

# ՀԱՐՏԱՐԱՊԵՏՈՒԹՅՈՒՆ ARCHITECTURE

---

DAVID KERTMENJIAN\*

*Doctor of Science in Architecture, Professor  
National University of Architecture & Construction of Armenia  
dakertmenjyan@gmail.com*

## ON THE PROTECTION OF THE ARMENIAN STONE-BUILT ARCHITECTURAL MONUMENTS

*Key words:* global climate changes, conservation, Armenian architecture, architectural monument, geology, mortar, composition.

### *Introduction*

Notable is the effect of climate changes on preservation of modern and historical buildings in the last decades. Very urgent is the update of documentary information of the case. State of the art includes the following problems: investigation, as soon as possible, of not only global but also local reasons of the changes affected by the climate on the monuments, finding the ways of recovering the damage caused, otherwise it will end in serious damages.

The main problem of the research is the study of existing progressive methodologies for the fixation and stabilization of the effects caused by climatic changes on the historical buildings in Armenia. The objectives include the following aspects of world and Armenian monuments: 1. Definition of the current climatic impacts; 2. Determination of soil media reactions to the result of climatic changes; 3. Behavioral analysis of the indicated buildings and particularly the **“Mitis” type of layered masonry technique used**; 4. hasty supply of diagnosis and mapping on some case studies carried out in Armenia, that is by means of the

---

\* Հոդվածը ներկայացվել է 28.08.20, գրախոսվել է 28.08.20, ընդունվել է տպագրության 04.12.20:

UNESCO-based computerized program of “Metigo map”<sup>1</sup>. The methodology of our research is the qualitative study and comparative analysis of the harms observed on the monuments. Since the restoration and other fields of maintenance are, as usual, connected with certain technical solutions, the study will focus on conservation aspects which result in a direct action of new climatic changes over stone-built historical buildings. The study is based on books by some scholars on the Armenian Architecture,<sup>2</sup> as well as on methodical studies published.<sup>3</sup> Relevantly, the study presented below will deal with aspects mentioned in the objectives.

#### *General Historic and Geographical Information*

Armenia is a typically mountainous country. About 90% of its territory is over 100m above sea level, of which 40% are over 2000m. Average height of the territory is 1830m. The highest point is 4090m and the lowest is 350m.<sup>4</sup> Most of the historical monuments are usually located within the zone of 1000m height. In fact the temperature in Armenia generally depends upon elevation<sup>5</sup>. The mountainous nature that has been suitable for the creation of habitable caves, the existence of almost all types of easily adaptable stones for construction and particularly mines of volcanic type available, as well as **the fertility of the plateau’s volcanic soil, etc., made Armenia one of the world’s earliest sites** of human habitation and agricultural activity. Besides, the interaction of the climate and natural environment has been a sensitive reason for frequent changes in building styles. The mentioned aspect became more and more activated throughout the civilizational and technological developments. Hence, our study should consider an optional approach applied against the background of the following architecture development periods: 1/ Prehistoric times (B.C. VII – III Millennia), 2 Urartian era (B.C. XIII c. – B.C. 586), 3/ Antique Armenia (B.C. VI c. – 301 A.D.), 4/ Medieval

---

<sup>1</sup> For details see: <http://ui.adsabs.harvard.edu/abs/2015EGUGA..1710588S/abstract>

<sup>2</sup> Of particular interest are: **Հովհաննիսյան** 1978, **Մարության** 1976, **Թորմանյան** 1984, **Հարությունյան** 1992.

<sup>3</sup> See Newbolt 2009, Snethlage, Siegesmund 2011, Fitzner and Heinrichs 2001 etc.

<sup>4</sup> It is important to note that the highest point in Armenia should be objectively considered **Ararat peak located on the southern boundary of Armenia with today’s Turkey**. The fact is that Ararat is on the Turkish side beginning from the first decades of XX c. The altitude of the mountain is almost 5000 m just located nearby Armenia.

<sup>5</sup> For details see: [https://en.wikipedia.org/wiki/Geography\\_of\\_Armenia](https://en.wikipedia.org/wiki/Geography_of_Armenia).

Armenia (301 – XIX c.), 5/ New era of the Armenian Architecture (XIX c.), 6/Modern or Soviet Armenia (1920– 1990), Contemporary Armenia (1991 – today)<sup>6</sup>.

*Theoretical Background and Special Features of the Climate Changes*

The rise of 2 degrees Fahrenheit over the Earth in the 20<sup>th</sup> century is a fact today predicting global climate changes. The main aspects of climate change in architecture are the qualitative alterations on the masonry of the buildings which are leading to deterioration and cracks of the used stone. How is it observed in Armenia that climate is getting more continental day by day? In winter the minimum cold is more and in summer the maximum temperature is higher. This is the reason for intensive sanding, active condensate reproduced in new restored parts, back weathering and, as a result, discoloration and brocks on the edges of masonry. Actually in hot places there are more dry days and fewer rains. In colder places there are more warm days and more rain. The growing season (the time of the year when plants can grow) is longer than before. And plants need CO<sub>2</sub>; more CO<sub>2</sub> is good for them, etc.<sup>7</sup>. This has another indication for the buildings and monuments. The mentioned problem can possibly be challenged by perfecting the building techniques. But in the case of historical monuments the situation is much more critical. Since most of the monuments in Armenia are preserved randomly, they are affected by the atmosphere, and consequently the penetration of the structure of the historical buildings by volcanic soil media, rain, weathering, snow, etc. and their interaction with the structure cannot be easily prevented. The effects are classified as: temperature effects (thermal expansion) and atmospheric effects (water and humidity, wind, water soluble salts, air pollution, etc.).

In reality the salts from the earth rise to the capillaries of the stone and cause the above-mentioned harmful damages. Such activation should be isolated or treated by means of conservation, i.e. ventilation on the ground level and in foundations should be undertaken, and a drainage system should be added inside and outside the area of the monuments. The salts penetrated into the stones should be filtered out. Otherwise, the processes of deterioration, discoloration,

---

<sup>6</sup> More detailed information can be found in: [https:// en.wikipedia. org/wiki/ Armenian\\_ Architecture](https://en.wikipedia.org/wiki/Armenian_Architecture).

<sup>7</sup> Barnaby 2009, 6.

etc. will be accelerated. However, attention should be drawn to the fact that most historical monuments and especially the monastic ones are in isolated locations. This means that the accelerated process is more typical of the monuments which are located close to inhabited placements or in areas under exploitation, such as industrial complexes, mines, etc. The problem is getting more urgent, if the issues of sustainability are considered. Air pollution from industrial throw-outs comes down onto the soil as industrial dust, which penetrates inside the monuments together with the humidity. It is also obvious that the influence of the described process varies depending on the historical period the monuments are attributed to. Thus, investigations of stone buildings from different historical epochs should be accomplished by optional experimentations. The problem is related to the building materials used, types of stone mines, the composition of the mortar used in the masonry, etc...

*Geological Background and the Method of Analysis of the Building Materials.*

Armenia is a country rich in stone. Stone is the main construction material used in Armenia throughout the history and until today. It is very important to know about its origin and classification in order to organize the conservation procedures, either by regions or for individual monument.

Stones in Armenia are nearly of all types, such as tufa, perlite, pumice-stone, zeolite, scoria, basalt, granites, marble, etc. For example, there are more than 100 mines of basalt, andesite, some of which are unique in their composition, **such as MgO in basalt of “khaladj”** type which includes mineral amounts to 11%, etc. It is an established fact that a restoration and preservation to be undertaken on monuments require the use of the same stones and even the same quarries if possible. This means that the geologic properties should be considered by their detailed references, including every region and even every monument under investigation. Actually, from the point of analysis of building materials used, in Armenia should preferably include the following approaches: should preferably be included.

- I. Methods of analysis at first should focus on coring and core analysis which is a direct measurement of petro-physical properties. The process is time consuming and expensive. The better way is the correlational laboratory method of tests and usually expressed by means of diagrams, including two

axis, one for the quantitative scale of the tested property, the other for testing the behavior of the selected stone under different pressures or loads.

II. From the point of rock formation analysis and the geology of Armenia, the large variety of stones existing in the country is striking.<sup>8</sup> Stones in Armenia geologically are classified in the following three rock kinds: 1/ magmatic, 2/ metamorphic, 3/ sedimentary. The first is the most widespread group and includes basalts (simple, melano-basalt, andesite and andesite mixed, etc.) and tuff stones of pyroclastic and tuff-lava types. The pyroclastic or volcanic tuff stones are various, such as tuff stones belonging to Yerevan, as well as Byurakan, Ani-Pemza, Hoktemberyan, Noyemberian regions. Meanwhile the Artik area tuff stone is of lava origin. **Special decorative peculiarities are particularly characteristic of “Felsite” type tuff stones of different colors.** In general in building industry besides the above mentioned, there are also travertine, granite, andesite, onyx, limestone, marble, etc.<sup>9</sup> Hereby the classification of stones in Armenia, and the composition of the mortars used in the masonry of historical monuments are very important. Since the matter differs from region to region the study refers to methodical research **so far carried out. Among them Vahagn Israelyan’s research is most relevant to stone conservation**<sup>10</sup>. The composition of the mortars used in the monuments has an important indication. The derivation of exact components of a mortar should usually be based on detailed analysis and laboratory experimentations.<sup>11</sup> Even for conservation reasons it is preferable to use the same rocks or the original mines used in the construction of the monuments. The matter is not that simple, it is related to geophysical knowledge and geology evolution. It is very important to know about the earth crust, its tectonics, mineralogy and the indication of clay throughout the world. However, every part of the world has its special composition of the stones and mortars used in the building industry.

---

<sup>8</sup> The following text is a general description of physical-mechanical properties and the places of mines. See in detail the restoration text book: *Հարտարապետական հուշարձանների վերականգնումը*, 2003, 252–260.

<sup>9</sup> See <https://www.stonecontact.com/stone/armenia>.

<sup>10</sup> See *Հարտարապետական հուշարձանների վերականգնումը*, 2003, 252–260.

<sup>11</sup> *Հարտարապետական հուշարձանների վերականգնումը*, 2003, table 2 and 3, 259, 260.

III. Of the building materials used in the Armenian monuments very important are the observed characteristics of the mortars<sup>12</sup>. That is because of the “Midis” masonry used in the medieval Armenian monuments as mentioned above (Fig.1). However, all the historical monuments, with only few exceptions, are built of Midis type masonry consisting of three layers: an inner masonry, external masonry and the mortar between them called “Xibar”. The mortar is a mixture of cement and medium size gravel. The thickness of the wall at minimum is 60cm. and at maximum 125 cm., actually the size and technology differ from those in ancient time and later periods. The side stones gradually decreased but the mortar part increased. Such regularity occurs as a result of diminution of stone size used. The ancient period masonry in Armenia was in dry order. The use of mortar added plasticity which was very important to perform curvilinear forms (dome, vault, arches of different types). Related to the mentioned, the technologies gained experience in an empiric way, which is important from the point of conservation<sup>13</sup>.

*Some Conservation Priorities to be Followed and Monitoring.*

Bearing in mind the above discussed as well as following the assessment order of historical monuments,<sup>14</sup> the preservation of monuments affected by climate change in Armenia should focus on the following aspects and activities of stone conservation.

1. Cataloging of the geographical location of the focused monuments and definition of their historical chronology.
2. Description of structure system of the monuments and their assessment according to their closeness to human settlements, industrial zones and mines.
3. **Detailed study of the area's** geology, as well as classification of the building material used.
4. The documentation of pollution changes in the surrounding area and environment.

---

<sup>12</sup> See Appendix 2, 236–237.

<sup>13</sup> Ճարտարապետական հուշարձանների վերականգնումը, 2003, 239–242.

<sup>14</sup> See for example: Brimlecomb/<https://www.sites.google.com/site/climatechangeand/monumentsihc/home/abstractsetc>.

5. The alterations observed on the monuments as a result of climate change, such as acceleration of the dilapidation, permeability, winding, **discoloration, condensate...**, etc.

6. Creation of archival data for every monument according to the criteria of the former point.

In reality from the viewpoint of building conservation, the most critical problems for argumentation are points 5 and 6. Thus, the study briefly concentrates on the following criteria:

1/ the study of petro-physical and petrographic properties,  
2/ the analysis of environment effects on the stone which caused the damage,  
3/ the classification or identification of the used stones and the composition of the building materials included,

4/ Decision of research means to diagnose and recover the indicated damages. In the above demonstrated aspects it is important to emphasize that the petro-physics is the study of physical and chemical rock properties and their interaction with fluids, density and solidity, acoustic and sound velocity, thermal effects by the weather, etc.<sup>15</sup> Such properties are lithology, porosity, water saturation, permeability, etc.. Their definitions are theoretically important, for according to them, it will be possible to calculate the dilatation of the stone, as well as the reproduced capillary pressure that caused the damage, etc..

### *Conclusions*

The effect of climate changes on stone-built architecture in Armenia has the following four main aspects:

1. From the point of view of the types of climate changes, increase of continentality or climate drift aspect, as well as atmospheric effects as a result of pollution produced from industrial throw-outs can be observed.

2. From the point of view of the effects of climate changes on the monuments, stone deterioration resulted of thermal and humidity aspects, desalination, and discoloration, cracks, etc. causing the damage, can be seen. Very critical is the acceleration of salts absorption in the masonry, which is dampening the mortar and from there penetrating into the capillaries of the stone.

---

<sup>15</sup> See Tiabb & Donaldson, 2004, 1.120–125.

3. From the point of view of stabilization possibilities of the produced harms the following is of utmost importance:

a. All the means of restoration and preservation of buildings are important. The most preferable treatment is the conservation of the historical tradition.

b. Supply of ventilation at the foundation is essentially required.

c. Parametrical drainage system should be mounted as soon as possible.

4. Monitoring and update of critical information and changes occurring to the monuments every year in an annual order require the following:

a. Specification of the main fronts affected such as: stone preservation issues, defected acts of external surfaces of the roofs and the domes, deterioration of stone ornamented parts, wall paintings, preservation of khachkars, etc. Case studies included the Holy See Cathedral of St. Ejmiadzin, the preservation of Narthex of St Gayane church and others.

b. The study should be divided according to the periods of the development of Armenian architecture. However, for Prehistoric monuments Shengavith and Zorakar, as well as Ughtasar are focused. From Urartian monuments the case of Erebouni is included. For Antique monuments the supply of information deals mainly with the Garni pagan complex, the situation of Artashat, Tigranakert of Artsakh expedition sites.

c. Prevailingly, among the medieval monuments with their stone, brick and timber constructions, such as the Dvin expedition, Basilica of Yereruk and some other functioning monuments from Vagharshapat area are included. The case of Western Armenia monuments are represented on behalf of Van, Kars and Mush areas, etc. Some aspects are represented from Modern Architecture instances too.

#### BIBLIOGRAPHY

**Թորմանյան Թ.** 1984, Հվարթնոց Գագկաշեն [ճարտարապետական գիտական ուսումնասիրություն], Երևան, «Սովետական գրող», 143 էջ:

**Հարությունյան Վ.** 1992, Հայ ճարտարապետության պատմություն, Երևան, «Լույս», 632 էջ:

**Հովհաննիսյան Կ.** 1978, Ճարտարապետական հուշարձանների վերանորոգումը Սովետական Հայաստանում, Երևան, «Հայաստան», 249 էջ:

Ճարտարապետական հուշարձանների վերականգնումը, 2003, ուսումնական ձեռնարկ, Երևան, «Դար», 280 էջ:



- Մարության Տ.** 1976, Ավանի տաճարը և համանման հուշարձաններ, Երևան, «Հայաստան», 200 էջ:
- Newbolt B. 2009, Climate Change, Oxford University Press, 56 p.
- Fitzner B. and Heinrichs K. (2002) Damage Diagnosis on Stone Monuments – Weathering Forms, Damage Categories and Damage Indices. In: Prikryl, R. and Viles, H.A., Eds., Understanding and Managing Stone Decay, Proceedings of the International Conference “Stone Weathering and Atmospheric Pollution Network (SWAPNET 2001)”, May 7-11 2001, Prachov Rocks, 11-56.
- G (h) eghard 1973, Documents of Armenian Architecture -6, Milano, 75 p.
- Siegmund S. und Snethlage R. 2011, Stone in Architecture: Properties, Durability, 4<sup>th</sup> edition, Springer Berlin Heidelberg, 565 p..
- Tiabb D. & Donaldson E.C. 2015, Petrophysics, Oxford: Elsevier, 918 p.
- [https://en.wikipedia.org/wiki/Geography\\_of\\_Armenia](https://en.wikipedia.org/wiki/Geography_of_Armenia).
- [https://en.wikipedia.org/wiki/Armenian\\_Architecture](https://en.wikipedia.org/wiki/Armenian_Architecture).
- <https://www.stonecontact.com/stone/armenia>.
- <https://www.sites.google.com/site/climatechangeandmonumentsihc/home/abstracts>

## ՀԱՅԿԱԿԱՆ ՃԱՐՏԱՐԱՊԵՏԱԿԱՆ ՇԻՆՈՒԹՅՈՒՆՆԵՐԻ ՊԱՀՊԱՆՈՒԹՅԱՆ ՇՈՒՐՋ

ՔԵՐԹՄԵՆՋՅԱՆ Դ.

### Ամփոփում

**Քանալի քառեր**՝ կլիմայի գլոբալ փոփոխություն, կոնսերվացում, հայկական ճարտարապետություն, ճարտարապետական հուշարձան, երկրաբանություն, շաղախ, շարվածք:

Վերջին տասնամյակներին հատկապես ուշադրություն է բևեռում երկրագնդի վրա կատարվող կլիմայական փոփոխությունների հետևանքով պատմական հուշարձաններում վնասվածքների առաջացումը: Հետևաբար անհետաձգելի են դարձել կլիմայական փոփոխությունների հայաստանյան առանձնահատկությունների և դրանցից առաջացած վնասվածքների վերացման միջոցառումները: Առաջավոր տեխնոլոգիաների միջոցով հայկական հուշարձանների պահպանության համար կարևորվում են փաստագրական տվյալների վերանայումն ու վերահամակարգումը, միջավայր-բնահող-շենք փոխհարաբերության մեջ կլիմայական փոփոխություններից առաջացած խնդիրների վերլուծությունը և այլն: Հաշվի առնելով բովանդակ տարածքի

սպտմաաշխարհագրական և երկրաբանական գոտիների առանձնահատկությունները, կարծում ենք, որ առաջնահերթ նշանակություն է ստանում հուշարձանների կոնսերվացման մեթոդական կիրառումը:

## К ВОПРОСУ О СОХРАНЕНИИ АРМЯНСКИХ АРХИТЕКТУРНЫХ ПОСТРОЕК

КЕРТМЕНДЖЯН Д.

### Резюме

**Ключевые слова:** глобальное изменение климата, консервация, армянская архитектура, архитектурный памятник, геология, раствор, кладка.

За последние десятилетия глобальные климатические изменения нанесли огромный ущерб памятникам архитектуры. Сегодня, как никогда, необходимо предпринять меры, направленные на ликвидацию последствий нанесенного ущерба. С этой целью следует задействовать мероприятия по сохранению памятников на основе использования передовых технологий в этой сфере.

Одним из путей решения вопроса является принятие мер по методической консервации памятников с учетом историко-географических и геологических особенностей исследуемых территорий.

