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ENVIRONMENTALISTIKA, HYDROGEOLÓGIA, INŽINIERSKA A LOŽISKOVÁ GEOLÓGIA

NIŽNÁ SLANÁ

Flooding of the Manó - Gabriela deposit

Type of geological work	: geological survey of the environment	
Stage	: orientation survey	
Cadastre	: Nižná Slaná	840 912
District	: Rožňava	808
Client	: SIDERIT, s.r.o., Nižná Slaná	
Contractor	: Ing. Marián Bachňák — ENVEX, Rožňava	

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Information about the geological task

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1 INTRODUCTION

1.1 Subject and objectives of the survey

This study was prepared at the request of SIDERIT, s.r.o. Nižná Slaná, resp. decision (No. 444-1153/2011 of 05.05.2011) on the imposition of measures in the mining area "Nižná Slaná", ordered by the OBÚ in Spišská Nová Ves. Its main objective is to develop a forecast of the quantity and quality of these waters after the end of pumping and flooding of the deposit, based on the assessment of the hydrogeological and hydrogeochemical conditions of the deposit in historical and current conditions of mining water pumping. At the same time, the study assesses the potential impacts of flooding the deposit on groundwater and surface water in the wider vicinity of the deposit area.

The main focus of the work was on evaluating and interpreting the information provided about the deposit from an environmental perspective, i.e. with regard to the current state of natural conditions in the deposit area and the overall economic use of the territory.

2 NATURAL CONDITIONS AND CURRENT STATE OF THE TERRITORY

Attention is paid primarily to those characteristics of the territory that are directly related to the objectives of the study.

2.1 <u>Geomorphological, hydrological and climatic conditions</u>

Geographical and hydrological conditions

The Manó — Gabriela and Kobeliarovo deposits are located in the cadastral territory of Nižná Slaná and Kobeliarovo, for which a mining area was designated by decision of the OBÚ in Spišská Nová Ves No. 33-465-Ka-Bz/97/III.

From a geomorphological point of view, the assessed area is situated in the Dobšinské predliorie section of the Revúcka vrchovina highlands in the Slovak Ore Mountains. The assessed area is located on the right bank of the Slaná River, above the I/67 state road connecting Rožňava and Poprad (Figs. 1 and 2).

The assessed area is drained by the Slaná River, which has been and will continue to be the recipient of mine water discharges.

Climatic conditions

Atmospheric precipitation is a variable element in terms of time and space. The spatial variability of precipitation is shaped by meteorological, circulatory and geographical factors. The nature of the relief, especially the elevation and ruggedness of the terrain, is decisive for the spatial differentiation of precipitation in connection with the prevailing air flow and the associated precipitation exposure.

Average precipitation totals **(mm) for Nižná Slaná** Table 1

Ł.	II.	III.	IV.	V.	Vl.	V11.	VII.	IX.	X.	Xl.	XII.	Year
34	35	35	45	79	102	101	85	56	56	66	49	743

Based on this data, the assessed area is classified as having a cold-warm mountain climate with temperatures ranging from -5.0 to -6.5 °C in January and 13.5 to 16 °C in July. This area is characterised by light winds, with the exception of higher windward and summit locations in the highlands, which are characterised by moderate winds. The prevailing wind direction is north-westerly.

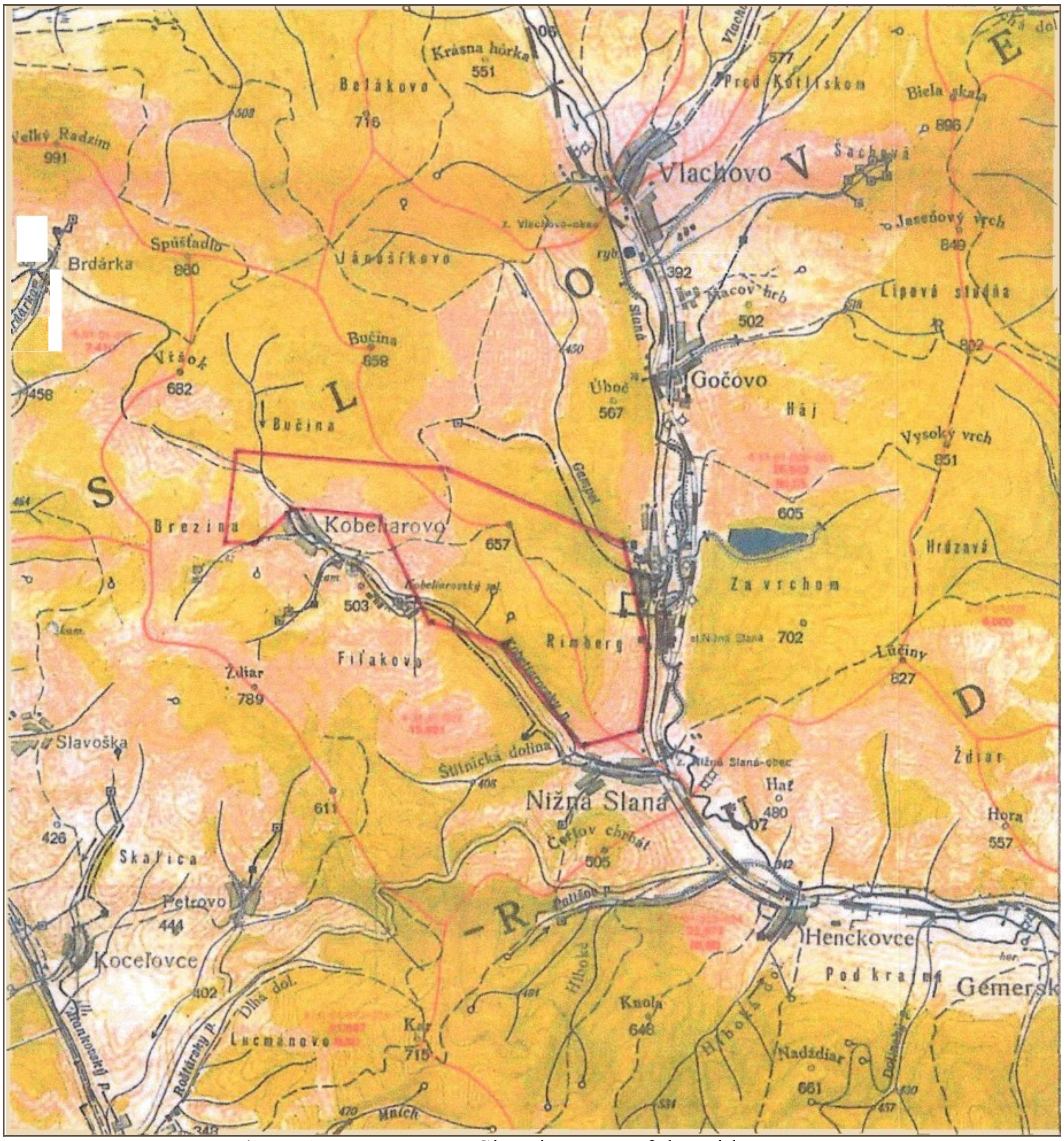

Figure 1 Situation map of the wider area

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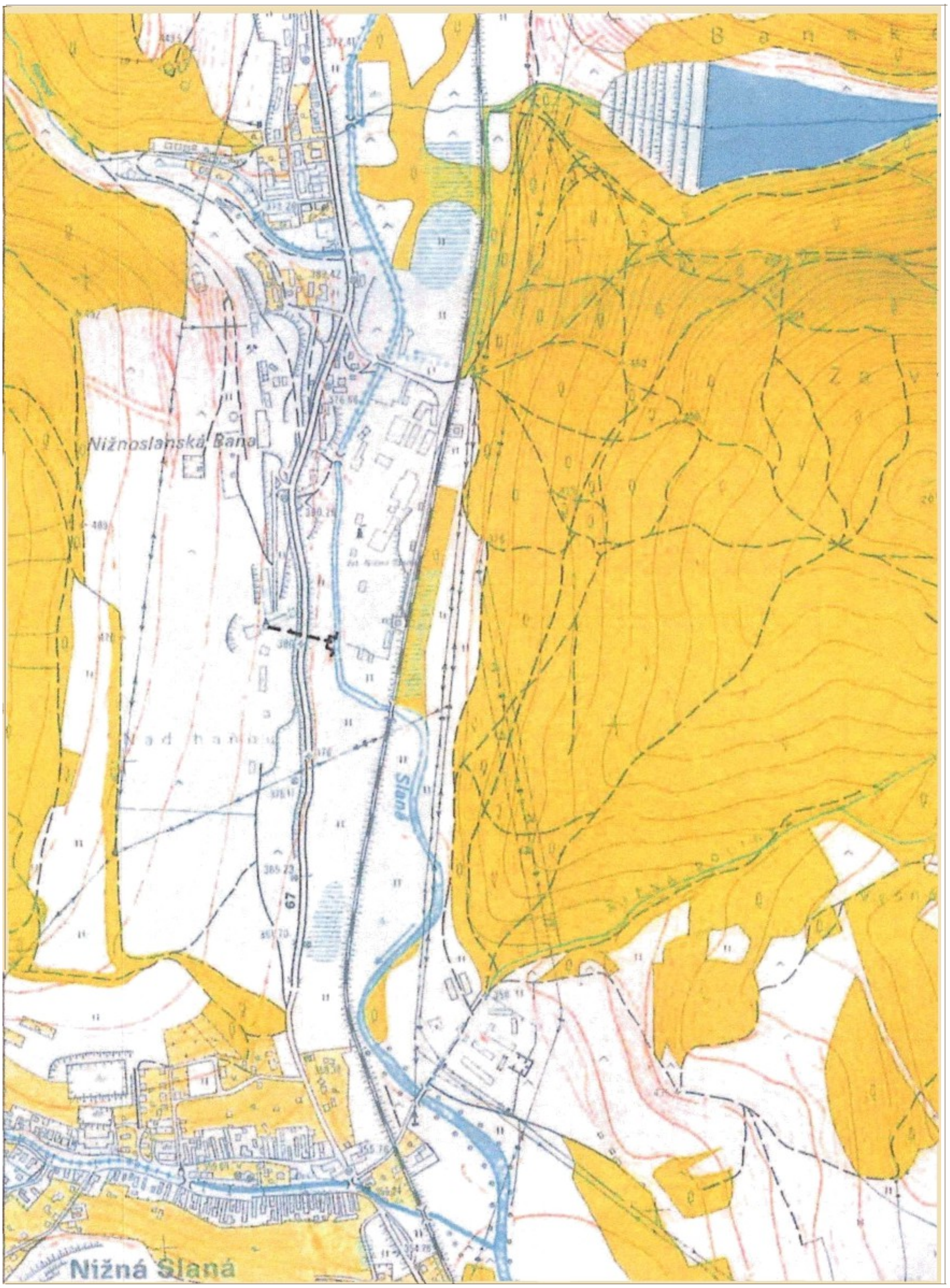

Figure 2 Situational map of the assessed area
M - I : 10,000

naviliovanã drainage pipe

2.2 Geological, tectonic and hydrogeological conditions

2.2.1 Geological and tectonic conditions

The immediate vicinity of the assessed area is currently one of the best explored deposit areas in the Spišsko-Gemerské Ore Mountains.

The Manó-Gabriela metasomatic siderite deposit in Nižná Slaná represents the largest accumulation of this type of ore in the Western Carpathians. Recently, it has been ranked among the deposits with the largest annual mining capacity, which in this deposit was approximately 700 kt of siderite per year, with a tendency to increase to 1,000 kt.

Mining activity in the vicinity of Nižná Slaná probably began before the 18th century. However, since the 18th century, more detailed data on this activity has been recorded in connection with the mining of iron ore, mercury ore and copper ore. The most significant deposit of mercury ore in this area was the Svätá Trojica deposit.

The most significant Hg ore deposit in this area was the Svätá Trojica deposit. It flourished most in the 18th and 19th centuries. At the end of the 19th century, the reserves at the deposit were exhausted and the mine was closed in 1900. The mining of Hg ore was also carried out in the area of the former village of Svätá Trojica.

The occurrence of metasomatic siderite lenses, which were mined in the Gampel and Ignác deposits, as well as the Manó deposit itself, was also significant. Initially, mining was carried out using surface methods, but later, after partial extraction of the reserves, it switched to underground mining.

Given the important mineral deposits in this area, modern geological work began in the 1950s. Exploration work focused both on the Manó deposit itself and on the entire strip of metasomatically altered carbonates in the section from Hanková to Volovec. The work focused on drilling, mapping and later also geophysical work. A more detailed overview of this work and its scope is provided in the final reports on these tasks (Abonyi - Zborňák 1960, Suchăr - Zborňák 1962, Suchăr - Zborňäk 1966).

These reports evaluate long-term exploration in stages of prospecting, detailed and mining exploration, which resulted in the verification of the Manó - Gabriela deposit.

The Manó-Gabriela deposit is open and was mined through the Gabriela shaft to level XII (+100 m above sea level) and extracted practically to level X (+210 m above sea level). The open part of the deposit contains 28.3 million tonnes of unexploited ore reserves. The deposit ends at a depth of approximately level XIV (-0 m above sea level). Ore reserves between level XII and the end of the deposit are approximately 11 million tonnes. The average content of useful components in the deposit is 33.71% Fe, 2.11% Mn, 7.09% Si 2 and 0.016% As.

Geological characteristics

The geological conditions of the wider area surrounding the assessed territory are complex, both in terms of lithological development and tectonic evolution. For this reason, there have been and continue to be differences of opinion regarding the geological structure, age, stratigraphy and tectonics of individual strata and entire rock complexes. The differences in opinion on the geological units forming the wider surroundings of the deposit are mainly caused by (Snopko et al. 1972):

a) the lack of significant sedimentary and petrographic differences between individual members of different formations and entire groups,

b) similar epimetainorfna facies varískycli i alpine folds, which obscure each other and also obscure sedimentary differences between strata and individual groups.

c) insufficient amount of organic remains.

The structure of the wider surroundings of the evaluated area is composed of Palaeozoic units, Mesozoic and, in part, Quaternary formations (Fig. 3). Palaeozoic and Mesozoic formations form the basic structure of the terrain, while younger Quaternary formations play only a subordinate role.

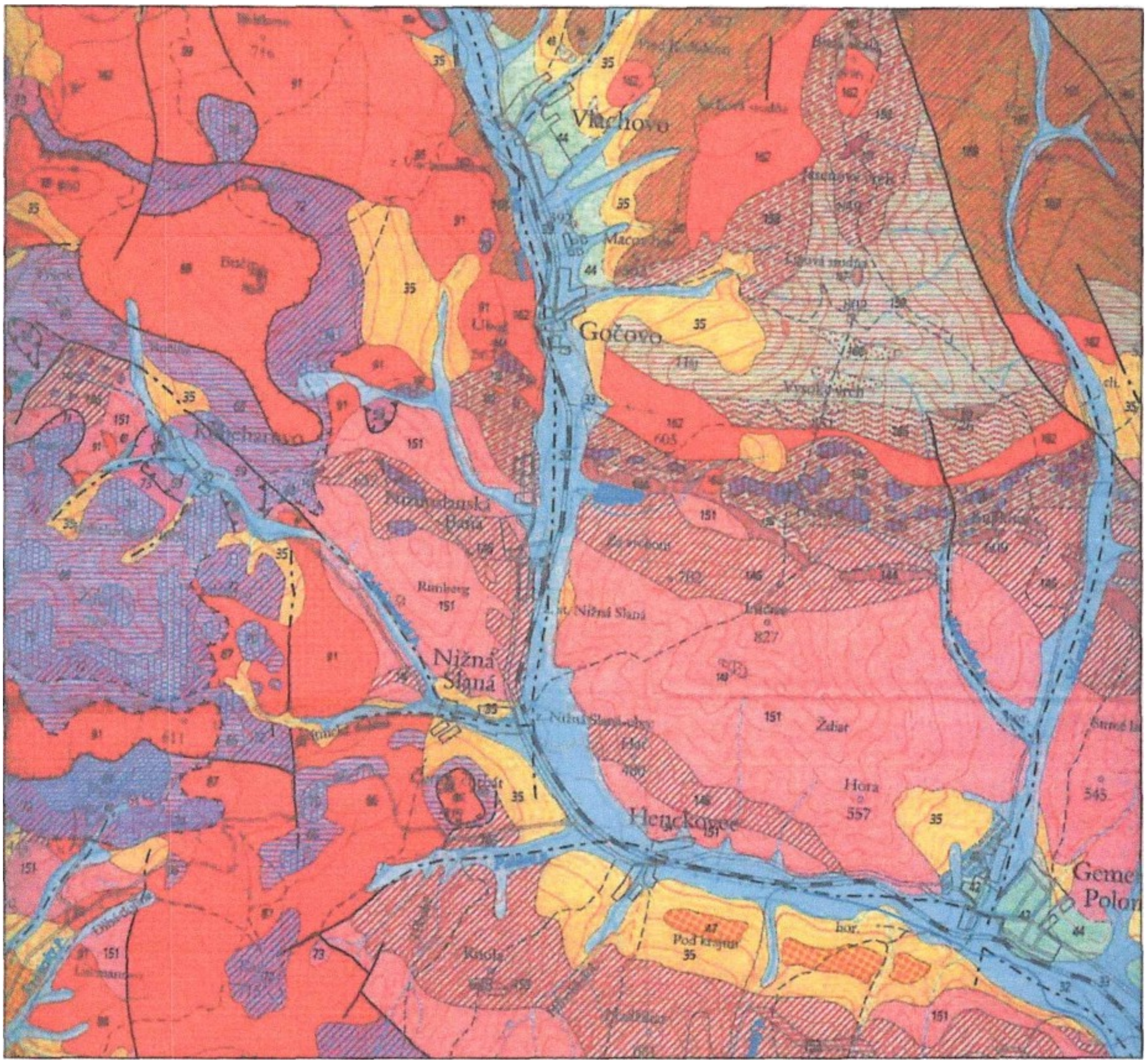

Fig. 3 Overview geological map of the surrounding area

Scale 1:50,000

Vysvetlivky

Quaternary

33 — proluvial sediments: gravel, silted gravel, fragments and blocks	Holocene
35 — deluvial sediments: clayey stony and clayey sediments	Pleistocene - Holocene

Old Palaeozoic

144 — metallids	Bystrý Creek Formation
146 — finely laminated quartz-sericite and graphite-sericite phyllites	Bystrý Creek Formation
151 — hntbozmné metaryolite tuffs	Bystrý Creek Formation
156 — crystalline limestones, locally ankerites, siderites	Vlachovské Formation
158 — cryptostratified sericitic-graphitic phyllites	

Vlachovské Formation

Older Palaeozoic

The oldest stratigraphic and tectonic formation in the area is the Gelnica Group (Bajaník et al. 1983). It represents the oldest, Caledonian developmental stage of the Gemer. The group is characterised by a complex of sedimentary and volcanic homines, which represent flysch sedimentation accompanied by lydites and carbonates with synchronous acidic volcanism. Based on palynological studies (Snopková 1964, Ğomá 1972, Snopková - Snopko 1979 in Bajaník et al. 1983), the stratigraphic range of the Gelnica Group is most likely Cambrian - Lower Devonian.

The stratigraphic division of the Gelnica Group has been interpreted differently in the past and is currently as follows:

- Vlachovské Formation,
- Bystrý potok Formation,
- Drnavské Formation.

The wider surroundings are formed by hominite formations of the Vlachovské and Bystrý potok formations.

The Vlachovské Formation occurs north of the Manó-Gabriela deposit itself. It is the oldest lithological member of the Gelnica Group and occurs in its typical development near the village of Vlachovo. The sedimentary members of the formation are represented mainly by shale-sandstone lithofacies and are deposited in larger, superimposed lithological units, mesorhythms.

In the wider vicinity of the deposit, the Vlachovské Formation is represented by microconglomerates, rhythmically layered metamorphosed quartz clasts, coarse-grained metaryolite tuffs, cryptostratified sericitic-graphitic phyllites, in which crystalline limestone layers or lenses are common. In their present form, these are often transformed into marbles, ankerites, dolomites or siderites.

The most widespread in terms of their current distribution are coarse-grained metaryolite tuffs and skarn-layered sericite-graphite phyllites. Lenses and layers of crystalline limestones are often lined with bands of metalydites. The above-mentioned crystalline carbonates, metalydites and sericitic-graphitic phyllites occur in a well-known band from the Gampel deposit towards Podsúl'ová and Volovec. A substantial part of the carbonates is of biogenic origin, partly of chemogenic origin. They thus form a whole range of transitions from clastic sedimentary rocks (carbonate phyllites) to homogenous clastic volcanogenic rocks (sericite-carbonate tuffaceous phyllites). In the past, carbonates, lydites and sericitic-graphitic phyllites were classified as part of the Betliar facies of the Vlachovo Formation, or formed the so-called
"Niżnoslanské layers" in the sense of Varg's classification (1970). Carbonate formations transformed into siderites and ankerites with interlayers of sericitic-graphitic phyllites and metalydites formed, according to Varga's classification (1970), their own "productive stratum" of the known deposit belt.

The most widespread in the vicinity of the deposit are the rock sets of the Bystré formation. stream. These lie in the normal stratigraphic overburden of the Vlachovo Formation. The lithological composition of the formation is similar to that of the Vlachovo Formation, but the volcanic members of the formation are more widespread here, as volcanic activity reached its peak during the sedimentation of the formation. The presence of carbonate members with lydite horizons is also typical for the formation. However, these are more intensively altered into ankerites or siderites, thus forming significant local accumulations (Manó - Gabriela, Kobeliarovo).

In terms of spatial distribution, coarse-grained metamorphic tuffs (porphyroids) are the most widespread, while quartz-sericite and graphite-sericite phyllites with metalydite layers or lenses of crystalline limestone, ankerite and lydite are also widespread. These form a continuous strip on the northern slope of Rimberg (656.8 m above sea level), which represents the eastern part of the Manó deposit on the surface. The least widespread are rhythmically layered metamorphosed quartz fragments.

According to Varga (1970), the aforementioned crystalline carbonates, siderites, metalydites and graphitic-sericitic phyllites are classified as part of the "productive strata of the Nižnoslanské layers". Coarse-grained metaryolite tuffs occurring in their overburden are referred to in older literature (Varga 1968, 1970, Suchár et al. 1962, Abonyi et al. 1965) as "overburden porphyroids". In the bedrock
of the "productive formation" also features a complex of volcanic rocks, which in the past was referred to as the "subsoil porphyroid" complex. The thickness of this complex in the areas where it has been verified is still unknown.

Later Palaeozoic

On the wrinkled base of the Gelnica Group, complexes of Early Palaeozoic rocks stand out, which are represented in the wider area by the Gočaltovská Group.

The Gočaltovská group as a whole borders the southern part of the Old Palaeozoic Gemerika. The group is represented by a complex set of mainly clastic sediments, in which acidic volcanic rocks, volcaniclastic sediments and detrital dolomitic limestones are subordinate. The most widespread rock assemblages in the area are those of the Rožňava Formation of the Gočaltovská Group. The stratigraphic extent of the group is Permian to Lower Triassic (?) (Bajaník et al. 1983).

The rock formations of the Gočaltovská Group and its Rožňavská Formation are in discordant contact with their basement, the Gelnická Group, in the wider vicinity of the deposit. The lithological composition of the Rožňava Formation is represented by oligomictic conglomerates, which are the most widespread in the area in terms of their current spatial distribution. These are characterised by a monotonous petrographic composition of pebble material, which consists of quartz and metamorphosed sandstones. The degree of workmanship of the pebble material is very low. Within the conglomerate horizon, from the basal to the upper part, the size of the pebbles decreases and the percentage of quartz increases compared to metamorphosed sandstones and quartzites.

Other rocks of the Rožňava Formation include metamorphosed sandstones, sericitic, sericitic-chloritic and chloritoid phyllites, sandstones and conglomerates mixed with volcaniclastic material of metaryolites, metadacites, and rhyolites, which are more or less widespread. sericitic, sericitic-chloritic and chloritoid phyllites, sandstones and conglomerates mixed with volcaniclastic material of metaryolites, metadacites and their tuffs or tuffites. The latter are most widespread mainly in the vicinity of Kobeliarovo (Bučina, Ježovec, Spùšt'adlo hills) and south of Nižná Slaná (Macibel hill, 504.9 m above sea level). They are represented by a volcanic-sedimentary complex containing bodies of ash tuffs and greenish-grey felitic metaryolites. The complex corresponds to the set that Fusán (1959) referred to as the "Bučina layers".

Mesozoic

The Paleozoic hominid sets are overlain by complexes of rocks of the Meliat group, or the Silicic Nappe. Their relationship to the bedrock is mostly tectonic, as they appear in the form of tectonically thrust sheets.

Meliat Group

It represents a diverse set of weakly and strongly metamorphosed rocks of Triassic and possibly Jurassic age. In the area in question, these occur in the form of tectonic windows and semi-windows beneath the Silica Nappe or lie in the form of tectonic scales on Palaeozoic complexes. The set of rocks of the Meliat group represents a eugeosynclinal complex with abundant manifestations of basic volcanism, mainly in the Middle and Upper Triassic. According to individual authors, the stratigraphic range of the group is Permian (?) - Lower Triassic and Jurassic (?), (Bajaník et al. 1983).

The following rocks of the Meliata Group occur in the area in question: brown and greenish shaly limestones with interlayers of chloritic shales (Lower Triassic), rauvaks and variegated breccia limestones (Lower-Middle Triassic?), sericitic phyllites (Lower-Middle Triassic?), light crystalline limestones (Anisian-Carnian?), grey chert limestones (Ladin-Cainian?), dark shales, phyllites, sandstones with dark limestone interlayers (Ladin - Kam) and quartz sericitic-chloritic phyllites with a predominance of metabasaltic tuffs (Middle - Upper Triassic?).

The above-mentioned rocks are typical for the Nižnoslanská depression in terms of their occurrence and are most widespread in the wider vicinity of Kobeliarovo.

Silica cover

It is represented by a diverse set of mainly carbonate rocks, whose stratigraphic range is, according to various authors, from the Lower Triassic to the Jurassic. However, a significant part of the siliceous nappe complexes disappeared in the Triassic. Based on this data, its development is often correlated with the Oberostalpine type of the Triassic of the Eastern Alps. The rock sets of the siliceous nappe are thrust onto the Meliat group, resp. the Palaeozoic complexes of Gemer.

In the area in question, south and southeast of Kobeliarovo, there are colourful sandstone and shale layers (Griesbach - lower Namal). They consist of variegated sandstones and shales (red, purple, green and grey), in places strongly silty with a monotonous flysch character.

Kvartér

Quaternary sediments in the area mainly reflect climatic and tectonic changes, overall uplift and the nature of the pre-Quaternary bedrock. The largest accumulation of Quaternary fluvial and deluvial sediments is in the Slaná River valley and on the adjacent slopes of higher elevations. They are represented by sandy and clayey gravels, clays and loams, and clayey-stony and clayey sediments. They represent the most recent developmental cycle of the Gemer - Pleistocene - Holocene.

A significantly different stratigraphic scheme of the Spišsko-Gemer Ore Mountains is presented. P. Greculom (1982). Its essence is the cover structure of the older Palaeozoic Spišsko-Gemerské Ore Mountains (Volovská Group), with three strata: Betliar (a series of black phyllites), Smolník (a series of green phyllites) and Hnilec (volcanic layer). The nappe structure of Gemerik is the result of Variscan orogenic phases, during which the Variscan nappes already behaved as a single tectonic unit and formed a single Alpine nappe with a Mesozoic cover called the Gemer nappe. The rocks of the Volovská Group are regionally metamorphosed mainly into green schist facies, but in many places the metamorphism reaches the level of garnet amphibolite facies. The age range of the Volovská Group is probably Silurian - Lower Carboniferous (?). The Volovská Group includes hominid assemblages previously referred to as the Gelnická and Rakovecká Groups.

Based on this lithostratigraphic scheme, the wider surroundings of the exploration area are built up by homogenous sets of the Humel nappe, with the so-called "productive strata" belonging to the Betliar strata. The characteristic rocks of the "productive formation" - carbonates and lydites - form the so-called Holec layers with two significant horizons - *lydite* and *carbonate.* The complex of the so-called "overburden" porphyroid, according to this scheme, would belong to the Hnilec Formation, to its Gelnica porphyroid complex, although certain features (significant metamorphic reworking of originally clastic sediments) could also reclassify this layer into the Smolník Formation.

Tectonic conditions

The characteristics of the tectonic conditions of the Spišsko-Gemerské Ore Mountains as a whole depend on the recognition of one or another stratigraphic scheme.

According to Bajaník et al. (1983), the tectonic structure of the evaluated area is the result of Hercynian and Alpine orogenic processes. During the Hercynian phases, relatively intense folding occurred, accompanied by the formation of layered crystalline schistosity. The Old Palaeozoic foundation of the Gemerika was intensively folded and tectonically reworked by Alpine orogenesis. During Alpine orogenesis, the tectonic units of the Gemerika were formed and its complex structure was created. The area of interest is characterised by a complex Alpine structure, in which, in addition to the Old Palaeozoic formation (Gelnica Group), the Young Palaeozoic strata (Gočaltovská Group) and the Mesozoic (Meliatska Group) also stand out. Their mutual structural relationships are very complex. The Late Palaeozoic strata (Nižnoslanská Depression) form tectonic scales in the overburden of the Old Palaeozoic strata and are often characterised by different types of metamorphism and deformation. In the overburden of the tectonic fragments of the Early Palaeozoic, the Meliat Group complex also appears in a tectonic position, characterised by a complex internal structure formed by several tectonic sheets.

The structure of the Gemer region is largely influenced by Alpine fault tectonics. This has created a diverse range of faults (directional and transverse faults) that complete the tectonic picture of the area. Transverse (NE-SW) dislocations are the most numerous in the exploration area, but directional (N-S, E-W) dislocations also occur. In the Nižná Slaná area, the most prominent transverse dislocation (NW-SE direction) is the "Kobeliarovsky fault" running through the Kobeliarovský stream valley.

According to Grecul (1982), the structure of the Gemerika is understood as a nappe. The individual nappes of the Gemerika are characterised by different tectonic styles in both the horizontal and vertical directions. In the area in question, the Humelsko nappe has been identified, which is characterised by the tectonic style of isoclinal and elastic folds with numerous thrusts and thrust faults.

DESCRIPTION OF THE LOF, ISKOVELIELIO BODY AND MINERAL FILLING

The Manó deposit is located in a zone of sedimentary rocks between volcanic rocks and has an oblique course on the surface.The thickness of the stratum is up to 450 m and contains carbonate and limestone horizons with carbonates metasomatically altered to ankerite and siderite. The deposit has a strike length of approximately 2.5 km, where the carbonate formation transitions into sericitic marble and calcareous phyllite. Siderite has the greatest thickness in the central part of the deposit, with a strike length of approximately 800 m and a dip of 350 m. In the deposit strip, siderite forms several positions separated from each other by various interlayers (black phyllites, limestones and ankerites). The actual thickness of the individual layers is variable and exceptionally reaches 50 m. The main useful component of the deposit is metasomatic siderite (fine-grained, dark grey in colour) and ankerite. These two minerals are the carriers of the essential part of iron, while the other minerals are insignificant from the point of view of the deposit. Siderite is high in iron and has a high Mn content, with Mg content decreasing as Fe and Mn increase. Undesirable impurities in the deposit include mainly As, S, Pb, and Zn, which occur in the form of oxides, sulphides, sulphates and sulphosalts. The most unfavourable component of the deposit is As, which is bound to arsenopyrite and is developed in some sections of contact between the siderite position and the overlying black phyllites and lydites.

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 as part of the Hanková - Volovec VP exploration project (Abonyi, 1963). The higher 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 in-situ mineralisation were identified at the deposit. A detailed survey by mining works was completed in 1995, and mining has been ongoing at the deposit since 1994. The direction is similar to that of the Manó - Gabriela deposit, but the dip is opposite, towards the south. In terms of chemistry, there is an approximately 2% increase in Fe content, a 0.001% decrease in As content and a 5% decrease in chromium content. The deposit is open and explored above the VI horizon, and mining has gradually reached 180 kt per year.

2.2.2 Hydrogeological and hydrogeochemical conditions of the wider area

Hydrogeological conditions of the wider surroundings

In terms of the hydrogeological zoning of Slovakia (Šuba et al., 1984), the assessed area and its wider surroundings belong to hydrogeological zone G-128, the Palaeozoic Revúca Highlands and Volovské Hills in the Slaná River basin. The boundaries of the district are largely determined by the geological structure of the territory, with only the north-eastern boundary following the surface water divide, which in the Palaeozoic is essentially identical to the groundwater divide. The Neogene Rožňava Basin is also included in the district, which probably drains part of the groundwater of the surrounding Palaeozoic.

The territory is mainly composed of Paleozoic hominids - phyllites, porphyroids, diabase, quartzites, etc. This rock complex is characterised by low, mainly fissure permeability and, on the whole, does not create favourable conditions for the accumulation of larger amounts of groundwater. More favourable for water accumulation are the locations of Palaeozoic crystalline limestones and ankerites, and Mesozoic limestones deposited on top of the Palaeozoic in the Dobšinej, Vyšná Slaná and Kobeliarovo areas, from which more abundant springs emerge. However, their greater accumulation capacity is limited in this case by their small area. The groundwater regime of the Palaeozoic is strongly altered by extensive mining activity. Relatively more favourable conditions for groundwater accumulation are created by the fluvial deposits of the Slana River.

Hydrologically, the assessed area and its wider surroundings belong to the Slaná River basin, which also forms an erosion base at an altitude of 359 metres above sea level. It belongs to the sub-basin with hydrological number 4-31-01-020 and 021, which, together with the unnamed left tributary from the tailings pond and the Gampel stream, has a basin area of 26.522 km².[2] The average specific runoff from this catchment area is 10.6 1. s"' .km^2 , and the average annual flow of the Slana River at Nižná Slana is less than 1.0 m^3 .s°'. As the entire Palaeozoic area in the assessed catchment area is very low and poorly watered, the type of water discharge regime is snow-rain. Of the climatic factors, the most significant is precipitation in the form of snow, which is the main source of increased flow in watercourses. In the summer months, there are storms and downpours, which cause secondary peaks.

From a hydrogeological point of view, the most significant are tectonic faults and islands of Mesozoic carbonate rocks, with fissure to fissure-karst permeability and high water saturation. They are widespread southeast of Kobeliarovo and are the source of the local group water supply for the municipalities of Kobeliarovo, Nižná Slaná and Nižná Slaná-závod. In terms of water management, the KO-33 borehole and the karst spring "Pod lomom" are used. A level 2 sanitary protection zone was also established for these sources (Orvan, 1984). In connection with the planned mining activity at the Kobeliarovo deposit, a decrease in the usable quantities of groundwater was expected, but this did not occur.

As shown by a hydrogeological survey conducted in the Kobeliarovský potok valley, southeast of the village (Cibul'ka. 1974), based on pumping tests, it was recommended to withdraw 4-5 I.s" from the KO-33 borehole and 5-6 1.s°' from the HK- l borehole. A series of dye tests carried out during the hydrogeological survey demonstrated a connection between the waters of the Kobeliarovský and the groundwater captured by the KO-33 borehole.

As part of the deposit survey, this area was the subject of a special hydrogeological survey within the Kobeliarovo Fe, PP task (Lukaj in "Sćuka, 1982). The last hydrogeological survey task carried out in the wider area was the Kobeliarovo h.g. VP survey task (Śčuka, 1989), which addressed the issue of a replacement water source from the area north-west of Kobeliarovo.

In the Nižnă Slaná - Manó deposit area, hydrogeological issues were addressed as part of geological and deposit exploration work (Suchár - Zborñák 1962, 1966). As part of these exploration tasks, a hydrogeological map was also produced, and the findings are discussed in detail in the subchapter on the hydrogeology of the deposit.

Overall, low-water-bearing rocks predominate in the Paleozoic homin complex.

Documented also the average specific groundwater discharge, which is usually 3.2-(Bajaník et al., 2.6 $l.s^{-1}.km^{2}$ 1983). The average mineralisation of Paleozoic groundwater is ranges from 330.5 mg.1'" (in Carboniferous rocks) to 124.4 mg.1 (in rocks of the Gelnica Group). They mainly belong to the calcium-magnesium-bicarbonate type of water, or to waters representing a transition to the calcium-magnesium-sulphate type. Waters with deeper circulation gradually transition to the sodium-bicarbonate type.

River deposits in the valley of the Slaná River have a thickness of 3.2 to 4.2 m, and therefore the thickness of water-saturated gravel (2.0 - 1.0 m) is also relatively small. The gravel is significantly silted, and therefore the filtration coefficient ranges from 3.2 .10" to 1.6.10"" m. s ' and the yield of wells from 0.4 to 1.0 1.s", locally in Goćovo up to 2.4 I.s°'. In the river sediments of the Slaná River, the groundwater is low in mineralisation, of the calcium bicarbonate or calcium sulphate type.

Hydrogeology of deposits

The evaluated area and its wider surroundings were the subject of a deposit-hydrogeological survey as part of the exploration tasks carried out at the Nižná Slaná deposit. Manó - Gabriela (Suchár — Zborňák, 1966). The hydrogeological assessment of the deposit was prepared by M. Lukaj and T. Repka. In the deposit area, they identified groundwater from pre-Mesozoic formations, groundwater from the Mesozoic era and groundwater from Quaternary sediments. From the point of view of the water content of individual lithological units, they identified the following formations:

a) Significantly water-bearing with fissure-karst permeability, where Mesozoic carbonates were classified.

b) Well-watered - permeable with pore permeability, where alluvial deposits of Slana and tributaries from the deposit area were classified. Permeable with fissure permeability, where the following were classified: siliceous conglomerates, crystalline and shaly limestones of the Meliat group, metasomatic carbonates, lydites and grey quartzites of the Gelnica group.

c) Water-bearing - permeable with pore permeability (rubble) - permeable with fissure permeability, where siliceous porphyries, conglomerates with chloritic cement, diabase, tuffs and tuffites, as well as porphyroids of the Gelnica group were classified.

cement, diabase, tuffs and tuffites, as well as porphyroids of the Gelnica group.

d) Weakly permeable - low permeability to impermeable.

This group includes Mesozoic shales and various types of Palaeozoic phyllites.

It follows from the above that the primary drainage of the Manó deposit was minimal, because the limestone inserts and lenses near the surface were completely transformed into siderite and ankerite and therefore did not undergo karstification. The main inflows of mine water during mining come from the collapse of joint cracks, from the old mine above the VI horizon and from mining near the transverse Kobeliarovský fault, which runs approximately through the centre of the mining field.

Cliemizmus poüzemnJcli vôü

In terms of the hydrochemical properties of groundwater from springs, these waters can be characterised as low to moderately mineralised (total mineralisation 260.49 to 371.64 mg.1[1]), predominantly calcium-bicarbonate type. According to their hydrochemical characteristics, these waters are deficient in gypsum, dolomite and calcite. These characteristics correspond to karst groundwater of shallow circulation, where the interaction of precipitation water enriched with aggressive COC in the rock environment of Mesozoic carbonates is decisive for the formation of the chemistry.

The groundwater from the deposit wells differs significantly in its chemistry from the yšsie described "karst waters". Although the total mineralisation is 217.12 to 358.9 mg.1 I their characterised as low to medium mineralised; according to the Palmer-Gazdová classification, these are mixed-type waters with a predominance of sodium bicarbonate. Of the other cations, these waters are characterised by a high content of Fe^{3} ’ (5.06 - 15.60 mg.l*), and of the anions, an increased content of sulphates (28.39 - 38.27 mg.1‘[1] S0Ą[2] *). These waters are also undersaturated with gypsum and calcite, with Mg cations predominating over Ca (Mg/Ca coefficient > 0.5). The chemistry of these groundwater bodies corresponds to the expected vertical zonality in the rock environment of Palaeozoic crystalline rocks with carbonate deposits.

2.2.6 Surface water quality in the deposit area

There is a wealth of data on the quality of surface waters in the deposit area, which has been collected mainly as part of state-funded projects to explore mineral deposits and also as part of the regional project Geological Factors of the Environment in the Slaná River Basin (GS SR – main researcher Ing. Stupák).

Shallow groundwater, which mainly emerges in debris and fissure springs in the mountainous area of the deposit, is low in mineralisation (70-200 mg/l) with a main Ca-Mg-S 4-HCO3opom chemistry, which is incorporated into the processes of hydrothermal alteration.low mineralised (70 - 200 mg/L) with a main Ca-Mg-S 4-HCO3op chemistry, which is formed during the hydrolysis of silicates and oxidation of sulphides in the given hominic environment. Higher mineralisation (around 200 mg/L) with a higher sulphate component is mainly evident in water flows from numerous old abandoned mining works, which in some cases have a very significant impact on the quality of surface waters. This is mainly reflected in high Fe and Mn contents (Fe 0.2 to 3.6 mg/1). Mn 0.1 to 3 mg/1), which, however, are also found in numerous local springs and represent naturally elevated concentrations of these elements due to the occurrence of iron ore deposits. Another important factor in terms of the impact of the mineralised environment on the quality of groundwater and surface water is the frequent occurrence of high Hg content in the original springs (from 0.001 to 0.01526 mg/L).

Comparison with **the limits set out in Slovak Government Regulation** No. **269/2010 Coll., which establishes requirements for achieving good water status** **Table No. 2**

Component	**NV No. 269/2010 Z. č Watercourses (mg/1)** Cat. A1 (M H)	**NV f. 269/2010 Z.** n **other flows (mg/1)**	**Contents** in **surface waters of the territory (mg/1)**
Fe	0.3	2.1	0.2 -3.6
Mn	0.05	0.3	0.1 -0.25
Hg	**0.001**	**0.00007**	**0.001-0.01526**

Compared to STN 75 7221 Classification of surface water quality, it is possible to classify these waters according to the content of other metals into class 2 (As, Cu, Pb) up to the 5th worst class (Fe, Mn.

Hg). From the point of view of toxicity, the frequent occurrence of elevated Hg contents is very unfavourable.

The quality of surface water in the Slaná River is regularly monitored by the SI4MÚ observation network at km 55.30 in the profile above Rožňava. According to the summary average results from 1999, the water quality at this location was classified as grade 3 in terms of Fe and Mn content. Most indicators classify the water of the Slaná River as class 4, but the content of insoluble substances classifies it as class 5. The metals Hg, Cd, Pb, As, Cu, Cr Ni and Zn were regularly monitored. Their average contents are tenths to units of micrograms per litre.

2.2.7 Quality of river sediments in the deposit area

The quality of stream sediments is mapped as part of the compilation of geochemical and ecological maps of Slovakia's regions, and considerable attention was paid to it in the compilation of the Geochemical Atlas of the Slovak Republic (Pramuka, 1999). The clay fraction of river sediments reflects not only the current but also the past quality of surface water through long-term sorption of metal elements from flowing water. The content of these elements represents a composite sample of rock material from the entire river basin.

Compared to other areas in the Slovak Republic, the river sediments in the deposit areas west of Rožňava have abnormal contents of As, Sb, Hg, Cr and Pb. These contents are clearly conditioned by anthropogenic enhancement of the original geogenic anomalies, i.e. the occurrence of ore deposits. They primarily document the increased geochemical background of these elements throughout the area.

The high proportion of As, Sb and Hg sulphides as well as FeO in the mud of the alluvial floodplain of the Slaná River clearly documents the original natural contamination of the area with elevated levels of these metals, caused by the presence of ore deposits in its wider catchment area.

Expected inflows to the deposit

The inflows to the Manó-Gabriela deposit are generally small and do not exceed 4 - 5 1.s" even during the spring snowmelt. These are mostly scattered inflows from more heavily cracked sections. Larger inflows occur after the formation of fault zones. These inflows are characterised by heavy rainfall and reach a yield of several l.s". They weaken relatively quickly and after a few minutes they are already characterised by low-yielding non-concentrated inflows. Thus, at the Gabriela shaft, the total inflows in the first years reached 10 - 15 l/s, and after the concentrated inflows reached 25 l/s.

The main inflows of mine water occur during mining from the collapse of the rock fissures, from the old workings above the VI horizon and from the workings near the transverse Kobeliarovský fault, which runs approximately through the centre of the mining area.

Based on the client's data, the current inflows into the deposit at the XII horizon level are 3.9 l/s and at the VI horizon level 6.5 l/s.

2.3 **Mining and technical** conditions in relation to **hydrogeological conditions**

2.3.1 Progress of mining and exploration work and the impact of the deposit's fragmentation on hydrogeological conditions

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 Sigmund granted Nižná Slaná the title of "Free Mining Town". In 1570, there were already 12 miners working here.

Slovak furnaces. 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 19th century during the lifetime of Emanuel Andráši, the so-called Iron Count. In 1843, a blast furnace was built in Vlachovo, and in 1868, the Etelka blast furnace was built in Nižná Slaná. In 1900, the deposit became the property of the Rimamuránska company, and at that time, the mining of iron ore, which had been mined here since before 1701, ceased. From more recent data, it is necessary to mention:
1924 - start of excavation of the Manó tunnel at level VI. horizon,
1929–1933 – mining restrictions due to the global economic crisis; 1945 – resumption of mining transport by horses and introduction of trolley transport;
1975 – start of operation of the first rotary furnace

In 1975, ore mining moved to the Gabriela shaft, where the deposit is accessible after XII. horizon (96.0 m above sea level). Since 1975, the mined siderite has been compacted in a new processing plant, where in the past the final product - blast furnace pellets contained 56% Fe; 3.5 % Mn and 5% SiO2 In 1997, construction began on a dry high-intensity magnetic separation plant for pre-treatment of mined ore before it enters the thermal process.

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 level VI). 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 consisted of the excavation of horizontal and vertical mining works. As a rule, two parallel directional excavation tunnels were dug on each horizon, one located entirely in the bedrock of the deposit and the other approximately in the centre of the carbonate strata. From these directional tunnels, crosscuts were dug at 50 m intervals to the thickness. Exploration along the dip was carried out through chimneys from the lower horizon to the higher horizon. The methodology of opening and exploring individual horizons was adapted so that it would fit smoothly into the system of follow-up preparatory and mining work.

As mentioned above, the main inflows of mine water during mining come from fractures in the rock, from old workings above the VI horizon and from workings near the transverse Kobeliarovský fault, which runs approximately through the centre of the mining area.

Based on the client's data, the current inflows into the deposit at the XII horizon level are 3.9 l/s and at the VI horizon level 6.5 l/s.

2.3.2 Current status of mine water discharge in relation to permits issued by the District Office of the Environment

After the end of mining, the drainage of the Manó-Gabriela and Kobeliarovo deposits under current conditions is ensured by the main pumping station at XII. Horizonte and the auxiliary station at XIII. obzore. The mining waters are led by a discharge pipe to the surface directly into the Slaná River (outlet No. 5), at river kilometre 67.25 on the right bank.

The latest decision of the SIŻP, Košice Environmental Inspectorate, Department of Integrated Permitting and Control (integrated permit), concerning, among other things, the discharge of mine water from the deposit, was issued on 26 October 2005 under number 895/97-OIPK/2005-Mi/570490105.

The above decision authorised the discontinuous discharge of mining water for 7.4 hours a day, 45 days a year, at **Qpn¢y,** = 18 l•t"'; ddeñ — 7.4 hud.' 47995 ÎT1^3 : Qrok' 21 57795

The source of emissions is mining water discharged through outlet No. 5 into the Slaná watercourse at river kilometre 67.25 — on the right bank.

The permissible pollution levels are specified in the Decision in the following indicators (for the Slaná recipient):

Table 3

Uk8EOVSt£P znečistenia	Limit concentrations hodnoty (mg.l^{-1})	Bilaa€né bodaety	
	qp" (average)	(kg.deB"'}	(t.rok^{-1})
pH	6.0 - 9.0		-
NL	40	19.18	0.86
As	0.4	0.192	0.009
Cd	0.01	0.005	0.0025
Cu	0.5	0.240	0.01
Fe	4.0	1.918	0.086
Pb	0.4	0.192	0.009
Zn	0.4	0.192	0.009
$NEL_{(UV\ IČ)}$	0.25	0.120	0.005
RL_{105}	850	407.58	16.34
RL_{550}	800	383.60	17.26
SO_4	500	239.75	10.79
Hg	0.03	0.014	0.0063
Mn	0.12	0.58	0.003

The limit values for CN, 1t and TOC are not specified due to their absence in waste water.

The following Table 4 shows the results of laboratory analyses of mine water samples (Appendix 2) and their comparison with the limits set in the IPKZ permit and in Slovak Government Regulation No. 269/2010 Coll., which was provided by the client.

Tab. č. 4

SbdO ukazovateľ	Concentration (mg/L) dátum / labor. číslo			IPKZ limit	Limit NV SRL. 269/2fi10 M (')
	7J.2@8	J2.SI	6.8.2010		
	613/BD8	i672/2QI9	IóP7/20t0		
$CHSK_{Cr}$	29,50	i0.40	< A9		
BSKt	1.17	&39	1.02		
pH	8.00	7.80	7.4	6.0 —9.0	6.0 —9.0
RL_{105}	3 664,00	8 837,00	20	850	
NL_{105}	44	156,00	< 2	40	40
Fe_{celk}	0.040		< 0.020	4.0	4,0
Mn_{celk}	0,290		< 0.010	0.12	
$N\text{-}NH_4$	1.042				
P_{celk}	0.09				
N_{celk}	6.30				
NH,	tJ36				
RL_{org}	878	-			
RL_{550}	2 786	6 231,00		800	
SO_4	2 519,20	6 880,00	44.0	500	
Mg	437,tXi				
Hg	< 0,00005			0.03	
Cd	< 0.00005			0.01	0J
Pb	0.0684			0.4	0
As	0.013			0.4	0.5
Cu	0.00629			0J	1.0
Zn	< 0.fXI3			0.4	Z,0
NEL	&I80	0,520		0.25	3.0

* prll. L 6, Part B, Table 3J

From Table 4 above, we can see that it is difficult to assess the quality of pumped mine water from laboratory samples, as the determination of values is very complex. it is problematic to evaluate the quality of discharged mining water from the above laboratory collections, given the large uncertainty of the determined values, the uniformity of the monitored indicators and the low frequency of measurements, which makes it difficult to take a clear position on the quality of the discharged mining water.

However, we can conclude that RL, NL, and SO4 caused significant exceedances of the permitted limits in 2008 and 2009.

Given the current method of discharging mine water and the proposed method, which will be outlined in more detail and addressed in a specific mine water drainage project, it will be necessary to apply to the water management authority for a new permit.

2.4 **Water management** use of the area

From a hydrogeological point of view, the complexes of Palaeozoic rocks in which ore bodies have developed do not have favourable conditions for the circulation and accumulation of large quantities of groundwater. For this reason, there are no groundwater sources in these complexes that would be suitable for water management use. Suitable sources for drinking water supply in this area are therefore concentrated on the use of springs or, in favourable conditions, shallow groundwater deposits.

From a hydrogeological point of view, the most significant are tectonic faults and islands of Mesozoic carbonate rocks, with fissure to fissure-karst permeability and high water saturation. They are located southeast of Kobeliarovo and are the source of the local group water supply for the villages of Kobeliarovo, Nižná Slaná and Nižná Slaná - závod. In terms of water management, the KO-33 borehole and the karst spring "Pod lomom" are currently used. A second-degree sanitary protection zone was also established for these sources (Orvan, 1984). *In **connection** with **the** extensive mining **activity** at the **Kobeliarovo deposit, it was expected** that **usable quantities** of groundwater **would be depleted, but this did not happen.***

3 FORECAST OF HYDROGEOLOGICAL AND HYDROGEOCHEMICAL CONDITIONS AFTER THE FLOODING OF THE DEPOSIT

3.1 Time horizon for flooding the mine

When forecasting the temporal development of water level rise in flooded mine workings, it is necessary to take into account, above all, the hydrogeological conditions of the deposit and its surroundings and the nature of the deposit's excavation. When choosing a method for estimating the rise in water levels in the specific case of the Manó-Gabriela mine, it is necessary to take into account the very low permeability of the homine environment in the vicinity of flooded mining works, but also the large hydraulic reach of permeable zones (spatially very extensive depression cone) with a significant vertical extent of the drainage system due to the distribution of the deposit. Given the considerable variability in permeability, the above conditions do not allow the use of mathematical relationships derived for the characterisation of laminar groundwater flow for forecasting purposes, and the method closest to reality appears to be estimating the time of mine flooding based on the known volume ofunderground spaces and the known average inflow into the deposit.

The above method is used to estimate the flooding time of the Manó-Gabriela deposit (plan for the liquidation of the main mining areas) for a total volume of excavated space of 9,237·714 $m^3$and 131·250 $m^3$for mining tunnels. Given that the excavated areas and mining tunnels are located deep below the surface and there are no signs of surface subsidence, I estimate the volume of free space to be 70% of the excavated areas and tunnels. The free volume is therefore 6,558·275 $m^3$and· for an average flow rate of 10.40 l/s, the flooding time for the excavated spaces is 7,298 days, which is 20 years.

However, the flooding of the mine will depend on climatic conditions and the overall water content during this period.

The Eobeliarovo deposit, however, will not be flooded.

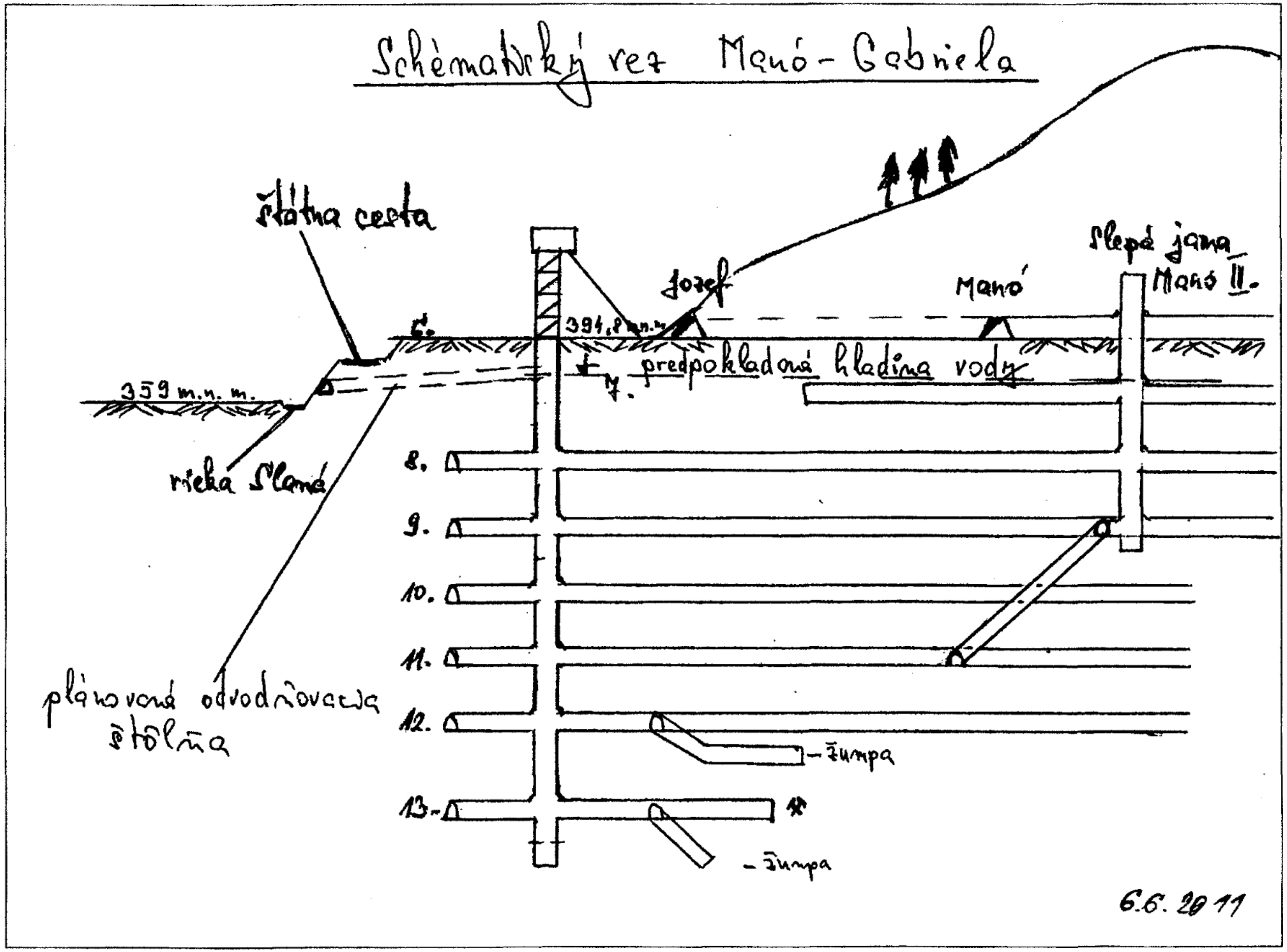

Figure 4

Schematic cross-section of Manó — Gabriela (compiled by Ing. S. Lukáč, CSc.)
No scale

3.2 **Expected** development in **the amount of mine** water and locations of its free outflow

Based on an assessment of the hydrogeological conditions of the Manó - Gabriela deposit and the results of measurements of inflows into the deposit and the nature of the flooding to date, we can predict the amount of mine water that will flow out after the mine is flooded. The nature of the drainage system indicates that the water level in the flooded Manó-Gabriela mining field will rise continuously throughout the entire drainage system.

If the location of their spontaneous outflow is likely, it could occur somewhere on the slope between the Gabriela shaft (394.8 m above sea level) and the Slaná river valley (360 m above sea level) if the mining water were not pumped out of the Gabriela shaft. For the above reason, the stability of this slope could be endangered, including the 1/67 national road.

Based on the above facts, it is considered necessary to excavate a drainage tunnel from a level just above the surface of the Slaná River (right bank) to the Gabriela shaft so that mine water from the flooded mine can flow freely into the Slaná River without endangering the stability of state road 1/67 and other structures on the slope from the Gabriela shaft to the Slaná River valley.

Given the purpose of the drainage tunnel, its long-term passability is essential to ensure the drainage of mine water and its concentrated discharge into the recipient via sludge tanks. Accompanying secondary seepage or springs on the surface outside the mouth of the adit are unlikely.

Based on an overall assessment of the hydrogeological situation at the deposit, we assume that even after flooding, the yield and inflow regime associated with the mining of the deposit will remain unchanged. Part of it may also be drained directly to the surface without entering the mine works. These inflows represent infiltrated surface water and shallow groundwater in the mine workings, which will no longer be drained underground. The amount of deep circulation groundwater inflows from the massif into the mine workings, mainly on the XII horizon, is likely to decrease significantly due to the effect of hydrostatic water pressure in flooded areas. If the piezometric level of most of these inflows is at the level of the local erosion base and lower, the inflow of deep circulation groundwater will be completely eliminated after the mine is completely flooded.

Based on the above, it is possible to estimate the average expected discharge from the deposit at 7–12 l/s, with maximum seasonal values of up to 20 l/s. Immediate extreme values of outflow from the mine during periods of high water levels cannot be estimated due to the low frequency of measurements.

Given the presence of non-rigid rocks (metapelites – giaphitic phyllites) in the deposit after the flooding of the mine areas, the possibility of disruption to the geotechnical stability of the mine works cannot be ruled out (although without any manifestation on the surface). For this reason, the occurrence of dynamic phenomena (e.g. collapses in air pockets) cannot be ruled out, which could cause isolated flash floods and sudden increases in mine water discharge.

3.3 Expected chemical composition of freely flowing mine water

Flooding the deposit significantly changes the hydraulic conditions for water flow, which is reflected, among other things, in a change in the duration of its contact with the rock environment. Flooding will dampen the drainage effect of lower horizons on groundwater in the vicinity of the ore body, and inflows will mainly concentrate at the VI horizon level. The water in the flooded areas will remain at around 360 m above sea level (between horizons VI and VII), which will be the new drainage level for shallow slope and alluvial waters in the area. The most intensive water exchange will take place around this drainage level. In addition to the disturbance of the environment by mining, the hominid environment of this part of the deposit is also characterised by a massive oxidation zone with frequent occurrences of minerals unstable in an aquatic environment (pyrite, arsenopyrite, which are bound to graphitic phyllites, where SO2 formation and emissions also occurred) filtered subsurface waters will carry dissolved oxygen, which will maintain an oxidative environment at this level and contribute to the intensity of oxidative and dissolution processes. We assume that a more pronounced oxidative environment will be maintained above the VI horizon, where it will be significantly influenced by inflows of mine water from other non-flooded parts of the deposit. Below the VI horizon, significant reduction conditions will be created at depth, resulting in changes in the overall chemistry of the water. This will manifest itself primarily in an increase in the overall mineralisation of water in the flooded areas of the deeper horizons. At these depths, better conditions for the stagnation of mine water are created. However, given the thermodynamic conditions at the deposit, complete stagnation of mine water cannot be expected.

These factors will have a decisive impact on the higher content of certain components in water and, compared to the current situation, its total mineralisation (above 1,000 mg/1), characterised as total dissolved solids (TDS), is likely to increase significantly. The increase in content will mainly concern sulphates, which may initially exceed 1,000 mg/1. This forecast is based on the fact that the chemical composition will be largely determined by the inflow of mine water from the uppermost horizons and old workings. Immediately after flooding, it is assumed that the water will be iron-tinted and will also contain increased amounts of insoluble substances (NL). This assumption is justified by the fact that flooding the old areas will stir up and wash out a significant amount of iron-rich sludge from the mine.

The pH of the effluent water can be expected to shift slightly towards the acidic range (5–6). We do not anticipate the massive formation of typical acidic mine water due to the nature of the environment and the neutralisation capacity of the carbonate filling of the ore body.

From the point of view of metal content, Fe, Mn, As and Hg appear to be the most critical. The Fe and In contents in particular are likely to reach levels in excess of 10 mg/L at the outset. Increased levels (in tenths of mg/L) of As can also be expected. These metals can be expected in the waters because their elevated concentrations are characteristic of the natural environment of the entire deposit area. The current and historical mining activity has disturbed the environment, which only increases the level of their total concentrations in the water. As a result, a large amount of secondary minerals (mainly Fe and Mn) has formed, even in old mining works, which will be intensively dissolved after flooding. However, it should be emphasised that the highest mineralisation of water with the highest content of the above-mentioned components will occur immediately after the flooding of the mine, at the beginning of the water outflow. Over time, after the homin environment has been saturated, the trend of decreasing mineralisation, and thus of all its components, will continue for a certain period of time (which cannot be estimated more precisely and can only be traced). However, even within this trend, fluctuations caused by seasonal changes in water quantities will occur. These seasonal changes in the mineralisation of the leaking mine water will remain even after a certain chemical equilibrium corresponding to the given natural conditions has been reached.

The gradual decrease in content will also apply to other pollutants in mine waters resulting from mining activities underground. These are mainly petroleum substances and technical products based on various organic substances (oils, lubricants, etc.). Given the long-term mining of the deposit, it can be assumed that these substances also have an impact on mine water. Their levels will depend on the method of technical disposal of the residues of this activity underground. This also applies to large quantities of fine ferrous sludge accumulated in mining works during decades of mining. Seasonal changes in the dynamics of mine water flow can cause varying degrees of ferrous turbidity in the outflowing mine water. The quantity of various old iron structures from the mining works is insignificant in view of the natural iron content in the mined (iron) ore.

4 FORECAST OF THE IMPACT OF OUTFLOWING MINING WATER ON GROUNDWATER AND SURFACE WATER IN THE AREA

4.1 Potential **changes** in groundwater **circulation and quantities** and in surface water **flows**

The flooding of the mining complex may cause changes in water quantities, which can be divided into two main groups:

1) **Changes caused by the cessation of pumping and deep drainage of groundwater by mining works**

Changes caused by the termination of pumping can be characterised as a restoration of the original groundwater circulation in the area to a certain extent. They can be most pronounced in the case of shallow groundwater if the flooding level copies the height of the erosion base of the area (stream valley). Shallow slope water will no longer be drained into the subsoil and will accumulate to a greater extent at the foot of the slopes. In the lowest places, natural springs may appear, or the original springs drained into the mining areas may be restored. These changes usually become apparent only after a certain period of time.

2) **Changes caused by the creation of new circulation routes – mining works**

These changes affect the distribution of total groundwater quantities in the area depending on the new circulation routes created by the mining works. They depend on the permeability of the mining works and are usually immediate. From this point of view, there is one risk area in the assessed area, namely the Slaná River valley.

<u>The Slaná River valley</u>

Based on the above facts, both types of changes may have an impact on the Slaná River valley, although this is unlikely. This could be increased waterlogging of the eastern slope foot below state road 1/67, at the level of the Slaná river floodplain. These effects will probably be significantly seasonal in nature and will depend on the water level in the flooded areas. The effects of increased humidity may also manifest themselves after a longer period of time, and it would therefore be useful to check the current condition of all buildings from this point of view. This applies not only to local buildings but also, for example, to the Rožňava - Dobšiná state road and the route of engineering networks.

4.2 Impact on surface and groundwater quality and relation to legislative limits

Based on the above facts, it is clear that the Slaná River will most likely be the direct recipient of the leaking mine water. A favourable factor is that this area is the middle course of the river with higher average annual flows (5 m^3/s). Given its flow and current quality above the deposit area, it is expected that immediately after flooding, surface water will be affected by an increase in total dissolved solids (mainly sulphates), insoluble substances and metal content, mainly Fe, Mn, As and possibly also Hg. This is likely to result in a general deterioration in the quality of surface water for these metals. However, given the mixing ratio, it is not expected that the limits set out in Government Regulation No. 269/2010 Coll. for permissible levels of water pollution will be permanently exceeded. From this point of view, the Mn content appears to be very critical, as the limit according to NV 269/2010 Z.z. for surface water (0.3 mg/l) is significantly stricter than for Fe (2.0 mg/l). In the case of permanent Mn content in mine water above 10 mg/l, this limit may be exceeded at lower water levels. For illustration purposes, we present (for the outflow from the Mária mine) a calculation based on a simple mixing equation from input values that may be decisive for

Exceeding the specified limit:

Average annual flow of Slana	Al' 5.0 1.s'" = 5,000 1.s'"
Average Mn content in the stream	Co 0.2 $mg.l^{-1}$
Average estimated amount of mine water discharge	Hz' 10 $l.s^{-1}$
Average estimated initial Mn content in mine water	Ci - 10 mg.l '
Total river flow after confluence with bdlJSk waters	Q3' Qi + Q2 = 5,010 1.s'"
Total Mn content (mg.1*')	C3

Qi i+ Q2 • C2' Qt . C3

5,000 x 0.2 + 10 x 10 = 5,010 x C3

Cz -- 0.22 mg.1°' > 0.3 mg.1'" (limit according to NV 269/2010)

It is necessary to point out that mine water will leak in these areas, which will also contain higher levels of Fe^2 and, if not detected in the water, may cause incorrect results in the determination of COD (chemical oxygen demand). The surface flow will be most affected in a certain period immediately after the mine water leaks to the surface. Over time, this impact will be significantly lower and there will be a real decrease below the NV limits. Once the chemistry of the mine water has reached a stable state, only seasonal changes in water availability will play a decisive role. However, potentially higher contents of undesirable components in larger quantities of mine water can be eliminated by increased river flow. There is a justified assumption *of the formation of liritzia, iron and grey-black manganese and sedimentation* at the confluence of river water and mine water.

The chemical composition of mine water after flooding will always be the result of natural factors in the given deposit area, modified to a certain extent by its disturbance through mining activities. This aspect must be taken into account when considering the possibilities of technical purification of these waters or their treatment in mine water treatment plants. The operation of a treatment plant would ultimately have a more negative impact on the environment (transport and storage of chemicals, sludge production, transport and storage, etc.) than the mining water itself.

A very important and positive factor in this case is the fact that in the event of mining water leakage, the *drainage system will be equipped with a collection tank.*
It will be a controlled discharge. This reservoir may capture potentially increased levels of insoluble substances and, to a certain extent, precipitate undesirable components from the water if necessary. Based on the knowledge of the deposit on which the presented forecast is based, it can be stated that after flooding the deposit, it is not reasonable to assume a permanently unfavourable situation in the development of water quality. The initially predicted higher values of Fe and Mn (as well as As and Hg) will most likely stabilise at significantly lower values over time, and these will always be only those components that are present in the locality due to the presence of ores as original geochemical anomalies. Therefore, for the Manó-Gabriela mine**,** it is optimal ***to direct the entire outflow*** *of* ***mine*** *water* ***directly into the Slanń River, so that any potential negative effects*** •*R**$*R^*1***•'*• ••***are minimised.***

5 MAIN CONCLUSIONS

Current situation

1) According to data from the mining organisation, the average total inflow of mine water into the mine works is currently at level XII of the 3.9 l.s‘[1]horizon and at level VI of the 6.5 1.s" horizon. This water is pumped from the mine and discharged into the Slaná River.

A significant amount of mine water is formed by the infiltration of surface water from the assessed area. The current situation is governed by a decision of the SIŻP, Košice Environmental Inspectorate, Integrated Permitting and Control Department (integrated permit), concerning, among other things, the discharge of mine water from the deposit, was issued on 26 October 2005 under number 895/97-OIPK/2005-Mi/570490105.

2) The occurrence of ore minerals in the assessed area causes high natural background levels of mainly Fe, Mn, Hg, and As in water and in medicinal sediments. This applies not only to the Manó — Gabriela and Kobeliarovo deposits, but also to the Svätá Trojica deposit located to the southwest and the Fe and Ni-Co ore deposits located to the northeast in the Dobšiná area.

Forecast of deposit flooding

1) The level of flooding of the deposit will be at 360 m above sea level. The most suitable method of draining mine water from the deposit will be to excavate a drainage tunnel at a level of 360 m above sea level.

2) Given the expected volume of mine water, there is no expectation of massive acid mine water formation.

3) Most likely, mining waters will have iron turbidity (content of undissolved metals) and increased (even several times higher than during pumping) content of sulphates (dissolved metals), CHS, and metals Fe, Mn, As and Hg. The level of these contents will tend to decrease and will later be significantly lower, but with seasonal fluctuations. In principle, there is no need for their treatment; from an environmental point of view, the construction and operation of a wastewater treatment plant would be a significantly less favourable alternative, but this will be demonstrated by monitoring the discharge of mine water.

4) From the point of view of dilution with surface water, the only recipient is the Slaná River, where, after dilution , it is expected that the limits will be met NV No. 269/2010 Z.z. for the upper reaches. Mining water from the deposit will flow into the recipient via an accumulation and decontamination tank and an oil separator.

6 MAIN RECOMMENDATIONS

Before flooding

Document the current state of the area from the point of view of objectively assessing the impacts caused by flooding the deposit. Focus primarily on:

- mapping the current state of all major objects in the vicinity of the anticipated outflow (buildings, road structures, utility network routes, etc.)
- installation of measuring points at selected locations and their geodetic surveying as the initial state from the point of view of assessing the stability of the territory
- ***prepare and install a*** *drainage system in a distance* ***of approx. 130*** *m from* ***the Slaná Jošaclity Gabriela river***
- Securing locations of potential mining water outflows to minimise the inflow of uncontrolled mining water seepage and waterlogging of the surrounding area.
- Ensure concentrated, isolated and free drainage of mine water (between the shaft and the mouth) from all likely discharge points throughout the entire section directly into the recipient.

During flooding

Monitor the rise of the water level and the chemistry of the mine water in the flooded areas and, depending on technical possibilities, take the first water sample for chemical analysis approximately halfway through the period to assess the overall chemistry and metal content. By evaluating this information, it will be possible to refine the expected development in the quantity and chemistry of water in flooded areas and take measures to ensure the quality of discharged mine water.

At selected time intervals, perform geodetic measurements at established measuring points to assess the stability of the area.

Once the critical altitude of the water level has been reached, intensively monitor all potential discharge points and, after verification, immediately take the necessary technical measures (e.g. concentration of discharges, structures for measuring discharge, etc.).

After flooding

Regular (as often as possible) monitoring of the yield of outflows at all locations. When mine water flows to the surface, monitor the quantity and quality of the water twice a month for 6 months in terms of the following indicators: pH, CHS " insoluble and soluble substances, SO4. Cl, Fe. Mn. As, Hg. NEL.

Comprehensive evaluation of data after six months and, after determining the development trend, update the frequency of further monitoring or prepare new possible technical measures.

Continue monitoring the stability of the area using geodetic measurements at established measuring points.

Request the relevant District Office of the Mining Authority to issue a new permit for the discharge of mine water based on the evaluation of measurements, chemical analyses and proposals for current technical measures.