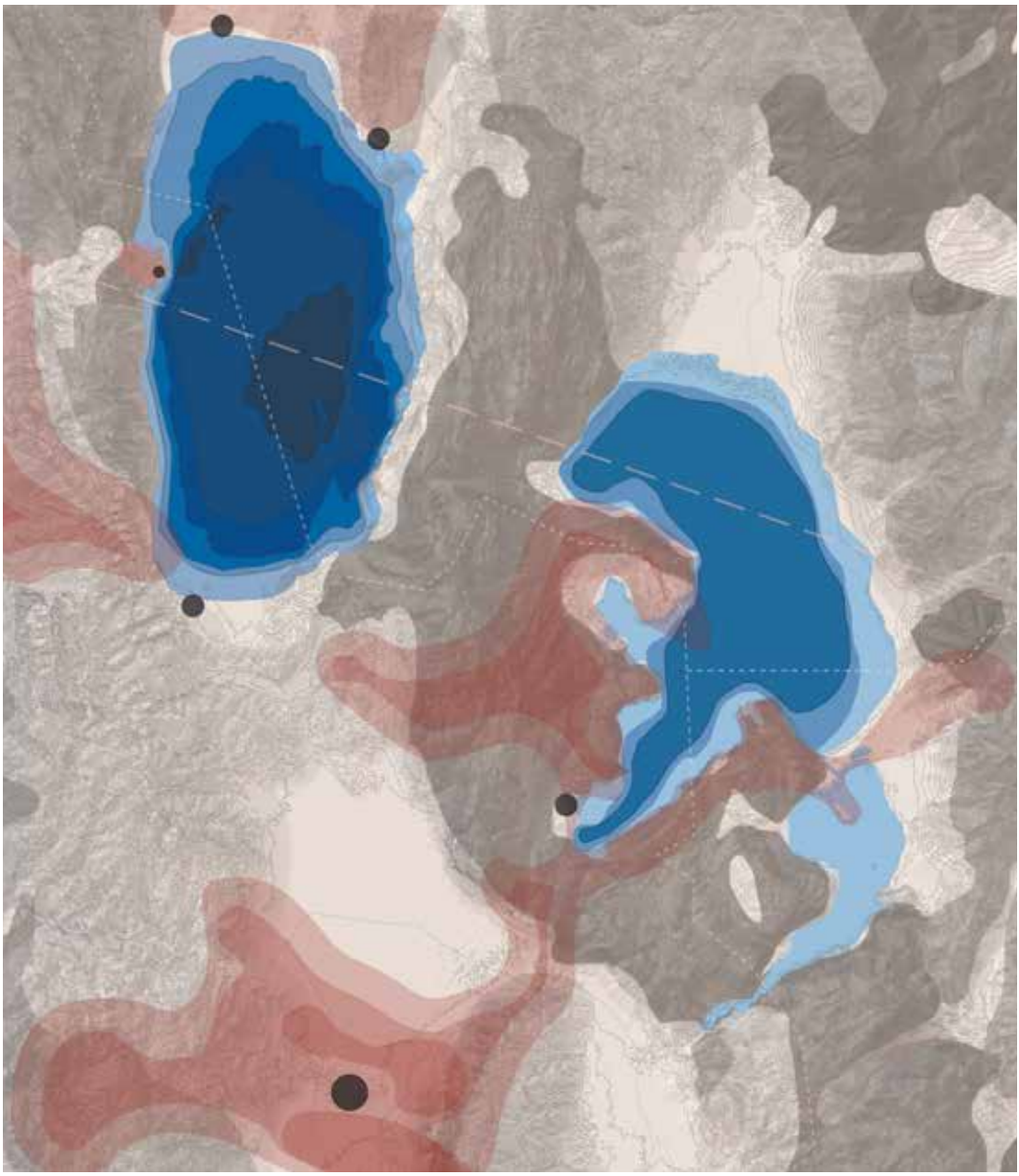

*Fig. 11: The superimposed map of Pustec's chronological geology and concentration of cultural heritage source/ author (2023)*

Tschumi's drawings and his view of Space Event [9]. Nevertheless, this framework often encounters the risk of becoming a utilitarian instrument within the design process, which falls into the trap of capturing movement and freezing it in time, achieving the opposite of what is intended and undermining dynamism and movement altogether. Hence the very temporal conception of architecture should not be dissected with the intention of turning it into a design tool, as much as understanding the very act of building and of the formalized matter as an entity that undergoes temporal mutations, which are not only transformed in itself but also transform the "Space-Event" around it. Cristina Parreño Alonso takes it a step further into suggesting that viewing architecture through such vast temporal time spans reveals a fluid view and implicates a much more radical paradigm shift that transposes "Space-Event" into what she calls "Material-Event" [10]:

*"Reorienting architecture toward the 'material-event' renders the building not as an isolated object-instance in a human timeline, but rather as a moment of convergence of material and energy that flows across deep temporal scales. It situates building at the intersection between human timescales and Earth cycles, between geology and technology in their act of world-making, both equally translated into actions that relate to material, place, and process—collapsing, eroding, releasing, capturing, calcifying, diluting, flowing—inevitably blurring the boundary between culture and nature. It suggests the possibility of a deep-time architecture that fully embraces tectonics in its multiple meanings: tectonics in architecture, as the science of construction and techniques of material assemblies, and tectonics in geology, as the structure of the crust of the Earth, its processes, and its evolution through time."*

## Tools and Methodology

### Methodology

The concept of "Material Event" emphasizes the moment of connection between earth and architecture on a spatial-temporal scale. One influencing the other, it is suggested that tectonics in architecture and geology can have instances of intersection in this scale. For this reason, a comprehensive and layered mapping approach was employed, where the methodology combines geological mapping with cultural heritage mapping to visually demonstrate the spatial and temporal connection between the natural and human-built structures.

The phase of the analysis involves both qualitative and quantitative methods where the former tackles historical documents, architectural records and previous research studies conducted on the heritage of the site. This research was examined to contextualize the findings within the theoretical framework. A visual analysis of the geological maps of Pustec was also conducted to interpret the patterns and their prominence within the scope of the research. While, quantitatively, GIS tools were used to perform spatial analysis on the territorial map, quantifying the extent to which cultural heritage sites were disbursed within the area.

### Geological Map

The methodology itself branches into two different scales: the regional scale and the architectural scale. The regional scale takes into account the administrative area of the Pustec municipality together with parts of the neighboring areas and consists of a visual display of its geological features

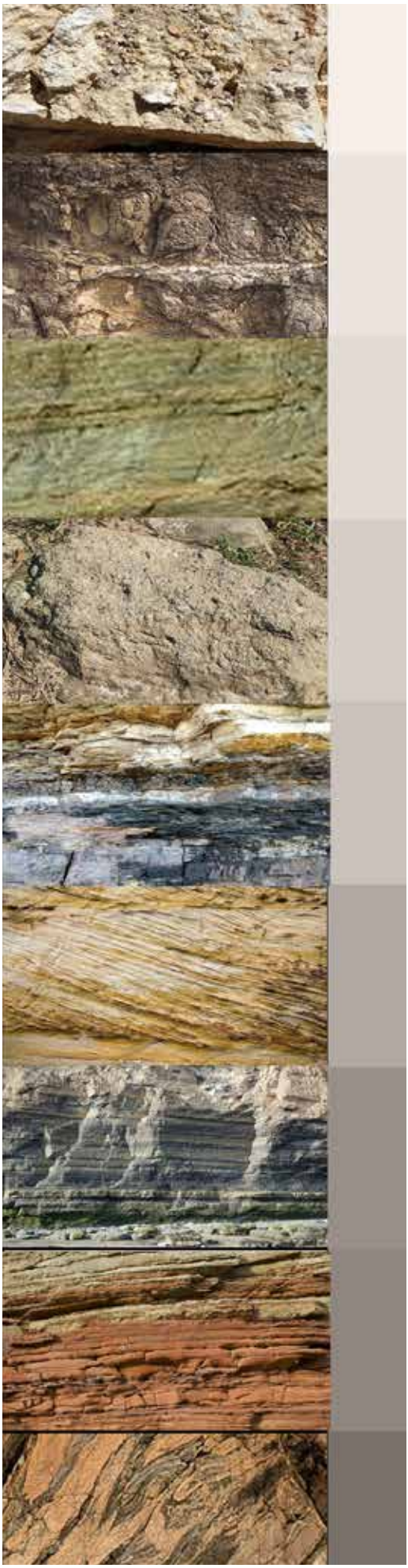

*Fig. 12: The superimposed map of Pustec's chronological geology source/ author (2023)*

and heritage centers. This data was extracted from local archives, historical records, field observations, and the Geographic Information System. The derived heritage map plotted the locations of sites where objects of cultural importance are situated and this information was visually interpreted into concentrated areas with a red gradient of intensity. We can see that a large cluster of built heritage is concentrated on the western side of Prespa. The result is superimposed on a processed geological map which used the existing geological map of Pustec as a base layer. The latter included various geological strata such as Precambrian, Triassic, Jurassic, and Cretaceous, however, it did not predominantly illustrate their ages. To address this, the map was reprocessed with a technique similar to William Smith's first geological map in the first publication of a geological map of a country. [11] Smith's innovation was in using color as a way to represent the underlying strata within each other as a way to indicate their age. Similarly, the processing of Pustec's geological map consisted in ordering the strata from oldest to newest and a gradient of color was attributed to each geological timeline where the oldest strata (precambrian) is represented by the darkest color. The colors gradually become lighter according to the strata's age, resulting in a chronological map of the site's geology. In this map we can clearly see that the Prespa Lake (and also Ohrid) is surrounded by old strata. The scientific evaluation of Ohrid and Prespa being the oldest lakes is now visualized. This processing provided a clear visual representation of the geological history of the area, which made it easier to correlate the geological formations with the cultural heritage sites. The superimposition of the map of cultural heritage concentrations and the chronological map of the site's geology allows for the identification of patterns and correlations between the two polarities (Figure 1).

## Case Study

On the architectural scale, the focus shifts to specific case studies of cave churches in the Pustec region. These structures represent a unique convergence of natural geological formations and conscious human design, embodying the principles of Alonso's "Material-Event." The karst landscape, characterized by its limestone formations and natural caves, provides a dynamic backdrop for these architectural interventions.

This notion can be encountered particularly in the philosophies of the East where a fundamental emphasis is placed on the constant metamorphosis of geological formations, particularly evident in the processes of erosion which shape limestone



*Fig. 13: Maligrad island cave section and plan showcasing the cave-church source/ author (2023)*

and karst landscapes as a product of partially dissolving and re-solidifying mass. Loo when analyzing the aesthetic and philosophical value of rocks to the Chinese literati as a focal point of contemplation says: "The most admired specimens were sedimentary rocks easily shaped by nature but also craftsmen"(p.7)[12]. It can be said that the karst landscape and its transforming nature is the meeting point of nature and man as geo-morphic agents. Prespa region is a site where this kind of landscape has been used to merge natural erosion with conscious architecture. The karstic formation of the region has allowed for a unique form of architecture to emerge such as that of the cave-churches.

The southern and western shore of Prespa is composed of karst rock. The Galičica Mountain (Mali i Thatë), which stands between Prespa Lake and Ohrid Lake is itself a karst massif with a high presence of sinkholes near the two shores. It is this sort of topological formation that allows a hydrological relationship between Lake Ohrid and Prespa, among which the latter recharges the former with water [13]. The same geological formation has formed natural caves around the southern and western shores of Lake Prespa altogether with the shores of the Maligrad island which is positioned in the middle of the lower half of the lake, close to Pustec.

The island's area is relatively small at only 0.05 km2 with a tadpole shape while the elevation to 850 m is abrupt and steep, forming a circular cliff which stands as a monolith laterally eroded where the caves are formed. Besides the presence of the cave churches used as hermitage places, the island has been and still is inhabited, favoring the presence of snakes and vegetation to thrive.

The Maligrad cave church is one among six known rock monuments and chapels that were constructed as memorials by minor local nobility. They were either hermit foundations or shrines/ mausoleums. Now monuments of cultural heritage, they date back to the XIV century, among which the most noted one is the Saint Mary church on the island of Maligrad built in 1369 by Kesar Novak who also appears in the valuable fresco paintings of the church [14][15].

The church is located within one of the southernmost caves of the island, situated at an elevation approximately midway between the island's highest and lowest points. It is a small single-aisle basilica that initially was built in 1344 by Boyko and his spouse Evdokia with a low-pitched roof, but under the patronage of Cesar Novako in 1369 extensive renovation and painting endeavors ensued. These efforts resulted in the church's enlargement, the substitution of its wooden roof with a semi-cylindrical arch which is visible only inside, and comprehensive interior and exterior fresco adornment. This ornamentation bears remarkable significance where the surviving mural fragments from the initial phase of 1344 exhibit intricate calligraphy, decorative motifs, and vivid portraits showcasing the artistic ethos of the time which suggest a direct influence from Ohrid, a prominent ecclesiastical hub of the time and the presence of renowned workshops active during the 14th century. The subsequent phases' frescoes exhibit dynamic compositions, emotive facial expressions, and a rich palette emblematic of the artistic flourishing during the Palaeologan Renaissance era. [16]

The church is interestingly positioned near the edge of the cave, its lateral wall facing the opening, whereas its rear wall though nearby does not adjoin the cave walls. The position of the church very obviously adheres to the tradition of facing eastwards, however, the choice of building the left wall in very close proximity to the cavern's periphery also appears as a conscious choice. This incorporates the very form of the church to that of the cave, making the church into an element of confinement to the naturally eroded space. (Figure 2)



## Results

The superposition of the geological map and the cultural heritage map revealed significant patterns in the area of Pustec. Importantly, the cultural heritage buildings are mainly concentrated on the oldest geolithological features, predominantly the Precambrian and Triassic layers. One conclusion we can draw from these findings is that the geological age of the landforms is strongly associated with the presence of heritage sites. The geological context in which these sites are found, intersects with both historical and architectural understanding, grounding them in the cultural landscape, and reflecting how the natural landform has shaped human history over time. The geological impact of the oldest layers fixed the most stable and attractive locations for population and construction and affected the distribution and preservation of cultural heritage in the specified region.

The intersection of geology and architecture is further illustrated in the case study of the Maligrad church, which, situated within a naturally formed cave on the karstic Maligrad Island, exemplifies Alonso's concept of "Material-Event". The church's adaption and intersection with the existing geological features in the karst landscape, make it a meeting point between two temporal timescales: the geological one and the architectural one, both fluid and everchanging. This merge of Earth's and human actions as geomorphic agents reflects the transformative power of their intersection.

The results from GIS analysis also supported these qualitative observations of the visual and spatial characterization of the map. The spatial analysis, found that cultural heritage sites are correlated with distinct geological formations, and showed strong match between cultural heritage sites and the geological features of the earth's crust. Such a quantitative approach encapsulated this relationship in a straight forward, graphical form that separated cultural heritage sites neatly adjacent to the most ancient geological features. Finally, color gradients were applied on the map where geological timelines overlapped again to enhance the clarity by highlighting the spatial relationships allowing the reader to identify and analyse these correlations. This comprehensive approach to mapping both illustrated the historical connections between geology and architecture and offered a methodological structure to the investigation that can be replicated in studies that focus on the interactions between natural landscapes and cultural heritage.

On a temporal scale, although the human perception and the geological timespans are vastly different, on the map they graphically appear with the same weight suggesting a comparison between two spans that appear equal. Although Bruno Latour's ambition and representational concept were not achieved through a tangible technological technique, the effect produced by the map shows Earth presents human activity and geological activity as one holistic matter that has flowed through time.

## Conclusions

Pustec and the Prespa region thus present a very particular context where the intersection occurs in many planes of knowledge. Its landscape is the temporal-spatial void where the natural geological formation, heritage, and architecture have their meeting point, blurring the boundaries.

By methodological study it is indicated that the oldest geological formations in Pustec significantly influence the distribution and preservation of cultural heritage sites and likewise the concentration of these heritage buildings on ancient geological layers suggests that these foundational geologies have historically provided stable and strategic locations for human settlement and construction. This predicament suggests the importance of considering geological context in cultural heritage preservation, highlighting how natural landscapes have shaped human activities and architectural developments over centuries.

The insights gained from this research advocate for a broader acknowledgment of geology's role in architectural and cultural heritage studies. Such an integrated perspective not only enriches our understanding of historical human-environment interactions but also offers valuable guidance for future conservation and development efforts in geologically significant regions. This holistic approach, embracing both the scientific and the humanistic, reveals the deep symbiosis between the earth's physical history and the cultural legacy it supports.

## References


*[1] Wagner, B., Vogel, H., Francke, A., Friedrich, T., Donders, T., Lacey, J. H., ... & Zanchetta, G. (2019). Mediterranean winter rainfall in phase with African monsoons during the past 1.36 million years. Nature, 573(7772), 256–260. https://doi.org/10.1038/s41586-019-1529-0*

*[2] Ruskin, J. (1904). The Works of John Ruskin: The stones of Venice, the sea-stories. United Kingdom: G. Allen.*

*[3] Smith, H. L. (1848). The world: Or, first lessons in astronomy and geology, in connection with the present and past condition of our globe. M. C. Younglove and Company.*

*[4] Gilin, E. J. (2016). Stones of Science: Charles Harriot Smith and the Importance of Geology in Architecture, 1834–64. Architectural History, 59, 281–310. http://www.jstor.org/stable/26449108*

*[5] Reiner, M. (1964) The Deborah number. Physics Today, 17, 62. http://dx.doi.org/10.1063/1.3051374*

*[6] Jonathan O'Neil, Richard W. Carlson, Jean-Louis Paquette, Don Francis. (2012) Formation age and metamorphic history of the Nuvvuagittuq Greenstone Belt. Precambrian Research, 220-221, pp.23-44. ff10.1016/j.precamres.2012.07.009*

*[7] Latour, B., Yaneva, A. (2008), «Give Me a Gun and I Will Make All Buildings Move»: An Ant's View of Architecture, in R. Gesier (ed.), Explorations in Architecture: Teaching, Design, Research, Basel, Birkhäuser Verlag, pp. 80-89.*

*[8] Graham Harman, (2017), Buildings are not Processes: A Disagreement with Latour and Yaneva, Ardeth [Online], 1, Online since 01 October 2017, connection on 10 December 2020. URL : http:// journals.openedition.org/ardeth/997*

*[9] Tschumi, B. (1994). The Manhattan Transcripts. Italy: Wiley.*
*[10] Cristina Parreño Alonso (2021) Deep-Time Architecture: Building as Material-Event, Journal of Architectural Education, 75:1, 142-144*

*[11] Sharpe T. (2015). Geology. The birth of the geological map. Science (New York, N.Y.), 347(6219), 230–232. https://doi.org/10.1126/science.aaa2330*

*[12] Loo, E. (2023). Grotto-Heavens: Rockeries, Dreamscapes and the Chinese Garden. DMJournal–Architecture and Representation, No. 1: The Geological Imagination. Drawing Matter Journal, 1. Advance online publication. https://drawingmatter.org/tag/the-geological-imagination/*

*[13] Anovski T,. Andonovski B., Minceva B. (1991). Study of the hydrologic relationship between Ohrid and Prespa lakes. Proceedings of IAEA International Symposium, IAEA-SM-Vienna, 319/62.*

*[14] Anamali S. (2002). Historia e popullit shqiptar në katër vëllime (in Albanian). I. Botimet Toena. pp. 294–295*

*[15] Dhamo, Dh. (1965), Kisha e Shën-Mërisë ne Maligrad, Studime Historike, 2, 1963*

*[16] Xhaferaj E., Nesturi E., Marika Z. (2013). The 14th century frescoes by artist named Alex in the chapel of St Mary, Gollomboç (Prespa). In: Iliria, vol. 37, pp. 245-261.*