

Integrated Cross-disciplinary Approach to Dating the Architectural Heritage Objects

Based on Abkhazia and Chechnya Architectural Monuments Dating back from 2nd to 11th Centuries*

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Abstract—Results of research on development of complex techniques of chemical, petrographic, X-ray phase and X-ray diffraction methods of medieval lime mortars studying are presented in the article. 12 samples from New Afon, Abkhazia and one from v. Khoy, Chechnya, have been studied. Results of analyses have confirmed estimated dates of the second defense line of Anacopia fortress foundation within 570-580 y., reconstruction of Gate tower in 910 – 930 y. and entrance gate – the 950th y. The analysis of lime mortars from screen church near Anacopia (Akuach's temple) has given time of 650-680 y. Has been revealed that gate in citadel wall have been constructed at the end of II in AD, western tower of a citadel – 680-690 y., reconstruction of the temple of Feodor has been made in 910-930 y. Data of results of a complex research of lime mortars are supported by the documents of the Roman period (2nd century AD), the Byzantine period of the end of the 6th century, construction activity of Abkhazian archonsars in the VII-X centuries. In comparison, tower in village Khoy was built in 11 c. The offered methods of researches allow to reconsidering the developed approaches to studying of limy mortars and their dating.

Keywords—*Byzantine architecture and building technology; dating methods of architectural heritage objects*

I. INTRODUCTION

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One of important tasks of modern history of architecture is dating architectural objects. It allows us to attribute a monument to this or that school of architecture, helps us select the building materials during restoration works etc. The method of defining the brick mortars to date monuments can be the main one because the announced margin of error of 50 years is often insignificant.

Despite the fact that scientific study of ancient building mortars began in year 1930 (Shvetsov, Surovtsov, 1930), medieval lime mortar are still poorly studied. The reason is that, on one hand, there aren't enough studied samples and, on the other hand, that different methods were used in the process. The latter fact doesn't let us compare the results with each other. The proposed method of defining the mineralogical composition of the binding substance of ancient lime mortars was developed in the department of Building materials in collaboration with of General Geology of SFEDU, "Eleia" company (Lyons) and "Verdes" company (Barcelona) in 2012.

The goal of the research of lime mortars of medieval monuments of Abkhazia was to clarify, with the help of the above mentioned method, the dating put forward by the authors on the basis of historic and architectural research. Abkhazia is the most appropriate region to pilot and adjust the method because in a small territory in the same climatic conditions we can find a big number of objects of the cultural legacy from the II century to the XIX century. It permits us to make a complete scale of dating for this region with the help of building mortars. Taking into consideration the difficulty of the goals we used a complex of methods, both compulsory and recommendatory ones, described in scientific and normative-technical literature. We took into

account the fact that represented samples were made on the basis of local starting materials, we studied the geologic framework of the region where the samples were taken from. The study shew that different types of limestone are widespread in this region; they can be used to get lime and as aggregate. Due to the fact that face work, as a rule, was renewed during centuries after the building, we tried to take samples from inner parts of the walls and the pack. Because we has been found the analog of the unique arch executed in the traditional equipment from the Anakopiysky vorotny tower only in a tower of the settlement of Hui, Chechnya, this sample of solution also has been involved in a research.

In total we studied 11 samples from the Anacopia fortress and its suburbs (the Republic of Abkhazia) Because the analog of the unique arch executed in the traditional equipment from the Anakopiysky gate tower has been found by us only in a tower of the settlement of Hoy, Chechnya, this sample of solution also has been involved in a research. The results of the study were compared with data from historiography and architectural studies.

II. DISCUSSION

In data from historiography and architectural studies there is no unity concerning the dating of architectural and archaeological objects in Abkhazia. Notably, in the fortress of Anacopia all the researchers distinguish to periods in the building of the circular gate tower, but the researchers date them back to different time periods. A. V. Bashkirov attributes the first period of building to the byzantine building technology and in the elements of two last floors he finds the Italian gothic technology of XIV-XV centuries. Archaeologist M. M. Trapsh dated the first period of building to the VII-VIII centuries, and the second one — to the XI-XII centuries. Archaeologist V. G. Lekvinadze dated the first period of building the tower to the VII century, and the second one — to the XI-XIII centuries. The gate assembly, which includes the gate tower, the west wall adjacent to the tower, the gateway and the cistern attached to this part of the wall were researched by archaeologists in years 2014-2015. A. V. Argun suggested that the second defense line was built in the second half of the VI century after year 565, and he dated the second period of building to the VIII-X centuries [1].

The most ancient building in Anacopia is the citadel wall. On Mount Anacopia in one of the tombs was found a coin of Emperor Hadrian which had been minted in Caesarea (117-138 AD). The building technology of the citadel of Anacopia also shows its roman origin. A. V. Bashkirov dated its building back to the 2nd c. BC- 2nd c. AD. Archaeologist V. A. Lekvinadze basing on comparing the building technology of the citadel with more famous nearby fortresses suggests that the citadel can be dated back to the IV-V centuries AD. Archaeologist M. M. Trapsh dates the construction of the citadel walls to a period not earlier than the turn of the late V century AD — early VI century AD. Historian G. A. Amichba thinks that the citadel and Trachea of Procopius of Caesarea are identical and dates it back to the IV-V centuries [2–6].

In order to clarify the dating of the objects and to distinguish the chronology of the main periods of building in Anacopia we took samples of lime mortars to study them using the proposed method. To prove the announced margin of error for the objects of the historic and cultural legacy of Abkhazia basing on natural and climatological peculiarities of the region we also studied the mortar from the fortress of Sukhumi which was built in 1724 (sample No. 5–2).

III. METHODOLOGY AND RESEARCHING RESULTS

The process of defining the relative age of the given samples was based on the fact that lime used as the binding substance in the building of the above mentioned objects of the cultural legacy can carbonize. In such a case in course of time one can observe the growth the structural perfection of calcite (crystallinity). This process is rather long and depends on internal factors – the properties of lime itself and external natural factors — the location of the material in building constructions, humidity, temperature, carbon dioxide content of atmospheric air etc.

It is known that the process strength gain of lime mortars and job-mixed concretes consists of three stages. During the first stage, which lasts for about a month, the strength of a mortar is conditioned by the formation of a crystalline joint of calcium hydroxide, the chemistry of its formation following the reaction. Then comes the stage of hardening of the crystalline joint due to its carbonization with carbon dioxide from the atmosphere according to reaction:

With that in the process of carbonization evolves chemically-bound water, that is why during first 1-2 years of exploitation of buildings the walls rendered with lime mortars remain humid. During this process of interaction between calcium hydroxide and carbon dioxide forms a dense layer of calcium carbonate about 1-2 mm. However with course of time this layer growth and increases the strength of the material.

During the third stage, which lasts tens and hundreds of years, the mortar gains strength due to the reaction between crystalline and silica of sand creating hydrated calcium silicate.

The resulting species has high durability and becomes waterproof. There are examples which prove that when 90-100 year old buildings crumble, the bricks, not the mortar in the brickwork are broken.

Preparation of the samples for the X-ray analysis was conducted in two ways. According to the first way a layer of less than 0,08 mm, i.e. the binding substance itself was taken from the samples through mild destruction. According to the second way a layer of less the 5 mm i.e. binging substance+ fine aggregate, was taken. The samples prepared according to the first way were basic for determining the age because they represented the most —“valuable” material. The samples prepared according to the second method were used for comparison, for determining the structure and determining the type of fine aggregates used in building.

Particularly the relative age was estimated according to the intensity of the main diffraction peak of calcite, that is the higher the intensity is, the older a sample is. However we made certain assumptions taking into account particular proved data: the lime for building was made of the same material (Cretaceous limestone), which is widespread near the city of New Afon and not far from the place where the sample were taken; production of lime follows a common technology preserved for centuries; the samples were in the same natural settings (temperature, humidity, carbon dioxide content in the air, etc.); all the samples have porous structure, which doesn't prevent the access of carbon dioxide and growth of micro crystallites of secondary calcite; the samples were shot in the same conditions during the X-ray phase analysis; marble and other carbonaceous rocks, in which one can clearly see regularly-shaped crystals of calcite, have the highest crystallinity of calcite in nature, chalky and other pelitomorphous limestones have the lowest crystallinity.

For comparison we conducted an X-ray phase analysis of limestone used as fine aggregate, which was in one joint with mortar sample No. 4-2, and which, very likely, was used to get lime binding mortar. For example, in images 1-5 we represent X-ray holograms of some of the samples of lime binding mortar which became the calcite of ancient mortars. In "Table I" we show the results of the process of estimating the age.

Concerning the first period of building of the second defense line we proved that the construction of its objects took place in the last quarter of the VI century (570–580). Basing on the fact that the second line of defense was built in roman-byzantine building technology, discovered analogues in the territory of the Byzantine empire, similar both in space-planning and architectural decisions we shall state that the second defense line is a construction of the Byzantine empire of the end of the VI century. Archaeological data doesn't contradict architectural data.

Speaking of the gate assembly of the fortress, we must note that the results of the study of the mortars of the vault of the tower, an additional wall near the gates proved the fact of a major reconstruction of the gate tower which took place in 910-920, reconstruction of the gate in the middle of the X century (about 950). The analysis of repair mortars near the gate also revealed some activity in the XI century; it is proved by the data from the sources mentioning Anacopia due to the capture of the fortress by the Byzantines in 1030s [3]. It was also discovered that structures of the mortars of the middle of the X century and those of the first half of the XI century i.e. within 60-70 years correspond, which shows that a local building school was formed in Anacopia.

TABLE I. SUMMARY TABLE OF RESULTS

No.	No. of a sample during experiments	The place where a sample was taken	Intensity of the main peak of calcite	Presence of portlandite – Ca(OH) ₂	Dating.
1	No. 2-7	Natural limestone taken from a massif near the citadel of Anacopia fortress	4900	-	-
2	No. 2-6	Limestone with the mortar of sample No. 2-4	4800	-	-
3	No. 2-4	The citadel wall. From the pack inside, near an ancient doorway, filled up by the monks	4600	-	2 nd half of the II century
4	No. 2-1	North entrance to the circular gate tower, the second defense line, Anacopia fortress	4400	-	570–580
5	No. 1-1	Side entrance to Akuacha temple (village of Anukhva, 5 km. from Anacopia fortress)	4200	-	650–680
6	No. 2-2	West tower of the citadel. Mortar from the pack. Anacopia fortress	4000	-	680–690
7	No. 1-2	Gate tower of the second defense line, mortar from the vault of the fourth floor. The second building period, the second defense line, Anacopia fortress.	3200	-	910–930
8	No. 2-3	The Temple of Theodore in the citadel. Anacopia fortress.	3200	-	910–930
9	No. 4-1	End grain of the picker of the gate arch, the second defense line, Anacopia fortress	2800	-	950–960
10	No. 3-1	South wall of the entrance of the gate assembly, the second defense line, Anacopia fortress	2500	yes	1030–1050
11	No. 2-5	Wall of Sukhumi fortress. Build by architect Yusuf-aga in 1724.	1600	yes	1740–1750
12	No. 6	Tower in village Khoy, Chechnya	2700	yes	1050-1090

Basing on aggregate data we can definitely link the second period of building of the second defense line in the fortress of Anacopia with the time of building activity of Abkhazian tsars. For example, the end of the IX century is the period when Constantine III was ruling (893-922 or 899-929) [4]. His son George II (922-957 or 929-960) possessed the title of grandmaster in the byzantine table of ranks, his grandsons Leon III (957-967 or 960-969) and Demetrius III (969-976) continued the building activity. George II established a new episcopal cathedra in Martvili; it implies that there was a vast church reform, which explains building of new churches in Abkhazia and reconstruction of the old ones. An analysis of the brick mortar from a hall church near Anacopia (Akuacha temple) dates it back to 650/680; this data needs to be thought through with the help of cultural and historic methods. At this stage we can record that in the suburbs of the main political center of Abasgoi amid closer political and economical contacts with Constantinople the process of active temple building was restored. It was in the VII century when Abkhazia was covered with a chain of churches, the sources of this era call the Abasgoi “Christ-loving”. By 660 the church organization of Abasgia was represented by Archdiocese of Avasgia with the center in Sevastopol the Great. A. V. Argun dates the first period of the formation of the Kingdom of Abkhazia and cancellation of Archon system in favor of greater sovereignty to this time. [1].

It was revealed that the reconstruction of the temple of Theodore took place in 910-930 at the same time when upper floor of the gate tower were built on. Earlier it was thought that the temple of Theodore was founded in the VII century. A. V. Bashkirov wrote: “Basing on the shape of the plan and details of the construction we date ancient parts of the basilica to the period before the VIII century; the restoration of the basilica and its reconstruction – to the XI-XII centuries”. L. G. Hrushkova thinks that a temple built on the cusp of the VI and VII centuries could exist in Anacopia[5]. The time when the temple was founded at the top of the mountain, basing on the fact that its building technology is identical to that of the second defense line, must be the end of the VI century.

After the reconstruction the temple lost some of its old architectonic elements but acquired several new ones. For example, the apsis became five-sided, two of its three windows were filled up and hidden under new siding which peeled off with course of time. The middle window became much narrower. These features are typical for the Abkhazian school of building. We agree with researchers who think that the west wall of the temple, in which the main entrance is located nowadays is a more recent structure. A. Y. Vinogradov and D. V. Beletskiy’s idea that the reconstruction of the temple in the citadel was a part of “George II’s program of restoration of orthodox sanctuaries in his region” was proved by the data from the analysis of mortars [6].

The west tower of Anacopia citadel is a more or less rectangular building with three rounded corners. The tower is located near south-west part of the citadel wall and is in contact with it via stone arched lintel block, built-in the

citadel wall. One may incorrectly conclude that the west tower was built simultaneously with citadel walls. Archaeologist M. M. Trapsh thought that the walls were built in VII-VIII centuries. V. A. Lekvinadze agrees with him. But the above mentioned objects were built in different architectural styles and using different building technologies. This fact contradicts the fact that they were built at one time. For example, in the towers of the second defense line we can see ceramic ledgments characteristic of roman-byzantine building technology, we don’t see rectangular buildings with rounded corners. The brickwork of the west tower is similar to the regular quadra work with elaborated front bricks exterior façade. The results of the study of mortars from the object do not contradict archaeological data and show the time period between 680 and 690.

The most ancient object in Anacopia fortress is the citadel. The technology of quadra work with the cordon on the rib can be compared to Hellenic building technology applied during the roman period, mainly in the II century BC.

The fortress of Anacopia can be compared to the city of Kign mentioned by a roman historian in the I century AD. Pliny Secundus the Elder writes: —“Asilae tribe, the fortress of Sebastopol 10000 steps from Fasis, Sanic tribe, the city of Kign, the river and the city of Peniy...” [7].

Unfortunately, in Russian historiography we cannot find any convincing suppositions concerning the location of the city of Kign, which was situated in the territory of the Sanigs between Sebastopolis and Peniy, which can be identified with Pitiy. Probably, we have the earliest mention of a location in the suburbs of Anacopia, whose citadel appeared as the main dominant political center of Sanigs tsars during such an early epoch.

The presence of full-fledged attributes of a defensive fortification proves that we can consider the citadel as the first defense perimeter of Anacopia. One remarkable architectural element is the keystone in the straight lintel block of the ancient gate. We took samples for the analysis from the pack near this aperture. According to the results of the analysis of the mortar the gate in the citadel wall was built at the end of the II century AD, we suppose that the main part of the walls was built at the cusp of the I and the II centuries, because the gate looks refurbished.

IV. CONCLUSION

The data from the results of a complex analysis of the mortars proves the presence of building of the roman period (II century AD) in Anacopia and also of the byzantine period of the end of the VI century; we can also distinguish the period of building activity of archon-tsars in the VII century and tsars in VIII-IX centuries, and we can confirm our hypothesis about vast building activity of Abkhazian tsars in the X century. The date of foundation of the second defense line was set within 570-580, the reconstruction of the gate tower – 910-930, entrance gate – 950s. The analysis of the brick mortar from the hall church near Anacopia (the temple of Akuacha) shows the period between 650 and 680.

We revealed that the gate in the citadel wall was built at the end of the II century AD, the west wall of the citadel – in 680-690, the temple of Theodore was reconstructed in 910-930, at the same time when upper floor of the gate tower were built on.

The proposed research method lets us reconsider the historic stages of the formation of Anacopia fortress in Abkhazia. The data can be important for dating the objects, which do not have building inscriptions, and also can be used to date the cultural layers in archaeology. Further data collection concerning ancient mortars will let us study the evolution of building technology, reveal the tendencies and geography of Abkhazian school of building, clarify the datings of uncharted monuments in Abkhazia. The assumption was confirmed that the Abkhazian kingdom had cross-cultural communications with the nakhche people.

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