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GEOLOGY OF THE NIŽNÁ SLANÁ DEPOSIT AND ITS SURROUNDINGS GEOLOGY OF NIŽNÁ SLANÁ DEPOSIT AND ITS NEIGHBOURHOOD

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Abstract: Carbonates in Early Paleozoic complexes appear in the upper part of the thick black phyllites formation (Betliar Formation). They are present in the Holec Beds containing black metapelites with lydite and the upper carbonatic horizon with a slight admixture of basic volcanism. From the genetic point of view the stratiform and ankerite deposits of Gemericum are regarded to be of hydrothermal-metasomatic origin. Owing to the positive results of the geological survey, the Nižná Slaná region has become the most important basis of Fe-ore in the Spiš-Gemer Ore Mountains, but also in the Western Carpathians. The potential of industrial siderite was 63 million tonnes.

The Mano deposit surfaces on the southern slope of Rimberg hill, where the superficial parts of the formation of black phyllites with carbonatic bodies are located. The formation, thick to 450 m, contains carbonatic and lyditic horizons with carbonates metasomatically changed to ankerite and siderite. The largest siderite bodies have a maximum directional length of 300 m and a thickness of 100 m. The accumulation of metasomatic siderite near Obeliarovo is located in the northern limb of the anticline in the Betliar Formation. Ore bodies are a typical example of a blind deposit.

The average quality of economic ores is as follows: Fe 33.5%, Mn 2.18%, SiO_2 8.5%, As 0.001–0.2%, Pb 0.001–0.03%, Zn 0.002–0.009%, S 0.5–1.5%. The basicity of siderite is 1.4–1.7.

1. Introduction

The complex situation in mining, and especially in iron ore mining concentrated in the ŽELBA, š.p. Spišská Nová Ves company, is being overcome relatively successfully only by the SIDERIT mining plant in Nižná Slaná. Over the past few years, the plant's management has managed to maintain employment and increase the extraction and production of blast furnace pellets year on year. The extraction and subsequent processing of ore creates around 1,100 jobs, making the Nižná Slaná plant the largest employer in this part of Upper Gemer.

Deposits and occurrences of stratiform metasomatic siderite and ankerite are found in the younger and older Paleozoic Gemerika . In the older Paleozoic, carbonates occur in the upper part of black phyllites / Betliar Formation / in the Holec layers, which contain black metapelites with lydite.
and the upper carbonate horizon. The majority of carbonate occurrences are represented by bodies of ankerites, crystalline marbles and dolomites. Only some of them are siderites, which were mined in the western part of Gemer (Železník, Rákoš, Hrádok, Gampeľ, Ignác), while others are currently mined in Nižná Slaná-Manó and Kobeliarovo.

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2. Nižná Slaná - Kobeliarovo deposit area

Thanks to the positive results of geological exploration work, the Nižná Slaná deposit area has become the most important base for Fe ores in the Spišsko-Gemerské Ore Mountains and even in the Western Carpathians over the last 35 years. It stretches west of the Slaná River valley between the villages of Gočovo and Nižná Slaná, forming a triangle with its western peak at Ježovec (677 m above sea level) west of Kobeliarovo.
/ Fig. 1 /. At 12 km ^{2} there are all significant deposits of metasomatic siderite, associated with older Palaeozoic carbonates . The potential of the siderite balance was 63 million tonnes . The ankerite reserve has not been determined. Vein deposits are insignificant here. The deposit area belongs to the Hanková - Volovec - Holec ankerite zone, specifically to the Betliar Formation of the older Palaeozoic era (black phyllite formation). The basic tectonic structure of the ore field is an asymmetrical anticline with a reduced northern wing.

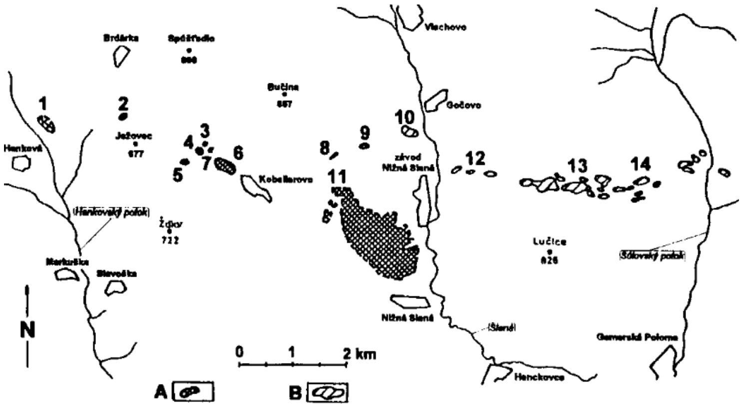

Fig. 1. Overview map of deposits and occurrences of siderite in the vicinity of Nižná Slaná. A - ore bodies of metasomatic siderite (with the serial number of the deposit or occurrence), B - ankerite bodies.
Locations: Hanková - Brdárka, ankerite, 2 - 9. Mája / Álmos / tunnel, siderite, 3 - Jarok Mine , ankerite ,4 - Vybraná / Michaeli / , siderite ,5 - Amália I - II , ankerite ,6 - Kobeliarovo , siderite , 8 - Ignác, siderite, 9 - Gampeľ, siderite, 10 - Go-čovo, ankerite, 11 - Nižná Slaná - Manó, siderite, 12 - 14 Zoltán, Attila, Koloman Viktor, Leontína, Peter, Bonaventúra, ankerite / Mihók in Grecula et al., 1995 /.

The actual productive strata – the Holec layers – with metasomatically altered carbonate bodies form grey and black phyllites with lydite occurrences. The main part of the stratum consists of carbonates such as crystalline limestone, dolomite, ankerite and siderite, which are partly biogenic and partly chemogenic in origin and contain inclusions of clastic and volcanic rocks. Layers of limestone, ankerite and siderite alternate.
in the vertical section of the deposit and are stratiform in nature. The Nižnoslanské deposit is generally considered to be hydrothermal-metasomatic , Andrusov / 1958 /, Varga (1970) and other authors assumed that these were bioherm formations in which the distribution of siderite and ankerite deposits was primarily governed by pre-ore tectonics and selective metasomatism. The absence of organic remains was attributed to metasomatism. The theory of metasomatic formation of carbonates is contradicted primarily by the textural features of carbonates in the deposit, which are not typical for bioherm formations. There is not only one siderite position in the deposit, but several siderite positions have a balanced character.

The formation of siderite probably occurred in a slightly reducing environment, likely already in the diagenetic stage, which was conducive to the formation of siderite and ankerite. The basic types of carbonates are very similar in terms of their chemical composition, degree of contamination and trace element content. The increased content of Mn, and apparently also P, in siderite, ankerite and limestone also points to the fact that sedimentary, diagenetic and metamorphic processes played a significant role in their formation (Turan and Turanová, 1993).

Geological and geophysical studies in the western part of Gemer have revealed that this area has a thrust-like to scaly structure with shallow deposits. The separation of individual tectonic scales (partial nappes) is based on a layer of black shale. As a result, the lithostratigraphic sequence of rocks repeats itself. In this sense, the tectonic structure of the Manó deposit can also be interpreted as meaning that the so-called underlying porphyroids already belong to another tectonic unit. In their bedrock, there should again be a layer of black shales with carbonates (siderites) (Grecula et al., 1989, 1992).

3. Manó deposit

On the southern slope of Rimberk Hill, a layer of black phyllites with carbonate bodies emerges between porphyroids on the surface of the Manó / Manó s.s. deposit in the western part and Gabriela in the eastern part /
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3.1 History of the deposit .

Historical data on mining activity in the vicinity of Nižná Slaná are scarce. The first written records date back to 1360, but given the surface occurrence of carbonate ores here and in Dobšiná, it is assumed that iron ore deposits were already being mined in the 13th century. In 1417, King Sigismund granted Nižná Slaná the title of "Free Mining Town." In 1570, two Slovak furnaces were already operating here. The development of mining began in 1669, when Count Mikuláš Andráši obtained the exclusive right to mine metals (e.g. in 1779, 900 q of ore was processed in two Slovak furnaces in Vlachovo and Poloma), but especially in the second half of the 18th century.
19th century, during the lifetime of Emanuel Andráši, the so-called Iron King. In 1843, a blast furnace was built in Vlachovo
and in 1868 the Etelka blast furnace in Nižná Slaná . In 1900, the deposit became the property of the Rimamuránska company / at that time, the mining of mercury ore, which had been mined here since before 1701, also ceased. From more recent data, I will mention:
1924 - start of excavation of the Manó tunnel at level VI,
1929 - 1933 - restriction of mining due to the global economic crisis, 1945 -
resumption of mining after World War II,
1956 - elimination of horse-drawn mining transport and introduction of trolley
transport, 1975 - start of operation of the first rotary kiln.

In 1975, ore mining moved to the Gabriela shaft, which provides access to the deposit at an altitude of 1,200 metres above sea level
/ 96.0 m above sea level/. Since 1975, the mined siderite has been compacted in a new processing plant, where s the final product - blast furnace pellets containing 57% Fe, 3.5% Mn and 5% SiO_2 . In 1997, construction began on a dry high-intensity magnetic separation plant for pre-treatment of the mined ore before it enters the thermal operation.

3. 2 Deposit exploration

The Manó deposit has been mined underground regularly since the second half of the 19th century. Gradually, hereditary tunnels were dug here (the last one at the VI horizon level). The deposit was explored in the preliminary exploration stage by surface drilling (1950–1960) in a 100 x 100 m grid, followed by detailed exploration by mining works on individual horizons at 50 m vertical distances. The detailed survey consists of the excavation of horizontal and vertical mining works. As a rule, two parallel mining tunnels are excavated on each horizon, one located entirely in the bedrock of the deposit and the other approximately in the middle of the carbonate formation . From these guide tunnels, crosscuts are excavated at 50 m intervals to the thickness . Exploration along the dip is carried out through chimneys from the lower horizon to the higher horizon . The methodology for opening and exploring individual horizons is adapted to fit into the system of follow-up preparatory and mining work. Core drilling exploration is necessary to accurately determine the reserves from the mine workings excavated in this way.

3. 3 Geological structure

The Manó deposit is located in a zone of sedimentary rocks between volcanic rocks and has an arcuate course on the surface . The thickness of the formation is up to 450 m and contains a carbonate and lydite horizon with carbonates metasomatically altered to ankerite and siderite . The deposit has a strike length of approximately 2.5 km
with a dip of 30 ^{o} to the south. Towards the depth, there is a known formation with carbonate development over a dip length of approx. 2.5 km, where the carbonate development transitions into sericitic marble and calcareous phyllite.

The sequence of rock complexes from the bottom up is as follows (Fig. 2):

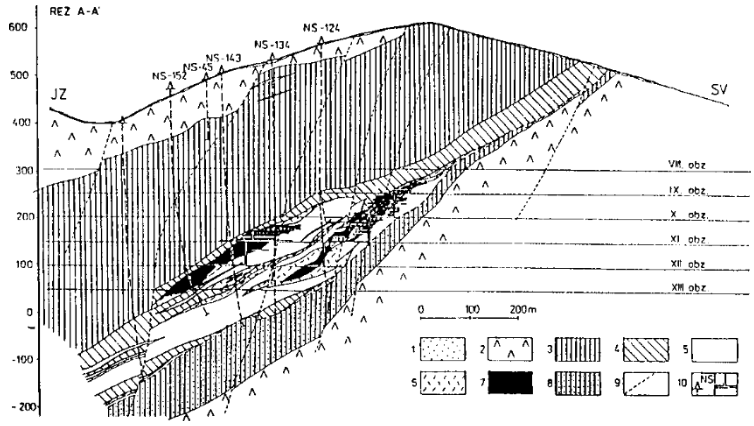

Fig. 2. Cross-section of the western part of the Nižná Slaná - Manó / Mihók siderite deposit, 1994 / 1 - debris, 2 - porphyroid, 3 - grey and black phyllites, 4 - black phyllites with lydite inclusions, 5 - limestone, 6 ankerite, 7 - siderite, 8 - underlying sericitic phyllite, 9 - faults, 10 - borehole and mining works.

1. The underlying porphyroid with semi-sericitic-quartz tuffitic phyllite forms the bedrock of the productive stratum.
2. Underlying black and grey phyllites with minor occurrences of tuffaceous phyllite. The formation forms the immediate bedrock.
carbonate bodies. The contact with the underlying porphyroid is tectonic.
3. The deposit stratum, which develops through a gradual transition, consists of metasomatic siderite and ankerite deposits, as well as various textural varieties of marble with bituminous admixtures, sericite, quartz and black phyllite inserts. Over a large part of the deposit area, there are several carbonate bodies superimposed on each other. The original rocks of the deposit formed a carbonate complex, but not every horizon has the typical features of bioherm sedimentation.
4. A layer of overburden clasts with an overburden position of black phyllites with numerous metalydite positions. In the direct overburden of carbonate bodies, bituminous black phyllites and lydites are found in most of the area.
5. The overlying porphyroids developed from the previous stratum through a gradual transition.

3.4 **Description of deposit bodies**

Siderite is most abundant in the central part of the deposit, with a strike length of approximately 800 m and a dip length of 350 m. The shape and distribution of the deposit bodies is documented by the geological profile (Fig. 3), which was compiled after detailed mining of the deposit. In the deposit strip, siderite forms several positions separated from each other by various interlayers (black phyllites, limestones, ankerites). The actual thickness of the individual positions is variable and exceptionally reaches 50 m.

The main mass of the deposit consists of metasomatic ankerite and siderite. These two minerals carry a significant portion of iron, while other minerals are insignificant in terms of the deposit; they only complete the overall picture and characterise the type of deposit. The Nižnoslanské ore field contains hydrothermal metasomatic siderite as well as vein siderite. The main deposit mass consists of metasomatic siderite, which is fine-grained and dark grey in colour. Nižnoslanské siderite is high in iron and also has an increased Mn content, with the Mg content decreasing as the Fe and Mn content increases. The average Fe content in the ore is 33.5% and Mn 2.18%.

Manganese is bound isomorphically in the siderite lattice. Undesirable impurities in the deposit include mainly arsenic, sulphur, lead and zinc, which occur in the form of oxides, sulphides, sulphates and sulphosalts. From the point of view of undesirable impurities in the mined ore, great emphasis is placed on arsenic, which is mainly bound in arsenopyrite and is developed in some sections of the contact between the siderite deposit and the overlying black phyllites and lydites. The average As content in the mined ore ranges from 0.01 to 0.1%. The siderite deposits themselves contain a significant amount of limestone and ankerite, the delineation and prevention of their entry into mining is the subject of mining exploration.

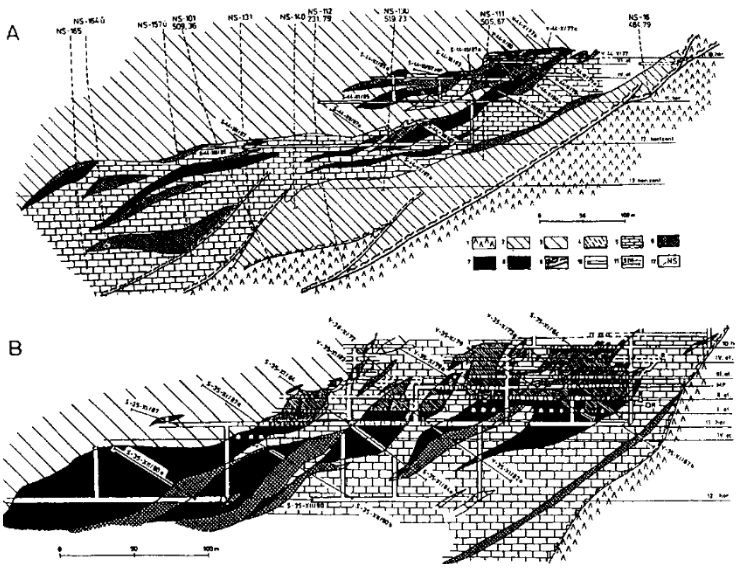

Fig. 3 Detailed geological profiles of the Nižná Slaná metasomatic siderite deposit – Manó section /Mihók, 1994/. A – eastern section, B – central-western section. 1 – porphyroid, 2 – underlying black phyllite, 3 – black phyllite with lydites, 4 – siliceous grey-green phyllite, 5 – limestone, 6 – ankerite, 7 – siderite, 8 – mined part of the deposit, 9 - thrust line , As - arsenopyrite mineralisation , 10 - mining workings , 11 - underground borehole , 12 - surface borehole.

At first glance, poor mineralisation does not indicate a complicated origin based on several generations of both main minerals with a relatively large number of other, sporadically occurring minerals. The following minerals have been identified in the deposit: siderite I - IV, ankerite I-IV, quartz I - V, sericite I - III, pyrite I - V, arsenopyrite, gersdorffite I - II, chalcopyrite I - II, ullmanite I - II, dolomite I - II, pyrotite, pentlandite, siegenite /?/, milerite, violarite, marcasite, magnetite, sphalerite, tetrahedrite, bournonite, jamesonite, boulangerite, calcite, rutile, zircon, raphite, tourmaline, hematite, kaolinite as a hypogenic mineral, and goethite, malachite, azurite, melanterite, evansite, barite skorodite / ? / as hypergenic minerals. Impregnations of rumelka, but also pure mercury, occurred in the vicinity of the faults.

Precious metal mineralisation (Au, Ag) of deposit significance, which was detected in the excavated part of the Manó-Kobeliarovo deposit, was not confirmed in dark phyllites and lydites or in other rocks of the deposit formation (Mihók 1995). Verification of this mineralisation in industrial concentrations, mainly in dark phyllites and lydites, would indicate the possibility of treating and processing waste generated after dry separation of siderite ore, or possibly mining some particularly interesting concentrations of these elements in certain parts of the deposit.

Au and Ag content in individual rock types:	Au [g t $^{-1}$],	Ag [g t $^{-1}$]
Siderites	< 0.005	0.04 - 0.74
Ankerites, dolomites	< 0.005	0.04 - 0.31
Limestones	< 0.005	0.04 - 1.20
Dark phyllites and lydites	< 0.005	0.04 - 3.30
Arsenopyrite and other sulphides	< 0.005	0.23 - 17.0

4. Kobeliarovo deposit

The accumulation of metasomatic siderite deposits near Kobeliarovo is located in the northern arm of the anticline in the Betliar Formation. The deposit was first discovered during the verification of a positive gravimetric anomaly of + 2 mgl as part of the Hanková - Volovec VP / Abnoyi exploration project in 1963. A more advanced stage of exploration was carried out 14 years later using surface core drilling in a grid with a density of 100 x 100 m. Two productive carbonate positions with balanced metasomatic mineralisation were identified at the deposit. Detailed exploration by mining works was completed in 1995, and mining has been underway at the deposit since 1994. The direction is similar to that of the Manó-Gabriela deposit, but the dip is opposite, towards the north. In terms of chemistry, there is an approximately 2% increase in Fe content, a decrease in As content (0.001%) and a 5% decrease in quartz content. The deposit is open and explored above the VI horizon, with gradual ramp-up of mining to 220-250 kt per year. The methodology of exploration, preparation and mining is applied similarly to the Manó-Gabriela deposit. The mined ore is transported through a 4 km long underground transport tunnel to the Gabriela pit yard, where it is mixed with ore from the Manó deposit. The hidden siderite deposit near Kobeliarovo is already in the initial development stage 50 m below the surface. The overburden rocks, black phyllites and lydites, are easily collapsible.
and the extraction of siderite raw material causes the surface above the deposit to collapse.

5. The mined deposits of Ignác and Gampeľ

The Ignác ankerite-siderite body is located in grey sericitic and black phyllites. The deposit has an ovoid shape and its horizontal section was ellipsoidal with semi-axes of 80 to 100 m, with a dip of 80 °to the northeast. The quality of the ore is similar to that of the deposit in Kobeliarovo, with siderite predominating over ankerite. At the contact points with black phyllites, pyrite and arsenopyrite occur to a greater extent. The deposit was intensively mined from the second half of the 19th century until it was completely exhausted in 1960. The drilling survey carried out by the mining plant before the mine was closed down was aimed at determining the possibility of continuing at depth. The result was negative.

The lens-shaped body of the Gampeľ deposit had a flat end and consisted of fine-grained ankerite and irregular siderite deposits. The approximate length of the lens was 80 m, the dip depth only 40 m, the dip of the body 80 °to the south, and the thickness up to 50 m. An iron cap developed near the surface at both deposits.

6. Potential ore reserves at known deposits

Proven geological reserves of all categories at both siderite deposits amount to nearly 31 million tonnes, of which 17.4 million tonnes are open pit mines or ready for mining. Eight million tonnes of ore reserves are recorded under the XII horizon of the Manó deposit and five million tonnes under the VI horizon of the Kobeliarovo deposit (as of 1 January 1997). The average content of useful components in the raw ore is 33.99% Fe and 2.20% Mn.

7. Extractability and contamination

Both deposits are mined using caving methods, achieving 70% recoverability and 12% contamination. The ore is contaminated mainly by black phyllites, which are easily separated from the overburden of the ore deposit, but also to a considerable extent by inserts of unbalanced carbonates - ankerites, limestones, as well as the intergrowth of siderite with the aforementioned rocks. The yield is significantly influenced by nd pressure , manifestations , in penetrations , excavated , tunnels , and , as well as , cohesion , ore , and fillings with regard to the safety of mining operations. As a rule, better results are achieved in blocks with greater thicknesses; smaller locations show greater contamination and are more risky from the point of view of mining operations and safety. In recent years, the excavability, safety and hygiene of work have been severely affected by the , a hitherto unidentified vein in a large part of the underlying blocks of the XI horizon.
/ approximate length 300 m, R 35 - 41 /, accompanied by sulphur dioxide emissions. The cause of this heat has not yet been reliably explained. The cause of the fumes is probably the flow of mine winds through not completely collapsed excavated areas, which oxidises the overburden rocks - black phyllites and lydites rich in pyrite.

8. Possibility of new siderite bodies occurring in the vicinity

Since 1995, exploration has been underway in the vicinity of known siderite deposits under the project "Nižná Slaná - okolie, siderit, VP" (Lower Slaná - surroundings, siderite, VP). The project is managed by GEONVEX s.s r.o. Rožňava, and drilling and exploration work is carried out by Rima - Muráň s.s r.o. Rožňava . Three locations were selected 3 in the exploration area where accumulations of siderite bodies could occur in the Betliar Formation:

1. SE continuation of the Manó / Nižná Slaná - Henckovce deposit. Two boreholes were drilled in the Nižná Slaná depression, but neither of them penetrated the productive carbonate formation.
2. Western continuation of the deposit stratum. Two surface boreholes were drilled again west of the Kobeliarovo/Hanková deposit. Although one borehole drilled through the carbonate stratum (ankerites), the balance development (siderites) was not verified.
3. Southern continuation of the Gampeľ - Ignác deposit formation. At the beginning of 1997, an underground borehole was drilled from level VI of the Manó - Kobeliarovo transport tunnel, which should verify the possibility of nd continuation of the carbonate formation in the previously mined siderite deposits of Gampeľ and Ignác. The borehole was designed on the assumption that the Gampeľ deposit/productive area
and Ignác is part of a compression-type shear zone / Grecula, 1996 / . This means that the Manó deposit is part of one thrust tectonic unit lying on top of another, the upper part of which consists of the so-called bedrock porphyroids of the Manó deposit. This concept suggests that there is another tectonic plate/thrust in the bedrock of the Manó deposit, which will contain a productive stratum with carbonates in the bedrock of the so-called "underlying porphyroids", represented by the Gampeľ-Ignác deposit. Grecula (1996) assumes that this second, or lower, deposit/productive position in the Alpine epoch was
in the compression-type shear zone, pushed out and compressed into a narrow zone representing today's Gampeľ and Ignác deposit section. Until now, the thickness of the so-called underlying porphyroids was unknown, and values of 300-500 m were not ruled out. Evaluation of new results of structural analysis from the deposit area

Ignác - Gampeľ - Manó / Sasvári et al., 1997 / shows a more complex morphostructural structure of the Hnilec anticline in this part of the Nižný Lanský ore field. The northern fold arm of the anticline between the Ignác deposits Gampeľ represents a loaded structure of the Hercynian age, transversely bent into a local synclinal structure in the NE-SW direction. The Gampeľ deposit is part of the eastern part of the syncline, and the Ignác deposit is part of the western part

. The productive strata are represented by graphic phyllites with metakeratophytes, metalydites and light phyllites. This means that the so-called "underlying porphyroids" lying beneath the productive strata fill the Hnilec anticline with a thickness of at least 1,200 m, according to the GVL-Snopko structural borehole (1968).

The above-mentioned mining structural borehole was completed in mid-May 1997, reaching an inclination length of 460.2 m. Almost the entire borehole passed through a set of porphyroids and tuporfroids. In the first quarter of its length, the borehole drilled through several tens of metres of thick dark phyllites.

9. Conclusion

As already mentioned, the potential of siderite reserves at both mined deposits amounted to 31 million tonnes of siderite as of 1 January 1997, which, with a 70% recovery rate, gives the plant a lifetime o f 20 years. The immediate vicinity of the Manó and Kobeliarovo deposits can be considered to have little potential after the drilling of five exploratory wells as part of the exploration survey.

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