Measurements of the observation of rock mass movements in field no.1 in the "Kłodawa" Salt Mine S.A.

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Abstract

Stability of excavations in salt rock mass requires addressing a number of problems in the field of geomechanics and safety on the surface and underground. The presented investigation focused on observations of the movements of the rock mass in Kłodawa salt mine in Poland. The measurement were done in field no. 1, which was the first excavated field in this mine. The excavation began in 1962 at the depth 450 m, by setting up observation lines for leveling and length measurements. Further at the end of the 1980 convergence started to be measure. Observation of the convergence is a crucial goal for mine surveyors in Kłodawa salt. The convergence measured in field no. 1 has the most significant impact on the stability of the caves and the land subsidence. Presented research are focused on description of methodology of salt rock strata measurements in order to control the deformation processes taking place in field 1.

Key words: geodetic measurements, observations, mining excavation, mining field

1. Introduction

The salt mining is a complex process. Safety in the mine and the potential hazard related to that activity on the surface is a crucial issue. The volume excavated underground, where the rock mass balance is disturbed, can lead to failure of buildings and infrastructure on the surface (Figure 1).

Figure 1. Sinkhole caused by salt cavern collapse, Wapno salt mine, Poland (https://tvn24.pl/poznan/wapno-wciaz-osuwa-sie-ziemia-przygotuja-plan-jak-ratowac-miejscowosc-5405290, 21.05.2022)

Due to that fact monitoring of the salt masses stability is significant challenge as well as ground movements on the surface (Galve et. all, 2018; Kim et al. 2018; Malinowska et. all, 2019; Móga et. all, 2019; Onencan et. all 2018).

2. Study site

The Kłodawa salt mine has complicated geological an mining conditions. The mining is done in the salt dome covered by gypsum cap.

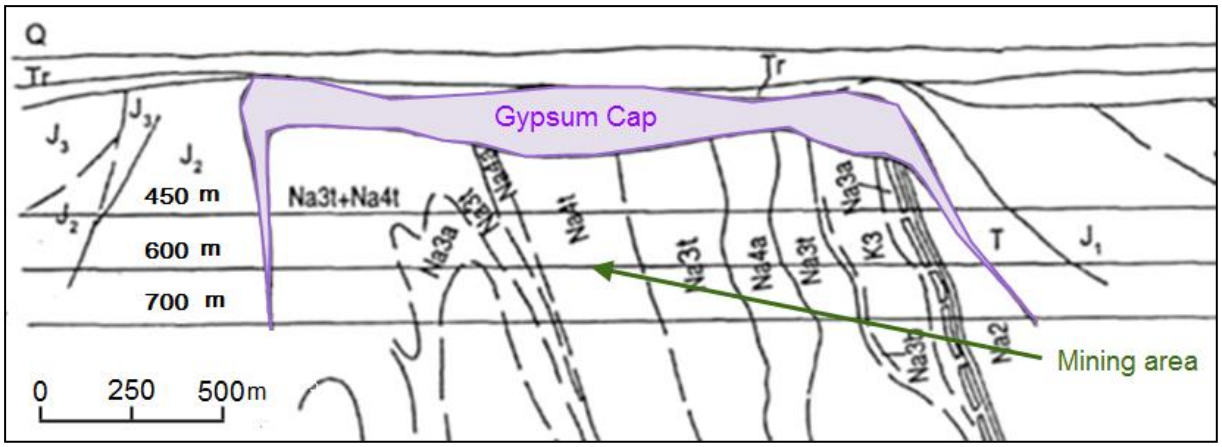

Figure 2. Geology of the Kłodawa salt mine (after Poborski, 1997)

The geological and the chemical properties of the salt conditions are complicated due to that fact the planed mining was divided into 7 mining fields. The most significant part of the mine

is field no. 1 where the stability of the mining caves can be distributed (Figure 3). Field no. 1 is situated along the extent of the dump in the NW-SE direction, and its length is approx. 1000 m. The mining workings of field no. 1 are located at a certain distance from the natural boundaries of the dome in this area (Figure 2, 3). The field is separated from the NE border of the dump by a safety pillar, which is 50 m wide up to the level of 600 m (Figure 3). On the other side (SW). From the side of the roof of the excavation, field no. 1 is protected by a 150 m thick safety pillar. Above field no. 1 there is a clay-gypsum-anhydrite cap with a thickness of 100 ÷ 150 m (Figure 2). Due to the occurrence of natural hazards in field no. 1, it was qualified by the orders of the Manager of the Mining Plant Operations to the following levels and categories of hazards:

- water hazard - 3rd degree; and in the case of commencement of mining works related to the progress of the face using explosive material:
- risk of gas and rock outbursts - category III;
- methane hazard - II category.

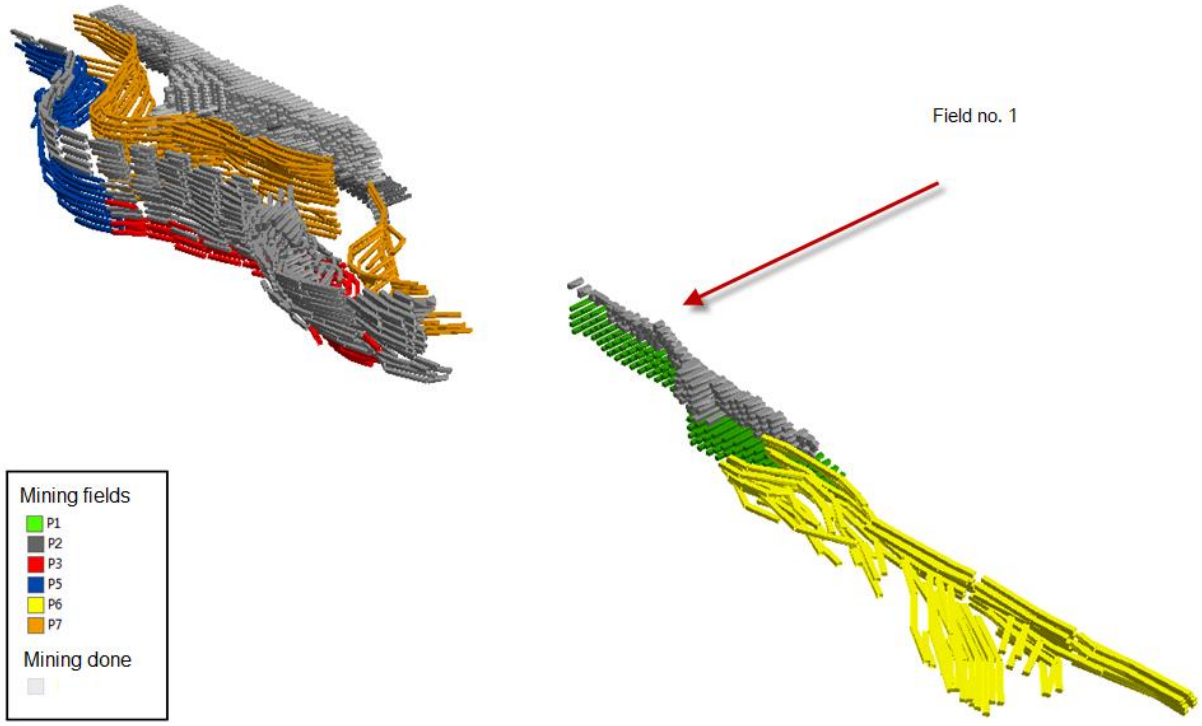

Figure 3. Mining excavation planed in 7 mining fields in Kłodawa salt mine

In order to control the stability of the rock masses the constant monitoring is provided by mine surveyors . These measurements are performed using the geometric, trigonometric and length leveling methods. The leveling and length measurements have been carried out since 1962, and convergence measurements since the end of 1979. In field no. 1, the exploitation

ended in the 1980s, but in field no. 1 the exploitation of new levels is planned from 2035, and it is also planned to fill the post-exploitation voids from 2025 (Figure 4).

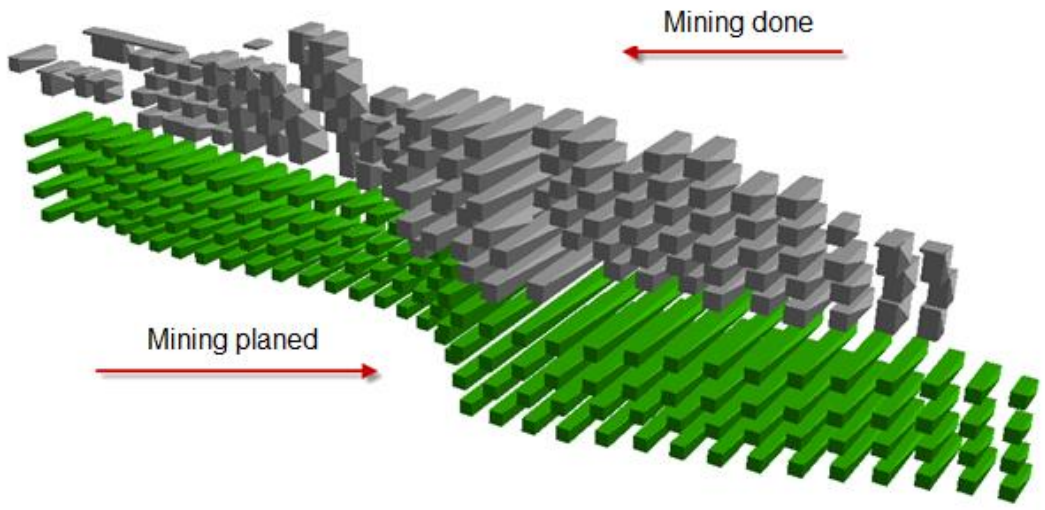

Figure 4. Mining done and planed in field no. 1

The field 1 is now significant testing site which is used to analyze the natural deformation processes due to its remote location from other mine exploitation fields that do not affect the process of convergence.

3. Observation network in field no. 1

The rock mass movement observation network in field no. 1 consists of 59 leveling points (Figure 5) and 66 convergence measurement stations located in the drift and chambers (Figure 6). The network is used to measure the deformation of the roof above field no. 1 which protect the excavation form the water ingress. The remaining network is used to measure the deformation of chamber.

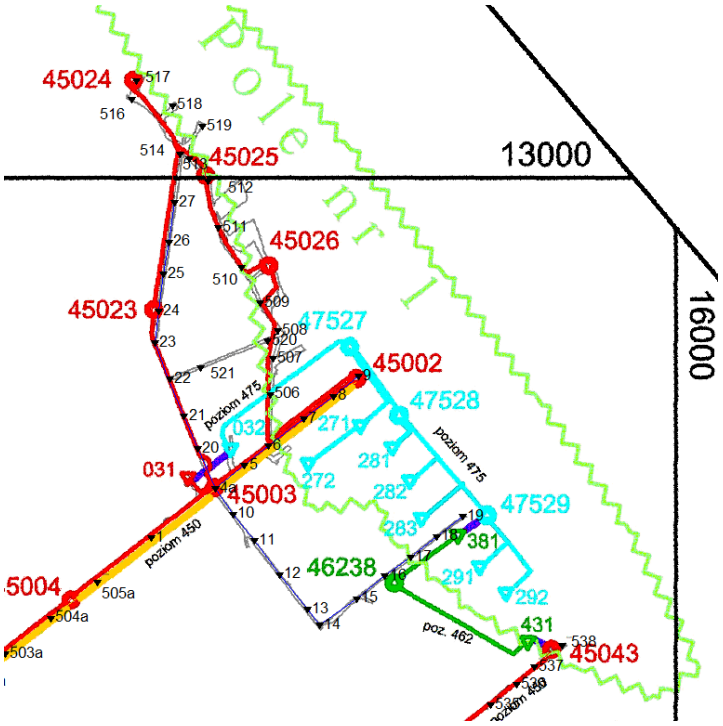

Figure 5. Observation network is used to measure the deformation of the roof above field no. 1

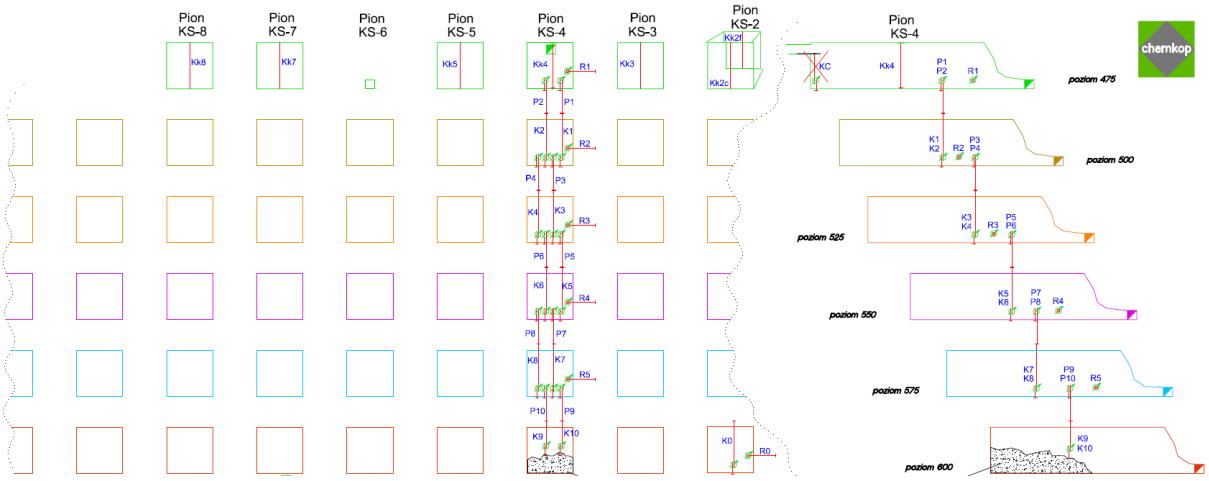

Figure 6. Location of the stations used to measure convergence in salt chamber and above them

Due to the fact that in field 1 there are networks of observation points established in different time periods it was decided to make observations of all available points in 2020. Which allowed for the unification of the coordinates of that points.

4. Analysis of the observation network in field no. 1

The volume of the field no. 1 is relatively small. Although, the mining done in this field reached the depth of 600 m. The impact of mining on the surface from the beginning of exploitation reached - 0.12 m (measured at the end of 2017). The maximum subsidence measured underground in field no. 1 reached - 0.56 m. That maximum subsidence was observed in the central part of the field. There is a decreasing trend of subsidence observed after 1994 year, when the mining was stopped in 1980 year in that field (Figure 7).

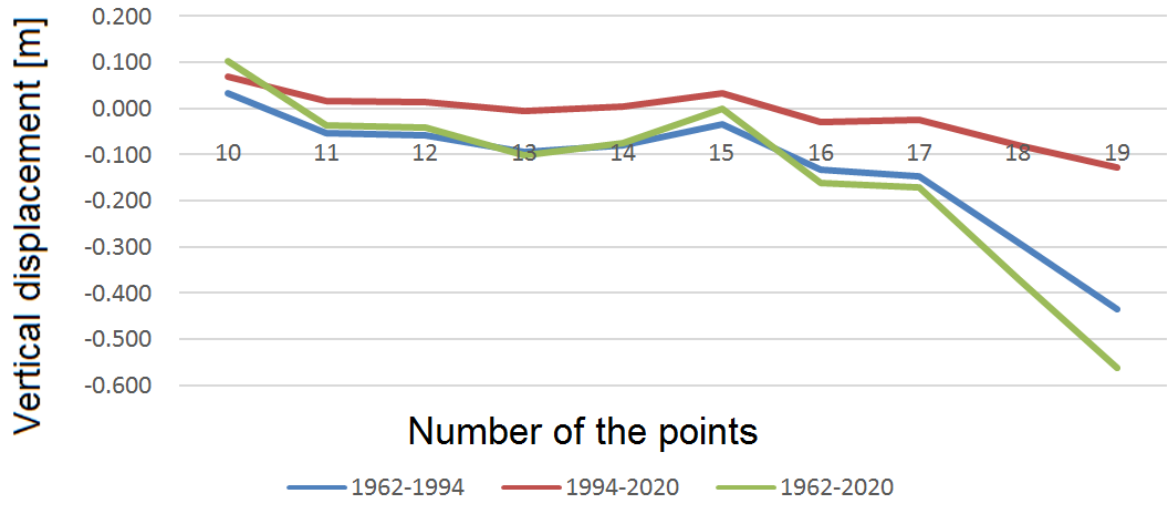

Figure 7. Movement of benchmarks in the period 1962-2020

The analysis of the displacement of the leveling network points for field no. 1 is limited only to the level of 450 m. The level is located directly under the floor of the protective anhydrite cap. Further research will be focused on continuation of the measurements and intensify the them.

5. Summary

The measurements of the observation of the movement of the rock mass, which are performed in field no. 1, provide information about the changes taking place in the salt rock mass. The observation network in field 1 is a guide lines the future measurements in other fields in salt mine. The observations carried out in the mine workings show that the maximum subsidence is observed in the central part of the field no. 1 and it reached -0.56 m for the period of almost 60 years. On the other hand, the impact of mining works on the terrain surface is over four time slower. It can be noticed that there are may be two measurement cycles remaining, which will not be disturbed by the planned mining in the field 1. So soon field 1 will lose its unique status of a natural deformation process. In the future, the current observation network will

have to be prerequisite research site to built the novel methodology of measurements of rock salt convergence and to better understand the process of the deformation in rock masses and on the surface.

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