Exploitation of Mineral Raw Material in Croatia

1. Introduction

The exploitation of mineral raw material is based on the destruction of a rock massive. The consequence of it is the change of a natural form of the deposit after taking down overburden layers and excavation of mineral raw material as well as all kinds of damages resulting through a technological process (dust, noise, pollution of natural water and the sea, etc.).

Accompanying harms of a technological process are being solved ever more successfully (mechanical moving away of dust, modernization of mining machinery, purification of waste waters), while recultivation following mining works should be aimed to the creation of new forms and contents conforming to the environment and to an appropriate redestination of excavated spaces.

With this scope in view the present state should be defined and the final state of mining works preliminary evaluated.

The difference in the space between these two states represents reachable quantities of the mineral raw material and their traces left in nature represent a possible form of an appropriate redestination. This possible redestination of excavated spaces directs a concept of excavation and of performing mining works as much as it is allowed by the environment, by the conditions of a deposit in nature, by the technology of the works and by the professional regulations. Basic presumptions for all this should be a veritable analysis of the environment and a preliminary report of a technological process. Further, optimal production and appropriate protection of the environment is defined by creativity of a mineral-ecologist together with the other participants in the project. Newly shaped areas should be gradually positioned or the expected contents of redestination. The quarry “Pruina” on the island of Pag, Croatia, is one of the models for professional and scientific researching in this field.

2. Position of the Quarry, Direct and Wider Environment

It is planned to open the quarry in the southeast of the island of Pag, which is situated in the central group of the islands of the Croatian Adriatic sea (Fig. 1). The chosen locality is on the peninsula Pruina, in the immediate vicinity of the tourist village Pavlovići (6 km away) and not far from the city of Zadar (about 40 km). Access to the depository is possible by the sea, the route predesigned for the discharge of excavated mass, as the stone blocks are planned to be sold to wider market or to be exported. The environment is very challenging as exceptional beauty of the Mediterranean environment and its atmosphere is in question. This region is exposed to strong north winds bura, which bring saltiness so that the north-east part of the deposit is bared, which is a characteristic of the greater part of the island of Pag. On the island there are some field plateaus where agriculture is being developed, oasis of vegetation with numerous herds of sheep in pasture (well known cheese of Pag). Additionally, a number of greater or smaller tourist settlements have been erected throughout the island (the surface area of the island is 285 km²).

3. The Exploitation Borders and Reserves

The peninsula Pruina, where the quarry named after shall be opened, as well as the whole island of Pag and its wider environment are built of limestone rocks of the Chalk and Eocene formation.

The exploitation field (Fig. 2) takes about 25 ha on the surface. Its longer side makes about 1000 m and a shorter one about 200-300 m, south-east. The level of excavation is 5 m above sea level and 20 m distant from the seaside, so it cuts into a natural plateau of the hilly formation of the peninsula. The locality has been researched through holes and cuts so the reserves of technical-calculating stone have been defined and determined in the amount of about 6 Mm³ of loose mass which satisfies all the building criteria. The production is forecasted in the amount of...
200,000 m³/year, therefore the life time of the quarry makes 30 years. There is a possibility of enlarging reserves production depending on the market requests and on the accepted exploitation concept.

3. Variants of Excavation in the Function of Shaping and Redestination of Finally Excavated Areas

Regarding the position of the quarry, the form of the deposit and requirements of the environment (landscape) there are possible more ways of developing mining works in the field of the Prutna deposit. Hereby, the three variants of the works are presented which refer to the approved reserves, then reduced and enlarged reserves against the claims of the environment, as shown in Figs. 3, 4, 5 and 6.

**Variant I** treats the excavation in the limits of approved reserves (Fig. 3). Disadvantage of this variant is its complete opening of current mining works towards the sea where strong north winds directly bear on it saltiness and obstructing the works (dusting is being potentiated) which would very negatively reflected even in any recentestimation of excavated spaces.

**Variant II** includes the leaving of a protection reef by the northeast side of the deposit till the sea, where by means of the incisions (width 20 m, length 100 m) entering into active spaces of the quarry, mining production is developed.

In Fig. 4 final excavated spaces are presented based on this variant of the works and in Fig. 5 their adaptation for a nautical port (marina) is shown, whereas the works go down 5 m under the sea level. By this way additional quantities of the raw material are obtained as well as a qualitative redestination of excavated spaces because current works and final forms of excavation are isolated from the sea side what will positively be reflected on the landscape, dusting, noise and biological sanitation of the finally excavated spaces.

Disadvantages of this variant are presented by loss of approved reserves which is taken by the left protection reef (about 15%) but there is also the gain of reserves when lowering down the works under the sea level.

At the same time, some parts of the upper edge of the final mining excavation stand out in the space because the limits of the reserves follow the natural relief which is of a changable height so some higher parts of excavated spaces will be permanently seen in the landscape.

**Variant III** accepts all the requirements of the landscape and directs the works in a way, that the upper border of the whole excavation should always be on the same level (approx. K 20), which will not be noticed in the landscape except from air (Fig. 6). In this way the reserves are considerably enlarged amounting to about 10 Mm³ as the whole hilly formation on the south-east part of the deposit is exploited. In Fig. 7 (Section A-A, Fig. 6) the image of a possible technical and biological sanitation of the finally excavated spaces with the optimal variant of the works is given. By means of a planned position, by correct conducting and consistent executing of the mining works it is possible, at the same time, to create a significant space which will be, at the end, exclusively redestinated. It is a question of building a nautical port-marina which in the mining reshaped space (basic plateau of excavation of 36 ha at the surface, around the side protective construction about 20 m high, final inclination of excavation prepared for biological recultivation, accomplished a direct access or a number of them towards the open sea can be easily and in a short time adapted for its use.
4. Conclusion

Generally, the necessity expressed for the elimination of damages and the reduction of the production imperilling for the environment, and in course there is a significant sanitation of the active mining works.

The solutions bring savings of all the expenditures, the substitution of disputable products and in particular in finding out ecologically acceptable production.

Therefore, a miner should act ecologically to reduce, to alleviate or to eliminate probable damages of a technological process, while the mining production is to be carried on and even enlarged.

In case of technical-building stone where reserves are practically unlimited, the location of action becomes a basic reference of a possible resource. Shaping and redetermination of the final excavated spaces as well as the choice of location may be decisive for the continuation of the existing quarries and for the activation of new quarries.

The observation model (quarry, "Prutna", island Pag) is a minor object which is to be activated in a very complex environment. Through an expert positioning of current mining works in space and the time of their execution, they become maximally isolated what favours the landscape and reduces the other accompanying damages of the technological process (dust, noise, etc.) and especially it is appropriate for a redetermination (marine-nautical port) which is to be realized beside a regular production.

Literature
