



THE IMPACT OF THE OLD MINING WORKS IN BENTOMAK MINE - KRIVA PALANKA ON THE CONSTRUCTION OF THE ROAD INFRASTRUCTURE

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***Abstract:** In the paper are presented the old underground mining works made in the last century by the “Bentomak” Mine for bentonite clay located near the town Kriva Palanka. Also, in the paper are shown, their location and their impact on the construction of the route on the new express road “Rankovci - Kriva Palana”. The paper also proposes some technical solutions to overcome this problem, namely the continuation of road construction and its permanent stabilization.*

***Keywords:** Mine, old underground works, bentonite clay, road*

1. INTRODUCTION

Geological exploration to find bentonite clay deposits in the Slavishko Pole-Kriva Palanka area, began in 1950, and in 1954 bentonite clay exploitation began. Bentonite deposits are of Miocene and Miocene-Pliocene age, and they are the product of volcanic glass alternation to bentonite clays. In the bentonite clays the most abundant mineral is montmorillonite and especially Ca-montmorillonite [2].

The ore exploitation was carried out in several bentonite clay deposits, namely: Rankovci, Ginovci, Ljubinci and Petralica, in a combined manner, i.e. with underground and surface mining. On selective mining was given great importance when it came to producing high quality final products. Particularly high quality bentonite clay was exploited by underground mines near the village of Petralica.

Bentonite clay processing plants were part of the state-owned enterprise “Bentomak” based in the town Kriva Palanka.

The first plant was built in 1968 in the village of Ginovci, and had a capacity of 30,000 t/y, and the second was built in 1978 with an annual capacity of 60,000 t of ground bentonite. Both plants produced dried and ground calcium bentonite, and after alkaline activation - sodium bentonite. In 1983, was produced 70,000 t of alkali-activated bentonite [4]. Bentonite was sold in domestic and foreign markets. The Ginovci plants produced several types of alkali-activated bentonite: bentonite for foundries, bentonite for deep drilling, bentonite for injection, bentonite for pelletizing mineral concentrates and as filler. The quality of the products was controlled in a factory laboratory and in close cooperation with consumers.

Today, the Mine “Bentomak” is privatized by a company called “Bentomak Nova”, and it does not exploit bentonite clay.

A few months ago, construction of the A2 express road, Rankovci-Kriva Palanka, started with a length of 23 km and a width of 12.5 meters. The route in a certain section is passing over and adjacent to the old underground mining works of the “Bentomak” Mine. In order to determine the impact of mining activities on the express road construction and its future use, it was necessary to identify the underground facilities and determine their exact location given that they were built in the middle and second half of the last century.

2. OPENING AND DEVELOPMENT OF UNDERGROUND MINING DEPOSIT AND METHOD OF EXPLOITATION

According to the main mining project, the Ginovci-Petralica deposit should have been open with a system of two declines, one of which is for hoisting and the other for ventilation, Figure 1.

The hoisting decline should have been made from the surface pit and to cut the central bentonite clay zone. The slope of the decline according to the project is 9° . The ventilation decline should have been constructed in the immediate vicinity of the hoisting decline and to be connected to the surface via a short ventilation shaft. The ventilation and hoisting declines should have been coupled in a system of short ventilation corridors. Further, the deposit should have been developed with a system of hoisting and ventilation corridors at 10 meters' intervals, that are constructed from the two sides of the main opening drifts up to the limits of the ore deposit. These corridors according to the project should have been constructed with the dip of the bentonite layer and connected with ventilation raises and thus the field of operation to be divided into a number of excavation stopes, with dimensions of 20 x 10 meters.

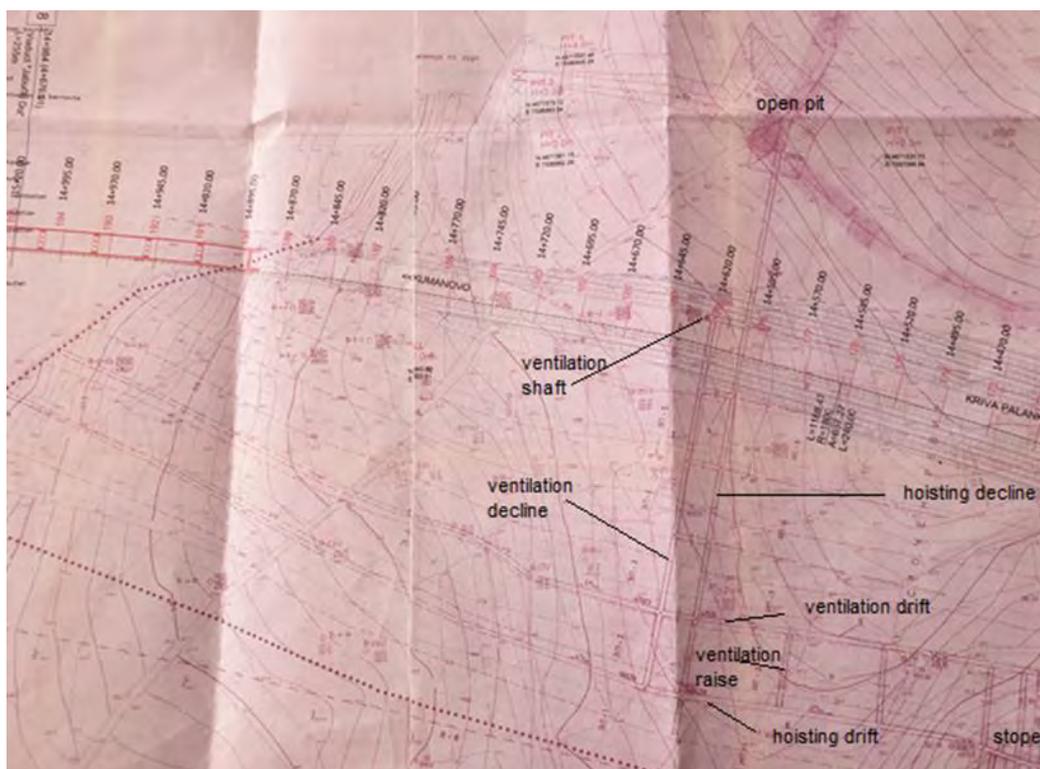


Figure 1. Plan for opening the Ginovci-Petralica deposit according to the main mining project with the route of the express road Rankovci-Kriva Palanka

For exploitation of bentonite clay was used the mining method with ground support of the stopes and additional caving of the hanging wall.

From the hoisting corridors were made preparatory excavations raises and declines so that the excavation front followed the dip of the bentonite layer.

The clay was excavated with pneumatic hammers whose working element was like a paddle. The mined clay was transported to the hoisting decline where it was loaded into a wagon type Radusha, which then was hoisted to the surface using an export winch.

3. LOCATION OF THE OLD UNDERGROUND MINING FACILITIES AND THEIR IMPACT ON THE CONSTRUCTION OF THE NEW EXPRESS ROAD RANKOVCI-KRIVA PALANKA

During the construction of the Mine, there were some changes in the concept of opening, so instead of one were built two hoisting declines, Figure 2. The main ventilation decline was not constructed because the hoisting decline served also as ventilation decline. The hoisting declines are connected with short ventilation shafts, Figure 2.

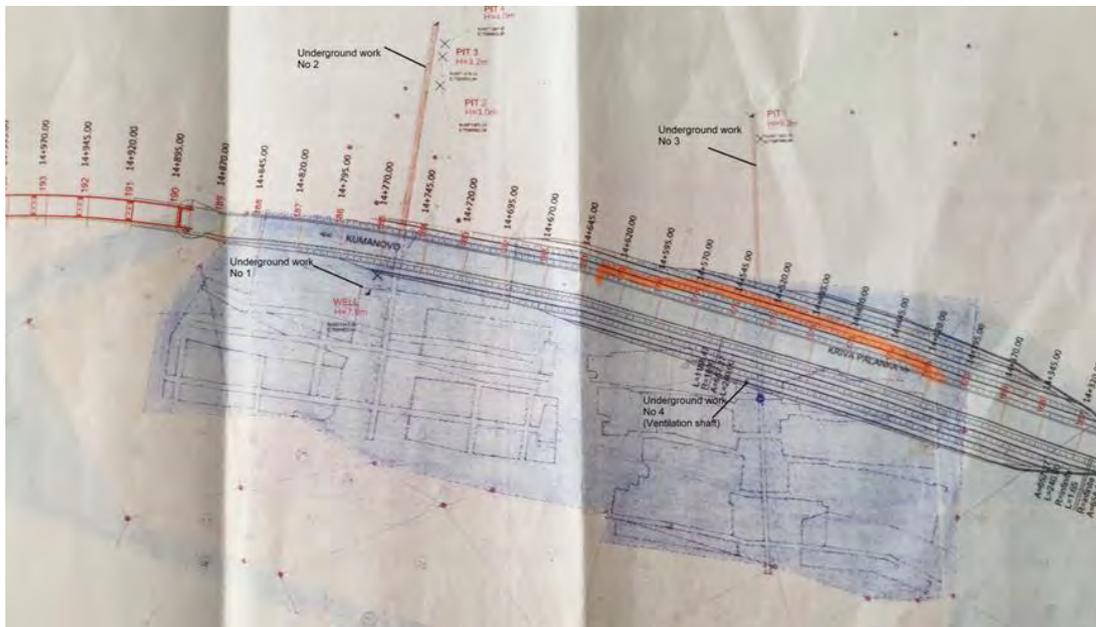


Figure 2. Plan of the actual condition of the underground mine for bentonite clay and location of the express road

Company DIVI-Skopje which supervises the construction of the express road Rankovci - Kriva Palanka has submitted a request to the Faculty of Natural and Technical Sciences at “Goce Delcev” University in Shtip to assess the impact of the old underground mining works by the Mine for bentonite clay – “Bentomak”- Kriva Palanka, on the construction of the express road A2, Rankovci - Kriva Palanka, on the part of the route from km 14 + 495 to km 14 + 795 (approximately 300 meters in length). To examine the current situation, a site visit was made on 30.05.2019.

In addition, an analysis was made into the available design and technical documentation of the Mine for bentonite clay – “Bentomak”, in order to determine the exact location of the old mining activities - hoisting declines, ventilation shafts, stopes, their position and impact on the express road construction.

Based on the in-depth study of the available project and technical documentation, and also discussions with experts - direct participants in the mining production, onsite visits of the surface and underground facilities, we concluded the following:

- In the immediate vicinity of the express road alignment, four underground mining facilities have been identified, of which only facilities numbered 2 and 3, shown in Figure 2, intersect the route of the road;
- The position of their entrances is checked by surveyors, and they can also be seen on the surface as well;



Figure 3. Photographs of old mining activities: a) Underground Ruins No.2 - Hoisting decline No.1; Underground facility entry No.3 - Hoisting decline No.2

- At decline No.1, there is a visually noticeable ventilation shaft located on the left side of the road, at a station location, km 14 + 760;
- The entrance of decline No.1 is 110 m from the right edge of the excavation route, i.e. 150m from the left edge and it has dimensions: height 2.2m and width 3.0m;
- In the road zone, the hanging wall section of decline No.1 viewed from the side of its entrance- right side of the road is located at a depth of about 15 m from the projected elevation of the asphalt road, and the left side of the asphalt road is at a depth of approximately 17 m, and it passes under the route at, km 14 + 760, Figure 4;

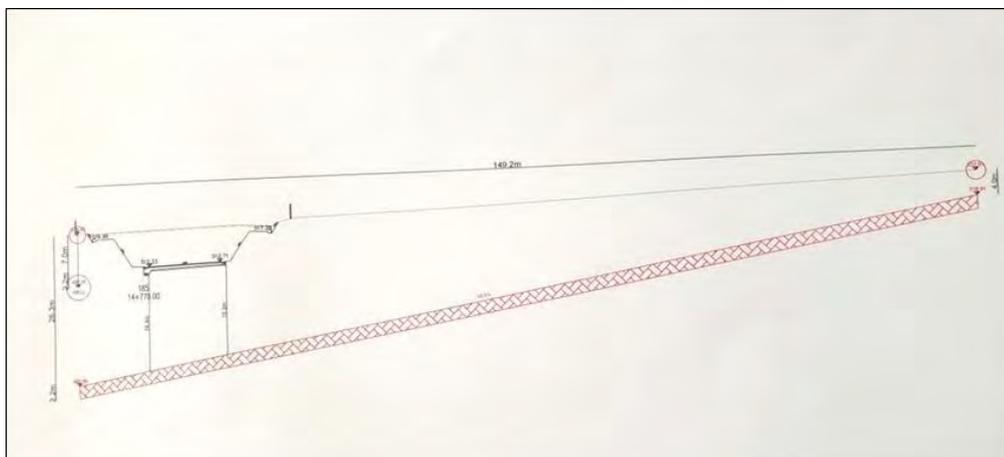


Figure 4. Estimated Location of hoisting decline No. 1 in relation to final road condition

- At decline No.2, there is no visually visible ventilation shaft, but from the technical documentation it is located at 160m from the entrance of decline No.2;
- Based on guided conversations with experts working at the Mine, there is the possibility of another ventilation shaft located at 80m from the entrance of decline No.2, and this shaft is out from the route of the express road, and is not visually found;
- The entrance of the decline No.2 is 100m from the right edge of the excavation of the road, i.e. 160m from the left edge, and has dimensions of 2.2m height and 3.0m width, Figure 5;
- In the road zone, the hanging wall section of decline No.3 viewed from the side of its entrance - the right side of the road is located at a depth of about 8.5 m from the projected elevation of the asphalt road, and on the left side of the asphalt road is at a depth of 10.5 m, and it passes under the route of km 14 + 530, Figure 5.

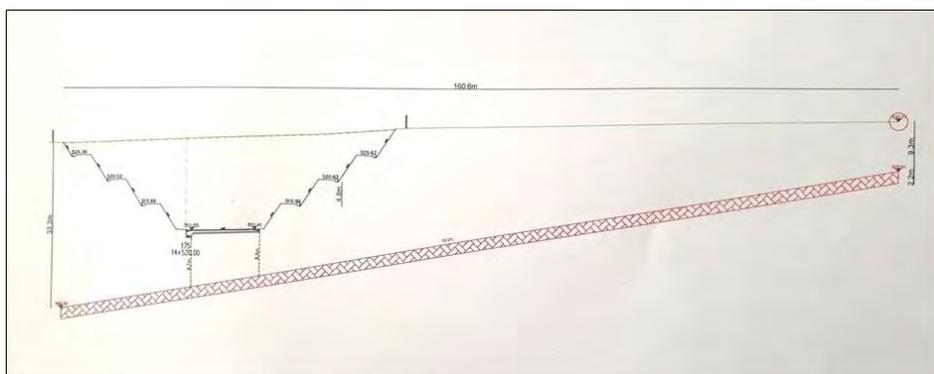


Figure 5. Estimated Location of hoisting decline No. 2 in relation to final road condition

4. SOME TECHNICAL SOLUTIONS TO SOLVE THE PROBLEM

During the construction of the road, the contractor must perform the excavation work with particular caution, especially in the places where the old mining activities cut the route of the road at depth. At these sites, georadar measurements and investigative drilling are required in order to accurately determine the position of the declines under the road. Once the exact location of the underground facilities has been determined it is desirable to fill in the empty spaces by injecting a concrete mixture. This will permanently stabilize the road, bearing in mind that it will be specifically loaded at the time of its use and subject to both static and dynamic loads. The part of the excavations stopes especially in the immediate vicinity of hoisting decline No. 2, will have no impact on the road. Possible slopes in the hollow spaces formed by the stopes are in favor of slope stabilization and there will be no possibility of landslides on the road.

5. CONCLUSION

Although under the Mining law of the former SFRJ the “Bentomak” company was obliged at the sites where exploitation work was done and underground mining facilities were built to enforce all safety and permanent liquidation measures which would permanently exclude the possibility of danger to humans and animals, that obligation was not fulfilled as can be seen from the situation on the ground. Nevertheless, whether the road designers had information about the old mining operations of the “Bentomak” Mine, now it is not possible to change its route at the time of construction because it has a capital facility on one side - a bridge already under construction and on the other side the site has made a big cut and huge funds have been spent on earthworks. Therefore, there is inevitably a need to repair the old mining pits by filling them in and permanently stabilizing the express road.

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