

**MINING TECHNOLOGY FOR THE UPGRADE AND  
GEOLOGICAL INVESTIGATIONS ABOUT THE ARCHEOLOGICAL  
SITE STAROSSEL – CENTRAL BULGARIA**

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**Abstract:** Using a mining technology an access to the inner side of the hill filling of the biggest at the Balkans Early Thracian construction at Starosel village has been guaranteed. The file has been preserved too. It is build by analcime rocks and granites. Recent formation of anglesite, cerusite, anhydrite and gypsum has been established. Repeated seismic activity has affected the construction.

**Key words:** Stone artifacts, Thracian under hill construction, mining technology, raw materials, contemporary minerals, seismic influence.

The usual way for the archeological digging of the old aged Thracian hills is the manual removal of the soil surface layers to open the structure. This method is very slow and expensive and needs preliminary planning and a lot of funds. The Thracian hill near Starosel (Fig.1) village has been attacked earlier by the criminals and needed fast opening and upgrade, keeping the existing architecture, because of the uniqueness of the object. The action presumed the preserving of the possibilities for the archaeological investigations. To solve the problem, new method for mining technology has been created for the penetration and upgrade of the structure.

Mining operation and upgrade of the construction.

The archeological site is a two-space structure located inside the hill and at a distance of about 3.5-km westward of the Starosel village, Central Bulgaria. The outside diameter is 70-80 meters and the height – about 20 m. the

entrance is a quadrangle camera (2x2x5 meters) followed by a circle main space with a diameter of about 3.5 meters and height of about 3 meters (Fig. 2). Both spaces were fulfilled by a soil mixed with the processed stones fallen down from the roof with weight between 300 and 1100 kg (Fig. 3). In this circle space the mining works have been executed clockwise. For the entrance the mining work was performed from outside to the deeper part in N-S direction. Both empty spaces (circle and quadrangle) have been upgraded by a special wood frames with the distance between them – 0.58 m. and 0.48 m. To preserve and expose the inside upper preserved ornaments the columns have been positioned at a distances from 0.9 to 1.3m. The removal of the soil has been done manually to keep in good conditions the inside space with all specimens.

To preserve in good condition the archeological specimens, during the mining activity, the following measures have been done:

- The rich layer of specimens with a depth of 0.5m. has been proceeded in situ by the archeological staff of the expedition.
- The stones from the roof have been selected and arranged in a special place for further reconstruction purposes.
- Reports and photographs have documented the whole everyday work.

#### Seismic influence on the construction of the construction

The seismic activity in the region is dominated by the local Plovdiv source zone, with the maximum observed magnitude – 7.0 (the last strong earthquake in Bulgaria during 1928). The site has been affected many times by the strong motions due to its long life – more than several hundreds of years. The effects of these seismic affections are visible on the roof (Fig. 4A) and on the walls (clear sheer cracking) (Fig. 4B). A big frame cracked here shows more than 1.5 sm. horizontal displacement, which indicates clear seismic influence. The object has been destructed during the ancient times. Several stages can be outlined (at least three times due to the indicative inside soil layers). There is a possibility to consider some of them connected with the seismic old events. The monolithic position of the object together with the hill makes it stable. The hill shape increased the seismic influence at a level of about 10-12 meters where the roof is located. This means that a possible reason for the destruction is a suspected seismic influence.

### Petrology of the bricks building the object

During the ancient construction and building work of the site two main rock types have been used - analcime zeolitic rocks (Fig. 5) and granites (Fig. 6). The 2.41 m long crepis was built by granite stones. The stones for the central and lateral staircases are granitic too. Analcime rocks build the dromos, the columns, the walls and the roof in the cult center. Granites are leucocrate, biotite to two-mica. Analcime rocks are two types – yellowish, beige and pale greenish-beige. Under the microscope feldspar, pyroxene and biotite porphyres were distinguished. The lithoclasts observed are mainly from volcanic (andesite with porphiroid and hyalliclastic texture), rarely from metamorphic (schists, quartzites), sporadically from sedimentary (sparite limestones) rocks and singular bioclasts (Bivalvia). Glass shards were not observed. It was difficult to define and distinguish the clasts from the groundmass. The groundmass is built by fine grains of chlorite, calcite and clay minerals. The rocks studied were referred to as andesite tuffs/tuffites. Analcime completely replaces pseudomorphically the feldspar porphyres and fills unclear micropores and microfractures in the rocks. The analcime crystals are euhedral, clear, slightly anisotropic. X-ray patterns of the light fraction isolated show typical analcime picks and the cell parameters calculated are  $a_0=13.69165 \text{ \AA}$  and  $v_0=2566.6553 \text{ \AA}$ . It is obvious that the analcime was formed after processes of intensive hydrothermal activity.

The geologic scheme of the area of Sredna Gora between Panagiurishte and Stara Zagora points to the metamorphic rocks and granites as the main rocks source for the Starossel Thracian site. As for the analcime rocks there are very scarce data published about the presence of “zeolites” as alteration products after volcanic glass in the tephroid rocks and tuffs from the Panagiurishte area (Nachev and Nachev, 1986, Nachev and Sultanov, 1991). Analcime-clinoptilolite tuffs were reported for the first time in the fine tephroids in East Srednogorie, near Aitos (Sultanov, 1994). The cell parameters of the analcime from the andesite tuff-brecca (region of the mine “Radka”, Panagureista area) (Kirov, 1974) are very close to those calculated for the analcime mineral from the Starossel.

### Recent mineral forming after the object has been built

During the post built stage two mineral forming processes have been registered.

The first one is connected with the construction elements by the lead compositions. Due to the erosion the lead elements stabilizing the stone blocks are changed completely to anglesite and cerusite. Sometimes very rare relicts from the original lead can be observed covered by the above-described minerals. These changes show that the environment keeps the acid reaction (probably humus acids with Ca<sup>+</sup> ions) in the infiltrating solutions.

The second process has been developed in the spaces between the stone bricks and also is due to the infiltrating soil waters. As a result of this process – gypsum and anhydrite can be observed. Both minerals have macroscopic expressions on the processed surfaces of the analcime zeolitic blocks from the inside part of the object. They formed small crystals up to 2-3 mm. rising in the free space.

This paragenesis supports the described above character of the infiltrating surface solutions.

The successful attempt for the upgrade of the Thracian cult object has been made by a specialized mining technology. This is the first successful experiment of such size. The successful archeological and geological investigations made afterwards show that such technology is perspective and prospective for other objects upgrading.

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**Fig. 1.** General view of archeological site Starossel.

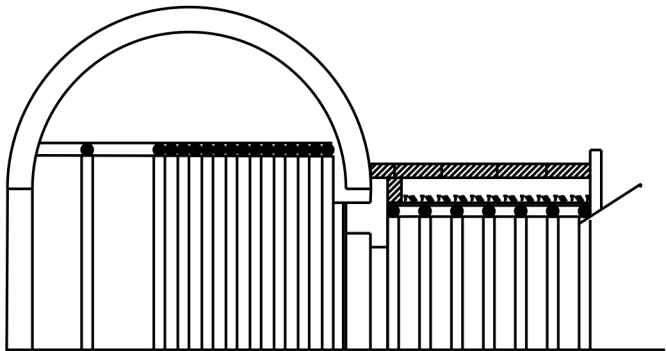
**Fig. 2.** Scheme of the construction and timber of the under hill construction: A. Longitudinal section; B. Plan.

**Fig. 3.** Mixture of soil and stone blocks, filling the interior of the circular camera.

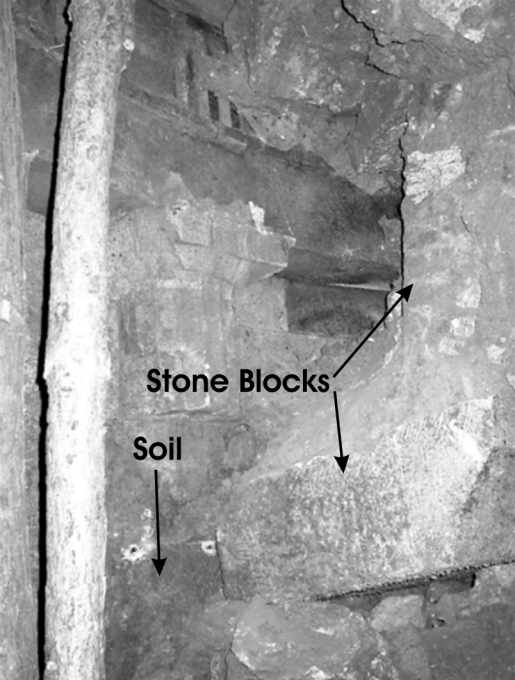
**Fig. 4.** Seismic influences over the construction: A. A fracture with a horizontal component of displacement in a ceiling beam of analcime tuff. B. Flake like fracturing in the stone blocks of a vertical wall near the corner.

**Fig. 5.** Rock frieze over analcime tuff: A. Analcime replacing feldspar crystal (Microphotograph). B. Analcime filling a micropore (Microphotograph).

**Fig. 6.** Granite blocks, building the outside wall of the hill.



**A**



**Stone Blocks**

**Soil**



**A**



