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The current condition and future of the “Wieliczka” Salt Mine

The article focuses on matters related to the operation of the “Wieliczka” Salt Mine, outlining its activity in 2021 as well as the plans for the years to come. It describes the securing and accessibility activities carried out by the company. In terms of tourism, this is being reintroduced after the pandemic restrictions. It also contains a concise synthesis of the implemented protective measures aimed to limit the natural hazards and to ensure the safety of persons who remain in the underground excavations through pro-environmental measures. The article also presents the activities of the mine for the subsequent years of its functioning.

Key words: *safeguards and accessibility, Crystal Caves, mining shafts, target model*

1. INTRODUCTION

“Wieliczka” Salt Mine is one of the most precious monuments of Polish culture. It is well known in Europe as well as globally, but primarily it is the heritage of the Polish nation. This article presents the key activities of the “Wieliczka” Salt Mine in 2021, as well as its priorities for the upcoming years. It briefly discusses its meaning, activities in the areas of security and accessibility, plans and intentions.

For over seven centuries, as many as 2391 chambers and over 245 kilometres of pavements have been excavated under Wieliczka mine. Twenty-six mine shafts (Fig. 1) and 180 interlevel shafts have been constructed, leading the way from the surface area deep into the ground. For centuries, rock salt mining has been carried out by hand. Later, tunnelling was carried out with the use of, among others, gunpowder, while in the 20th century, salt was mined wet. In the search for good quality salt deep underground, miners descended as low as 327 metres.

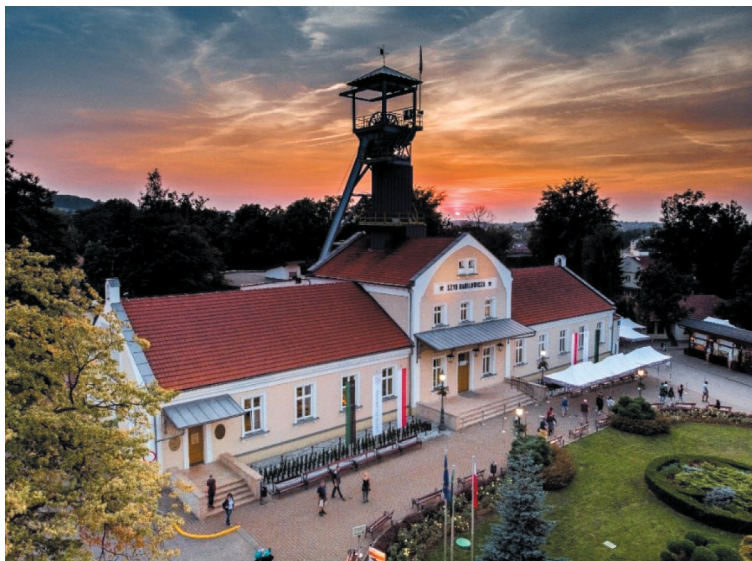


Fig. 1. Bird's eye view of M. Daniłowicza shaft (phot. R. Stachurski)

2. THE NEED TO PROTECT THE MONUMENT

For a significant amount of time, the salt in Wieliczka was so precious that it was referred to as white gold. The income generated thanks to the sale of salt comprised 1/3rd of the royal treasury, financing economic development, the construction of castles, fortresses and universities. Production continued to grow until the late 1970s, when it reached 260,000 Mg [1].

The low quality of the salt and the depletion of its deposits on the one hand, and on the other, the need to protect the underground led its exploitation to cease to be the key activity of the “Wieliczka” Salt Mine in the 1990s. The need to protect the underground layers at “Wieliczka” was recognised as early as in the 1970s, due to their exceptional value. The efforts to protect the monument were crowned with the introduction of the “Wieliczka” Salt Mine on the UNESCO list in 1978, ranking among the first 12 objects on an international scale.

The Crystal Salt Chambers are located over 80 m below ground level – they are one of the greatest underground phenomena in Wieliczka, with salt crystals that are unique on an international scale, as it is the only mine where crystals formed in the Miocene have been discovered. Another important feature includes the underground microclimate characterised by high chlorine, sodium, magnesium and calcium ionisation, bacteriological purity of the air, and the absence of viruses and fungi. These advantages allow it to be used as an underground spa for treating the diseases of the upper and lower respiratory tract. The under-

ground levels in the “Wieliczka” Salt Mine are also used as a venue for hosting numerous events and happenings, often of an international scale. In 2007, the Warsaw chamber hosted the participants of the Energy Summit, which was attended by the Presidents of Azerbaijan, Georgia, Lithuania, Ukraine and the envoy of the President of Kazakhstan at the invitation of the President of the Republic of Poland, Lech Kaczyński. The mine is also used as a venue for hosting New Year’s Concerts, New Year’s Eve Parties, galas opening or closing the Tour de Pologne, prom parties, dance tournaments and professional boxing galas. It is also worth mentioning that the salty interiors of the underground levels in “Wieliczka” are used by the AGH University of Science and Technology for organising Miner’s Balls and Jubilees of the AGH Alumni Association.

3. TOURISM IN THE CURRENT SITUATION

Currently, tourists are only admitted to a small fraction of the entire mine: approximately 2% of the underground excavations. The first visitors appeared in the Wieliczka underground as early as in the 15th century and it is probable that Nicolaus Copernicus was one of them. Mass tourism only began to develop in the 20th century and 45 million tourists have visited the mine since 1945. The number of tourists in the post-war period continued to grow in a steady manner, while the decreases in the number of visitors were mainly related to the repairs of the shafts (the mine was then being closed for tourists) or economic crises (Fig. 2).

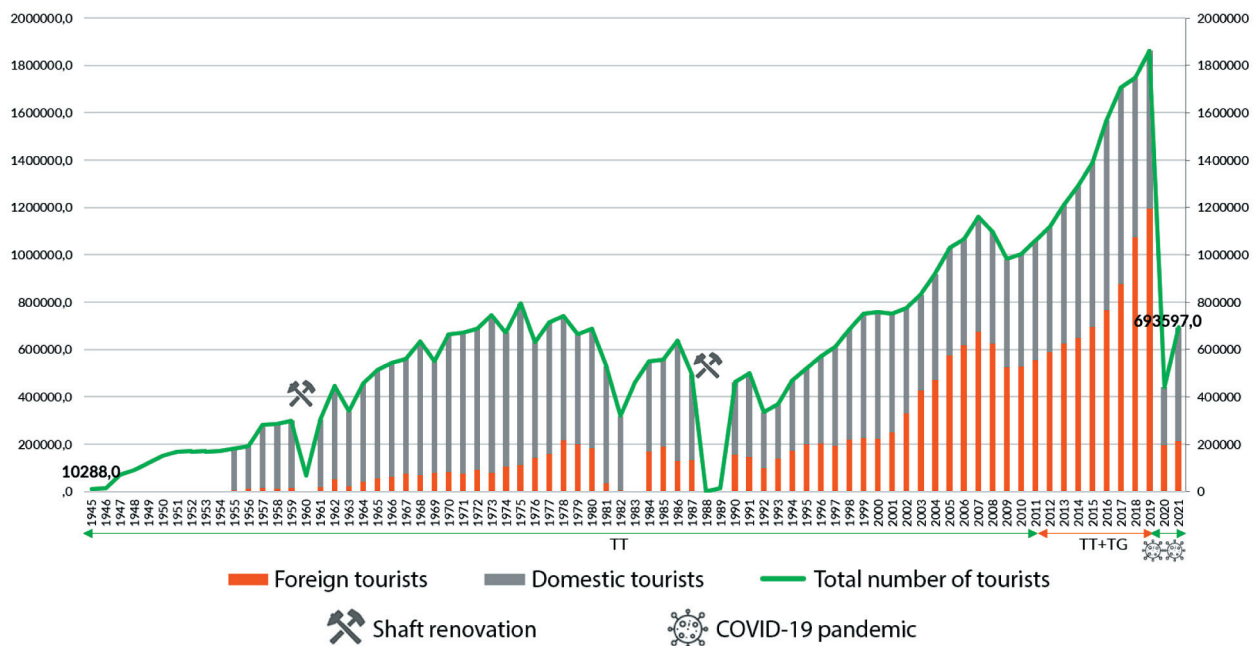


Fig. 2. The number of tourists in the “Wieliczka” Salt Mine between the years 1945–2021

The dynamics of growth in visits by foreigners has been particularly noticeable since the beginning of the present century, when the number of international tourists visiting the mine exceeded the number of domestic tourists each year.

2019 was the record-breaking year in the history of the “Wieliczka” Mine, when a total number of 1,861,843 visitors walked along the salt trails. In spite of the COVID-19 pandemic or the periodic travel restrictions, the mine hosted 441,100 visitors in 2020 (it was closed to the public for 140 days of the year) and 693,600 visitors in 2021 (it was closed for

77 days). Foreign visitors dominated in 2019 (64%) but the closure of the borders and the spread of the pandemic caused the percentage of foreign visitors to drop to 45% in 2020 and to 31% in 2021 (Fig. 3). Over 123,200 persons used the Graduation Tower in 2021 [2].

203,490 persons visited the Wieliczka underground in the period between January–April 2022 [3]. These good initial months of 2022 allow us to be optimistic about the 2022 tourist season, regardless of the war playing out beyond the country’s eastern border which affects foreign tourist travel to Poland.

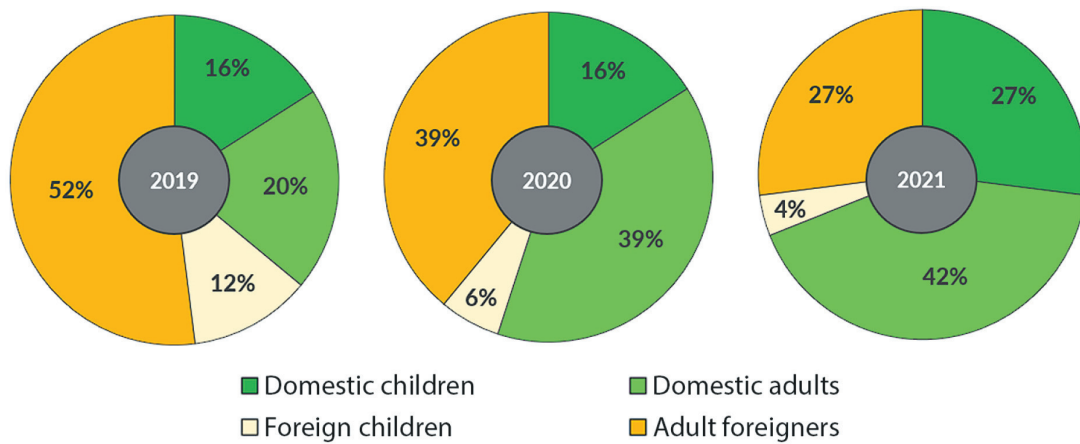


Fig. 3. The change in the structure of tourist traffic between the years 2019–2021

4. SAFEGUARDING AND ACCESSIBILITY

For centuries, Wieliczka’s main task was to supply salt throughout Europe while its current mission is to protect its legacy. Intensive mining operations

are underway in many areas of the mine to protect it against destruction. Another key area in modern mine operations is accessibility and involves facilitating access to the tourist section of the mine (Fig. 4).



Fig. 4. Tourists in St Kinga’s chapel (phot. R. Stachurski)

When securing the mine, miners carry out a number of works which include securing excavations, modernising shafts, counteracting the threat of flooding and cave-ins, maintaining the operation of the mine, revitalising post-mining areas, repairing damage, liquidating redundant installations, buildings, machines, developing projects, documentation and analyses. The tasks carried out focused on the activities specified below.

4.1. Modernisation of mining shafts

Mining shafts are a priority and during the final months of 2021, a number of retrofitting works were carried out in and around the vertical excavations.

The retrofitting of the main fan station in the “Wilson” shaft allowed to establish a modern facility (Fig. 5) improving the safety of the mine and its occupants. The works carried out resulted in the installation of modern fans, meeting the requirements of stringent environmental standards in terms of permissible noise levels. A new switchgear was additionally introduced, the servicing of the fan station was automated, and a control system for safety parameters was installed. The use of energy-efficient equipment has resulted in a one-third reduction in power consumption and a reduction in its operating costs [4]. This task was carried out with the financial support of the National Fund for Environmental Protection and Water Management in Warsaw.



Fig. 5. “Wilson” shaft after retrofitting (phot. R. Stachurski)

In 2021, repair works were carried out in respect to repairing the lining between levels II-VIII in St Kinga’s shaft (used for transporting personnel and materials for mining works), including the repair of the housing and the sub-roof on level VI, and the reinforcement between levels V and VIII was replaced.

The renovation of the upper section (down to a depth of 30 m) of the wooden casing of the “Daniłowicz” Shaft has started in the last quarter of the year (Fig. 1). It includes the replacement of wooden lining elements damaged by biological corrosion in order to improve the safety of the shaft and its functionality. The works are also going to include waterproofing of the shaft and construction of a new water drainage

system outside the housing. During the period when these works are being carried out, tourists are admitted to the mine using the 19th century Ignacy Paderewski shaft and leave using the Regis shaft, which was explored in the times of king Casimir the Great. The excellent preparation of the mine for such a complex topic is worth noting, as the rebuilding of these two shafts in recent years has made it possible. During the previous renovation of the “Daniłowicz” Shaft carried out between 1987 and 1989, the mine did not have the infrastructure to accommodate tourist traffic and the tourist route had to be closed for two years. The underground level of the “Geramb” shaft, connecting level III with IV, was also rebuilt (Fig. 6).



Fig. 6. Works carried out in “Geramb” shaft (phot. R. Stachurski)

4.2. Securing chambers

In 2021, mining works were carried out in 11 chambers, covering anchoring, erecting mining supports, carrying out the necessary rock mass stripping and removing excess spoil. The works were conducted, among others, in the “Kuchnia” chamber (lower part of the excavation), the “Margielnik” chamber, as well as in the complex of the “Geramb” chambers and the “Freitag” chamber.

A fragment of the northern aisle in St Kinga’s chapel was also secured, with the sidewall reinforced with anchors made of stainless steel. Similarly to the remaining chambers, they are inserted into the rock

mass, however using technology developed specifically for this site. The activities carried out in this area require particular precision and care due to the nature of the chapel and the positioning of the unique reliefs and salt sculptures. The work was carried out under the direction of scientists from the AGH University of Science and Technology, under the supervision of an art conservator and the conservation officer responsible for the Krakow saltworks. The traces of these works have been perfectly masked by the sculpting artists working in the mine.

The other important task also includes the protection of the protection of the area of the Crystal Chambers, which are unique on the international scale (Fig. 7).



Fig. 7. The crystals in the caves are unique on an international scale (phot. R. Stachurski)

These included the removal of spoil (waste rock) and securing the roof with walls of salt crumb in areas not covered by crystals. This is a multi-year task which is going to continue in order to ensure maximum protection for the Chambers. Due to the nature of the site and the climatic conditions, the work may only be carried out seasonally (from November to April).

The chambers that will be used as storage areas for the material excavated during mining works have also been secured with rockbolt supports. This has been done as they must be completely secure before, for instance, the scrapers that transport the excavated material can start working inside. The miners “positioned” (by filling out the cavities) 6,500 m³ ore, i.e., waste rock from other reconstructions.

4.3. Reconstruction of drifts

In 2021, mining works were carried out on 32 drifts, the total reconstruction covered 2,472 m of adits. The works included the dismantling of damaged mine

roof supports, the erection of new roof supports, adjusting roofs and sidewalls, and the replacement of railways. The excavations were rebuilt in sections which required such works. The reconstructions included, among others, the adjacent longwalls of the Crystal Chambers, which is a particularly valuable excavation due to its numerous geological exposures (inanimate nature sites). Carrying out works in the area of these sites required reaching an agreement with the Wieliczka City Council. The longitudinal “Geramb”, “Hauer”, “Layer”, transverse “King Saxon”, “August” and access roads to the water seeps in the western area of the mine on levels V and VI were also reconstructed.

Due to its historic nature (almost the entire mine is included in the register of historical monuments) the miners take care of every detail of the rebuilt excavation. Chambers and roadways are protected in a manner allowing their original character to be preserved to the greatest possible extent. Examples of such excavation sites include the “Wiszyn” drift, and the “Albrecht”, “Alexander” and “Lillienbach” corridors (Fig. 8).



Fig. 8. Reconstruction of the “Lillienbach” corridor (phot. R. Stachurski)

4.4. Filling and injections

The scope of mining backfilling and injection works aimed to stabilise the rock mass in selected areas of the mine or to protect it against the inflow of extra-bed water. Hydraulic backfilling covered 77 excavation sites, where 34,000 m³ of sand was deposited. Injection works (aiming essentially to reduce water hazards) covered 6,912 m³ of cavities. Due to the saline nature of the spac-

es to be filled, both backfill and injectors are produced using full-saturated brine from technological processes as well as from the concentration of mine seepage.

4.5. Modernisation, analysis and research

The electrical installations were partly modernised and new LED lighting was installed in St Kinga’s

Chapel (Fig. 9). It is the next stage of replacing the lighting at the mine for energy-efficient lighting. The mine also plans to construct a photovoltaic farm. An electric car was also purchased for the Security Department.

In 2021, the mine carried out a number of projects and analyses related to securing and protecting the underground area. These works included, among others, a geo-mechanical analysis of the central area (between the “Kinga” and “Regis” shafts), specialised studies of the inter-level shafts and inspections of the condition of the tall chambers. The studies car-

ried out are going to serve as the basis for carrying out the works in the subsequent years, as well as for the preparation of the document titled: *The Final Technical Form of the “Wieliczka” Salt Mine*.

As part of its investment in occupational safety, the mine maintains the condition of the excavations and also introduces modern equipment. New mine atmosphere condition meters were purchased in 2021 – replacing the worn-out methanometers and oxygen meters. As a result, employees carrying out their tasks in underground excavations have gained an additional modern element of safety inspection.



Fig. 9. The bas-relief “Miracle at Cana” with new LED lighting (phot. T. Kordula)

A new 3D scanner was purchased in order to facilitate the measurement works which allows for the precise inventorying of excavations and, after, computer processing of the files, they can be used for: inventorying, analyses, deformation studies, modelling and designing mining works aimed, among other things, at securing historic excavations.

5. PLANS FOR THE NEAR AND DISTANT FUTURE

In relation to Wieliczka mine, 2022 and the upcoming years are going to bring the implementation of mining works under the *Programme of complete liquidation of the non-historic part of the “Wieliczka” mining plant as part of the liquidation of the mine part and maintenance, protection and rescue of the historic part of the “Wieliczka” Salt Mine for the years 2021–2027*, financed by the Ministry of State Assets. The project is also going to involve the need to obtain

support from other sources, including the National Fund for Environmental Protection and Water Management, which is going to allow a wider range of activities to be carried out. This is especially important in the current economic climate, when the cost of implementing projects continues to significantly increase due to high inflation.

The works planned for implementation in 2022 include five projects aimed at protecting the underground levels and the mine sites against water hazards, co-financed by the National Fund for Environmental Protection and Water Management. One of the works involves the reconstruction of spill access roads and the securing of the “Freitag” and “Seeling” chambers. This task is aimed at protecting the ground surface against phenomena that may cause discontinuous deformation, degradation of the rock mass and disturbance of the existing hydrographic network, protection against water inflow into the mine excavations. The works aimed to secure are going to cover

a total of 13 headings on levels V and VI, with a total length of 3,403 m, as well as the two historic “Freitag” and “Seeling” chambers, located next to each other on level II “Kazanów”. In accordance with the plan, the works in the area should be completed in 2027.

A similar goal is pursued by another funded project, which is to secure the six adjacent “Geramb” chambers, as well as the “Geramb” drift and the “Frederick August” chamber. All of the excavations are situated in the lower level II of the mine. The works on the excavations have been continuing since 2015 and should be completed in 2022.

As part of the works carried out, the roof and stub walls were secured with anchor bolts, inter-chamber pillars were reinforced, chest lining was erected, redundant excavated material lying on the floor slab was removed and the upper parts of the chambers were filled with injection materials. In order to transport the materials required for the safety works, the “Geramb” longwall was also rebuilt – including the reconstruction of the masonry lining previously situated there, which contributed to maintaining the historic character of the excavation. The “Frederick August” chamber was filled with injection grouts.

The mine has recently received confirmation of the environmental effect of the task of protecting the “Margielnik” and “Wojtarowice-Liszki” chambers. The co-financed mining works in the “Margielnik” chamber included securing the chamber with composite anchors with a length of up to 10 m (the total length of the installed anchors exceeds 60,000 m), construction of timber towers, timber support shoring of varying design, injection works, reinforcement of a free-standing pillar and protection of the ceiling in the area of this pillar and its stub (by means of a net affixed with anchors). The pillar was reinforced with the use of steel tie-beams wrapped around it and by constructing a full-wood box crib. The “Wojtarowice-Liszki” chamber was secured with backfill, fed from the surface through a backfill pit drilled in the Górny Rynek area. The project has been ongoing since 2012.

Securing five “Baum” chambers at level II higher and II lower has been carried out since 2016. They are situated in the buffer zone of the Crystal Chambers reserve. The works aim to strengthen the roof by adding new cribs (the extension of existing pillars), constructing new cribs limiting the width of unsupported ceilings, constructing anchor bolting, remov-

ing excavated material from the bottom of the chambers, as well as equipping the “Schwind” shaft with a hoisting device for transporting materials from level III to lower level II. These measures are going to serve as protection of the excavations as well as the Crystal Chambers. The works are also going to impact the protection of the ground surface above this area – in particular in the area of the surface-affecting subsidence to the Schmidt chamber which occurred in the 1960s.

The final key project related to protecting the mine against water is the decommissioning of excavations in the area of the “Colloredo-Kloski” crosscut. The work consists in filling the excavations with injectants aiming to seal the area (in this case the central area) against the inflow of water. Injections with a total volume of 6,500 m³ are planned for 2022. Backfilling of selected gaps with sand (to stabilise the adjacent excavations) will be carried out in the central and eastern sections of the mine. The plan for this year is to fill the gaps with sand with a total volume of 29,000 m³.

The challenge for the years to come is to develop a target technical model of the mine, defining the technical shape in which it will operate in the future, once the bulk of the safety work has been completed.

The important tasks to be carried out in the years to come are aimed to introduce new technologies (material, energy-saving, photovoltaic, as well as those related to the liquidation of excavations), so as not only to develop protective activities, but also to safely conduct the traffic of tourists.

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