POSSIBILITIES OF PROFITABLE BUSINESS WITH NATURE ZEOLITE – AN EXAMPLE FROM THE NIŽNÝ HRABOVEC DEPOSIT, SLOVAKIA

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ABSTRACT
This article shows complex, integral and balanced view on Slovak nature zeolites, their occurrences, properties and possibility of their utilization and exploitation in the Slovak Republic, with special emphasis on the Nižný Hrabovec deposit. The article also brings information about possibility from the point of view of exploitation in the maximum utilization of zeolite. The main aim of the article is to evaluate and propose the best economic utilization of the raw material, whereby the stress is on proposal of the whole production structure, which should be offered to purchasers as presented in this paper.

Key words: analysis, proposal, business, zeolite

1 INTRODUCTION
Utilization of non-metallic materials is certainty all over the world; on the other hand, there is still problem with absence of sufficiency of cheap and clean energy for their exploitation, treatment, processing and also financial sources for import of important non-metallic minerals particularly for fertilizer production.

Detailed analyses of exploitation, processing, production, sale, distribution together with realizing analyses and connection in their fundamental do not exist yet.

In the term of protection of the environment and creation of environment is the situation development expressly as an advantage for non-metallic minerals and forms so-called group of ecological non-metallic raw materials. According to the way of their utilization we can divide them to three groups:

1. Non-metallic raw materials straight protected water, soil and atmosphere – bentonite, zeolite, perlite, limestone, dolomite, diatomite, etc.

Non-metallic raw materials have expressively will in number of application. Specific feature of many of them is continual innovation in application and particularly huge possibilities at environmental protection. The zeolite, mineral with micro pore crystal structure, which raises efficiency of fertilizers and by that decreases their required amount for hectare, increases hectare yields of crop-plants, potatoes and vegetables. Zeolite also favourably impacts on utility of domestic animals, them is added to food (Grećula, Lexa, & Tozser, 1997).

For non-metallic minerals, it is characteristic that their prices vary according to their quality sorts up to categories. Here, a big price variation exists between raw material transported in bags and freely placed, or between building raw material and special raw materials for gaining noble earths.

2 NATURE ZEOLITES IN SLOVAKIA AND THEIR UTILIZATION

Economics of Slovak raw mineral materials is nowadays realized in the way of cost reduction, minimum of investment and little stress on product finalization. The emphasis is on input prices reduction. For mining company is important to find one major purchaser who will purchase materials in minimum proceed condition – fraction, but is not offering specific product. We assume that this approach is non-effective and not much complex. It is necessary to analyse economic correlation, on the side of technology what means diverse and finalize products and to purchasers offer finished product. Nowadays it is common that products sell with their added value.

Economic deposits of natural zeolite occur in two areas in Slovakia. In the East Slovakian Basin, where they originated by alteration of rhyolite and rhyodacite volcanoclastic rocks of the Lower Badenian, and the second area of zeolite occurrences is in the region of the Central-Slovakian Neovolcanites (Fig. 1), where zeolites originated by the alteration of rhyolite tuffs of the Upper Sarmatian – Pannonian (Bartošova Lehôtk deposit).

2.1 Utilization of nature zeolite

Slovak Republic belongs with the quality and quantity of zeolites tuffs among rich European states. Zeolites tuff belongs with their mineral and chemical composition between quality clinoptilolite. According to Kozáč, Očenáš, Derco, and Rusnák (1981), zeolites are mineral raw materials of the twenty-first century. A number of possibilities of nature zeolites utilization includes e.g. agriculture, industry and environment, and construction. Following text, according to International Zeolite Association (IZA, 2010) brings short overview of such utilization.

Agriculture - covers some 70-80% of zeolite production, especially in the following areas:

- soil additive,
- crop protection,
- constituent of three-component mineral fertilizers,
- component of feeding mixtures for animals,
- litter additive;

Industry and environment:

- Wastewater, sewage and drinking water purification,
- dust and flue gas cleaning,
- filler in several industrial products (rubber, paper, wood);

Construction:

- Component of cement and concrete composites,
- Geosynthetic clay liner (IZA, 2010).

Within agricultural utilization of nature zeolite can be this raw material used as the sorbent improving management of solid with fertilizers and water. It also can be used for solid enrichment of biogenous and trace elements, improvement of animal nourishment, individual growth support, improvement of land Bonita and neutralization of acid bottom (Rybár et al., 1999).
Ecologic purposes of nature zeolite utilizations cover modification and filtration of drinking water, purification of natural gas from CO₂, H₂S, SO₂, NH₃, radionuclide fixing in waste water of nuclear power plant, neutralization of acid solid and forest wood, increasing of wood resistance, and elimination of gas oil (in combination with perlite) (Kozáč et al., 1981).

Industrial utilization of nature zeolite can take place within production of pozzuolina cement, manufacture of light building materials, filler (paper, plastic, gum) productions, detergent productions (replacement of toxic polyphosphates), carrier of pesticides, gas driers, and utilization in cosmetics, energetics and services (Rudinec, 1978).

According to the European Standards EN197-1, nature zeolites can be marked as a nature pozzolan. Similar, as other pozzolan is not hardening alone after mixing with water, but if it is finely grounded it reacts with the water with soluble calcium hydroxide in creation calcium silicates compounds and calcium aluminates, which are carriers of increasing strengthens.

Utilization of nature zeolites in construction is as the against corrosion admixture of cements. By application of 15% (weight) of zeolite as a replacement for common Portland cement we can achieve similar sulphate resistance as it is proven in using sulphate resistant Portland cement. Nature zeolite is suitable for application in challenging, aggressive sulphate surrounding, as a inert additive to the sealing compounds for ecological construction, for the purpose of restriction spreading contaminated waters from old environmental loads from chemistry, or another industry companies.

Nature zeolite significantly improves stability of cement suspensions. It is suitable for preparation cement suspensions for underground sealing walls purposes, injections of micro piles as for mixture injection of cable cavities. The cement- zeolites suspensions sediments slower and also the process of distribution on solid phase and liquid is slower. The stabilizing effect of nature zeolite relates with sorption and exchange ability (Janotka & Krajčič, 2000).

3 NÍŽNÝ HRABOVEC ZEOLITE DEPOSIT

The deposit of nature zeolite in Nížný Hrabovec represents volcano-sedimentary deposit type, where clinoptilolite originated by alteration of glassy ash, included in the matrix of rhyodacite tuffs, during the diagenesis. According to Greccula et al. (1997), Nížný Hrabovec deposit (known since 1974) and surrounding deposits (Kučín, Pusté Čemerné, Majerovce) are made up by zeolite tuffs, with clinoptilolite content of 40 to 65 %. Exchange capacity varies from 0, 80 to 0, 87 mol per kg. The origin of zeolite mineralization is related to hydrothermal alteration of volcanic rocks.

3.1 Geology of the Nížný Hrabovec deposit

From the geological point of view, Nížný Hrabovec deposit is located within the Eastern Slovakian Basin with its basement of graben-synclinal structure. The basin was filled by Neogene clastics, volcanogenic rocks and evaporites. The total thickness of the Neogene sequence reaches 7000 m. Diverse lithofacies were affected by volcanic activities of acidic to intermediate character, which continued during the whole Miocene period. Clay minerals and zeolites occur as the major or minor constituents of tuffs in all the Miocene stratigraphic stages. Zeolitization of stratiform character, showing vertical mineralogical zoning, constructed by clinoptilolite and analcime is associated exclusively with the bedded marine Lower Badenian sequence of rhyodacitic volcanoclastics, the so-called Hrabovec tuffs (Rudinec, 1978; Šamajová & Kraus, 1976).

3.2 Mineralogy and chemistry of the Nížný Hrabovec deposit

As summarized by Baláž and Kúšik (2012), Nížný Hrabovec deposit, as a part of Nížný Hrabovec - Majerovce - Kučín Formations, is characterized by stable occurrence of clinoptilolite (mostly K, Ca-rich), in association with low cristobalite, both as a result of silica glass alteration. Original pyrogenic minerals in the tuffs do not exceed 20% including quartz, plagioclases and sporadically chloritized biotite (Varga, 1984, 1988; Kozáč et al., 1981).

Clinoptilolite content, regularly checked by X-ray diffractometry and other techniques, ranges between 50 and 90% throughout the deposit. A representative rock composition is depicted in the
Table 1. Table 2 reports the chemical composition of representative samples of clinoptilolite–bearing tuffs (weight %) (IZA, 2010).

The cation exchange capacity (CEC), estimated according to ČSN 72 1076 Czech National Standard, based on cation displacement by a NH$_4^+$ solution, ranges from 1.2 to 1.5 equiv./kg. The crystal chemical formula of clinoptilolite from a representative sample of Nižný Hrabovec deposit is:

$$\text{[(Na}_{0.21}\text{K}_{1.74}\text{(Ca}_{1.71}\text{Mg}_{0.31}\text{(H}_{2}\text{O}_{18.28}}\text{[Al}_{6.11}\text{Si}_{29.90}\text{O}_{72}]}$$

The unit cell parameters of clinoptilolite from Nižný Hrabovec are as follows:

$$a = 17.79(2) \text{ Å}, b = 17.99(2) \text{ Å}, c = 7.43(1) \text{ Å}, \beta = 116.5(1)^\circ$$ (IZA, 2010).

4 **POSSIBILITIES OF PROFITABLE BUSINESS ALTERNATIVES**

Offering three alternatives shown below we propose several methods how to provide development of new products. Anyway, there exist more possibilities, where each of them has both, advantages and disadvantages.

**First alternative**

In this method we are thinking of establishment independent research centre next to mining company. The research centre should include laboratory, testing room, and testing equipment.

Advantages of this proposal are: quick reactions on demand from customer, without problem obtain laboratories or recruiting special employee. There is also possibility to use testing rooms and laboratories not just for new products development, but also for zeolites property verification.

Another possibility is gainful activity – rendition of services through the laboratory.

Disadvantages are as follows: already in the first phase of the investment, construction of new object, purchase of equipment necessary in laboratory and testing room should be taken into account. Necessity to hire new employees and to set their optimum number exists here also. It results in increase of salary costs etc.

**Second alternative**

In the second method is not necessary to build up new work places, development of new products would be given to other subjects, e.g. universities and/or science academies.

Advantages of second alternative consist in lower costs on new product development. It is not necessary to build independent work place, can be used laboratories and test rooms in the university. If time doesn’t matter by development of new product, it is possible to assign diploma work where are minimum costs for covering the problem. Another possibility is financing by grants or economic contract.

Disadvantages of second alternative are: possibility of delay delivery, problem in communication. There is a possible non-flexibility from the solutionist side, pedantic approach. There is necessity to handle with information leakage, patent protection etc. In the case of diploma work – student could ignore solution of the work; this is problem of consultant or work master.

**Third alternative**

In the third alternative we propose cooperation of mining company with already existed company, which is dealing with trade and development products of zeolites products.

How this should work: by the form of orders should be realized development of new products and their placement on the market. There is also possibility to create Subsidiary Corporation, where the sub-company of mining company is above mentioned company.

In that case here is a problem of laboratory co-financing, but costs are not reaching that amount, how this should be by building new work place. Another advantage is quick reaction on customer’s inquiry. We also have to remind, that subsidiary corporation could deal with marketing and advertisement, and there is no need to built commercial section in parent company.

Disadvantages: if there is a problem in any of both companies, it appears in both companies.
4.1 Potential purchasers and markets
For manufacturing enterprise could be harder realize business than production activity. By business strategy was given stress for occupation of markets and finding business partners home and abroad.

Home market
At the home market, by selling ground, crushed and granular packed zeolites will be large competition. Enforcement of company on the market is conditional of lower price offered products. Better services, quicker delivery, quality of package and quota discounts would take a role in the phase of market distribution, by competitors fight for customer. On the other hand, in retail business existing possibilities in selling special products, which are missing on our market. Good advertisement, distribution network, or network of own stores with the assortment not only zeolites products opens space for profit. The competition is in this area on minimum level and with good advertisement and edification is the forecast for retail positive. Another possibility is signature of contract agreement with big businesses which should use zeolites products for elimination of odor and humidity in their place of businesses. There are circumstantial evidences, that one of automobile producer could have interest in cooperation and also different distributive companies; there is need for good marketing and contacts, because for most corporation is signature not valid enough, not oblige. Biggest disadvantage by selling zeolites products is non – acquaintance of these products by costumer. It means there is the need to prepare large advertising campaign. The campaign should move zeolites products to cognizance of general public. This means higher costs, but expected profits from sale shouldn’t come so quickly, how would be wished.

Foreign market
Abroad direction should be to the north from two main reasons:
- No existing nature deposits
- Free, non-occupied market
Poland, Germany and Czech Republic have already shown their interest in raw material and products from mineral raw material. Another possibility is Scandinavia. Disadvantages could be connected with public non-acquaintance of zeolite raw material and products of it.

5 CONCLUSION
Following available information we have come to the conclusion, that economic evaluation of exploited raw material is most effective if we can increase added value, that means that we aren’t selling just “raw” material, but we should proceed it to the final form that demands costumer. Biggest advantage of this valorisation is the fact that on the market research we can certainly set the amount of exploited raw material in required quality for certain type of the product and also set exact costs to processing and modification of the material. The present state of exploitation technology and end product production technology are closely associated and output from mining company and converting company has minimum diversity. For some mineral raw material, or construct raw materials, for example andesite is hard to design single products, they will be used for construct purposes and they differ just with the size of fraction. However, zeolites products shouldn’t differ just by size of the, fractions but their specific properties allow us to produce several concrete products, or semi-products which require minimum modification from purchaser.
REFERENCES


Fig. 1 Locations of nature zeolite deposits in Slovakia (after Nerastné suroviny SR 2012, Kováč et al. in Oszczypko, 2004), 1 – Majerovce deposit, 2, 3 Kučín deposits, 4 – Nižný Hrabovec deposit, 5 – Bartošova Lehôtka – Paseka deposit, 6 – Sklené Teplice deposit
### Tab. 1 Representative rock composition of clinoptilolite (IZA, 2010)

<table>
<thead>
<tr>
<th>Phase</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinoptilolite</td>
<td>84.0</td>
</tr>
<tr>
<td>Low cristobalite</td>
<td>8.0</td>
</tr>
<tr>
<td>Quartz</td>
<td>traces</td>
</tr>
<tr>
<td>Feldspar</td>
<td>4.0</td>
</tr>
<tr>
<td>Illite</td>
<td>4.0</td>
</tr>
<tr>
<td>Carbonate (calcite)</td>
<td>&lt; 0.5</td>
</tr>
</tbody>
</table>

### Tab. 2 Chemical composition of clinoptilolite – bearing tuffs (IZA, 2010)

<table>
<thead>
<tr>
<th>Oxide</th>
<th>weight %</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>66.97</td>
</tr>
<tr>
<td>TiO₂</td>
<td>10.61</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>0.24</td>
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<tr>
<td>Fe₂O₃</td>
<td>1.72</td>
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<tr>
<td>MnO</td>
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<tr>
<td>CaO</td>
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<tr>
<td>MgO</td>
<td>0.73</td>
</tr>
<tr>
<td>K₂O</td>
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<tr>
<td>Na₂O</td>
<td>0.68</td>
</tr>
<tr>
<td>H₂O</td>
<td>12.90</td>
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</tbody>
</table>