Experiments on ancient objects in Cusco

Korotkov K. G., Galetskii D. V.

In June 2018, we had the opportunity to visit Peru and carry out Bio-Well with Sputnik sensor measurements on a number of ancient sites near Cusco on June 6, 8 and 9.

Every morning device was calibrated in a hotel in Cusco, all measurements were carried out off-line for 10-13 minutes with subsequent processing.

All the values of the parameters measured in the morning and in the evening at the hotel in Cusco, were 50-100% less than the parameters measured at the facilities. Let us consider the data.

Sacsayhuaman

Sacsayhuaman is on a par with Machu Picchu, is the most famous and visited ancient monument in Peru. Historians interpret it as a fortress, and to some extent it could have fulfilled this purpose, but from our point of view, its original function was different. Like other ancient buildings of Peru, it was a sacred religious center, especially from a military point of view, its position is very vulnerable. The surrounding hills exceed it in height, which allows for attackers to fire, remaining invulnerable. The height of the outer wall is not sufficient for defense: it is easy to overcome with short stairs. (However, if we assume that the wall was designed to protect against small-sized creatures, this changes the situation).

We measured for three days and the data correlated well. On different days, the humidity changed from 36 to 33%, the temperature was 19+ / -1 C. during the last measurement it was raining and, in the evening,, it got cold.

Data representation on Google-maps (Fig.1) allows to put forward a certain hypothesis. As can be seen from the figure, we can conditionally distinguish zones that differ in the magnitude of the signal. Note that the measurements were carried out for three days, and all the results were well matched for the presented scheme. Naturally, these results should be considered as preliminary, but they suggest the presence of a geo-active zone in the area with the strongest signal. As we can see, this area embraced the space in front of the fortress, which, as is known from historical evidence, was used for mass ceremonies.

Unfortunately, the lack of time did not allow for additional measurements, so this hypothesis was purely preliminary. At the same time, it allows to outline the direction of further research.

The parameter of Environmental Activity had low values at all measured points (table 1,2), which indicates a favorable energy environment for a person. To understand the value of this parameter, we present graphs of the time dynamics of the parameters at different measurement points (Fig.3). Obviously, the higher the variability of the data, the higher the parameter of the environment activity. Very high values of the activity of the environment is unfavorable for human activity.

Information on measurement points is presented in Table 1.

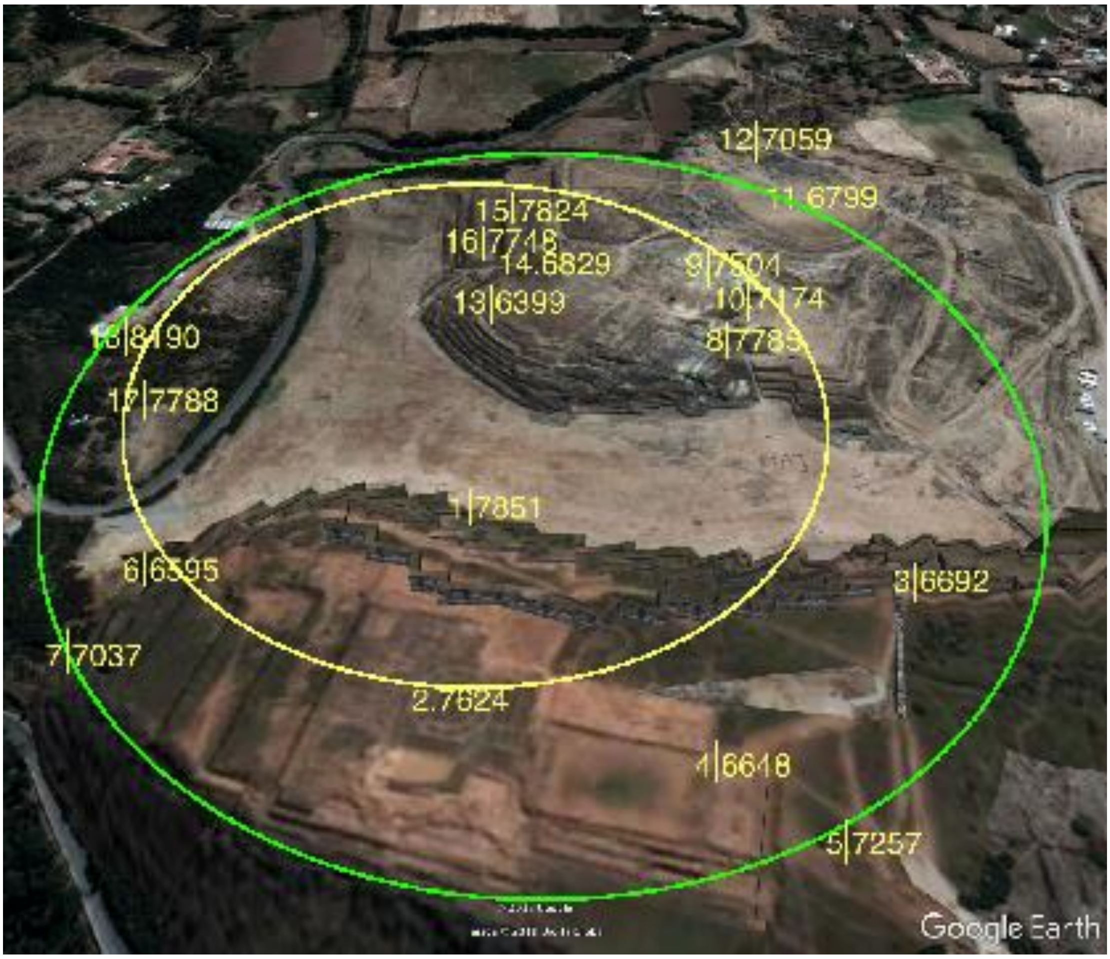


Fig.1. Map of Sacsayhuaman with the points of measurements. First number corresponds to the number in Table 1, number after the vertical line – measured energy (Area in pixels).

Table 1. The results of measurements in Sacsayhuaman.

N		Date	Time	Area	STD	Activity
1	At the bototm of the main wall	06-Jun	11.36	7851	193	59
2	Upper circle	06-Jun	11.57	7634	180	65
3	At the stares	08-Jun	11.36	6692	175	54
4	Top to the right	08-Jun	11.57	6648	173	47
5	The Head of Puma at the top	08-Jun	12.19	7257	117	57
6	Lower Big Wall	09-Jun	12.00	6595	126	56
7	Lower Big Wall	09-Jun	12.18	7037	116	54
8	Near the ladder	08-Jun	10.30	7785	206	78
9	Rocks	08-Jun	10.45	7504	178	55
10	cutted nishe	08-Jun	11.08	7174	218	54

11	Q'ocha circle	08-Jun	12.47	6799	163	88
12	zonas restrigiadas	08-Jun	13.09	7059	162	35
13	At the left side	09-Jun	10.56	6399	347	38
14	At the left side	09-Jun	11.13	6829	105	38
15	Too of the hill	09-Jun	11.36	7824	126	40
16	Iron stone	09-Jun	12.40	7748	130	43
17	Outside Low	09-Jun	13.04	7788	125	38
18	Outside Top	09-Jun	13.18	8190	380	48

Table 2. Parameter of environmental activity

Qénqa

This structure is smaller in size, and the nature of the masonry is much easier. It has a Central square with a large vertical stone and a small cave inside with cut stones. Near the complex is the rock formation from where the construction material for the site was taken, but the method of stone cutting was much simpler than in Sacsayhuaman: cutting of blocks was made from the top, while in Sacsayhuaman the ancient builders cut the required blocks from the center of the stone.

We measured in the inner part of the complex and in the cave (points 1, 2 Fig.2) and the readings there were quite high, while the measurements in the development area (point 3 Fig.2) and on the Central square (point 4 Fig.2) showed significantly lower values.

This may indicate that different parts of this building were created in different eras by representatives of different civilizations. Please note that the parameter of environmental activity, which is an estimate of the standard deviation of the area (table 3), had much higher values in the internal areas of the structure.

Fig.2. Map of Qénqa with the points of measurements. First number corresponds to the number in Table 2, number after the vertical line – measured energy (Area in pixels).

Table 2. The results of measurements in Qénqa.

N	Zone	Date	Time	Area	StD	Activity
1	Q"enqo inside	06-Jun	13.00	8898	291	88
2	Q"enqo cave	06-Jun	13.15	9535	410	130
3	siclaquancha at qénqa	08-Jun	13.38	6887	315	90
4	Qénqo central stone	08-Jun	14.00	6932	223	44

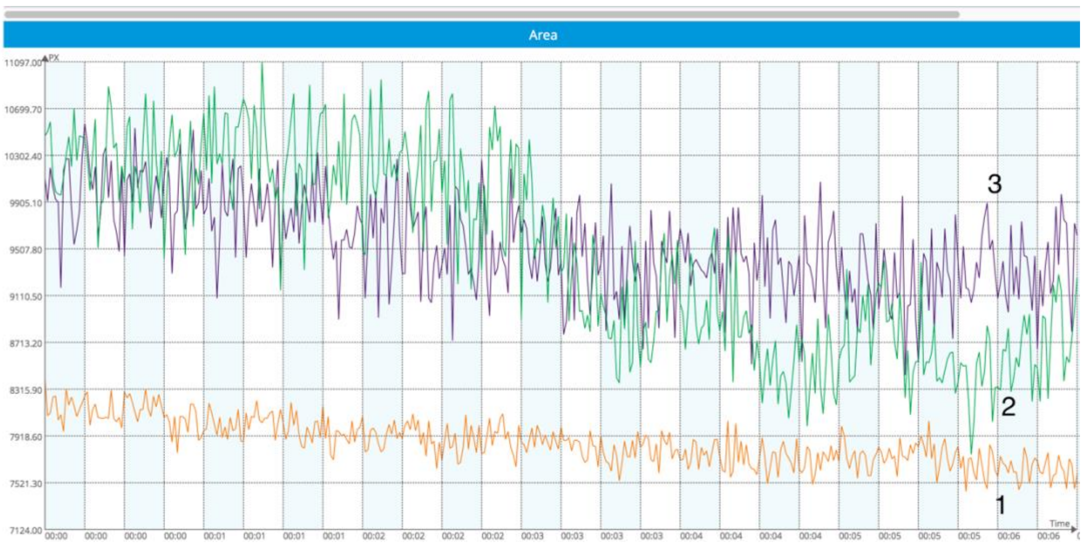


Fig.3. Graphs of time dynamics of parameters in different locations 06-06-2018: 1 – Sacsayhuaman A=60, 2 – Qénqa A=133, 3 – Puca Pucara A=278.

Puca Pucara

This small complex was built of poorly fitting stones of small size, which contrasts sharply with the other ancient structures in Peru. It is obvious that the builders did not have high technology of working with stones. At the same time, the sensor showed high values as on the Central site of the complex (point 1 Fig.4), and on a hill on the opposite side of the highway (point 2 Fig.4). The measurement on the outside of the complex showed a lower value (point 3 Fig.4). The high values of the environment activity parameter in the complex are noteworthy (table 4).

Fig.4. Puca Pucara map with the points of measurements. First number corresponds to the number in Table 4, number after the vertical line – measured energy (Area in pixels).

Table 4. Results of measurements in Puca Pucara.

N	Zone	Date	Time	Area	StD	Activity
1	Puca pucara	06-Jun	14.06	9422	820	278
2	Puca pucara hill	06-Jun	14.22	8659	626	186
3	Puca pucara outside	08-Jun	14.25	6861	182	57

Tambomachay

This complex of flowing water spring and aqueducts is a mixture of technologies – from ancient one with carefully fitted stones of complex shapes, to more and more primitive. It is obvious that the construction of the complex took place in different eras. It is known that in the Inca period it was a place of rest and channels irrigated flowering gardens.

The highest value was measured on the mountain above the spring (point 2 Fig.5, table 5), at the same time, the parameter of environment activity was high at all measurement points (table 5).

Fig.5. Map of Tambomachay with the points of measurements. First number corresponds to the number in Table 5, number after the vertical line – measured energy (Area in pixels).

Table 5. Results of measurements in Tambomachay.

N	Zone	Date	Time	Area	STD	Activity
1	Nearby water spring	06-Jun		7852	556	170
2	At the hill above water spring	08-Jun	15.07	8401	514,5	186
3	cave	08-Jun	15.25	7413	418,5	132

Conclusion

As can be seen from the above data, the values of the averaged parameters at different measurement points differed significantly (Fig.6). The height of the objects varied from 3550 m in Cusco to 3700 m in Tambomachay, which could not affect the results of measurements, weather conditions also did not change significantly. The distance between all objects does not exceed several kilometers (Fig.7). Note that high values of energy parameters corresponded to a high level of environmental activity. All this indicates the presence of geoactive zones in the area of ancient sites. Apparently, the ancient people could have identified these areas and chose them for the construction of ceremonial objects.

The data obtained in the Cusco area are preliminary and serve as a demonstration of measurement and data processing techniques. Taking into account that 10 minutes are required for measuring at each point, it is possible to measure 20-30 points during the day, which would allow to build a sufficiently dense measuring grid. At each point it is necessary to measure the geophysical coordinates for plotting on the map.

These data show that using the device Bio-Well 2 with the Sputnik sensor contouring objects to determine the location of the active zones can be carried out.

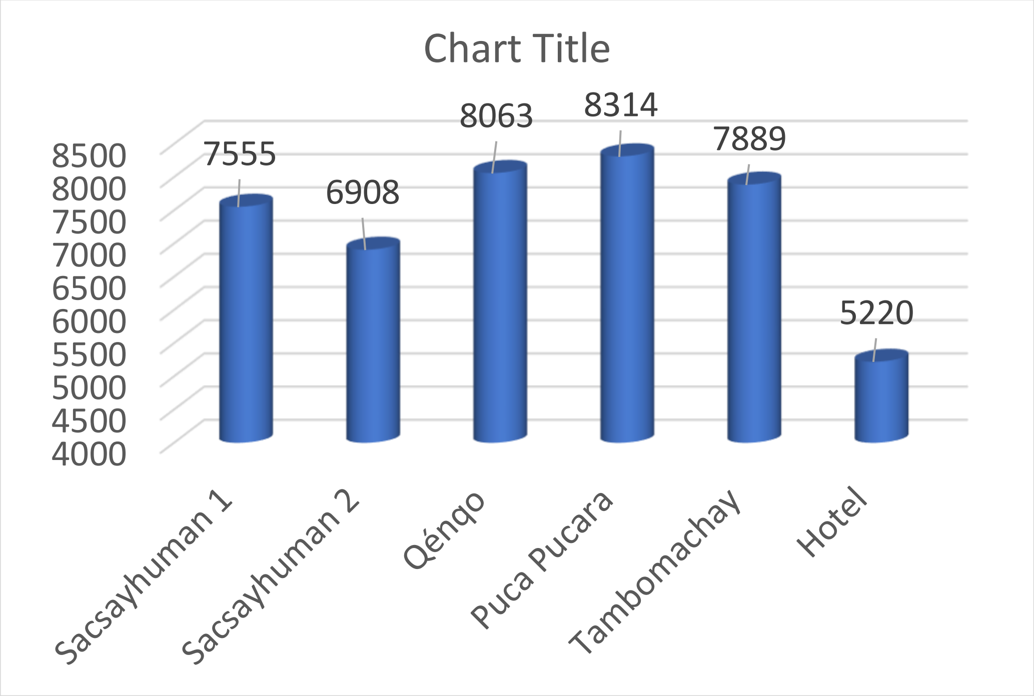


Fig.6. Averaged parameters in different points of measurements.

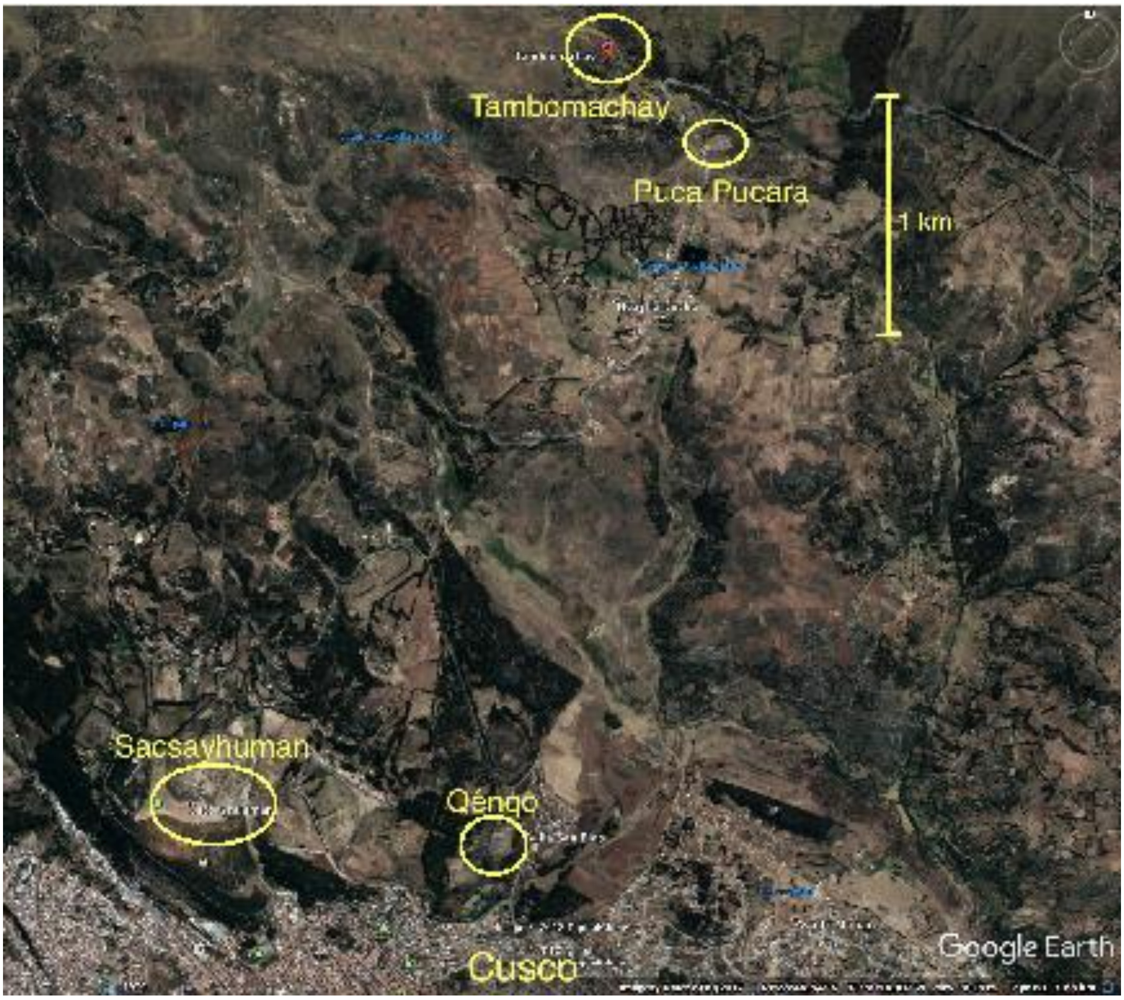


Fig.7. The map of locations.

It is interesting to note that the ancient objects examined by us are located inside a triangle with a top at the Machu Picchu (Fig.8). This area includes the Urubamba valley, which was revered by the Indians as sacred. It was the most fertile area of the Inca Empire. It would be interesting to understand how this is related to the characteristics of geophysical parameters in this zone.

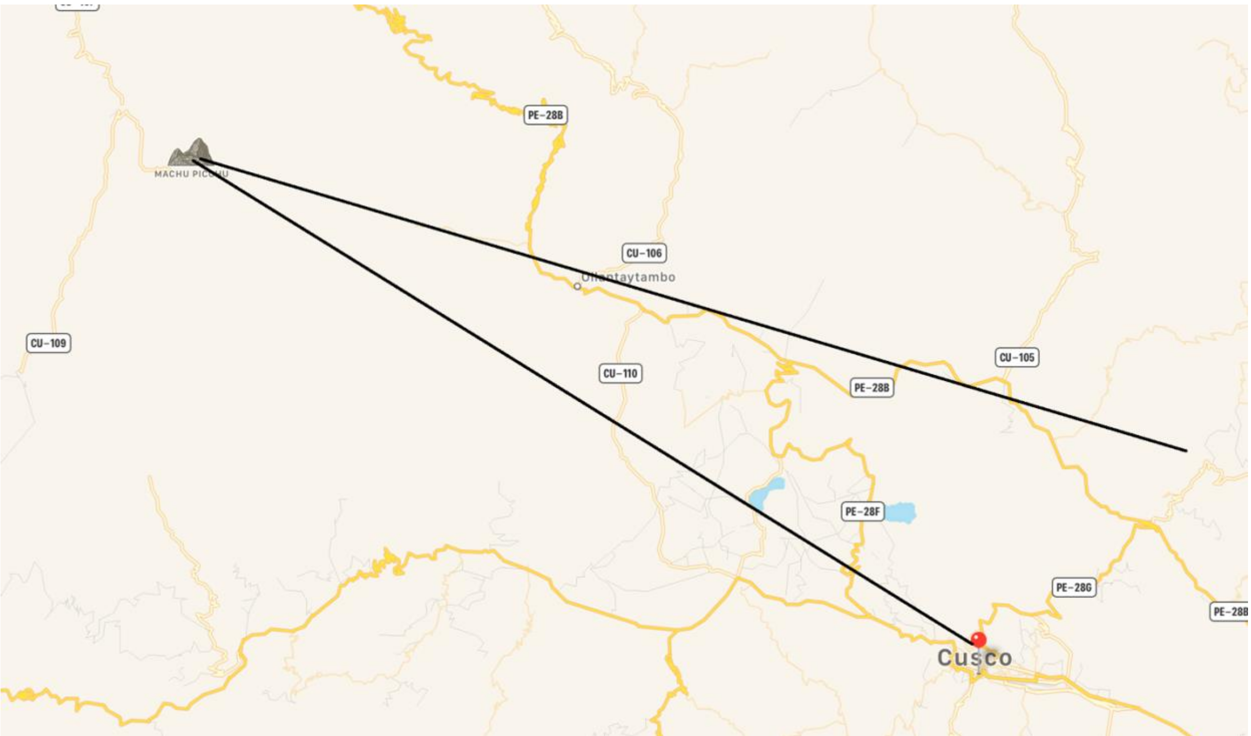


Fig.8. The map of the Cusco area.

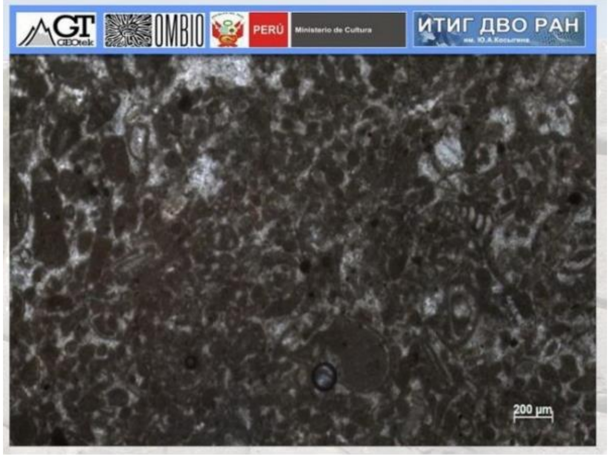
The enigma of polygonal masonry - plasticine technology in Peru

The blocks that make up the masonry walls of Sacsayhuaman, do not look cut down, or cut with some high-tech tool. With modern tools is very difficult, and often impossible to achieve such interfaces when working with solid material, and even in such huge complex. What can we say about the ancient peoples, who with a low level of technology had to make such a truly incredible act? After all, according to the current official version, the blocks were allegedly pushed out in the nearby quarries, and then dragged, processed from different sides for fitting and docking in the mates with the subsequent installation in the wall masonry. Moreover, given the weight of the blocks and the accuracy of the conjugation of their three-dimensional surfaces, this version becomes like a fairy tale.

The Incas, or their predecessors, have not had any high-tech tools, with which it would be possible to perform the full range of works on the construction of grandiose structures. No archaeological research confirms the existence of appropriate tools and devices. "Way out" of this situation offer the enthusiasts, allowing the factor of alien intervention. They say: aliens flew in, built the complex and flew away, or disappeared/extinct, leaving behind knowledge about the technologies used in the construction of walls. What can we say about this? Specifically, you can answer this question only by excluding all other possibilities. And as long as those are not excluded, it is necessary to rely on facts and sound logic.

A new look at this problem was developed after recent studies of Sacsayhuaman by Russian scientists of the Institute of Tectonics and Geophysics of the Russian Academy of Sciences (Scientific Director - N. V. Berdnikov, Deputy Director on scientific and innovative work, head of laboratory of physical and chemical research methods.) together with the Geo & Asociados SRL of Peru, who performed a georadar scan of the area to identify the causes of the destruction of the walls commissioned by the Ministry of Culture of Peru. Below is an excerpt from the official report: the results of the analysis on samples drawn from the area.

> In different years by independent researchers was investigated the material from which the blocks of the fortress walls were made. It is a gray limestone, composing the surrounding strata of the rock. Fossil fauna contained in these limestones, allowed to consider them as the equivalent of the Awakes limestones from lake Titicaca, belonging to the type of chalk. In this case, it is likely to assume a purely chemical origin of this limestone, which is known to be formed by precipitation from solution and usually needs to be expressed halitosis, pseudo halitosis, pleomorphic and fine-grained differences. At the same time, it is worth noting a sufficiently high density of limestone which composes the blocks.
>
> An important point is the absence of organic remains in the samples of the material taken from the blocks, as well as the presence of these in the samples taken from the intended place of production – "quarry".
>
> On the section of the sample taken from the block, organic remains were not observed. The fine-grained structure was clearly visible, while the study of the sample profile taken from the proposed quarry showed inclusions of organic remains.



> Thus, there is a similarity of chemical. compositions of both samples, characterized by the presence / absence of organic remains.
>
> First intermediate output:
>
> - limestone blocks in the course of construction was undergoing some sort of influence, the consequences of which was the disappearance/dissolution of organic remains in the path of the block material from the quarry to the place of installation in the wall.
>
> Let us consider carefully - what do we have? In fact, the composition of the studied samples indicates a direct analogy with marl limestone. Marl limestone is a sedimentary

rock clay-carbonate composition, and $CaCO_3$ contain is 25-75%. The rest is clays, impurities and fine sand. In our case, fine sand and clay were contained in small amounts. This is confirmed by the experiment with the dissolving of a piece of the sample with acetic acid, when an insoluble residue drops out quite a negligible amount of impurities. Consequently, silicon dioxide, instead of fine sand (which does not dissolve in acetic acid) is represented by amorphous silica, once contained in the initial solution along with precipitated calcium carbonate and other components.

It is known that marls is the main raw material for cement. The so – called "marl - naturals" are used in the manufacture of cement in pure form - without the introduction of mineral additives, as already have all the necessary properties and the appropriate composition.

It should also be noted that in conventional marls in the insoluble residue, the silica content (SiO_2) exceeds the number of one-and-a-half oxides by no more than 4 times. For marls with silicate module ($SiO_2 : R_2O_3$ratio) greater than 4 presented by coral structures, the term "siliceous" is used. Opal structures in our case are presented in the form of amorphous silica-hydrate of silicon dioxide (SiO_2*nH_2O).

Hydrate of silica is rock solid and ringing when struck. This characteristic corresponds well with the experiments with the blocks of the Sacsayhuaman. When tapped with a stone blocks make a kind of melodic ringing. The sound is intoned, reminiscent of the blows on the metal. It is possible that many blocks would sound, if they are placed in a certain position (hang out, for example).

Calculation of the silicate module ($SiO_2 : R_2O_3$) based on the results of the analysis of the sample from the "quarry", gives a value equal to 7.9 units, meaning that the studied samples belong to the group of "silica" limestones; for the block material, respectively, the module value is 7.26 units.

So the species of the material of the walls of the Sacsayhuaman can be described as "siliceous limestone" (according to the classification of G. I. Teodorovich), and as "micrite" (according to the R. Folk classification). Samples from so-called "quarry" can be described as "biomicrite" (according to the R. Folk classification).

Returning to the marls, we note that in addition to raw materials for the production of cements, marls are also used to produce hydraulic lime. Hydraulic lime is obtained by firing marl limestone at temperatures of 900°-1100°C (1600-1800 F), without bringing the composition to sintering (i.e., in comparison with the production of cements - no clinker). When firing, carbon dioxide (CO_2) is removed to form a mixed composition of silicates: $2CaO*SiO_2$, aluminates: $CaO*Al_2O_3$ and ferrates: $2CaO*Fe_2O_3$, which, in fact, contribute to the special stability of hydraulic lime in a moist environment after solidification and fossilization in the air. Hydraulic lime is characterized by the fact that it solidified and crystallized both in air and in water, differing from the usual air lime by less plasticity and much greater strength.

The relationship between the lime and clay part in conjunction with oxides, affects the special properties of this composition. This dependence is expressed by the hydraulic module. The calculation of the hydraulic modules according to the data obtained from the analysis of samples from Sacsayhuaman, is presented by the following results:

m = %CaO : $\%SiO_2 + \%_{Al2O3} + \%_{Fe2O3} + \%_{TiO2} + \%MnO + \%MgO + \%K_2O$

- for to the sample taken from the masonry, the value of the module: m = 4,2;

- for the sample selected from the so-called "query": m = 4.35.

To determine the properties and classifications of hydraulic lime, the following ranges of module values are accepted:

- 1,7-4,5 (strong hydraulic lime);

- 4,5-9 (low-hydraulic lime).

In this case it is possible to characterize the obtained result as "medium-hydraulic" lime with tendency to a strong hydraulic. For highly hydraulic lime, hydraulic properties and rapid growth of strength are particularly pronounced. The higher the value of the hydraulic module, the faster and more fully extinguished hydraulic lime. Accordingly, the lower the value of the module – the reaction is weaker.

In our case the value of the module is the average, which means quite a normal rate of both quenching and hardening, it is appropriate for a complex of construction works on the walls of Sacsayhuaman without the need to attract high-tech tools.

When combing burnt (after thermal processing) hydraulic lime with water extinguishing is going on – the transformation of the anhydrous minerals of the composition of the mixture in hydro-aluminate, hydro-silicates, hydro-pyrite, while the main mass transforms into the lime dough. The reaction of quenching of both air and hydraulic lime proceeds with the release of heat (exothermic). The slaked lime $Ca(OH)_2$ formed in this case, reacting with air CO_2 (($Ca(OH)_2 + Co_2 = CaCO_3 + H_2O$)) and composition $(SiO_2+Al_2O_3+Fe_2O_3)*nH_2O$, when solidified and crystallized, turns into a very strong and water-resistant mass.

When quenching both hydraulic and air lime, depending on the time of quenching, the composition of water and many other factors, a certain percentage of CaO grains remains in the lime test. These grains can be extinguished after a long time with a sluggish reaction, after the fossilization of the mass, forming micro-voids and caverns, or separate inclusions. Especially such processes are exposed to the surface layers of rock interacting with the aggressive influence of the environment, in particular - the effects of water or moisture containing various alkalis and acids. Presumably such formations caused by grains of calcium oxide can be observed on the blocks of the walls of the Sacsayhuaman in the form of white dots-inclusions.

Experimentally, when mixing lime with fine silica in the appropriate percentage ratios, followed by quenching and formation of the resulting dough forms, after solidification demonstrated a pronounced strength and moisture resistance compared to conventional lime (without the addition of fine silica).

Marked moisture resistance also affects the lack of slidenote of already solid sample with the newly prepared ones, laid closely with formation of seam without gaps. Subsequently, upon solidification, the samples are easily separated without showing solidity in the conjugation. When solidifying the samples, their surfaces become noticeably shiny, similar to polishing, which is most likely due to the presence of an amorphous silica in the solution, forming a silicate film in reaction with $CaCO_3$.

Second intermediate conclusion:

blocks of walls of Sacsayhuaman made from dough of hydraulic lime, obtained by heating the Peruvian limestone. At the same time, it is worth noting the property of any lime (both hydraulic and air) - an increase of the volume when quenching with water - swelling. Depending on the composition, you can get an increase in volume by 2-3 times.

Possible methods of heating the limestone.

The temperature required for firing limestone 900°-1100°C (1600-2000 F) can be obtained in several ways:

- the ejection of lava from the depth of the planet (assuming the close contact of the strata of limestone with lava);
- the explosion of the volcano, when minerals are burned and released under pressure of gases into the atmosphere in the form of ash and volcanic bombs;
- direct human intervention (technological approach).

Studies of volcanologists show that the temperature of lava pouring on the surface of the planet varies in the range of 500°-1300°C (900-2400 F). in our case (for calcination of limestone), lava should have temperature 900°-1100°C (1600-2000 F) these lavas are primarily silicon. The content of SiO_2 in such lavas are 50-60%. With the increase in the percentage of silicon oxide, lava becomes viscous and, accordingly, less spreads over the surface, well warming up the adjacent layers of rocks, directly contacting and alternating with the outer layers of the accompanying limestone deposits.

"The Inca throne " carved in one of the "threads" the Rodadero rocks, may be represented by aucremanne limestone with a high percentage of silica and alumina, the crystallization of which was completely different in comparison with obviously different base rock layers covering Rodadero. Accordingly, this assumption requires separate analyses and detailed study of the formation.

This bizarre-looking rock presented is in close proximity to the studied layers and is quite suitable for the role of "thermoelement", once warming up limestone strata to the necessary temperature. According to previous data, this rock consists from porphyritic diorite, (which is composed by 55-65% from silicon dioxide (SiO_2) included in the plagioclase ($CaAl_2Si_2O_8$ or $NaAlSi_3O_8$).

The stoned "streams" of Rodadero are not limited to the injection site, but continue among the strata under the limestone massifs of the area. The study of this formation is not completed and requires additional research and analysis, but all the signs of exposure to high temperatures (about 1000°C – 1800 F) are presented. Accordingly, the heated limestone (the resulting hydraulic lime) reacting with water - rain, spring, ground - immediately turns into lime dough (is extinguished). Crystallization and petrification occurs according to the previously considered scenario.

It should be noted that in this case, it is the reaction with water that turns the burnt source material into a fine mass (preliminary grinding into powder is not required). Accordingly, heating with subsequent quenching destroys all organic inclusions, producing a "transformation" by recrystallization from organogenic limestone to cryptocrystalline.

With the right approach, the lime dough can be stored for years, without letting it dry in the air. A striking example of the lime dough hardened is well - known, it is so-called "plasticine stones", on which the surface is often treated, or an upper layer, "skin" is removed - which is well combined with the assumption of heating the entire mass of the "boulder", when the near-surface areas were subjected to stronger thermal effects than the core. Most likely, this was the reason of appearance of specific traces - through the selection of plastic dough to the depth of the unheated layers, which remained intact preserving traces of processing to the present day.

It is not necessary, of course, to discount the human factor (in terms of heating the limestone). With a well-built fire, you can reach a temperature of 600°-700°C (1100-1300 F), and even 1000°C (1600 F). Note that the temperature of wood burning is about 1100°C (2000 F), coal – about 1500°C (2700 F). In this case, for firing and aging at high temperature it is necessary to build a special "furnace", which was not a big problem for ancient people. Naturally, more detailed studies will show what was the cause of heating the limestone - human or natural factors, but the fact remains - for the process of recrystallization from organogenic siliceous limestone to fine-grained siliceous limestone, which we can observe in the blocks of the walls of Sacsayhuaman, a long-term effect of temperatures of about 1000°C (1600 F) is necessary, followed by mixing the resulting quickened lime with water and the formation of dough from slaked lime. Taking into account the above facts, plastic "plasticine" blocks no longer raises doubts. The technology of laying raw hydraulic lime with packing in large blocks is quite affordable to the people of the ancient world. And in this case, the need for the use of high-tech equipment and fantastic tools completely disappears as well as manual overwork in displacing and dragging unmanageable blocks to the construction site.

Conclusion

This study conducted by leading Russian specialists, convincingly shows that in the construction of Sacsayhuaman was likely used the "clay" technology. Using soft limestone "dough” heated to a high temperature allowed to form the blocks, pouring them with water caused solidification, which allowed to lay on top the following soft block. In this case, the conjugation of three-dimensional surfaces occurs naturally. The same process explains the convex nature of the outer surfaces of the blocks and the presence of protrusions and depressions on them.

Apparently, the construction was carried out during the period of volcanic activity in the "quarry" area when lava flows poured out on the surface. The nature of the rocks in this area fully confirms this fact. So the ancient builders had to look for softened limestones and use this "dough". Therefore, on the rocks of "quarry" we see some areas with cut holes. This was the area of maximum heating. We do not know when this happened, but it was obvious that it was long before the Inca rule.

This hypothesis explains why other structures with polygonal masonry used much smaller blocks. Apparently, by that time the volcanic activity went down, warming up significantly smaller amounts of limestone.

Another assumption is that ancient civilizations used special furnaces for heating limestone, and later this technology was lost.

The hypothesis of "plasticine stones" was as well used to explain the methods of construction of dolmens constructed from huge stones waiting many tons, which are located on the slopes of the Western Caucasus. No reasonable way exist to explain how multi-ton blocks were transported tens of kilometers up the mountain slopes. Especially when you consider that the builders of the dolmens were at a lower stage of social development in comparison with the Peruvian civilization. If we assume that they used the technology of "plasticine stones", everything is easily explained. At the same time, it becomes clear why at some point the construction of dolmens completely stopped: there was no more lava capable of warming up limestone.

With all the appeal and credibility of the presented hypothesis, it does not explain how huge blocks of stone were transported during the construction of Oliantaytambo. We were unable to find any plausible explanation. It is obvious that this is a product of a highly developed civilization.