The using of liquid stone for the restoration and creation of copies of archaeological objects

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Abstract: It is an actual problem to investigate archaeological objects outside their native locations. New building materials make it possible to make the most realistic copy of archaeological objects, without destroying the object and extracting it from the natural environment. Liquid stone allows you to create objects with the imitation of color and texture of the original. This material can withstand high loads and it is used for prosthetics of the elements of archaeological structures. The technology of repetition of such objects allows making mass circulations of the most interesting archaeological objects. The technique makes it possible to restore objects from the remaining photos and description.

1. Introduction
The use of new materials in various fields of science and technology allowed to develop the directions of use that had not previously come to the attention of researchers. The methods for creating replicas of complex objects have proliferated with the advent of 3D modeling and reverse engineering. New materials make it possible to simulate the shape, color and texture.

The purpose of the article is to show how the new building materials can be used to recreate the cultural heritage.

The main objective of the study is to determine the possibilities and methods for creating models of archaeological and cultural objects using liquid stone technology.

2. New building material liquid stone
New materials with the properties which were not available to the construction and restoration technologies have appeared recently. Such materials have expanded the possibilities of the construction and restoration industries and have improved aesthetics and cost-effective creation and reconstruction of various objects. Aesthetics of materials makes the technology attractive for residential use. The economy is caused by the ability to use recycled materials. A similar material is a liquid stone. This material appeared on the market at the beginning of the 21st century was used to decorate the interior. The elements for bathrooms and kitchens, such as sinks, cutting tables, etc. were made of such a material. This material has attracted attention by the fact that it simulated a natural stone with the method of making compositions of mineral fillers and pigments cemented by polymeric resin.
Our method consists of several stages. On the first stage the material is a composition in the liquid state. The second stage is applied to a substrate by casting or spraying. On the last stage it is cured by adding the curing agent causing the chemical reaction of hardening. If required, the surface is ground. The experiments showed that the material has good adhesion and it does not peel off from concrete, wood, as well as iron, masonry, ceramics, plastic, glass, etc. The features of this material do not only create a surface with different color and textural characteristics, but also it may be a structural member itself, it can manufacture the volume elements in use, it can be exposed outdoors at various temperature and humidity conditions [1]. Besides the fact that the production of a liquid stone is environmentally safe, its composition can include production wastes [2]. Industrial waste can give a product both a natural and an artificial look. The researchers note the possibility of creating a diversity of textures and shapes, functionality, beauty, hygiene, maintainability, durability and excellent appearance, allowing a liquid stone to find its place at the market [3]. Initially, the manufacturer of a liquid stone deals only with major manufacturers such as: Corian - DuPont (US), Montelli - DuPont (China), Staron - Samsung (Korea), Hi-Macs - LG (Korea), Akrilika - Acrylic (China), Safas - Granicoat (USA) [4]. Now this technology has been mastered by small businesses and it can be implemented on any industrial site [5].

3. Technology Implementation Examples
As a result of the research with this material, various products have been created: kitchen worktops and sinks, large and medium sized chess. This material was used as covering for paving tiles of various sizes. A.Ya. Mashovich has developed the patterns of paving slabs, street chess; chess for a dynamic game (see figure 1). Our experience allows creating almost any shape and color, or a complex repeat structure.

![Figure 1](image)

**Figure 1.** Samples of developed products

4. Archaeological aspects of the use of technology
Archaeological and cultural objects of a great value, in some cases, cannot be removed from the location of their original residence and be placed in museums, often located in remote and inaccessible areas. It is not possible to fully involve them in active cultural and scientific revolution, making the subject of aesthetic observation. For example, petroglyphs elements masonry structures ancient buildings, stone sculptures, and structural elements burial al. The process of cultural familiarization of certain types of rock art is highly toxic to the objects themselves, it is conjugated with such changes for a safe and affordable way to review, which lead to the loss of the natural appearance and the surrounding landscape [11]. Something similar happened with the works of rock art in the caves of France and Spain, but the harmful effects of microflora imparted by tourists influenced on the works of primitive art.

Modern 3D scanning methods allow you to create not only accurate digital models of the surviving archaeological objects, which can serve as the basis for creating museum copies for exhibiting rock art, but also to recreate the once lost elements of archaeological heritage objects [7]. For example, the cleaved portion of sculptures or statues, the lost elements of decoration plants, the components of structures that are in a fragmented state. It is also possible to make prosthetic appliance of the structural parts of ancient structures, for the reconstruction of the lost initial appearance (column element, pillars, arch element, etc.) of a building or a structure. In such museum expositions, such as in open-air museums, it is possible to create archaeological expositions as close to the natural environment as possible using liquid stone technology: copies of rock paintings [8], constructions of burial mounds, megalithic structures and other objects. Often, the transfer of these archaeological heritage objects to the museum for a number of natural or legislative reasons is not possible.

The creation of such replicas is possible according to the preserved measurements, drawings, drawings and photographs. Prosthetics of fragments of ancient structures or sculptures, with the reconstruction of a more complete appearance of an archaeological site through 3D scanning, can provide the most accurate articulation of the preserved elements with prosthetic areas and a tight fit of these parts to each other is unattainable with other restoration methods [9]. In this case, it is possible to recreate the bearing abilities of ancient structures, which is important in the reconstruction of a more complete appearance of complex objects.

Figure 2. Samples of figures made of liquid stone and imitation of various types of materials
5. Description of technological stages
As a result of this study, the stages of creating replicas of archaeological objects were formed:
1. Creating an exact replica of a real object. The replica can be digital as a result of laser or optical scanning [1] or stereo shooting. An analogue replica may be made of gypsum or rubber.
2. Digital processing of the object, creating a form for filling.
3. Selection of the recipe liquid stone for repetition of color and texture and texture of the material cultural heritage.
4. Mold filling, hardening, extraction from the mold.
5. Finalization of the element of a liquid stone.
6. Transfer of the object to the customer (museums, theaters, cultural entities, educational sciences).

6. Research findings
The work done on the basis of these steps makes it possible to create different objects. For example, figure 2 shows chess pieces with an imitation of the surface of marble and cast iron, as well as the samples for creating surfaces of various colors and textures. The main conclusion of these studies is the ability to use this technology to create a replica of archaeological sites, with increasing or decreasing scale. A liquid stone is also a very durable material, so it can be used to replace the missing parts of archaeological sites and it can have sufficient bearing capacity. As a result, a great need for the research in this approach to the creation of replicas of real objects has been found.

References
[1] Wang H, Luo Y, An C., Huang L. and Zhang D 2019 Application of imaging polarimeters to enhanced detection of stone carving Journal of Cultural Heritage 40 pp 92-98
[2] Ruposov V L, Alexejenko V V and Mashovich A Y 2019 On the technology of utilizing drilling sludge for the purpose of building material production IOP Conference Series: Earth and Environmental Science 229(1) 012024
[3] Khater H M, Ezzat M 2018 Preparation and characterization of engineered stones based geopolymer composites Journal of Building Engineering 20 pp 493-500
[4] Krasilnikov D A, Kartashov T A 2014 Influence of mineral additive on the physical and mechanical properties of the ready liquid stone composition. Actual problems of the humanities and natural sciences 4-3 pp 79-81
[5] Mashovich A, Ruposov V and Moskvitin V 2018 Development of technology of production of powlines for conducting works with the use of local types of raw materials in low-populated and district areas Izvestiya vuzov. Investments. Building. The property 3 (26) pp 112-121
[6] Åhfeldt L K 2010 3D-scanning at the Archaeological Research Laboratory 2006–2009 URL: http://goo.gl/jwJIT
[7] Martin B Sweatman, Alistair Coombs 2018 Decoding European Palaeolithic Art: Extremely Ancient knowledge of Precession of the Equinoxes Wayback Machine Athens Journal of History
[8] Roussot A, Breuil et Lascaux 1990 Lascaux, premier chef d’œuvre de l’humanité. Les Dossiers d’Archéologie 152
[9] Pires H, Rubio J M and Arana A E 2015 Techniques for revealing 3d hidden archeological features: morphological residual models as virtual-polynomial texture maps International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences 6 pp 415-421
[10] Iakushkin O, Budlov E, Uteshev A and Grishkin V 2019 Automated creation of unique editable textures for three-dimensional models of archaeological artefacts Lecture Notes in Computer Science pp 752-760
[11] Draft Medium-term Strategy 2014-2021 / UNESCO. General Conference, 37th, 2014-2020 y.
