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GEOLOGICAL SURVEY AND EXPLORATION OF BARYTA DEPOSIT UMM GERAD

1. INTRODUCTION

About 95% of the approximately 4–6 million t/y of baryta consumed worldwide is used as a weighting agent in the drilling fluid or "mud" for drilling deep wells by the rotary method. The balance is consumed in a variety of minor uses including a functional white, high-density filler in rubber goods, paper, etc., a source of chemical barium for glass and ceramics, a feedstock for various barium chemicals, and an ingredient in pharmaceuticals and food additives. Although baryta is a fairly common, low priced mineral produced in more than 40 countries, there is extensive international trade designed to deliver large quantities to drilling regions such as the Middle East and North Sea. In many cases, baryta is shipped in a semi-crude form and ground to specification close to the point consumption, often by international drilling supply companies such as MI Drilling Fluids or Baroid.

In the Middle East, baryta is mostly used in the drilling fluid. Exploitation in large volume is carried out in Morocco (300,000 tons per year), Iran (165,000 tons per year), Turkey (130,000 tons per year), in smaller volume in Algeria (32,000 tons per year) and Saudi Arabia (12,000 tons per year). Barite is imported in the Middle East by Algeria, Saudi Arabia, Abu Dhabi, Tunisia, and Syria.

2. CHARACTERISTICS OF THE SURVEY AREA

Saudi-Arabia side has addressed Slovak company, the RIMA-MURÁŇ ROŽŇAVA s.r.o., and proposed cooperation in exploitation of the deposit. Following the visit at the locality and evaluation of the conditions, the contract on cooperation was concluded between Saudi Arabia and Slovakia. Subject of cooperation was to carry out geological

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survey, make reserves calculation, and propose the method of exploitation and ground works concerning the objective deposit.

Drilling works were carried out in the period from 16 November 2005 to 21 December 2005 and consequently in the period from 14 March 2006 to 12 April 2006, or to 20 May 2006.

Location where the works were executed is the Jibal Fukhda Mountain, located north-eastwards from the town called Rabigh. Since first discovered in 1950's, the Umm Gerad baryta deposit was exploited using the surface method. Surface-near sections of baryta veins were exploited in the disintegrated, cracked zone, with small amount of blasting works carried out. Depth of the surface mining reaches 20–30 m with the neck width of about 6 m (Fig. 1). It has also been verified in the past that baryta mineralization continues down to the above mentioned depth. Further possible deposit exploitation is therefore conditioned by verification of continuing baryta mineralization in economically interesting development.

Fig. 1. The surface mining of baryta

3. CONDITION IN THE TERRAIN

Rather large, but undefined extent of the mining and prospecting works in the area of 16 × 7 km, without any access to the above mentioned materials, required to have an orientation map of the whole condition.

Baryta veins are mostly exploited down to the depth of about 20 m, with the mining width of up to 10 m, and represent a possibility limit from the labour safety point view (mining shaft wall falling).

Majority of the mining bases is under the erosion base, they are sanded with layer of sand as mush as few metres thick, so it is mostly not possible to monitor its qualitative development (vein thickness) along the structure flow direction.

Suspension of exploitation was caused by the costs growth up to 1 ton of baryta from the initial USD 70 to USD 300, combined with completion of mining in the technically accessible reserves using the given mining method.

Under these conditions, 4 boreholes were demarcated during the first expedition in order to verify continuing baryta mineralization downwards in the structures “700”, “500”, and “600”.

4. OBJECTIVE OF GEOLOGICAL WORKS

Original objective of geological works was to verify whether baryta structures of the vein, exploited in the past, have more significant deep continuation which would enable mining continuation.

It is not possible to obtain further data on extension (parameters), economical potential of baryta mineralization by the means of surface geological works. Verification of baryta veins continuation downwards is possible only by technical works (shafts, holes).

Four holes located so that they would cover variability of geological structure of the whole territory should ensure instant obtaining of the primary view on the situation.

Regarding the lapse in the supply of drilling works ensured by the partner, increased extent of drilling works and the structure will be verified in more details, starting with structure 700.

This change is probably caused by an effort to commence exploitation as soon as possible, regarding the existing modifying line.

5. RESULTS OF EXECUTED GEOLOGICAL WORKS

Based on orientation geological mapping, it is possible to state that baryta mineralization is extended at rather large area (16×4 km) and is connected with tectonic development of the area. The structures have a general NW and N direction, steep declination of 90°C – 70°C, and thickness of dozens of centimetres up to 1.6 m. Type of vein structure development in their flow direction is conditioned by the mineral environment containing developed veins, when considering qualitative parameters of the veins.

Structural mineralization itself is mono-mineral and is formed by massive, course-grained, strip-shaped baryta, with fasciated symmetric texture at some locations. In the middle section of veins there are many cavities (in the SOUTH 700 structure they are even few metres large along the direction and the depth of the structure flow with walls covered with lenticular baryta crystals, surface of which is covered with Mn oxides).

Auxiliary Mn oxides are rather frequent; presence of auxiliary Cu (Chrysocolla) and Pb (Galenite) mineralization was observed.

In the southern part of the mountain the structures contain also calcite, together with baryta mineralization in more significant volume, at some locations even in the ratio of 1:1.

In-depth continuation of exploited baryta structures was verified by gradient inclined (60 degrees) holes, which were oriented on the observed surface-near vein flow. Development of baryta mineralization was verified in more details in the structure 700 by five holes. Executed technical works are listed in Table 1.

On the basis of executed boreholes we can state that baryta mineralization continues in the structure 700 deep down in such development as was present during exploitation in surface-near sections.

Table 1

List of executed drilling works

Borehole	Borehole length m	Borehole inclination °	Baryta from – to m	Notes
BH 701	71.5	60	64.63–68.11	
BH 702	128.8	60	99.20–100.30	
BH 703	65.3	58	60.00–60.90	
BH 704	79	60	60–63	Tectonic lines
BH 705C	115	60	73–76	Tectonic lines

Deposit capacity of baryta mineralization will be accessible in the whole mountain only after in-depth verification of vein continuation by additional drills, considering the fact that in case of other structures (mainly south and north), transition, or change of mineralization downwards can not be excluded.

Certain baryta capacity can be present also in the surrounding sediments within the deposit area (sprinkle deposit).

Orientation analyses (upon customer's request) on the presence of Au – mineralization has proved no presence.

6. RECOMMENDATION FOR FURTHER PROCEDURE

With the existing knowledge on the locality, the deposit can be exploited using the following methods:

a) **Exploitation by the deep mining method**
This method requires construction of the winze from the surface down to the deposit – specifically down to the depth horizon where exploitation will be carried out. The place where the winze will start must be sufficiently ensured against storm waters, which could significantly complicate driving the work and subsequent exploitation. Maximum depth horizon of exploitation will determine economic calculation of exploitation efficiency. Exploitation would be carried out by the means of small machinery, hand air-drills, using explosives and small loading machine. In less stabile sections it will be necessary to use mining reinforcement. Direction of the mining tunnel would copy the direction of baryta vein. Exploitation would be carried out downwards. Exploited areas would be filled up with waste rocks.

b) **Exploitation by the surface method**
First of all it is necessary to state that at present this method of exploitation will be effective only if the uncovering material is used as well for the construction purposes,

whether as the fill up material (lower quality material) or the quarry stone modified into different fractures in alligators for further various types of use (roads, concrete, asphalt mixtures, etc.). In that case baryta will be exploited as the parallel product. With this type of mining, deep distances will be reached by removing the rock plate-by-plate in gradual desks, with such slope height and inclination of each level that would not represent danger for exploitation on the neighbouring lower level. Under this method of exploitation the maximum depth will also be limited by economic effectivity. For this type of exploitation it will be necessary to ensure adequate machinery – excavator – Proclain (including the impactor), Caterpillar – dozer, trucks, etc. It is necessary to count with the fact that in some sections it will be necessary to use explosives. The scheme (mining hole cross section) is shown in the attached Figure 2 and the structural situation in Figure 3.

c) **Combination of a) and b) methods**

In case that further geological development shows that baryta veins suitable for the effective exploitation are located at places where the surface exploitation would be hard to carry out, the best method, dependent on the circumstances, will be the one that corresponds to technical and economical reality – either method a), or method b), or combination of the two. For example if we reach beyond the section in plane terrain exploited by the surface method accessing the foothill, in some cases it will be better to continue with the mining tunnel.

Based on the existing course of works and achieved results we can specify the following recommendations (requirements):

- Before any works on the task are commenced (not only on this one but on all future ones), it is necessary to ensure suitable maps, or air photos, as the case may be. This will enable terrain identification. Anyway, these documents are necessary for the control, evaluation, and planning of further works (reserves calculation); moreover, they are certainly required by the K.S.A. legislation. They are inevitable for the effective and safe control of the mining works.
- Ensuring the reports on previous surveys (archive data) significantly makes the works more effective, eliminates duplicity; it can be arranged only by the partner.
- To solve: – Drill core bisection (price includes sample storage) in relation to their legislation – an obligation (taking samples).
- To carry out further works by “improvisation” cannot be economically effective, gradual steps must be chosen.
- It would be advantageous to know the total in-depth extent of barite, or other mineralization – vertical borehole. Data on hydro-meteorological condition would be useful, as well as getting the limited source of water.
- On the basis of certain technological problems, it is recommended to use special chemical means to eliminate these troubles.

It is also recommended to drill the borehole sections, which are not important from the geological documentation point of view, using non-nuclear technology – with an immersion hammer, using the compressor. Time and water would be saved. However, it requires this technology to be purchased.

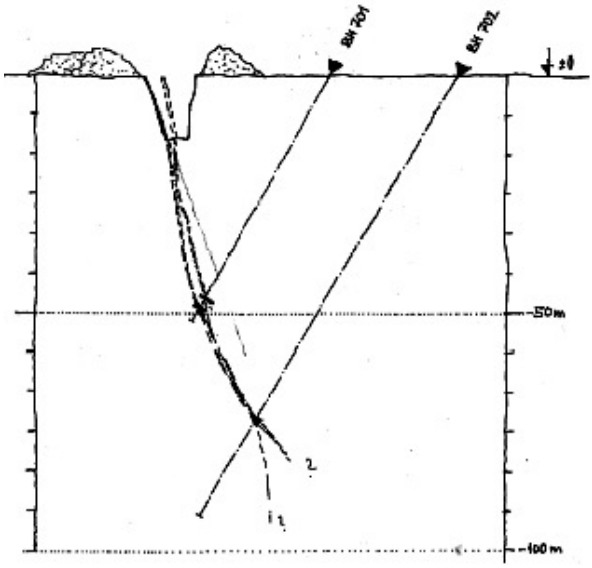

Fig. 2. Cross-section of mining hole

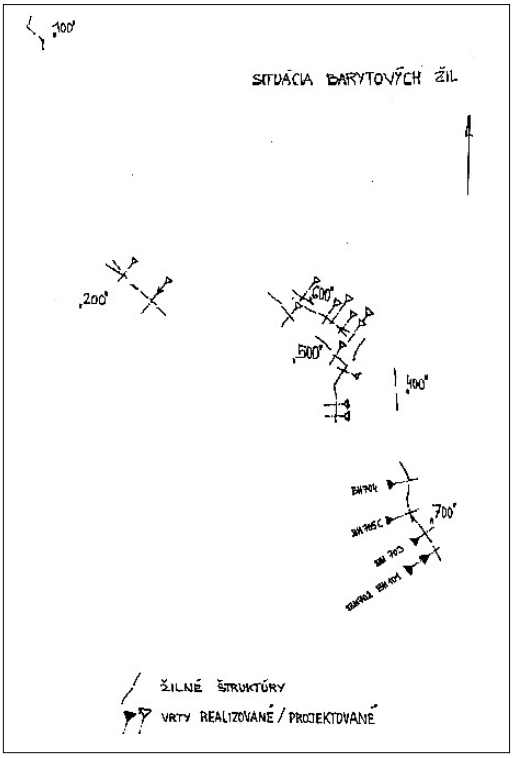

Fig. 3. Structural situation

7. ORIENTATION ASSUMPTION OF RAW MATERIAL RESERVES

Until now, the drills have verified in-depth continuation of the structure "700" down to the level of 50 m and 80 m below the terrain level. Baryta mineralization has similar qualitative parameters as in the exploited sections of the deposit.

In case that the following drills in the main structures "700", "500", and "600" confirm in-depth continuation of baryta mineralization in similar quality, it is possible to expect verification of baryta reserves down to the level of 50 m below the terrain, verification shown in Table 2.

Table 2

Baryta reserves

Structure	Length m	Reserves t
"500"	400	54,000
"600"	500	60,000
"700"	900	84,000
TOTAL		**198,000 tons**

Note: Assumed thickness of the structure /barite/ 0.5 m.

In other structures "200", "400", "100", and structures in the southern part of the mountain, it can be assumed that down to this depth level the same amount of reserves would be confirmed.

In the surface exploitation of baryta veins and parallel stone mining for production of crushed stone for construction purposes it would be necessary, in order to ensure slopes stability, to remove amounts of stone specified in Table 3.

Table 3

Stone quantity

Structure	Stone volume m^3	Stone tonnage t
"500"	872,000	2,354,000
"600"	1,090,000	2,943,000
"700"	1,962,000	5,297,400
TOTAL	**3,924,000 m^3**	**10,594,800 tons**

Note: General inclination of the mining slope is 57^o, in plate wall inclination of 70^o.

Exploitation would be executed down to the level of – 50 m below the terrain.

8. CONCLUSION

Baryta deposit UMM Gerad can be exploited economically in combination with mining of the surrounding rocks for construction purposes.

It would be useful to verify overall in-depth extent of baryta mineralization, or change of mineralization downwards. Secondary effect could be to obtain the water source (with limited capacity). This procedure would enable choosing the most suitable method of possible future mining (in-depth) opening, so that the least possible amount of problems appears in future.

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