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STABILISATION OF ROCK AND GROUND WATER LEVEL AT THE SALT DEPOSIT OF TUZLA

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ABSTRACT
In order to reduce leaching of salt sediments and to stabilise rock complexes at the salt bedding, a decision was made in the beginning of this century that explotation in Tusanj mine should stop as well as exploitation of salt water at the mining district of Hukalo-Trnovac in the central city zone. In this way salt water should saturate gradually and dissolution of salt sediments should stop as well as increase of water level into quasi-natural state, i.e. the level before the beginning of intensive exploitation.
Rising level of ground water, i.e. the time required to make the water level similar to the one before the intense exploitation, under different vertical and horisontal porosity will be acheived earlier than planned. These researches show that flowing conditions are different than previous interpretations and that inflow quantity of water Q_u (m^3/day) is significantly higher, taking into consideration that flow occurs over the aluvium of Jala river and water from the primary water system.
Key words: rock salt mining, rock stabilisation, ground water level, cavity-karst, hydrogeological characteristics, conditions of bedding flow,and drainage.

1.INTRODUCTION
The terrain of city zone of Tuzla has been deformed horisontally and vertically caused by the mass deficit in lithosphere due to dissolution of rock. Exploitation of brine causes space filled gravitationally with sediments of waste rock material undissolved in water. Subsidence of terrain as the most visible process causes huge economic, material, social and ecological problems. Already in the beginning of 50-ies there were visible deformations of buildings as well as bulges or sinkholes of the terrain. Buildings in the centre of the town were covered by bigger or smaller cracks, translations, torsion, shearing slides, so that some of them had to be battered down. Primary water and drainage systems were severely damaged before as well as now, which causes enormous ecological problems. In the period after World War II exploitation of salt water increased abruptly as well as subsidence process, that according to the data og geodetic control points in that period was 14 metres, especially it the area of the present «Pinga».

Dissolution of salt and explotation of brine has been known in this area for hundred of years. Industrial production of brine in the city area began in 1892, while more intense leaching starts from 1885 when a smal Salt factory was built in Simin Han and 1891 in Kreka, as well as Salt factory in Lukavac.
In order to reduce leaching of salt sediments and to stabilise rock complexes at the salt deposit, a decision was made in the beginning of this century that explotation in Tusanj mine should stop as well as exploitation of salt water at the mining district of Hukalo-Trnovac in the central city zone. In this way salt water should saturate gradually and dissolution of salt sediments should stop as well as increase of water level into quasi-natural state, i.e. the level before the beginning of intensive exploitation.

2. CAVITY-KARST AND MECHANISM OF ROCK COMLEX STABILISATION

The bedding of stone salt in Tuzla dates from the period of Lower Myozene , i.e. it is of carpat and sediment origin. The bedding is located witihn the synclorium Trnovac-Tusanj and has irregular elyptic shape, with the surface of 1,5 km^2.

Cavity-karst source with the irregular geometrical shape, includes leaching zone of I series of salt in the narrow zone of the bedding, a part of salt formation above immediate II salt series which includes also pelite layer as well as margin, leaching parts with anhydritic breccias. A basic body of salt bedding of broken type has been formed in this complex, which has subartesian characteristics in present conditions. This body appeared as a consequence of salt leaching within salt body or salt partings in band-like marl and pelite. Salt leaching over many years (natural and artificial) made a space filled with water in the domain of salt bedding, which could be caved. Rock mass deficit in the salt bedding, as well as decrease of piesometric pressure in the source, causes static instability, which further causes cracking and sagging of roof sediments, by which primary cracking systems change geometrical chracteristics of sources and their hydro-dynamic properties.

Salt dissolution in the salt water exploitation process, thereby increase of secondary porosity, was caused by formation of pandams along which water flows. Intensity of dissolution depends on the level of water saturation and streaming speed. Based on the previous researches, it was concluded that I series of salt at the most part of the bedding has already leached, while other salt series have leached only partially.

This streaming mechanism, drainage of salt and appearance of cavernous, secondary porosity, with the consequences visible through intensifying of cace porosity of surrounding rock, form a complex hydraulic system with abrupt changes in hydro-dynamic parametres, spatial and time related.
It is assumed that piezometric levels in cavity-karst source were within elevations 180-215 before the beginning of the continuous salt water exploitation. Recorded piezometric levels in cavity-karst source in the 80-ties were significantly lower and within elevation limits 40-60m.

By exploitation of salt water, the existing uncontrolled drainage accelerates circulation of ground water around the deposit partially mineralised water flow into the deposit and dissolve salt bodies. In the beginning this dissolution appears around salt layers, so called «peripherial leaching». Space filled with salt water are formed at salt partings. Dimensions of such space can be huge, so that sometimes immediate roof can colapse and they can be filled with pieces of marl. In that way «unloading zone» can be formed, where their radial cracks usually cover more surface than the one before the drainage process. Along the cracks, subartesian water of lower horisons, climb bellow the surrounding younger salt layers that, beside rim water» in this way get water also at the bottom. This causes conditions for «roof leaching» which is quicker than peripherial leaching. While rim leaching is common for all salt layers, by development of unloading zone upper salt layers, are influenced directly by immediate roof leaching which accelerates their degradation.

Newly formed leach space causes cracking and colapse of old roof and further water increase bellow the next salt layer. In this way limit of leaching for each next layer moves more within the deposit causing steep overlapping of cavity-karst source with salt bodies.
Deactivation of salt water exploitation at the mining district of Hukalo-Trnovac proceeds in accordance with the project, in three phases, with a simultanuous conduction of water level rise, quantity of exploitation of salt water, salinitety, geodetic measurements of surface points as well as other projects and appearances in the rocks as well as at the surface. According to the project, it has been evaluated that the total inflow of water into the deposit equals Q_u = 3.370 m^3/day, whereas 70%Q_u would be exploited in the first 3 months with the asumed level rise of 4,5m. In the following 6 months 50%Q_u with the level rise by 8,3m and in the third phase in the duration of 3 months, 30%Q_u would be exploited with the level rise of 4,9m. The next phae assumes full stopping of salt water exploitation where water level will rise to 42m, i.e. the level approximately similar to the one before the intensive exploitation.

The ground water level is monitored on a daily basis and measured at 10 different observation boreholes. Tr-180 has been chosen for bench mark borehole where the starting water level has been measured at the elevation of 144,8m. General characteristics of water level measurement result at all observation boreholes are their different values of water level rise and identical rising trend. Which points out a good hydralical compound of common source with different filtration characheristics in horisontal and vertical profile, (Fig.1., 2., 3).

Measurement of ground water level in the first three months was conducted in the conditions of where water exploitation was higher than the planned, average 0,79 Q_u, which caused 80% higher level than expected. 0,70Q_u was exploited in the first two months of the second phase which cused water level rise less by 55% than expected. In the following three months explitation of salt water was reduced to 0,57Q_u with the level rise 186% higher than expected. This rising trend of water level that is higher than expected will continue.

Based on analysis of engeering-geological and hydrogeological characteristics, conditions of bedding flowing and drainage, as well as conditions for stabilisation of rock complex, it can be concluded that there is an enormous nonlinearity in porosity i.e. in the process of stabilisation of rock complex. Previous researches of this problem implied that by stoppage of exploitation salt melting will stop, water saturation and stabilisation of roof sediments. In our opinion the process of water saturation will go very slowly taking into consideration water drainage (along partings, cracks, Tusanj mine and aluvium of Jala). In our point of view leaching of sediments in peripherial parts of the deposit will be visible which can cause spreading of the deformation line of the terrain surface (subsidence and bulging, landslides on the slopes)

3.CONCLUDING REMARKS

Rising level of ground water, i.e. the time required to make the water level similar to the one before the intense exploitation, under different vertical and horisontal porosity will be acheived earlier than planned. These researches show that flow conditions are different than previous interpretations and that inflow quantity of water Q_u (m^3/day) is significantly higher, taking into consideration that flowing occurs over the aluvium of Jala river and water from the primary water system.
Stopping of salt exploitation in this area is fully justified, but there is a new risk that by rising of water level can cause different processes in and at the terrain surface. Due to that fact it is necessary to contiune monitoring of the process and take necessary measures that would control the whole process.

Relation between rising level ground water and days exploitation of brine:

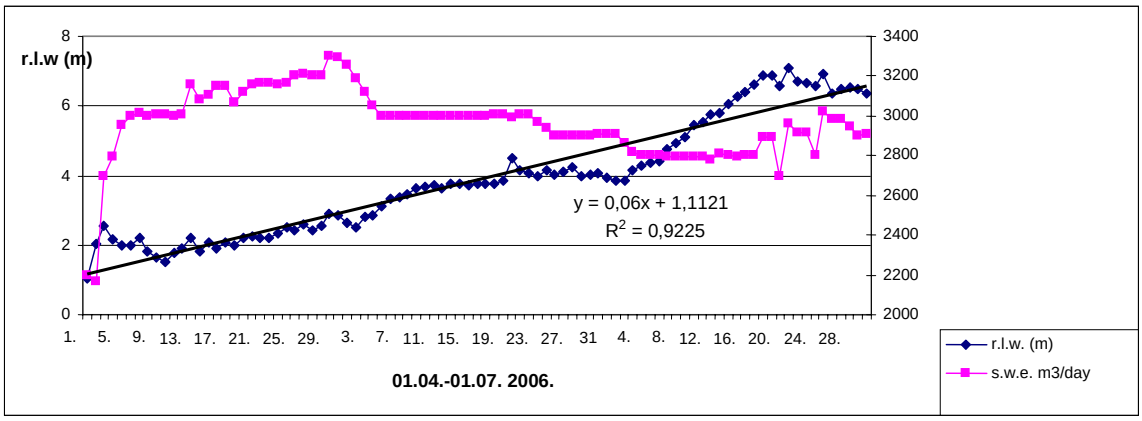

Figure 1.

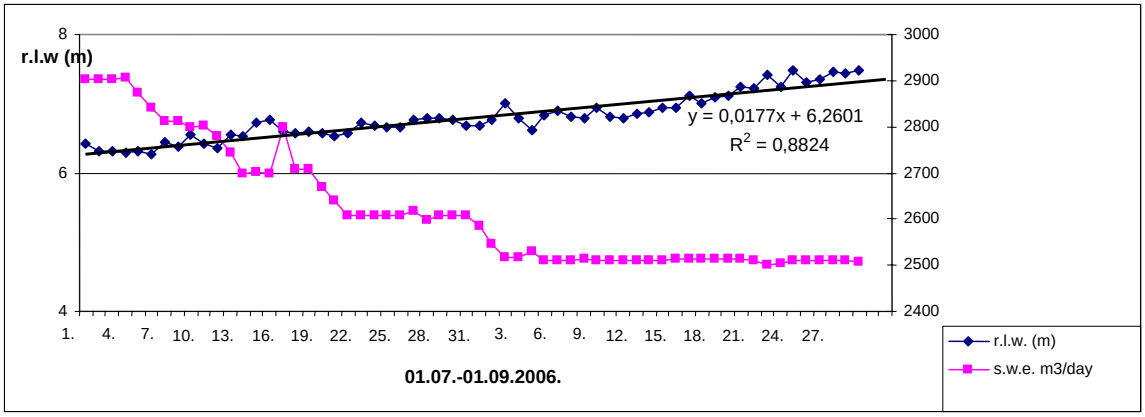

Figure 2.

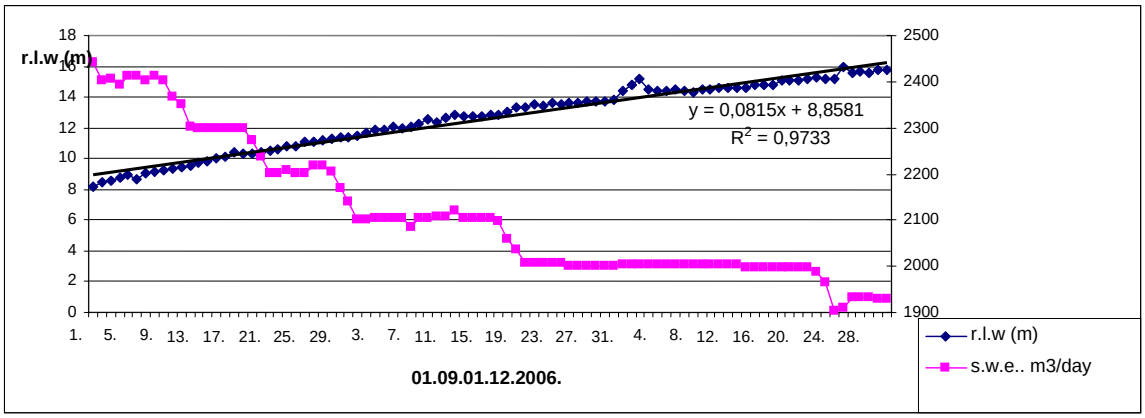

Figure 3.

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