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CONTENTS

MONITORING OF GRAVEL PITS BY SATELLITE REMOTE SENSING LOCATED IN THE NATURE 2000 SITE ROSPA0114 MIDDLE COURSE OF SOMEȘ IN SĂLAJ COUNTY

GEORGE IONUȚ RĂZVAN FAZACAȘ[1], RALUCA GÂLGĂU[2]

Abstract: *Starting from the importance of the mining industry and the way the gravel pits negatively influence the protected natural areas, this study focuses on monitoring by satellite remote sensing of the mining perimeters regulated by the environmental protection authority of Sălaj County, as well as on the compliance of the economic agents with the correct exploitation and positioning of the regulated mining perimeters.*

Keywords: *satellite remote sensing, Sentinel-2, gravel pits, mining perimeters, protected natural areas, environmental authorizations.*

1. INTRODUCTION

Mineral resources play an important role in the development of local, regional infrastructure and in the national economy. The most widespread extractions of sand, gravel and ballast come from alluvial deposits, transported and deposited by flowing waters [1].

The exploitation of mineral aggregate deposits can be carried out in the watercourse bed, on the bank of the watercourses, outside the watercourse, on land, below the hydrostatic level and depending on the position of the exploitation field and the level of the water or aquiferous canvas [1].

In Sălaj County, the most widespread mining perimeters of the gravel pits are located between the left bank and the right bank of the major riverbed and, respectively, the minor riverbed of the Someș River, perimeters that overlap the protected area of Avifaunistic Protection Middle Course of someș ROSPA0114 [2], Someşul between Rona and Ţicău ROSCI0435 [3].

In this study we approached the field of satellite remote sensing because it allows us to carry out analyses and studies on the subjects pursued [4] and can identify, measure and analyze the characteristics of objects of interest without direct contact [5]

The satellite remote sensing system monitored extractions of sand, gravel and ballast from ballasts prin cneedleul their radiometric indices of water NDWI, MDWI, MNDWI+5, AWEI, through these indices to detect water bodies [6]

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These indices are parameters to quantitatively and quantitatively assess the environmental elements that can be transposed on satellite images, these indices can be calculated by specific formulas [4] following the extraction of useful mineral substances, fish lakes will be made from where the water bodies will result.

2. MATERIALS AND METHODS

2.1. Data collected and research classification

For this study we used the Sterographic coordinates1970 of the mining perimeters from the environmental permits regulated by the Environmental Protection Agency of Sălaj issued in the period 2015-2023 for the gravel Pitsnăpradea Sud [7], Tranis Vanera [8]. Țărmure Smart [9] , Țărmure Smart-1 [10], Someș Arcada [11], Băbeni Precall [12], Ochiuț 2 [13], Băbeni Barcău [14], Lemniu Atos [15], Somes Ritorsa [16], Ciocmani Sus [17], Traniș [18], Băbeni Sud , Babeni Sud-extindere [19], Someș Agro [20], Someș - Odorhei [21], Benesat [22], Letca-Zaton [23], the studied gravel pits overlap the protected area of Avifaunistic Protection The Middle Course of the Someș ROSPA0114 [2], Someşul between Rona and Ţicău ROSCI0435[3]**,** mapped in figure 1.

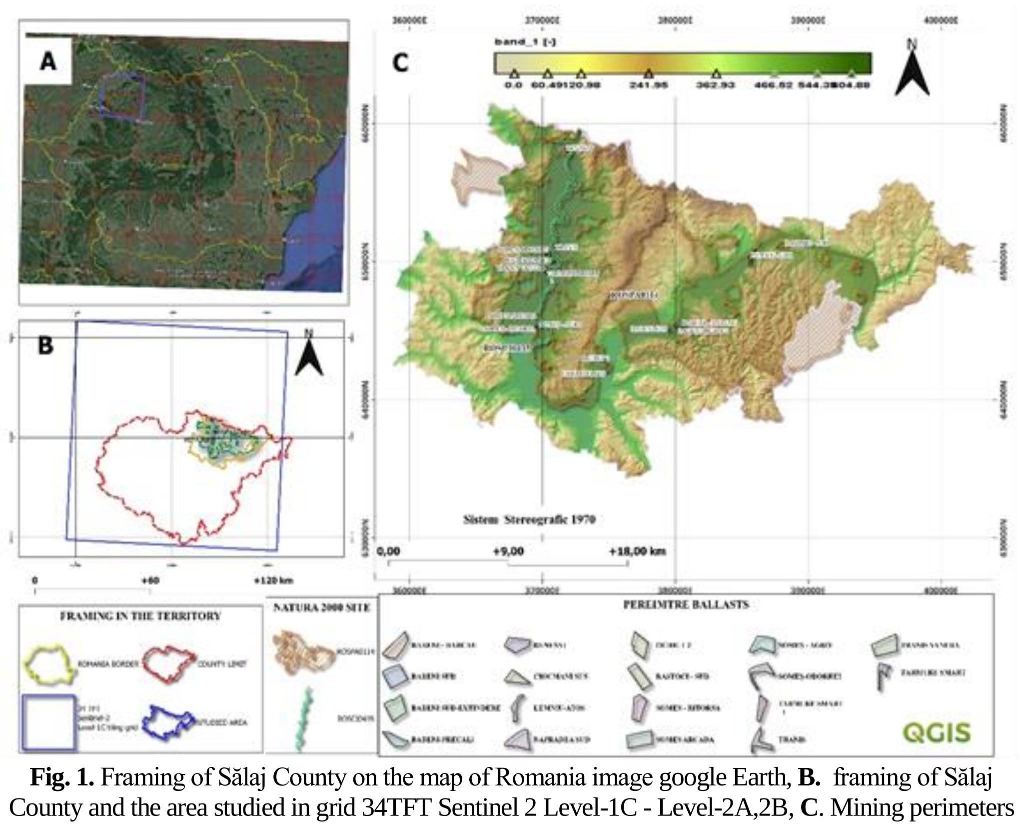

Fig. 1. Framing of Sălaj County on the map of Romania image google Earth, **B.** framing of Sălaj County and the area studied in grid 34TFT Sentinel 2 Level-1C - Level-2A,2B, **C**. Mining perimeters of the superimposed ballastsare over the protected area Middle course of someș ROSPA0114, Someşul between Rona and Ţicău ROSCI0435, maps made with open-source software QGIS Desktop

We purchased 8 batches of sentinel 2 satellite images S2A, S2B between 2015-2023 from different seasons presented in Table l , the reference data of the images used are provided by the European Space Agency ESA data available Copernicus Open Access Hub [24].

The processing of the 8 batches of Sentinel-2 images was processed with the open-source SNAP version 9.0.0 software developed by the European Space Agency (ESA)) [25].

In the open-source QGIS Desktop software version 3.28 [26] the text files of the Stereographic coordinates 1970 of the mining perimeters of the ballasts from the environmental authorizations [7-23], perimeters mapped in figure 1C, and the polygons resulting from joining the Sterographic coordinate points1970 were converted into ESRI shp files with the software QGIS [26].

Table 1. Date and reference of images

DATE	IMAGE ID	SENSING ORBIT NUMBER
2015-08-08	S2A_MSIL1C_20150808T092006_N0204_R093_T34TFT_20150808T092544	93
2016-11-20	S2A_MSIL1C_20161120T092302_N0204_R093_T34TFT_20161120T092301	93
2017-06-11	S2A_MSIL1C_20170611T093041_N0205_R136_T34TFT_20170611T093433	93
2018-10-31	S2A_MSIL1C_20181031T092121_N0206_R093_T34TFT_20181031T095845	93
2019-12-30	S2B_MSIL1C_20191230T092309_N0208_R093_T34TFT_20191230T103643	93
2020-12-09	S2A_MSIL1C_20201209T092401_N0209_R093_T34TFT_20201209T110759	93
2021-11-24	S2A_MSIL1C_20211124T092321_N0301_R093_T34TFT_20211124T103812	93
2022-11-22	S2A_MSIL1C_20221122T093311_N0celo400_R136_T34TFT_20221122T113209	93
2023-01-23	S2B_MSIL1C_20230123T092159_N0509_R093_T34TFT_20230123T100002	93

2.2. Radiometric indices of the water used

For the detection of water bodies we will use 4 radiometric indices of water NDWI *water with normalized difference* (1) McFeeters, which proposed the detection of surface water in wet environments and to allow the measurement of the extent of surface water [6], MNDWI modified *normalized water index* (2) allows the suppression and even elimination of accumulated land noise, as well as vegetation and soil noise, and therefore the improvement of the extraction of water bodies [6] , MNDWI+5 *modified normalized vegetation index* (3), this surface water index will have negative values (<0) so opposite to all other water indices [6], AWEI *is the automatic water extraction index* (4), designed to improve the accuracy of water extraction with a stable threshold value [6], these indices can be calculated according to the equations:

$$NDWI = \frac{Green - NIR}{Green + NIR} = \frac{B3 - B8}{B3 + B8} \quad (1)$$

$$MNDWI = \frac{Green - SWIR1}{Green + SWIR1} \quad (2)$$

$$MNDWI+5=\frac{NIR-\mathrm{Re}\,d}{NIR+\mathrm{Re}\,d}=\frac{B8-B4}{B8+B4} \tag{3}$$

$$\begin{aligned}AWEI &= Blue+1.5*Green-1.5*(NIR+SWIR1)-(0.25*SWIR1)=\\ &= B2+2.5*B3-1.5*(B8-B11)-(0.25*B12)\end{aligned} \tag{4}$$

2.3. Calculation of radiometric indices of water

To calculate radiometric water indices, a graph of graph builder instruments has been created [6] Figure 2, the 4 radiometric water indices are for all 8 batches of images where the mathematical equations (1)-(4) will be introduced, this graph is processed with the SANP software.

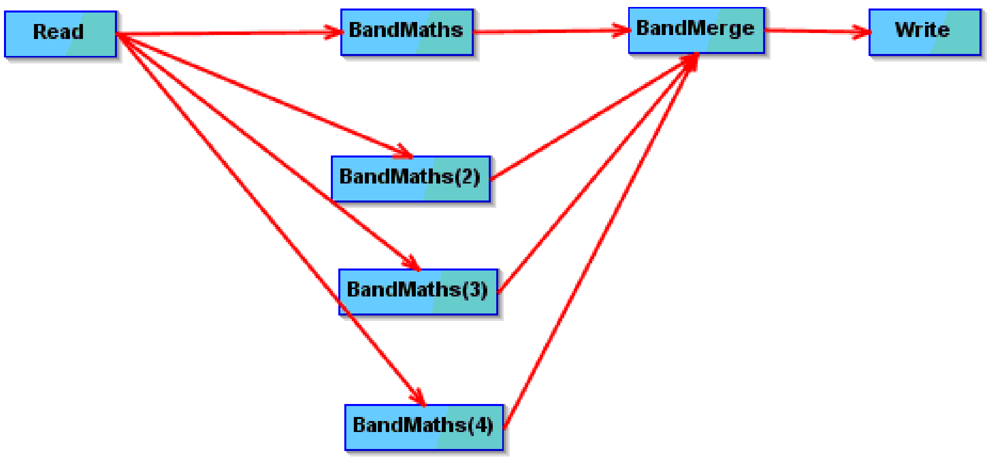

Fig.2. Graph Builder -Band Math 1 NDWI (B3-B11)/(B8+B11),
Band Maths2 MNDWI (B3-B11)/(B8+B11), Band Maths3 MNDWI5 (B8-B4)/(B8+B4),
BandMaths4 AWEI B2 + 2.5 * B3 – 1.5 *(B8-B11) – 0.25 * B12

2.4. Results and analyses

After processing the 8 batches of images from point 2.3 coming from the 4 radiometric indices of water we would create threshold values for the pixel to be classified water, pen all bands NDWI, MNDWI, AWEI the threshold will be equal to >=0, in the case of the values of pixels derived from the pixels of the MNDWI+5 index with values below 0 so <=0 represents the surface of the water [6].

In order to see the water fence from 2015-2022, the images will be processed by creating a new *Graph Builder* graphic, where we will extract based on the pixel values coming from all four water indices *NDWI*, *MNDWI*, *MNDWI+5*, *AWEI*, in the processing of the graph, the if *relationship is introduced (MNDWI>=0 or NDWI>=0 or*

MNDWI5<=0 or AWEI>=0) then 1 else 0 [6], this method will create a single strip that will contain only the surface of the water.

After this method of extracting information on the water area, in Figure 3 are presented the water masks for the periods of time 08.08.2015-22.11.2022.

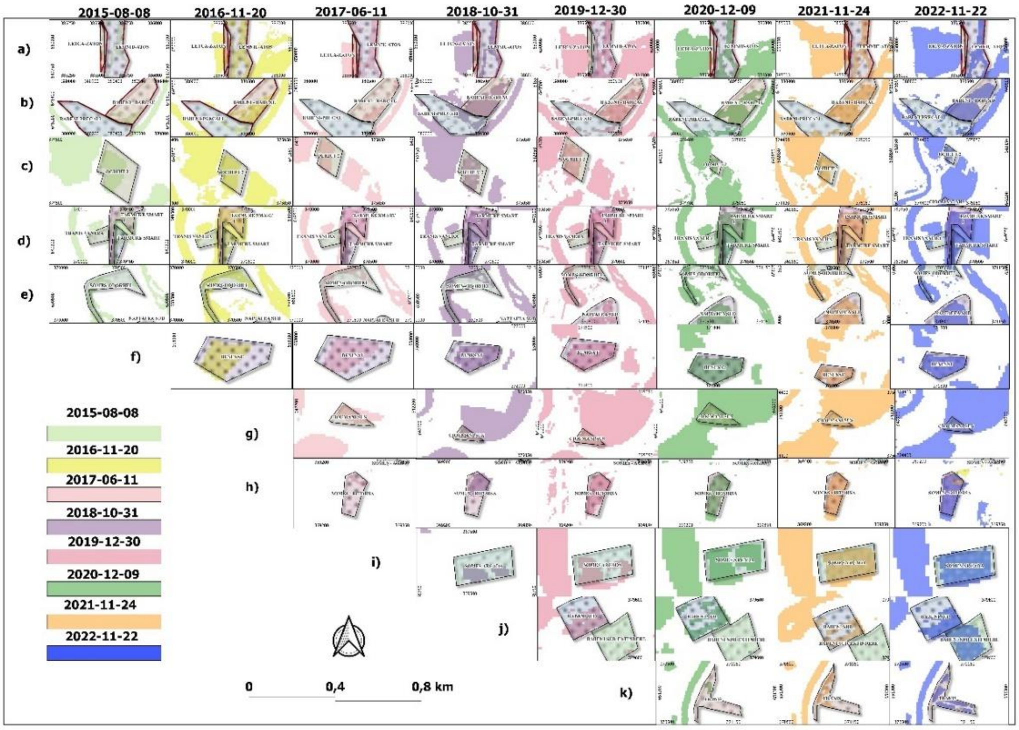

Fig.3. Mining perimeters of gravel pits superimposed on water masks for the period 2015-2022, maps made with open-source software QGIS Desktop

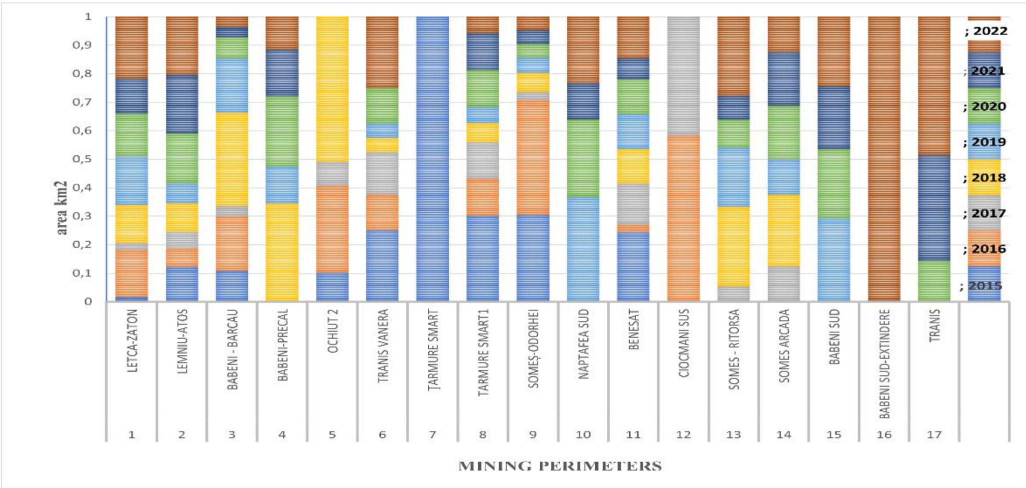

Fig.4. Changes in water surfaces by sand and gravel extraction of gravel pits for the period 2015-2022

In order to observe the evolution of the quarryings in figure 3, the ESRI shp files of the mining perimeters are imported over the geoTIFF water mask into the QGIS software in order to be able to visualize the dynamics of the mineral aggregate exploitations of the ballasts in the period 2015-2022 highlighted by colors and the extension of these perimeters outside the areas regulated by the environmental authorizations. Also through QGIS software, the water areas were extracted by converting raster files to vector format, figure 4 highlights the areas of the authorized mining perimeters.

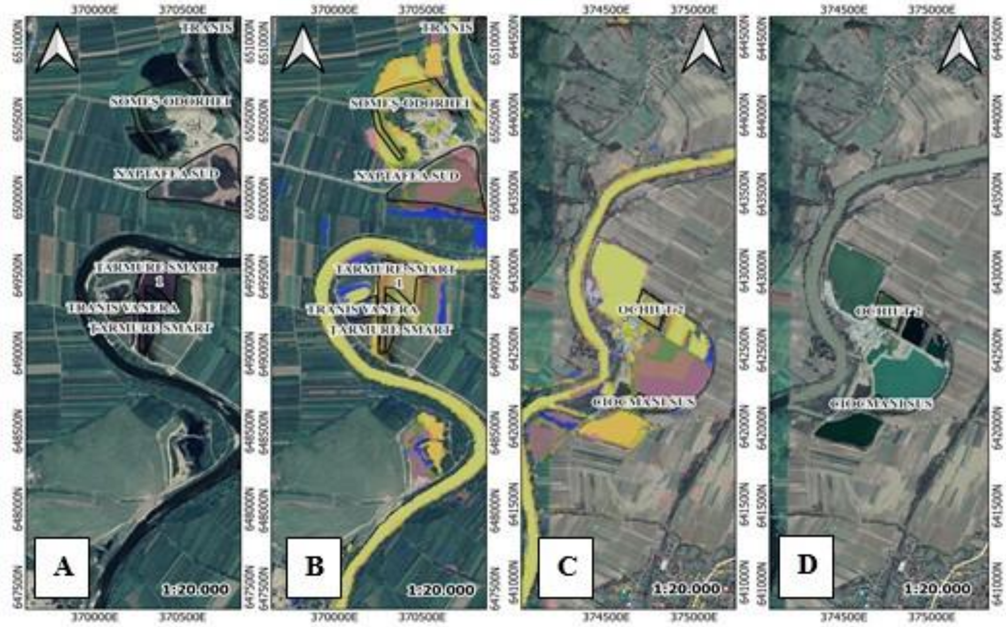

Fig.5. The dynamics of gravel quarrying. sand and ballast of the ballasts in the period 2015-2022 highlighted by colors, the black outline represents the authorized mining perimeter, Google Earth overview

In the overall picture from Figure 5 you can see the evolution (A, B, C, D) of exploitation in gravel pits , colors are represented by the water known between 2015-2022 , these perimeters superimposed on the satellite images show that the vast majority of mining perimeters do not comply with the exploitation surfaces and the correct positioning in the field of the coordinates in the mining perimeter sheet and in environmental permits issued by the Environmental Protection Agency of Sălaj County.

In order to compare the analyzed satellite data with those from the tern, we made topographical measurements determined through the National Geodetic Network, by GNSS technology [27], using the RTK method [27], for the mining perimeters of the gravel pits: Băbeni Sud-extindere, Băbeni-Sud, Traniș Vanera, Țărmure Smart, Țărmure Smart described in Figure 6.

The topographic measurements were made on 19.01.2023, and the satellite image Sentinel 2 S2B_MSIL1C was collected on 23.01.2023

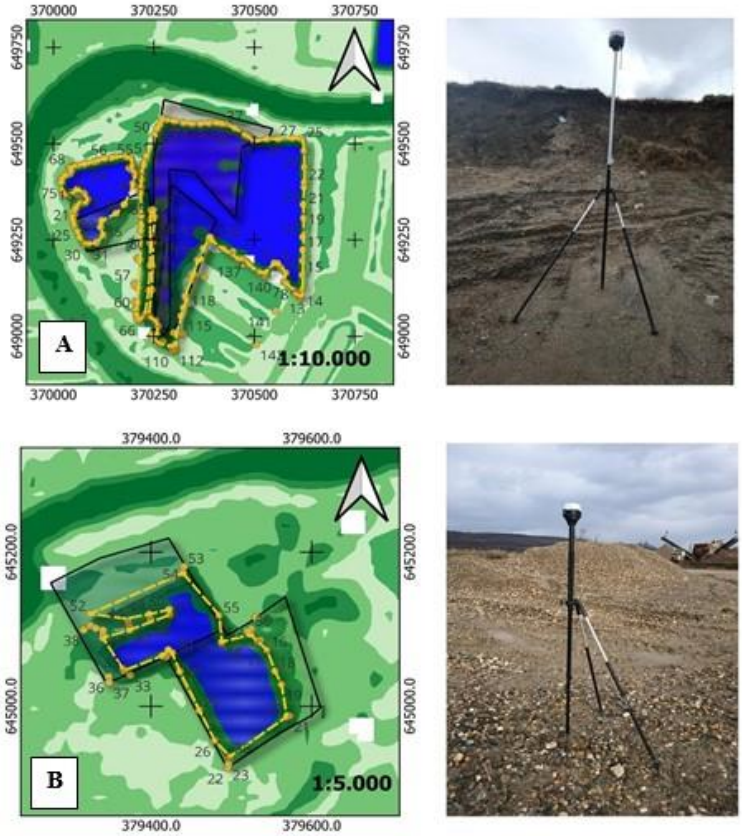

Fig. 6. A, B the dynamics of gravel quarrying. sand and ballast of gravel pits, yellow outline topographic measurements, black outline studied mining perimeters superimposed on the image NDWI (Normalized Difference Water Index) period 19.-23.01.2023

After processing the topographic measurements and the satellite image, it was found that the accuracy rate is quite high by comparing the satellite measurements with those in the field, in Figure 7 the mapped surfaces of the mining perimeters studied out of 19 are described. -23.01. 2023, and in Figure 6 are represented by the blue color the extras water contour based on the pixel values coming from the calculation of the NDWI water indices [6], yellow outline represents the topographical measurements, and the black contour represents the authorized mining perimeter.

STUDIED SURFACES	UM	MINING PERIMETER NAME		
		TRANIS VANERA	BABENI SUD - BEBENI SUD EXTINDERE	TARMURE-SMART TARMURE-SMART 1
SURFACE WATER MASK	km^2	0.031	0.024	0.15
SURFACE FROM TOPOGRAPH SURFACE FROM TOPOGRAPHIC MEASUREMENTS	km^2	0.03	0.02	0.16
AUTHORIZED MINING PERIMETER SURFACE	km^2	0.02	0.05	0.09

Fig.7. Mapped surfaces of the mining perimeters studied from 19-23.01.2023

Comparing the overall images A and B, in Figure 6, it can be clearly seen that the mining perimeters studied from the image A, *Traniş Vanera, Țărmure Smart* and *Țărmure Smart 1* do not comply with the exploitation in the authorized mining perimeter and in the immediate vicinity of the perimeter *Țărmure Smart* and *Țărmure Smart 1* an unauthorized exploited area of approximately 0.065 km^2 has been identified.

For the perimeter of *Băbeni Sud-extindere* and *Băbeni* in image B it can be seen that the exploitation was carried out in the authorized perimeter.

3. CONCLUSIONS

This approach to monitoring satellite remote sensing mining using Sentinel 2 multispectral images has helped me detect illegal mining areas on a larger scale.

As shown in Figures 3, 5 and 6, it can be seen by color changes made to the mining perimeters for the period of time 2015-2022, most water bodies were detected in the vicinity of regulated perimeters that come from extractions of sand, gravel and ballast.

In order to have a certainty of the facts, periodic topographic measurements are mandatory in order to be able to compare the data in the field with those in the satellites.

Geo-spatial information collected from the field but also scriptic information is important to be able to create a database and digital maps.

In conclusion, this study managed to combine the notions of remote sensing with those in the topography and with GIS geographic information systems that could be an example of implementation for inspection and control authorities as well as regulatory authorities in order to be able to bring the reality on the ground.

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BRIEF REVIEW OF MINING PRESSURE AND ITS MANIFESTATION REGIME IN UNDERGROUND MINING WORKS

MIHAELA TODERAȘ[1]

Abstract: *This review paper presents an analysis of the research possibilities of the regime of manifestation for mining pressure in mining works and highlights the factors affecting mining pressure depends. Experimental research, both in situ and in the laboratory, allows obtaining the cumulative effect of all determining factors, without the possibility of separating their effects. Due to this, but also since mining develops in different geomechanical conditions, specific to each deposit or even part of the deposit, the problem of ensuring the stability by evaluating the pressure manifestation regime has a local aspect. The results of these researches can be used in order to: improve the existing support monographs, by choosing the optimal support density; establish a correct support technology; establish the appropriate difference between the digging front and support front, etc.; design new types of support; assess the effectiveness of the new support technologies in the given geomechanical conditions; optimize supporting monographs which must be analyzed from the point of view of maximum satisfaction of the required conditions on the work by its role in the production process, throughout its existence, with minimal execution, maintenance and exploitation expenses and in perfect conditions of work safety. For this purpose, the measurement methods and equipment must focus on determining: the movement of the surrounding rocks; the deformations of the underground work profile; the displacements and deformations of the support system and the loads on the support.*

Keywords: *mining pressure, rock massif, underground work, depth, support, stability, deformations, research directions.*

1. INTRODUCTION

The objective and primary information about the laws that can characterize the rock massif from a geomechanical point of view, which governs its behavior, which reproduce qualitatively and quantitatively the mode of deformation of the rock massif, which elucidates the manifestation of the pressure regime in all its hypostases, and further both for creation the possibilities for improvement and development of new methods for the specified purpose, as well as for finding the means to ensure the stability of mining works corresponding to the level of technical and scientific development, can be obtained only on the basis of complex research in laboratory and in situ conditions and finally combined with analytical research [2, 7, 20, 24, 34, 39, 44, 45, 46, 478, 57,

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60, 66, 67, 68]. Concerning the possibilities, experimental research methodologies applied in the laboratory and in situ, but also regarding the equipment used in this regard, the specialized literature provides a lot of information [2, 12, 16, 17, 22, 24, 35, 62, 67].

In the case of an undisturbed rock massif by underground works, according to the hypotheses of Heim, Kuhn-Terzaghi, Fener, Dinik and others, as a result of an external force (self-weight of the overlying rock masses) a stress-deformation state prevails. This stress state is known as lithostatic pressure or rock pressure.

If, however, in the relative rock formation an underground work is performed, the labile equilibrium of the massif is disturbed, the stress state around this underground work changes fundamentally, both in size and distribution as compared to the initial state. Depending on the depth at which the underground work is located, the shape and dimensions of the cross-section, the physical-mechanical, elastic and rheological characteristics of the massif, as well as other factors (those which contribute to the stability of an underground excavation) [3, 23, 25, 31, 39, 41, 49, 56, 57, 58, 59, 60] in the surrounding rocks, stresses whose size exceeds several times their initial value, occur. The redistribution to a new equilibrium of this stress state on the outline of the work and towards the massif creates stress concentrations [3, 28, 29, 37, 39, 40, 42, 43, 51, 55, 64, 66, 67, 68, 69].

In the roof, walls and bottom of the underground work such a phenomenon will cause deformations, fissures and cracks, which develop in time; as a result, they will lead to the appearance and development of partial detachments, caving or landslides of large masses of rock, all of which tend to reduce the outline of the underground work and in time to destroy it.

Such a manifestation of the forces generated by the redistribution of the initial stress state was called primary lithostatic pressure [23, 25, 43, 47, 52, 56, 60, 65] during the period immediately following the excavation of the underground work and stabilized lithostatic pressure at a time range after its excavation.

If the new stress state, by its concentrations, exceeds the mechanical strength of the rocks, the massif is cracked and around the underground work, inelastic deformation zones of different shapes are formed (circular, elliptical, irregular in shape); the rocks located in such vaults will exert, by their weight, an active mining pressure, which actually goes through the two mentioned phases: primary and secondary [26, 27, 32, 33, 60].

From the beginning, digging and supporting of the horizontal underground works imposes a seemingly simple problem, namely: how raised is the safety of a sustained or unsupported underground space and what is the criterion of choosing to support these underground works in order to prevent their destruction, due to the disequilibrium of the rock massif?

It is precisely such a disequilibrium that also manifests itself around the underground works that cannot be entirely explained. For this reason, today there is a great divergence regarding the value of the active mining pressure when using the mining works statics, as well as the way of determining this pressure.

2. ACTUAL STAGE OF KNOWLEDGE OF THE MINING PRESSURE REGIME MANIFESTATION ON UNDERGROUND WORKS

The intensity and character of the manifestations of mining pressure depends on natural, technical and technological factors, including: the large diversity of rock types with their various categories; physical properties; geomechanics and geological history of the massif and rocks that compose it; the depth location of mining work; the dimensions and excavation procedures; the bearing capacity and execution technology of the support; the operation time of the underground work; the existence of neighbouring excavations etc.

In the actual stage in the study and prediction of the mining pressure regime of manifestation on the main horizontal mining works, three fundamental research directions can be outlined: analytical, laboratory and in situ, which in fact are mutually interconnected and conditioned. Laboratory research is carried out by modelling the pursued mining phenomenon: the knowledge of the stress states; the states and the deformation and displacement character of the rocks; the study of the active mining pressure manifestations according to the working characteristics of the support. The choice of one or the other of the laboratory methods is made according to the character of the phenomenon or the real given situation, the degree of fidelity and the required rapidity to obtain the results. Thereby, the deformation state of the mining works was tried to be determined by the figurative method, using photographic models as methodologies based on the principles of photogrammetry [11, 14, 15, 31, 32, 33]. The determination of the absolute and active stress state, of the displacements and deformations around the horizontal mining works and implicitly the size of the mining pressure by the modelling on equivalent materials method, is still often used [23, 31, 58, 59, 60, 70]. With regard to this methodology, we can only summarize that in the last decades, there has been an improvement of the modelling, in the sense that through a dimensional analysis the problem is studied in order to determine the number of objective variables that must lead to solving the problem, with the desired accuracy and as close to the real conditions. This seems to have become necessary, because either, an insufficient number of variables were introduced from the beginning, and the end result was mistaken, or too many variables were included and the final result, although correct, contained too many terms to model; this fact made the functional relationship of the model difficult to be investigated and represented [4, 5, 13, 16, 18, 28, 29, 41, 42, 43, 53, 60, 64].

Many researchers, sceptical of the obtained results in the laboratory, have approached the path of in situ experiments, developing in this sense the methodologies and the equipment needed to measure the pressure manifestation regime. If in situ methods, modelling and photoelasticity tend to be the main methods of experimental investigation of stress - deformation states around the horizontal mining works, we can specify that the analytical path is nothing less than the experimental one, because the analytical methods and the numerical processes have experienced an exceptional development [30, 39, 46, 66, 67, 68].

Thus, the actual state of knowledge of the mining pressure regime of manifestation around the main horizontal mining works is mainly tributary on the analytical research path. We note that at present, the mathematical apparatus, with all its obvious possibilities in other technical fields, has started to be used on a larger and more efficient scale to determine the stress – deformation states, the displacement of the rocks and the loads on support of horizontal mining works. For example, based on the geological conditions, a mechanical stress distribution model was established in the pre-working face under the influence of mining pressure; this model was based on the hemispheric stress distribution theory [66]. Knowledge in the field of elastic-plasticity, is used in the study of the failure mechanism of the rocks that are surrounding the underground mining works located at depth; based on the use of artificial neural network prediction model, a rock classification was made and a network model was performed. This model offers the possibility of the correct choice of the support system, so as to reduce the displacements of the top wall [46]. The obtained results showed that with the advance of the working face, the displacement of the surrounding rocks in the section located at a great distance from the working face will gradually decrease, and the rock will be stable.

The field of analytical research includes a very large number of hypotheses, very dispersed regarding the regime of manifestation and determination of mining pressure. We explain such a diversification precisely by their inability to comprehend and highlight simultaneously the whole range of factors that favor the mining pressure manifestation regime. This situation resulted from the fact that each hypothesis was issued, by taking into account a single factor or a group of factors that were of a particular importance in a specific case and in this sense the relative hypothesis becomes valid only for the geological and mining conditions referred to, by the one who created it. Consequently, it seems that we still cannot speak of a general theory of mining pressure, applicable through the particularization of each situation.

Based on the data provided by the specialized literature, within the analytical investigations of the mining pressure manifestation regime around the main horizontal mining works, three main directions are distinguished.

In the first direction are included the researches of the mining pressure and its manifestation regime based on practical data, stability criteria and calculation hypotheses characterized by using approximate technical - engineering computing methods, without highlighting the rock massif – support system interaction phenomenon: the hypotheses of lithostatic pressure; the hypotheses of the equilibrium vault and stability criteria. All these assumptions can be framed within the "force hypotheses" [14, 15, 58, 59, 60], because all consider that the load on support can be assimilated by the weight of the volume of rock contained either within the limits of a column of rock or within the limits of the equilibrium vaults. Within the hypotheses of lithostatic pressure, there are two major groups, namely: hypotheses assuming that the mining pressure is given by the entire rock column to the surface (Tyal, Heim, Bierbaummer, Belov etc.); hypotheses which consider that not the entire rock column creates the pressure on the support (Gon, Sparre, Sulţ, Slesarev and many others). The principle of these hypotheses given by Tyal in 1838, the author of the well-known normal law, considers that mining pressure can be calculated using the simple relationship:

$$p = \gamma_a H \quad [t / m^2] \tag{1}$$

where: γ_a is the apparent weight of the rocks, kg/m^3; H – depth, m.

To this principle, Heim returns in 1905 from the position of restoring the natural stress state, to which many followers joined [32, 33, 58, 59, 60]. In 1913, A. Bierbaummer considers that on the roof of horizontal mining works carried out at greater depths, a mining pressure will act, given only by a part of the weight of the rock column to the surface:

$$p = \gamma_a H k \quad [t/m^2] \quad ; \quad k < 1 \tag{2}$$

Bierbaummer takes a step forward to establish the mining pressure regime by creating the hypothesis group of sliding prisms.

The practical requirement for deep exploitation of the useful mineral substance has led to the confirmation of the invalidity of the relations of form (1) and (2) as general laws for determining the load on the support of the horizontal mining works.

The idea of the vault was expressed by Peroll [58, 60]. According to this group of hypotheses, the load on the support does not depend or depends in a small proportion on the depth. Here are distinguished: the hypotheses of the vault caving that determine the configuration and the dimensions of the volume of rock that separates from the massif and equilibrates on the support (Peroll, Ritter, Enghesser, Comerell, Bierbaummer, Protodiakonov, Brodschi, Kaco, Dinsdale etc.); the pressure vaults hypotheses that analyze the mechanism of formation of vaulted stable openings, subgroup developed by Terzaghi, Haak, Jiliter, Spacheler, Sprut, Kvapil, Ekart, Orlov etc.

The particularity of all hypotheses shown and known is that the pressure on the support is represented as a given static load, which depends neither on the type and construction of the support, how to achieve this support, nor on the interaction between rock and support.

The shown order corresponds only to a certain extent to the hypotheses occurrence chronology and to a known extent, characterizes the evolution of the representation of the rock acting mechanism as an external force on the support of horizontal mining excavations.

Truly, the vault hypotheses were an important step forward, but the development of the science of mining pressure was neither straight nor the alternation of hypotheses so consequent. As an example of the above, it can serve the difference itself that has long existed, regarding the representations about the active mining pressure concerning the horizontal and vertical mining works. However, it is inadmissible that the enumerated hypotheses to be examined at the present time as a chain of rejected scientific wanderings over time. They are also included in our present representations regarding the interaction of rocks with support, as particular cases of such reciprocal interaction. In their time, each of these hypotheses gave and represented some general laws.

Between the hypotheses of force and the second direction of research, there are a number of hypotheses that take an intermediate place; they were expressed based on observations and experiments, assumptions regarding the rocks state mechanism around the horizontal mining works. All these assumptions are only qualitative, so on their basis, the mining pressure cannot be determined, but they have prepared the ground for the further development of the concept of pressure calculation.

The second main direction is based on the use of the deformations hypothesis, founded in 1938 by Fenner, which actually takes into account the phenomenon of rock-support interaction [1, 56, 58, 59, 60]. Based on this hypothesis Fenner says that: „the pressure on the support is the result of the displacement of the rocks along the contour of the horizontal mining works, which at some point come into contact with the support and when an increasing reaction of the support begins to be felt, the state of equilibrium will be restored" [56, 58, 59, 60]. Depending on the construction of the mining work, the mounting time of the support, the rock-support equilibrium state can be achieved at different sizes of the rock pressure on the support. Adepts of such hypotheses, are: Labasse, von Iterson, F. Mohr, Salustovici, Ruppeneit, Krupenicov, Erşov etc.

Labasse starts from Trometer's observations and acquires Fenner's viewpoint according to which rocks cannot be considered elastic except outside the influence limit of the mining work. In this context he admits that around the horizontal mining work of circular shape three zones are formed: the area with strongly fissured and even loose rocks; the supporting area and the transition zone to the stress state of the intact massif. These three areas do not have a static character, but evolve in close connection with each other, but also with the support of the underground work. The shape of these areas is assumed to be circular and the pressure uniform. However, with all the simplifications that Labasse has made, applying this hypothesis is still difficult, because the real equation of the covering surface from which the radius of this area can be deduced, is not known. However, Labasse's hypothesis is complex and includes many real aspects of the regime of manifestation of mining pressure, but it also presents shortcomings, in the sense that: in the assumptions and simplifications made, on the one hand, he characterizes the rock mass only through the angle of internal friction and considers a coefficient of uniform internal relaxation, and on the other hand the simplifications made imply an approximate character of the calculations [58, 59, 60, 61, 64].

Ruppeneit, using the hypothesis of incompressibility in the area of plastic deformations and the condition of continuity of the displacements at the boundary of the elastic-plastic zone, considers that around the horizontal mining works an elliptical shaped zone is formed; for the value of the pressure the author obtains a function that also depends on the contact between the rock and the support. The calculation scheme that is at the base of Ruppeneit's investigations is quite close to reality, but the deduced formulas include a series of physical-mechanical characteristics of rocks whose accurate determination is difficult to achieve. At the same time, in these conditions the influence of time is not taken into account. In the research that the author has continued, it is noted that he tried to take this factor into consideration, but it leads to complications and difficulty in order to apply relationships.

By developing these ideas and taking into account not only qualitatively, but also quantitatively the phenomenon of rock-support interaction, in this stage there is a tendency to abandon the path of hypotheses and to move towards the creation of mathematical models that can reproduce more accurately the complex of rock massif - support system with its inherent anisotropies, heterotropies and the full range of mechanical, elastic and rheological properties of the rock massif and of the support too.

In the last decades, for the study of phenomena, different types of models are used in theoretical research. For the analysis of rock massif - support system interaction, the mechanical model is used as a model, a scheme for designing and calculating the interaction, whose mathematical analysis allows the determination of the quantitative and qualitative parameters of the interaction for each concrete case [4, 5, 8, 26, 27, 37, 42, 50, 51, 56, 58, 59, 60, 61, 66, 67, 68, 69, 70].

Unlike the actual modeling where the outline of the model is regulated by laws of similarity, the choice of the mechanical model presents anyway a number of difficulties. The basic mechanical models regarding the rock massif - support system interaction are: the elastic model; plastic – rigid; elastic – plastic; viscous – elastic; viscous – plastic. The names of the models are conventional, so we will make some clarifications in advance. The mechanical model of interaction is not reduced to a simple modeling of the rock massif, although its physical, mechanical, elastic and rheological features constitute one of the determining systems in choosing the model. One and the same rock massif can be represented by different models, depending on the correlation of the characteristics of the massif with the characteristics of the natural field of stress, the required character of interaction, the type of support and finally depending on the studied problem. Of course, these models mentioned above cannot and should not be considered universally valid. Choosing one or the other of these models or proposing improved mechanical models, I think involves two fundamental issues, namely: in-depth studies on the rock massif and analysis of the possibilities of supporting the mining works (the material of the support, the applicable excavation and support technologies, the purpose or role of the underground works and their duration), which may ultimately determine us to decide on a certain type of model; the second aspect is to ensure such a model, so that in comparison with the others in the existing conditions it is the most rational. This last aspect we called "the action of conducting the interaction".

In the third research direction noted in the development of the analytical study of the mining pressure manifestation regime, this pressure is seen through the prism of loss of rock massif stability, loss accompanied by the change in the shape of the mining work. In this case the hypotheses take into account the critical state of the rock-support system in which the massif loses its stability. In this context, Erjanov recommends that in order to ensure the stability of a mining work it is necessary to mount a support whose reaction is equal to the critical value of the load on the support [14, 15, 18, 19, 21, 60, 61, 64].

From the analysis of these details regarding the current state of knowledge of the mining pressure manifestation regime around the main horizontal mining works and indeed around any horizontal underground work carried out in a rock massif, we can note the following:

Obtaining reliable quantitative results with the help of computational relationships proposed by different researchers is limited to some extent by the impossibility of accurately determining the physical-mechanical and elastic properties of rocks simply and quickly.

We must take into account that in most cases, the obtained results based on the outlined principles are almost always approximate because of the rock massif idealization. Therefore, like other researchers, we propose to consider the anisotropy of massif, because in principle the problem for anisotropic environments differs to some extent from the problem for isotropic ones. A special feature of solving the problem is that it is necessary to take in account the changes in rock properties in different directions [21, 23, 26, 327, 36, 37, 57, 58, 60, 61].

However, with all the difficulties encountered in the analytical research of mining pressure, the practice shows that some of the modern methods of calculation (numerical methods), through their fair use, can be successfully used to create a series of empirical and analytical possibilities that allow obtaining quantitatively and qualitatively good results [6, 9, 10, 13, 38, 53, 54].

We can say, with certainty, that the assumptions in the first direction cannot be used longer to determine the size of the mining pressure. The behaviour of the rock massif can be described, of course with a great degree of approximation, with the hypotheses from the second and third directions of research. If we want higher quality values, then it is necessary to use the mechanical models of analysis of the rock massif - support system interaction [60, 61].

Based on the information given by specialized literature, a synoptic presentation of a classification of the used models by the researchers, in order to obtain information about the rock massif and study of different phenomenon with fundamental implication in ensuring the stability of mining works it was tried, figure 1 [60].

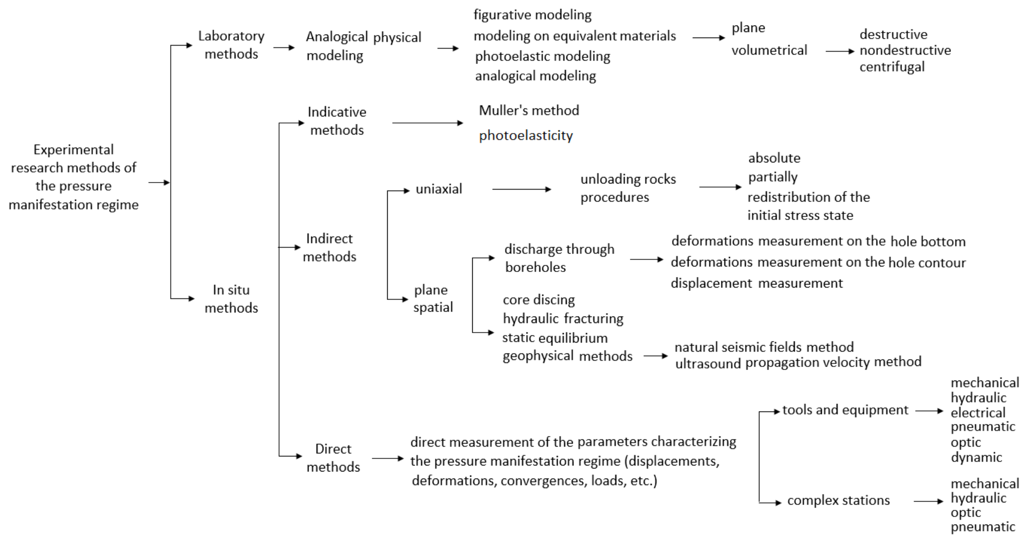

Fig. 1. Synoptic classification of laboratory and in situ research methods of the pressure manifestation regime (according to [60])

3. REQUIRED CRITERIA IN THE IN SITU RESEARCH OF THE PRESSURE MANIFESTATION REGIME

In the process of mining works construction and exploitation, the purpose of the observations and measurements of the mining pressure manifestation and rocks displacement for the monitoring of the mining works state and especially of mining works of major importance in the production activity, is that of control carried out on the correctness of the applied measures, and if their correction is necessary, taking measures in time to ensure stability throughout their entire period of activity, regarding the support computing and others [38, 39, 41, 43, 45, 46, 47, 50, 51, 52, 53, 60, 61, 64, 67, 68, 69]. The tasks of these researches are to establish the quantitative relationships between the parameters of mining pressure manifestation in the carried out mining work and the geomechanical, technical - mining and organizational conditions for its achievement. These researches allow to establish the appropriate empirical relationships, to specify the indicators and computing parameters that must be the basis of the design, to correctly clarify the initial calculation data. The experimental in situ researches (underground or open-pit exploitations) ensure obtaining representative factual material for given conditions, quantitatively more reliable than generalized project data.

The in situ research must be carried out as uniformly as possible to create the possibility of comparing both the measurements carried out within the same mine basin and the measurements carried out in different basins, but which present similar geomechanical characteristics. The use of a unique measurement methodology ensures the correctness of research works so that their application can become useful and effective.

In situ investigations quantitatively and separately assess the effects of the determining factors on the rock zone surrounding the mine workings themselves and on the support system. Such effects are characterized by: degree of rocks cracking, unblocking, rock detachments, caving, stress concentrations, penetrations, convergences, upsetting and bottom or floor swelling, concentrated loads, deformation of the support elements, internal stresses, etc.

In situ research must include the following aspects: visual observations, the simplest measurements of the movements and deformations of rocks and support in the mining work during its digging, support and exploitation; complex instrumental measurements through special measuring stations carried out on displacements, rock deformations, loads on the support and its deformations. In the case of mining works in the exploitation phase, the following are additionally required: the collection of data related to the conditions of mining work support, and to the consumptions necessary for its realization and support; the periodic monitoring of the mining work in order to explain the state of its support, the causes of its damages / disturbances, and also the deformations appearance and development and rocks disturbance around the mining work. In the conditions of the manifestation and influence of the exploitation works (working faces) the researches must be extended not only on the studied mining works and the rock massif areas adjacent to them, but also on the whole massif area which includes the shafts, the main horizontal mining works and which are subject to displacements, deformations under the influence of the exploitation of the useful mineral substance. For the study of such an area, it is useful and efficient to use the mine openings included in the areas, the ventilation and exploitation shafts, and the wells, with the measurement of the vertical and horizontal displacements in different sections.

Both the measurement and results processing methods create the possibility of knowing the degree of dependence between the measured effects as a function of time and the factors that determine them, so that it can be established on which of the factors and in which way to remove or reduce these effects; the appropriate analytical model must be chosen to approach the stability of the mining works within the researched area.

The measurements must be carried out in previously established mining works, in measuring stations located along the gallery at the most representative points from the point of view of the observed phenomenon. Therefore, a first step to carry out the measurements is to establish the places where they will be made, which requires making a certain volume of preliminary visual observations. Through such observations, it is indicated to detect the most important factors whose change or adoption can improve the general state of the phenomenon. The preliminary visual observations must lead to the establishment of the main elements to be pursued by measurements. At the same time, such observations must define, at least qualitatively, the main constructive deficiencies of the studied support system, so that simultaneous with the study of the pressure regime, improved or new experimental support sections can be built, on which the same studies can be carried out. Only the data resulting from the preliminary visual observations give the possibility of correctly establishing the places to carry out measurements. When choosing the place to carry out the measurements, it is necessary to ensure the probity, authenticity and safety of the results, the generalization and elaboration of practical recommendations, for which they must result from chosen places, where: to be able to make qualitative-quantitative observations of the technical-mining situation, of its change in time and space; to be able to install the appropriate equipment for evaluating the mining pressure, rocks displacement and to know the study methods that require to be approached. The choice of the research site must ensure obtaining the minimum and maximum characteristic parameters of the mining pressure manifestation for the mining work. The requirements involved in the study of the geomechanical, technical - mining conditions in the places where the research is carried out consist in the required quantitative connection of these places both within the limits of the controlled mining work area and to the locations of other mining works that influence the area of the massif taking into account by changing their location and dimensions in time and space. All these requirements must be realized through the construction of the cumulative plans of the mining works and the characteristic sections with the indication on them of all the changes in the technical-mining situation during the entire operation period of the mining work.

The geomechanical characterization of the rock massif around the mining works must be based on the existing data, and in the situation when such data do not exist or are extremely limited, it is necessary to include their determinations in advance, especially for the established places to carry out in situ research; as a rule, the volume of determinations and properties are established through the contribution of specialized institutes in this sense. There should be no lack of data on the rocks rheological characterization, especially necessary for highlighting the laws of mining pressure manifestation and stability of mining works. Simultaneously with the visual observations to determine the in situ research sites, a theoretical approach to the phenomenon to be researched is required, from which, based on a dimensional analysis, the factors and parameters to be followed and established should be specified. Simultaneously with the visual observations to determine the research sites in situ, a theoretical approach to the phenomenon to be researched is required, from which, based on a dimensional analysis, the factors and parameters to be followed and established should be specified.

After establishing the measurement place and the elements that must be followed, we pass to the organization of the measurements. For this purpose, it is necessary to know the geological, geomechanical and mining documentation of the underground work in the measurement places chosen for: appreciation of the geological structure and settlement conditions of the considered area; knowledge of the micro- and macro-petrographic characteristics of the surrounding rocks; the structural-textural appreciation of the rocks (cracking, bedding and their elements), the anisotropy and heterotropy of the massif; knowledge of the geomechanical characteristics of the surrounding rocks.

The methods and technical means of measuring the regime of pressure manifestation are usually chosen differently, depending on the solution of the problem and the research program with reference to the type of mining works (galleries, shafts, faces, rooms, pillars, etc.) and the technical possibility to carry out the measurements in given conditions. In particular, when determining displacements and deformations, the rigidity of the equipment must be minimal and not exceed 5% of the forces that require such manifestations; in such a range it is allowed to change the rigidity of the support or of support-rock system; the measurement of the forces must be done on surfaces with linear dimensions and which do not exceed at least 5 times the maximum dimensions of the structural blocks of the massif; the characteristics of the measuring tools and equipment must be stable (to meet the flameproof conditions as required, namely permissible electrical equipment) during the required period of the measurements.

The measurement method consists of performing at regular intervals the monitoring of the imposed elements by the created program, such as: measuring the sliding (displacement) of the elements of the support system at the joints; measuring the support deformation; measuring convergences and displacements of the contour of the underground work; measuring the deformation of the floors; measuring the swelling of the floors; reading the values recorded by the pressure measuring equipment or by the dynamometric support systems; measuring the resistance of the bottom (its penetration); taking periodical photos, etc. The frequency of the measurements is established according to the rate with which the observed phenomena expand. Such a velocity is dependent on the determining factors involved in the manifestation of the phenomenon. In general, it can be recommended that in the period immediately after the setting of the equipment, the measurements should be made daily, for at least 5 days, in order to verify the functioning of the installed equipment. Further, measurements can be made at intervals of (10 - 30) days. We do not recommend a lower rate, because, due to the in situ conditions, the operation and measuring station state must be checked relatively often in order to be able to carry out the corrections that become necessary.

In the situation where the measurements are made at points located in the area of influence of the faces, the frequency is established according to the face's distance. Thus, at a distance of 100 m from the measuring station to the front line, it is indicated for measurements to be made at least once every 14 days, at distances smaller than 50 m, at least 6 days, and at distances of (-15) m and (+15) m at least once every 2 days. The methods of control measurements and research in the case of a vertical mining work consist of the following: observations and measurements until the digging of the shaft, observations and measurements during the digging of the shaft and during its exploitation.

The forms of support disturbances as well as their character of manifestation in the context of dynamization and non-uniformity of the deformation process determine certain aspects of the support, namely: the microcracks of different orientation that appear in the support, with openings up to 1 mm are grouped according to microcracking systems [28, 29, 36, 61, 64, 69]. Such microcracks have an opening and a distance between them from 1 m to 3 m. They occupy considerable areas disappearing at the transition joints. The appearance of such defects in the structure of the support confirms the beginning of the loss of support stability; the existence of cracks with the size of 1 - 2 cm, differently oriented and of different length (up to 15 - 20 m) appear singularly and quite rarely, they form crack systems. Cracks appearing as a result of compression stresses show shear tracks on the edges. Follow the orientation of the cracks in the thickness of the concrete support is difficult, although the situation of the presence of cracks in the support has a particular importance on the characterization of the losing process of underground works stability; the chippings and falls of the support are the result of the development of the cracking process. Chippings are the result of the occurrence of subsequent relative displacements of the edges of supports in their development. The support loses its bearing capacity. Concrete support pieces fall as a result of shearing or under the action of the support's own weight. The disturbance areas with surfaces of 1 - 5 m2 are oriented towards the crack. The falls are formed in the areas of the intersection of the cracks and the total loss of the bearing capacity of the support. The support can yields on considerable surfaces, up to 20 - 30 m2, being accompanied by the fall of the surrounding rocks. Locally the stratification and splitting of the concrete support is produced in the form of lenses with surfaces of 0.1 - 0.3 m2, but not over the entire thickness. Such a phenomenon reveals the appearance of the limit working conditions of the support. The same working limit state of the support is confirmed by the appearance of the peeling phenomena of the concrete surface, the masonry of the prefabricated blocks, and the stratification of the support surface in the mining works from the plats. The formation of shear steps, sliding of the support confirms the movement of the rocks on the stratification; such a phenomenon, however, is quite rare.

4. CONCLUSIONS

The existing geomechanical situation in the rock massif until its disturbance by the carrying out of the mining works changes considerably during and after their completion. In certain situations, such changes occur so quickly that it becomes impossible to take sufficiently effective measures to remove their unwanted consequences. The actual design of excavations in the rock massif can usually be carried out only on the basis of laboratory data, combined with those resulting from in situ measurements, using the time behavior of the rock massif in the computations. On the other hand, only taking into account all factors in the design ensures its optimization at the current stage, that is, a safe and economical exploitation, the preservation and maintenance of a judicious management of the deposits. At this stage, the art certainty of rock mechanics must intervene, namely: finding the point from which current computing can solve the multitude of problems related to the stability of underground works.

The rock mass (stratified or unstratified) with its inherent geomechanical discontinuities (anisotropic and heterotropic) characterized by certain geomechanical properties and a natural stress state in interaction with the support can be represented in the form of different calculation systems or existing models in the specialized literature. We believe that the problem of establishing the laws of mining pressure manifestation, of the relationships of quantitative assessment of the load on support, is still open.

In order to ensure the stability of underground works by means of their support, it is necessary that the surrounding rock massif and the support system constitute and work as a unitary whole, so that the loads acting on the support system do not depend only on the model of the rock massif, but also by the rock massif - underground work complex (the geometric characteristics of the work, its digging technology with the involved parameters) and the support system, starting with the parameters of the used material, the parameters of the support system, the parameters of the mounting technology and ending with the behavior of the support system during the entire period of ensuring stability.

Once the increase in mining depth, the importance of ensuring the stability of mining works by means of support becomes more and more obvious. At great depths and in the case of rocks of low strength, the surrounding rock pressure increases with depth from the surface, and as a result, in such situations, the maximum use of the load-bearing capacity of the rock massif is required.

All underground mining constructions must be calculated taking into account the possible unfavorable combinations of loads and actions that may occur simultaneously, either during their construction or during their exploitation. In this context, basic and special combinations of loads / actions can be provided with the following specifications: the basic combinations include the forces due to constant and temporary long-term loads and the short-term forces. The constant loads/actions are in turn composed of loads conditioned by the mining pressure, the own mass of the construction, the load given by the buildings and constructions placed above the mining work and by the hydrostatic pressure.

The temporary loads and actions are the consequence of the nearby mass of transport from the surface or underground, the additional pressure when digging with compressed air, from the injection of rock behind the support, the mass of equipment, materials, etc.; the composition of special combinations can include seismic actions, loads that appear as a result of temperature changes, the action of water pressure inside the rock, etc. If underground mining continues to advance to great depths, then of course deep mining will take place in a very challenging environment, which means that in such conditions significant innovative solutions are required and additional safety standards must be implemented.

The main load acting on the mining works is the one conditioned by the mining pressure; in most cases, this determines the dimensions and basic parameters of the support system. The correct and as realistic as possible determination of this parameter is and remains one of the most complex problems of the design and realization of underground mining constructions.

The size of the loads due to the mining pressure can be determined based on the experience of carrying out mining works in similar geomechanical and technical - mining conditions; based on experimental data obtained by in situ measurements; and through theoretical calculations. The way of determining the loads on the support due to the mining pressure, based on the experience obtained through the method of analogy, is widely used in the practice of designing support systems for the main mining works and mine openings from the mines in operation, although the obtained data on this basis do not lead to the most economical solutions.

Even if the most authentic data, related to the calculation of the parameters of the pressure regime, necessary in the design of the procedures for the realization and ensuring the stability of the underground mining works (rocks consolidation, support systems) are obtained on the basis of in situ experimental research and whose obtaining involves a large consumption of work and materials (in the sense that it requires equipment whose installation and use is extremely laborious); the obtained results refer only to the local, given conditions and mostly, these laws cannot be generalized except on the basis of an extremely large volume of experiments.

Today, through the possibilities offered by the computer, the use of mathematical modeling (the finite element method, the boundary element method, and the discrete element method) the experimental analytical method is the only one that offers the possibility of a generalization of the laws that can be the basis of the mining pressure theory. However, the basis for using computers for the specified purpose is the mathematical model which must be sufficiently simple and at the same time reflect the essence of the problem as accurately as possible so that the solutions found with its help have a defined value.

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COMPARATIVE CASE STUDY OF COMPLEX GEOPHYSICAL INVESTIGATIONS IN SLANIC PRAHOVA SALT MINE, ROMANIA

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Abstract: *There were done multiple geophysical investigations in different environmental conditions by calibrating the acquired data with the direct information from geological survey and/or borehole drillings along Romania. In a previous project during 2021, there were used georadar investigations in the salt mine of Slanic Prahova for outlining and positioning of the fractures and intercalations of clay layers. Considering that the georadar is responding to the electromagnetic conductivity of the geological layers, there was proposed to start a pilot project which to overlap a refraction seismic profile along a georadar profile done previously and to analyze/compare the results. The choice of geophysical methods and the work procedure are carried out according to the international standards in force, ASTM D6429-99 "Standard guide for Selecting Surface Geophysical Methods", ASTM D5777-00 "Standard guide for Using the Seismic Refraction Method for Subsurface Investigation, ASTM 6432-99 "Standard Guide for Using the Surface Ground Penetrating Radar Method for Subsurface Investigation", STAS 1242/7-84 "Geophysical research of the land by seismic methods".*

Keywords: *seismic investigations, geophysics, georadar, seismic refraction, applied geophysics, salt mine.*

1. INTRODUCTION

The salt deposit from Slanic Prahova chosen for this project has a lenticular shape, having a length of 2,7km on north-south direction and a width between 800 and 2300m, with a maximum thickness of 499m. The stratigraphy of the salt deposit fits between Paleogen and Cuaternar interval [3], [4], [5].

The Paleogen is represented by the following stratigraphic periods:

the Eocen formed of clailey - sandy and marls with globigerinas deposits (Plopu strata) and schistose – sandy deposits (Colti facies).

The Oligocen wasn't intercepted in boreholes in the Slanic area;

The transition series is found at the limit between Oligocen and Miocen (Paleogen and Neogen):

Slon's breccia horizon formed from red senonian marls and eocen sandstones and limestones;

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Lower gypsum horizon is found over oligocen deposits (Slon's facies) or over eocen deposits on the norther part of the Slanic syncline, and over upper oligocen deposits on the southern part of the Slanic syncline. This formation is represented by massive gypsum with clay shists intercalations.

The Miocen formations are the core of the Slanic syncline and are divided in:

Lower Burdigalian (Eggenburgian) by Cornu strata. These deposits are discordant over lower gypsum horizon, or over Slon's breccia;

Upper Burdigalian (Helvetian, Ottnangian Carpatian) is strating with Brebu conglomerates that are discordant over lower Burdigalian. The upper Burdigalian is formed of three lithological complexes:

Lower complex is starting with conglomerates, pebble and conglomerates, having a variation of seizes between 0,06 – 1,50m. Gradually the conglomerates become thinner, passing to a fine fraction, more sandy-marly.

Middle complex is formed of marls, tuffs, gypsum and sandstones and have bentonite intercalations.

Upper complex is formed of pelitic deposits with a thickness of 250-500m, made of sandstones and marls (the first 150m), followed by gypsum marls (about 270m thick). The upper complex is ending with a red marls level with sand intercalations.

The Badenian is formed of the following intervals: zeolitic tuffs and marls with globigerinas, salt and gypsum (upper salty formation), and marls with spiriallis.

Zeolitic tuffs and marls with globigerinas interval has three levels:

Lower interval formed of whitish green dacitic tuffs;

Middle interval with whitish green tuffs and marls with globigerinas;

Upper interval light green tuff.

Upper salty formation (gypsum and salt sequence) with two lithological facieses: one fluvial – marine, and one lagoonal.

Marls with globigerinas sequence that cover the salt deposit is named also the salt breccia. This lithological sequence is massive and can be covered with other breccia formations (Cosminele and Pietraru breccia). This sequence contains lenticular gypsum intercalations. Marls with Spiriallis sequence formed of marls with thin sandstones intercalations.

The Pliocen interval is very narrow developed being represented by yellowish green sands with gray calcareous sandstones. The Cuaternar interval is discordant over older formations being represented by terrace, alluvionar, diluvial and sol deposits.

From the tectonic point of view, the geological formations are included in a miocen syncline. The lower and middle miocen formations are framed between two major faults: Audia and Cosminele. The maximum development of the Slanic deposits is along the Slanic valley to Bertea and Varbilau valleys (west), and Prajani and Bughea valley (est). The maximum development of the salt formation can be found only in the Slanic valley, and possible to Prajani and Bughea valleys. The salt that occurs in the midle of the syncline is intensively folded caused by the pressure from the Homoraciu direction. In the northern central area of the deposit, the salt presents a weak diapiric tendency by penetrating upper badenian deposits.

The main types of rocks that appear in the deposit are: salt, volcanic tuffs, clays, marls and sandstones. The salt deposit is presented in the form of stratiform deposits of white colour, alternating with bands of grey salt. The color change indicates the change in the precipitation conditions, both due to climatic variations and the terrigen input, more or less abundant.

The excavation works indicate a lamination of the salt massif towards its edges, also presenting marl-clay interstratifications, especially at the salt-sterile contact. From a petrographic point of view, salt is presented in the form of an aggregate of crystals.

Microscopically, salt has the following minerals in its composition: halite and, in reduced proportions, anhydrite, gypsum, clay minerals, organic substances, etc.

Volcanic tuffs appear in the bed of the salt deposit, composed of the horizon of tuffs and marls with globigerina and in the roof of the salt massif, within the horizon of schists with radiolarians, in the form of thin banks interspersed between sands and gypsum.

From the point of view of the chemical composition, the contents of the following elements were determined from the samples taken from the research drillings and from the mining works: $NaCl$, KCl, $CaCl_2$, $MgCl_2$, Na_2SO_4, K_2SO_4, $MgSO_4$, Fe_2O_3 insoluble in H_2O and insoluble in HCl.

The salt exploitation started to the lower horizon (number XIV) that is locating to the altitude of +145m (reference level Black Sea), and depth of approximately 250m from the ground level. According to the last finite element modelling [4] “the corresponding decrease in the safety coefficient, at least at the level of the outer surface of the pillars - thus worsening the stability conditions of the supporting structures” for the exploitation horizons bellow +129m.

Considering the decreasing of calculated safety factors and the salts deposit behaviour, we considered the application of geophysical methods in understanding the behaviour of in situ salt deposits. Thus, we chose two complementary geophysical techniques: georadar and refraction seismic.

2. GEOPHYSICAL METHODS

2.1. Seismic method

Geophysics studies the behavior of waves propagating inside materials. A seismic signal changes according to the characteristics of the medium it travels through. Waves can be generated artificially with a battering ram, hammer, etc. The seismic signal can be decomposed into several phases, each of which identifies the movement of particles driven by seismic waves. The phases can be:

P-Longitudinal: compression depth wave;

S-Transverse: shear depth wave;

L-Love: surface waves composed of P and S waves;

R-Rayleigh: Surface wave composed of elliptical and retrograde motion;

Rayleigh waves – “R”.

In the past, studies on seismic wave propagation focused on the propagation of depth waves (P, S) considering surface waves as a "noise" of the seismic signal to be analyzed. However, recent studies have allowed the creation of advanced mathematical models for the analysis of surface waves in media with different stiffnesses.

For this project, a SYSMATRACK Seismograph equipment with 2 channels and 24 4.5Hz geophones and 10Hz trigger was used. The seismic source used was an 8kg seismic hammer.

Signal analysis using the MASW technique:

According to the fundamental hypothesis of linear physics (Fourier's Theorem) signals can be represented as the sum of independent signals, called harmonics of the signal. These harmonics, for one-dimensional analyses, are sine and cosine trigonometric functions, and behave independently without interacting with each other. Focusing our attention on each harmonic component, the final result in the linear analysis is equivalent to the sum of the partial behaviors corresponding to the individual harmonics. Fourier analysis (FFT spectral analysis) is the fundamental tool for spectral characterization of the signal. The analysis of Rayleigh waves, by means of the MASW method, is carried out by the spectral processing of the signal in the transformed domain where it is possible, in an easy way, to identify the signal relative to Rayleigh waves compared to other types of signals, noting, moreover, that the speed with which Rayleigh waves propagate is a function of frequency. The speed-frequency relationship is given by the dispersion spectrum. The dispersion curve identified in the f-k domain is called the experimental dispersion curve and represents the maximum amplitudes of the spectrum in the given domain.

Data processing

Starting from a synthetic geotechnical model characterized by thickness, density, Poisson's ratio, S-wave speed and P-wave speed, it is possible to simulate the theoretical dispersion curve that connects speed and wave length according to the relationship:

$$v = \lambda \times v \quad (1)$$

By changing the parameters of the synthetic geotechnical model, an overlap of the theoretical dispersion curve with the experimental one can be obtained: this phase, called inversion, allows the determination of the velocity profile in environments with different stiffness.

Modes of vibration

Both in the theoretical and in the experimental inversion curve, the various configurations of ground vibrations can be identified. The modes for Rayleigh waves can be: deformations in contact with air, nearly zero deformations at mid-wavelength, and zero deformations at high depths.

Depth of investigation

Rayleigh waves decay at a depth approximately equal to the wavelength. Short wavelengths (high frequencies) allow the survey of shallow areas, while long wavelengths (low frequencies) allow surveys at great depths.

Seismic refraction studies allow the interpretation of the subsurface stratigraphy through the physical principle of the refraction of the incident seismic wave on a discontinuity, detected between two bodies with different mechanical properties (refraction horizon).

Table 1. Vp-Vs velocities of the main sedimentary rock types according to Geol 615: Geostatistics – University of Mississippi [9].

Type of rock	P waves velocity (Vp) – m/sec	S waves velocity (Vs) – m/sec
limestones	2500 - 6000	3100
sandstones	1400 - 4000	2400
gravel, sand	400 - 2300	80 - 880
clay	200 - 2200	100 - 1500
soil	100 - 500	50 - 180
Slanic Prahova salt[1]	4110 - 4215	-

[1] according to Slănic Prahova documents

The basic requirement for conducting seismic refraction studies is one for which the succession of layers to be investigated is characterized by an increase in seismic velocity with increasing depth. In this way, up to 4 or 5 different refraction horizons can be analyzed. The processed seismic data resulting from the survey, it will be compared with Vp-Vs velocities of the main sedimentary rock types according to the Geostatistics – University of Mississippi (Table 1) and with regional or local geological data.

Surveys are based on the measurement of elastic wave travel times for which, assuming extended discontinuity surfaces compared to the wavelength or, at any rate, with weak curvature, the wavefronts are represented by relative seismic waves. The analysis is based on Fermat's principle and Snell's law.

Fermat's principle states that the wave travels the distance between the seismic source and the receiver following the minimum propagation time. Given a plane separating two media with different elastic properties, the seismic wave is the one that propagates along a plane perpendicular to the discontinuity containing both source and receiver.

Snell's law is a formula that describes the refraction modes of a seismic wave in the transition between two media characterized by different wave speeds or, equivalently, by different refractive indices. The angle formed between the surface of the discontinuity and the seismic ray is called the angle of incidence θi while that formed between the refracted ray and the surface normal is called the angle of refraction θr. The mathematical formula is:

$$v_2 \sin \theta_i = v_1 \sin \theta_r \tag{2}$$

where v_1 and v_2 are the velocities of the two media separated by the surface of the discontinuity.

2.2. Georadar method

Georadar GPR prospecting, along with magnetometric, electrometric, electromagnetic induction prospecting, is one of the newest geophysical techniques widely used. This method is based on the reflection of radar waves by geological buried structures, pipelines, pipes, concrete, asphalt, material differences, etc. The dielectric constanta is chosen according to the internal Prism software list or according to the https://www.engineeringtoolbox.com/relative-permittivity-d_1660.html website [7]. GPR georadar prospecting enables the identification of underground structures with an unparalleled spatial resolution. Georadar is capable of detecting a wide range of buried structures: geological layer boundaries, walls, floors, ditches, voids, pipes, foundations, archaeological sites, etc. Georadar measurements are also used for paved surfaces (floor, asphalt, concrete).

Its physical principle is to send a pulse of electromagnetic energy into the ground to the material to be inspected, and the equipment records the resulting response. After receiving the signal, the software allows the interpretation of the obtained data, which makes the analysis in real time, even in 3D format. It is applied to concrete structures, pipelines or underground elements with applications for roads and bridges, measurement of asphalt and concrete layers, serving as the main tool for geological, geophysical, geotechnical and archaeological investigations.

The georadar results are more calitative being used in spatial positioning of different underground structures.

3. Field data acquisition

The field data acquisition was done in two different periods: georadar survey in december 2021 and seismic survey in June 2022 [6],[8]. Both surveys are measured along the acces galery of the XIV floor from the Slanic Prahova salt mine. The profiles are overlapped according to figure 1 such as the results can me compared further on.

The location of seismic acquisition was chosen along the stall road of XIV horizon where there is a sudden hump in its floor and the roof. We wanted to see if there is a fault along the salt deposit or other local structure using both data presented in this project.

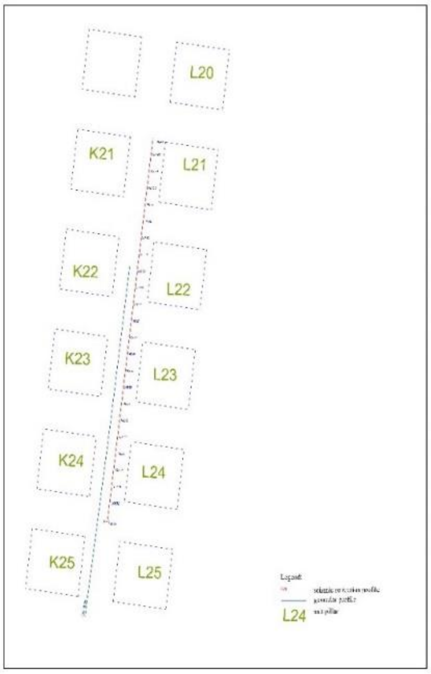

Fig. 1. Seismic and georadar profiles positioning

Seismic data acquisition was done using the following configuration [8]:

Number of geophones: 24 (fixed range)
Distance between geophones: 5.00m
Investigation depth: 30m
Orientation: S-N
Number of Stations: 1 (24 geophones/Station)
Source type: hammer, 8kg
Distance between sources: 70m
Number of sources: 3
Sampling interval: 0.000133 s
Recording length: 0.681s

Technical details of the georadar Zond 12-3 advanced system equipment:

Number of channels: 2
Time window: 1 to 2000 ns with 1 ns sampling step.
Repetition pulse frequency: 115 KHz
Scan rate: 320/160/80/40 scan per second
Measurements per second: 128/256/512/1024 x 16 bit
Live selectable filters: Weak, Strong, Super strong, or custom
Data transmission: Wi-Fi or Ethernet to PC Power: 10.5-13 V DC 0.6 A (rechargeable batteries)
For this study, georadar antennas with a central frequency of 75MHz.

The georadar acquisition have been done using the following parameters [8]:

Medium: Dry salt, 6
Samples: 1024
Software Stacking: 1
Sounding mode: Continuous
Channels mode: Tx-Ch1, Rx-Ch2
Antenna: 75 MHz dipole
High-pass filter: Super Strong
Pulse delay: 192
Gain: Points quantity 2 (dB/Sample/0/0, 18/1024)
Sounding mode: 800 ns
Positioning: Manual

The first step of the seismic acquision process was to drill small holes in the gallery floor at every 5.00m along a tape measure (fig. 2) to fix the geophones in the salt rock. The process is very important because every geophones must be well rooted to avoid any external noise induced by random movements of them.

The second step was to position precisely every geophones using a total station (fig. 3).

Fig. 2. Drilling the holes in the gallery floor

Fig. 3. Positioning geophones

The third step was the data acqusition that have been done by three shotpoints along the profile: the first one positioned at -10m (the beginning), the second one positioned at the 60m (middle), and the third one at +128m (the end) [8].

The georadar acquisition was made by continuously profiling (positioned as fig. 1) along the gallery floor with an unshielded 75MHz antenna (fig. 4).

Fig. 4. Georadar data acquisition

The georadar acquisition with a 75MHz antena has a general vertical resolution of about 2m therefore, further in the interpretation process, we considered only geololgical structures that have dimensions bigger then 2m [8]. During the acquisition, we measured the distance to the gallery ceiling (about 4.00m) knowing that the data will receive reflections from the surrounding obstacles. The choice of the georadar antenna was made to be able to reach a greater depth of investigation, the XIV horizon being the last excavated horizon.

4. GEOPHYSICAL DATA PROCESSING

4.1. Compressional waves – P – processing

The data processing was carried out with the help of EasyRefract software:

Data import (fig. 5)

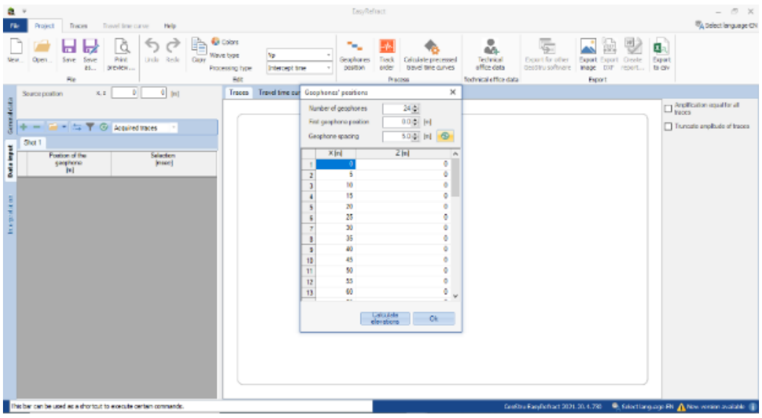

Fig. 5. Loading recordings

Data filtration (fig. 6)

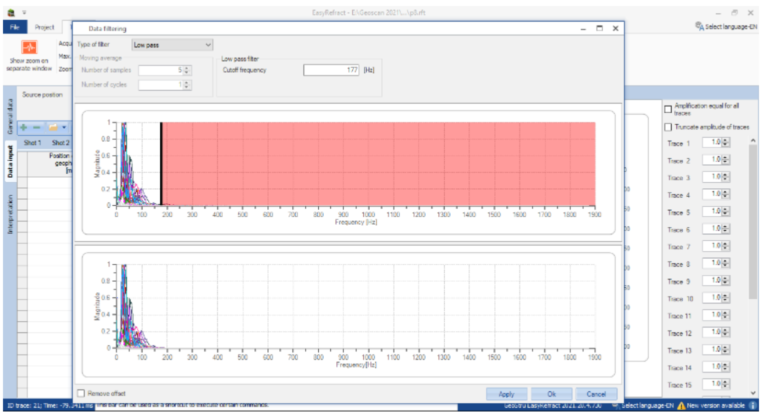

Fig. 6. Filtration process

Choosing the first arrivals (fig. 7)

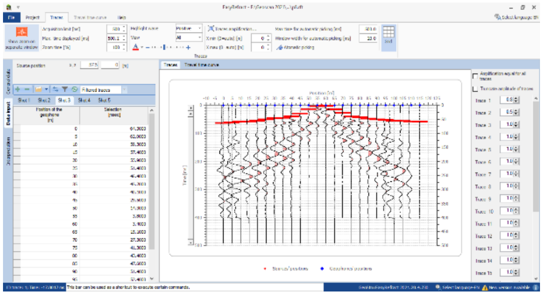

Fig. 7. Choosing the time for the first arrival

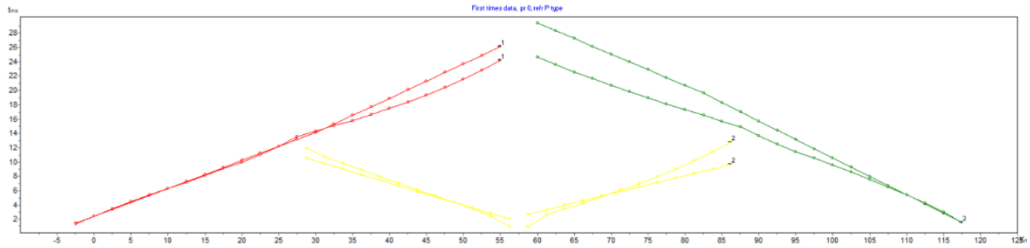

Fig. 8. Calculation of speed curves

4.2. Georadar data

Georadar data were processed and interpretate using Prism software. The georadar data acquisition have been done with the following configuration:

Control Unit: Zond-12e GPR Advanced
Unit Type: DUAL10
Medium: Dry salt, 6
Samples: 1024
Software Stacking: 1
Sounding mode: Continuous
Channels mode: Tx-Ch1, Rx-Ch2
Antenna: 75 MHz dipole
High-pass filter: Super Strong
Pulse delay: 192
Gain: Points quantity 2 (dB/Sample/0/0, 18/1024)
Sounding mode: 800 ns
Positioning: Manual

Before interpreting the results of georadar measurements, the following steps were performed:

- Georadar data filtering;
- Realization of situation plans in UTM coordinates;
- Loading of positioning data into working georadar files;
- Load profiles topography.

The filtering was done by eliminating horizontal banding (background removal tool), eliminating external frequencies (Ormsby bandpass), and horizontal LP-filtering.

5. COMBINED GEOPHYSICAL DATA INTERPRETATION

After data processing of both georadar and seismic data, we obtained a vertical section model for each applied method (refraction seismic and georadar) presented in the fig. 9 [8].

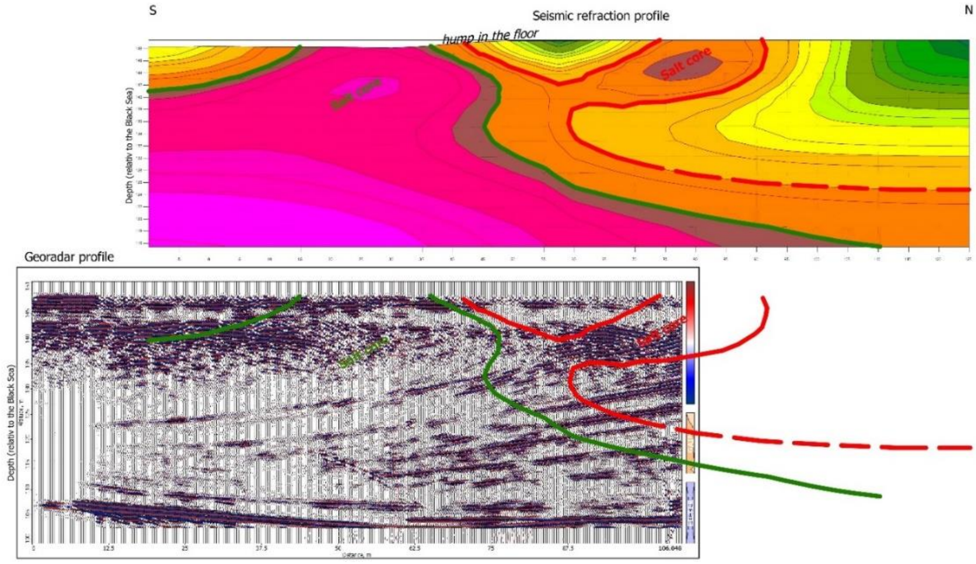

Fig. 9. The gephysical vertical section of both seismic (above) and georadar (below) data

Using the seismic profile we deliniated two salt diapire like structure noted salt core (fig. 9). Both salt structures have a high P waves velocity (the left one 5,2 – 5,9 km/s, and the right one 4,8 - 5,2 km/s) that indicates a high density of both structures and, possible, high tectonical stress [1]. Comparing the obtained P waves velocities with those indicated by internal documentation of Slanic Prahova mine of 4,11 to 4,21 km/s, we observe an excess of the resulting P-wave velocities. This may indicate a concentration of tectonic pressures/stress in these areas, which results in an increasing speed of seismic waves.

Based on the seismic interpretation, we designed the same limits of the salt cores on the georadar profile as seen in the fig. 9. As it can be seen, the georadar waves reflections have a relativ parallel shape along the profile and it does not indicate diapir like structures (salt cores) resulting from seismic measurements. The georadar reflections horizons represent an electric property vertical change (dielectric conductivity) in the salt deposits. Dielectric conductivity varies depending on the type of material and can be influenced by temperature, pressure, and other factor (as humidity). Dielectric conductivity vertical variations can influence the georadar profile view so that this can be a reason for the different images resulting from georadar measurements.

We know that the speed of seismic waves increases in a material that is subjected to increasing stress [1], but we only assume that georadar waves can increase in speed (decrease the dielectric constant) in a material in which increasing pressures appear. Following the results of these measurements, the conclusions are unclear, thus forcing us to plan additional measurements in the future.

The results of the investigations are spectacular, but, considering the existence of only two partially overlapping measurements, it is difficult to draw a revealing conclusion on the results of the two geophysical methods.

6. CONCLUSIONS

The geophysical measurements were carried out in two different stages in the XIV horizon of the Slanic Prahova salt mine: initially the georadar investigations were carried out in December 2021, then the seismic measurements in the form of a pilot project, in June 2022 [8]. The purpose of the seismic investigations was to compare the results with those obtained from georadar measurements from a structural and stratigraphic point of view.

The main interpretation was made on the seismic profile by delineating two adjacent salt cores as in the fig. 9. Then the interpretation was overlapped on the georadar profile to analyze the differences and similarities of the results of the two methods. The results analyzed in this way did not have a clarifying conclusion indicating differences or similarities between the graphic presentation methods of the two methods.

By comparing the seismic wave speeds measured and previously published for the Slanic Prahova salt mine, we observe an increase in the speed of P waves in the area of the XIV horizon, a fact that may indicate an increase in tectonic pressures/stress.

At first sight of the results, the two graphic presentations are different, but, knowing the response of electromagnetic and seismic waves in different materials, the data obtained so far requires further additions of field data and analyses.

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MONITORING INDOOR AIR POLLUTION THROUGH NUMERICAL SIMULATION BY DEVELOPING A COMPUTATIONAL FLUID DYNAMICS MODEL

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Abstract: *The health crisis we have experienced has sharply raised the issue of monitoring indoor air pollution, especially in rooms where people are carrying respiratory viruses. Within this context, this paper aims to present a case study where air patterns are numerically simulated in a two-bed hospital reserve, by using or not a portable air conditioner, by developing a computational fluid dynamics model. The key purpose of the work is to identify the manner the air pattern found in absence of the portable air conditioner gets modified in its presence. Actually, the particular idea is to find the most appropriate bed to host a patient who fortuitously got a flu when staying in the hospital with minimal threat on the health state of the other patient – supposing that the reserve serves for other purposes than treating for transmissible breathing diseases.*

Keywords: *air pollution, simulation, dust generator, HVAC, CFD, experiment*.

1. INTRODUCTION

In the last years, lots of studies related to air pollution were conducted, especially on suspended particulate matter (PM) (for different sizes). A specific direction was set to the indoor air quality (IAQ) control.

IAQ control is found in lots of recent studies [1-16]. Most of the case studies related to indoor air pollution consider commercial or domestic spaces.

Especially because of the health crisis we have experienced, the studies considered healthcare spaces, such as hospital reserves (in clinics or hospitals) [1-16].

This paper presents the results for a comparable case study, in which air patterns are numerically simulated in a two-bed hospital reserve (with or without a portable air conditioner), by developing a computational fluid dynamics model, its key purpose being identifying the manner in which the air pattern found in absence of the portable air conditioner gets modified in the presence of this device.

Such a study is important, as the health crisis we have experienced has sharply raised the issue of monitoring indoor air pollution.

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2. MATERIALS AND METHODS

2.1. Materials

A two-bed room in the City Hospital of Turceni (Gorj County - Romania) was considered for the experiment.

Supplementary, a portable air cleaner (PAC) was used in the room (because the risk of infectious diseases transmission is presumed to be reduced by the use of it) together with the existing downward heating, ventilation and air conditioning (HVAC) [1-17].

A dust generator was used – shown in Figure 1, left up. For dust concentration measurement, a portable device was used (Grimm's Environmental Dust Monitor EDM 107) - presented in Figure 1 (left down). To measure the air velocity (at the PAC opening and for different volume flows at different locations) a portable anemometer (HHF11A) was used - Figure 1 (right) [17].

Fig.1. Equipment used in the experiment: portable dust monitor (left down); dust generator (left up); portable anemometer (right)

In Figure 2 are presented the main components of the ventilation system: PAC, HVAC air intake port and HVAC air exhaust port [17].

Fig.2. Ventilation system components of the hospital room: PAC (left), HVAC air intake port (center), HVAC air exhaust port (right)

The experiment room has 4.6 m length of, 3.8 m width and 3 m height. The calculated room volume (V) is 52.44 m^3.

Two hospital beds (with two bedsides referred to as «bed and bedside no. 1/2»). The dimensions (in meters) of the hospital beds are 1.9 x 0.8 x 0.7 and 0.4 x 0.4 x 0.7 [17].

The hallway door has an area of 2.6 m^2. The total area of the windows is 6.68 m^2. Neither the door or the windows are open during the experiments. The other details of the room present no importance for the conducted experiment.

The considered ventilation system consists of HVAC and PAC (the mixing fans were not considered – they were turned off during the four experiment series; thus, they are not parts of the described ventilation system).

HVAC unit has two ceiling (square shaped) air intake ports (mentioned as AIP – with an effective area of 0.36 m^2 for each AIP) and two floor-level (square shaped) air exhaust ports (mentioned as AEP, with an effective area of 0.16 m^2). The HVAC effective air exchange rate was set at 7 h^{-1} (during the experiment).

PAC has the following dimensions (in meters) 0.4 x 0.4 x 0.6. It exhibits also an opening of 0.0497 m^2 (on its top) for the outlet clean air. The polluted air intake enters through a curved surface located at floor-level. Six fan speeds (manually selectable) are available for PAC (HealthPro Compact device).

The ventilation properties of PAC are given in Table 1.

Table 1. Ventilation properties of PAC (where n stands for the selected air delivery speed)

n	CADR (cfm)	CADR (m^3/min)	CADR (m^3/s)	CADR (m^3/h)	S (m^2)	$v_{m,calcd.}$ (m/s)	V (m^3)	Eff. AER (h^{-1})
1	45	1.27665	0.0212	76.599	0.0497	0.428	52.44	1.4607
2	75	2.12775	0.0354	127.665		0.714		2.4345
3	115	3.26255	0.0543	195.753		1.095		3.7329
4	150	4.25550	0.0709	255.330		1.427		4.8690
5	180	5.10660	0.0851	306.396		1.713		5.8428
6	240	6.80880	0.1134	408.528		2.284		7.7904

The theoretical effective air exchange rate (AER) represents the quotient of clean air delivery rate (CADR) – indicated by the supplier – and the experimental room volume (V); also, the medium velocity of air particles, calculated at the PAC opening ($v_{m,calcd.}$) results from dividing the CADR value to the opening area [17].

2.2. Methods

In the beginning, we managed to produce a uniform concentration of particles in the room (using the dust generator presented left up in Figure 1 and two mixing fans).

Then, the mass concentration was measured for different sizes of PM at different locations, in order to get input data required for mathematical modelling.

The PM concentration were measured outdoor and indoor (background). The mass concentration was monitored for four fractions (of the air pollutant), related to the particulate size:

PM_1 – PM having the diameter of 1 micron or less;

$PM_{2.5}$ – PM having the diameter of 2.5 microns or less;
PM_{10} – PM having the diameter of 10 microns or less;
PM_{30} – PM having the diameter of 30 microns or less.

There is a size ranges overlap (PM_{30} includes PM_{10}, which includes $PM_{2.5}$, this one including also PM_1). Four experiment series were performed.

The HVAC unit or the PAC unit were not turned on when performing the first experiment series and recording the data.

The HVAC unit was turned on but the PAC unit remained turned off when performing the second experiment series and recording the data. The data recorded in the third experiment series, was performed with the PAC unit turned on and HVAC unit turned off. Both the HVAC unit and PAC unit were turned on when recording the data in the fourth experiment series.

To model the air patterns, the obtained data were used in a CFD (Computational Fluid Dynamics) simulation by using the ANSYS Fluent CFD software [17].

CFD represents a computer based mathematical model that uses numerical algorithms to study issues related to a fluid flow (the space occupied by the fluid being divided into a grid).

In order to model the air currents in a room (in this case a hospital room) it was found that ANSYS Fluent software contains all the needed broad physical modelling capabilities. The mathematical equations for the described phenomena will be indicated in the next section.

The removal of almost all of the suspended PM is expected to be performed by the PAC unit, including virus-carrying liquid-droplets that are released by the sick persons when coughing, sneezing or talking. CFD simulation was used to predict the air patterns inside the hospital room. Also, the most appropriate bed (of the two beds) to place a patient with flu was found (when in the respective room are placed patients with some other problems).

A uniform 3D-grid at 0.1 m (containing 52440 cubic unit cells) was used for the CFD simulation. A uniform 2D-grid (corresponding to the horizontal planes) at 0.1 m (containing 1748 square unit cells) is presented in Figure 3.

The median plane perpendicular to the floor was considered (containing AIP centers and AEP centers of HVAC unit). The three reference axis are: x axis (at the intersection of the median plane and the floor), z axis (at the intersection of the median plane and the windows wall) and the y axis (at the intersection of the windows wall and the floor). The center of the orthogonal axes system (having the cartesian coordinates (0, 0, 0)) is represented by the point belonging to all three considered planes [17].

In Table 2 are given the spatial coordinates.

Table 2. The three-dimensional coordinates on the 3D-grid of the most important locations

Location	x values	y values	z values
PAC (clean air outlet)	±0.1	0.4±0.1	0.6
PAC (polluted air intake)	±0.2	0.4±0.2	0.6±0.1
HVAC - air intake ports (AIP)	±0.3	1.2±0.3	3
HVAC - air exhaust ports (AEP)	±0.2	0	0.4
Patient no. 1 (most probably)	1.6±0.3	3±0.3	1±0.3
Patient no. 2 (most probably)	1.6±0.3	0.6±0.3	1±0.3

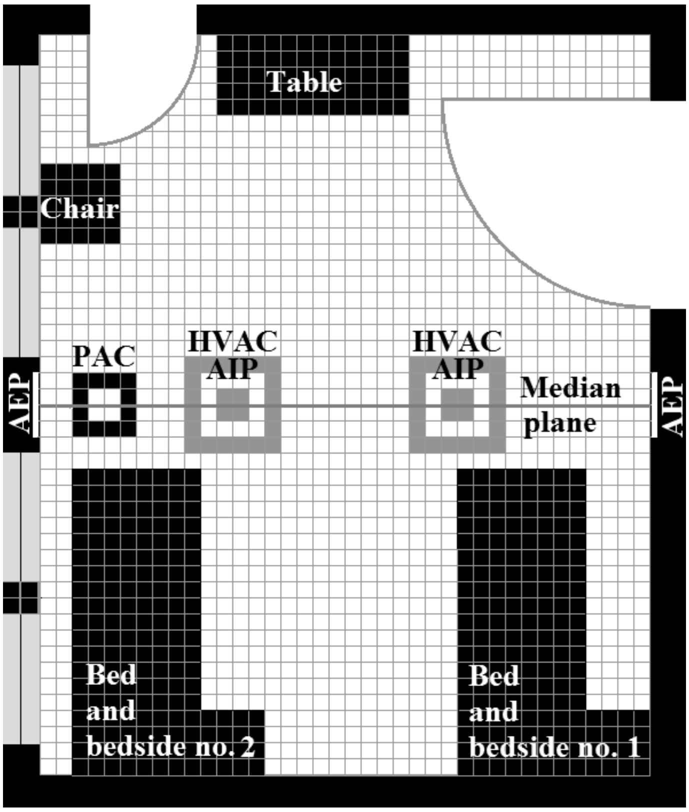

Fig.3. 3D-grid of the room

The value of the average speed in the experiment (resulting from dividing the air rate to the area of each diffuser) was used as the air speed from the supply diffuser.

The value of the outdoor temperature (17°C) was considered the supply air temperature in the experiment series set-up.

The room geometry was previously presented. The walls are assumed to be well isolated and presumed to be adiabatic (in the CFD simulation). A non-slip boundary condition was applied to all elements (the walls, ceiling and floor). The air particles of the indoor air were considered to be well-mixed.

As previously mentioned, the 3D-grid has been set at 0.1 m (consisting of 46 x 38 x 30 cubic unit cells).

3. EQUATIONS AND MATHEMATICS

3.1. Goal and requirements

The main goal of the experiment is to provide input data (*i.e.*, PM mass concentrations at different moments of time) used in the CFD simulation of air patterns. Two cases were considered for the selected hospital room: one was obtained with the downward HVAC system turned on and the second was obtained by using both the HVAC system and the PAC unit [17].

The intention is to compare the two CFD simulations related to air patterns, to establish if adding a PAC unit to the HVAC system has a certain influence, and (if it is found to have an influence) to found the best location in the hospital room (as an effect of adding the PAC to the ventilation system) and to find out that if using the PAC (under the presented conditions) meets the requirements.

To be more specific, there are two requirements in using a PAC unit in case of a downward ventilated room: first, the PAC should exchange all (or almost all) the air in the room (as presented in the Guidelines for Environmental Infection Control in Health-Care Facilities) and second, when the air patterns are important (for example hospital rooms), the PAC should not be able to disturb the existing air pattern generated by using the HVAC system.

At a first analysis, the two previously presented provisions seem to be in opposition: if the PAC can create, in the closed room, an overall air circulation, this will imply the disturbing of the initial air pattern. Also, if a PAC does not disturb the air pattern (initial), it will have no significant influence in exchanging the air (in the respective room).

However, the two requirements can be simultaneously met when the additional device only improves the air pattern of the HVAC (and cannot be considered as “disturbing” it).

This paper presents the PAC placed in the position proved to be the best in the room.

Nevertheless, the results obtained by placing the PAC at different positions (different coordinates on the floor) will be presented further (showing the influences of this position on the air flow pattern and also the identified solution regarding the most appropriate bed - in each case).

3.2. Mathematical modelling used in CFD simulation

In numerical analysis, differential equations are often used in case of particles within the indoor air (considering the well-mixed condition of particles) [17].

First an examination of the physical quantities is performed together with the measuring units.

The PM mass concentration (expressed in mass per volume units), is further denoted as $[PM](t)$ (as its variation in time is expressed in mass per volume and per time units). Also, the PM mass variation in time is expressed in mass per time units.

Further, it is obvious that the mass variation of the PM in time (in the studied room) may be determined by multiplying the volume of the room by the mass concentration variation.

Moreover, the mass variation in time can be represented as a balance between the PM «mass gain in time» (denoted as *G)*, and the PM «mass loss in time» (denoted as *L)*.

$$V\frac{\partial}{\partial t}[PM](t) = G - L \quad (1)$$

Also, G (representing the PM «mass gain in time» and expressed in mass per time units), is expressed as:

$$G = Q_{in}[PM]_{in} + (1 - \eta_{HVAC})Q_{HVAC}[PM]_{out} + S \quad (2)$$

where Q_{in} is the PM infiltration into the room (expressed in volume per time units); $[PM]_{in}$ represents the indoor PM mass concentration (expressed in mass per volume units); η_{HVAC} is considered the removal efficiency of entire HVAC system; Q_{HVAC} represents the intake air rate of HVAC (in volume per time units); $[PM]_{out}$ is the outdoor PM mass concentration (expressed in mass per volume units) and S represents the PM «mass gain in time» (expressed in mass per time units) from a source of particles (for example a person which coughs, sneeze or talks during an active flu). Were considered two cases for simulation, by considering the patient in each bed (with the dust generator in use). The PM «mass loss in time» (mass per time units) can be expressed as:

$$L = (Q_{ex} + Q'_{HVAC} + \eta_{PAC}Q_{PAC} + KV)[PM](t) \tag{3}$$

In equation 3, Q_{ex} represents the PM exfiltration (volume per time units) from the room; Q'_{HVAC} represents the HVAC exhaust air rate (expressed in volume per time units); η_{PAC} is the PAC removal efficiency; K represents the PM settling coefficient (expressed in invers of the time units); $[PM](t)$ - already defined.

It can be seen that:

$$Q_{ex} = Q_{in} \tag{4}$$

and:

$$Q_{HVAC} = Q'_{HVAC} \tag{5}$$

From the equations (1), (2) and (3), by considering (4) and (5), it results:

$$V\frac{\partial}{\partial t}[PM](t) = Q_{in}[PM]_{in} + (1-\eta_{HVAC})Q_{HVAC}[PM]_{out} + S - (Q_{in} + Q_{HVAC} + \eta_{PAC}Q_{PAC} + + KV)[PM](t) \tag{6}$$

and the solution of the presented differential equation is:

$$[PM](t) = \frac{Q_{in}[PM]_{in}+(1-\eta_{HVAC})Q_{HVAC}[PM]_{out}+S}{Q_{in}+Q_{HVAC}+\eta_{PAC}Q_{PAC}+KV} + \left([PM](0) - \frac{Q_{in}[PM]_{in}+(1-\eta_{HVAC})Q_{HVAC}[PM]_{out}}{Q_{in}+Q_{HVAC}+\eta_{PAC}Q_{PAC}+KV}\right)e^{at} \tag{7}$$

where a is further defined as:

$$a = \frac{Q_{in}+Q_{HVAC}+\eta_{PAC}Q_{PAC}}{V} + K \tag{8}$$

Equation (6) is the most general and equation (7) represents its solution (where a is defined by using equation (8)).

If one part of the ventilation system is not in function or both parts are off, the presented expressions will simplify. If we consider a situation where PAC is off and HVAC is on, equation (6) will be replaced by (9), (7) – by (10) and (8) – by (11).

$$V\frac{\partial}{\partial t}[PM](t) = Q_{in}[PM]_{in} + (1-\eta_{HVAC})Q_{HVAC}[PM]_{out} + S - (Q_{in} + Q_{HVAC} + KV)[PM](t) \tag{9}$$

The solution is determined as:

$$[PM](t) = \frac{Q_{in}[PM]_{in}+(1-\eta_{HVAC})Q_{HVAC}[PM]_{out}+S}{Q_{in}+Q_{HVAC}+KV} + \left([PM](0) - \frac{Q_{in}[PM]_{in}+(1-\eta_{HVAC})Q_{HVAC}[PM]_{out}}{Q_{in}+Q_{HVAC}+KV}\right)e^{at} \tag{10}$$

and *a* is determined as:

$$a = \frac{Q_{in} + Q_{HVAC}}{V} + K \quad (11)$$

If HVAC is off and PAC is on, equation (6) will be replaced by (12), (7) – by (13) and (8) – by (14).

$$V\frac{\partial}{\partial t}[PM](t) = Q_{in}[PM]_{in} + S - (Q_{in} + \eta_{PAC}Q_{PAC} + KV)[PM](t) \quad (12)$$

Now, the solution is:

$$[PM](t) = \frac{Q_{in}[PM]_{in} + S}{Q_{in} + \eta_{PAC}Q_{PAC} + KV} + \left([PM](0) - \frac{Q_{in}[PM]_{in}}{Q_{in} + \eta_{PAC}Q_{PAC} + KV}\right)e^{at} \quad (13)$$

and *a* is determined as:

$$a = \frac{Q_{in} + \eta_{PAC}Q_{PAC}}{V} + K \quad (14)$$

In case no ventilation is present (in the hospital chamber),

$$V\frac{\partial}{\partial t}[PM](t) = Q_{in}[PM]_{in} + S - (Q_{in} + KV)[PM](t) \quad (15)$$

the solution is:

$$[PM](t) = \frac{Q_{in}[PM]_{in} + S}{Q_{in} + KV} + \left([PM](0) - \frac{Q_{in}[PM]_{in}}{Q_{in} + KV}\right)e^{at} \quad (16)$$

and *a* is determined as:

$$a = \frac{Q_{in}}{V} + K \quad (17)$$

The differential equations and their solutions were presented for all the four cases.

3.3. Case study

Mass concentrations mean values for $[PM]_{in}$ and $[PM]_{out}$ – depending on their size, were indicated (for four PM types): smaller than 1 micron (PM_1); between 2.5 microns and 1 micron ($PM_{2.5 - 1}$); between 10 and 2.5 microns ($PM_{10 - 2.5}$); between 30 and 10 microns ($PM_{30 - 10}$).

Table 3 presents the $[PM]_{in}$ and $[PM]_{out}$ values (for each situation).

Table 3. Values of $[PM]_{in}$ and $[PM]_{out}$

PM type	$[PM]_{in}$ (μg/m^3)	$[PM]_{out}$ (μg/m^3)
PM_1	44	97
$PM_{2.5 - 1}$	8	42
$PM_{10 - 2.5}$	6	53
$PM_{30 - 10}$	4	70

The portable anemometer HHF11A was used to measure the air velocity (at the PAC opening). The medium velocity values, v_m, were found to be higher than the values of $v_{m,calcd.}$ (as specified in Table 4). Thus, the Q_{PAC} values were higher than those specified by the supplier (CADR), so the Q_{PAC}/V calculated values were found to be higher than those of the effective AER (also indicated in Table 4), related (probably) to the perfect (initial) condition of the filter.

Table 4. Comparison of the experimental data to those specified by the supplier

n	$v_{m,exp}$ (m/s)	$v_{m,calcd.}$ (m/s)	Q_{PAC} (m³/h)	CADR (m³/h)	Q_{PAC}/V (h^{-1})	Eff. AER (h^{-1})
1	0.47	0.428	84.093	76.599	1.6036	1.4607
2	0.82	0.714	146,715	127.665	2.7976	2.4345
3	1.23	1.095	220.072	195.753	4.1966	3.7329
4	1.64	1.427	293.428	255.330	5.5455	4.8690
5	1.93	1.713	345.316	306.396	6.5850	5.8428
6	2.33	2.284	416.884	408.528	7.9497	7.7904

Considering the above presented, it was assumed (in all cases) that η_{PAC} as being equal to the unit. Both HVAC and PAC were turned off when performing the first experiment series. To determine Q_{in}/V and K, experiments were conducted, to be able to use these values in analysing the results of the next (third) experiment series, this being actually the scope of this present work.

The differential equation (15) was considered for the CFD simulation, together with its solution presented in equation (16), and a written as in equation (17).

At first, in the room was created a uniform particle concentration (with the help of two mixing fans and dust generator). They were turned off after creating the uniform particle concentration in the room.

After performing the data fitting (by using the least squares method in fitting the particle concentration variation; also reporting R^2), Q_{in}/V and K were found by observing the particles settling down (as given in Table 5).

Table 5. First experiment series - results

PM type	Q_{in}/V (h^{-1})	K(h^{-1})	R^2
PM_1	0.031	5.42	0.53
$PM_{2.5-1}$		1.23	0.76
$PM_{10-2.5}$		0.70	0.94
PM_{30-10}		0.09	0.95

HVAC was turned on and PAC was turned off in the second series of experiment.

The CFD simulation used the appropriate differential equation given in equation (9) with the solution given in equation (10), with a written considering equation (11). The efficiency of HVAC was estimated. The filters removal efficiency (of HVAC system) has been determined by operating this system alone.

The determined values of Q_{HVAC}/V were used to analyse the results obtained in the third experiment series.

A uniform concentration field of particles in the room was again generated (by using the same equipment – dust generator and two mixing fans). These were turned off during the performing of the experiments.

The effective AER of HVAC, Q_{HVAC}/V, was set at 7 h^{-1}. The obtained results of Q_{in}/V and K, were kept as before (as presented in Table 6). To fit the results, the least squares method was again used.

Table 6. Second experiment series - results

PM type	$Q_{HVAC}/V(h^{-1})$	η_{HVAC}	R^2
PM_1	7	0.51	0.42
$PM_{2.5-1}$		0.82	0.70
$PM_{10-2.5}$		0.95	0.82
PM_{30-10}		0.99	0.97

The third experiment series was conducted with the PAC on and HVAC off. In this case, the differential equation used for CFD simulation was equation (12), with the solution provided by equation (13), and a was written considering the equation (14).

The particle concentration variation was examined (at different points) considering the cartesian coordinates (x, y, z) related to the position of the patients (the most probable one), as it can be seen in Table 2.

The effective AER of PAC, Q_{PAC}/V can now be estimated for different locations.

The obtained results are given in Table 7.

Table 7. The third experiment series - results (the PAC was used at third speed)

Patient location	**PM type**	Q_{HVAC}/V (AER, h^{-1})	Q_{in}/V (AER,h^{-1})	K (h^{-1})	Q_{PAC}/V (h^{-1})	R^2
Bed no. 1	PM_1	7	0.031	5.42	6.8	0.32
	$PM_{2.5-1}$			1.23	7.2	0.48
	$PM_{10-2.5}$			0.70	7.7	0.55
	PM_{30-10}			0.09	6.0	0.89
Bed no. 2	PM_1	7	0.031	5.42	2.9	0.40
	$PM_{2.5-1}$			1.23	1.2	0.58
	$PM_{10-2.5}$			0.70	1.7	0.65
	PM_{30-10}			0.09	2.3	0.87

HVAC and PAC have been turned on for the fourth series of experiments.

The most general form of the differential equation (equation (6)) was used to perform the CFD simulation, the solution is given in equation (7), and a is determined as in equation (8).

As considered in the previous case, first a uniform particle concentration was generated with the help of the dust generator and two mixing fans. After that, the fans and the dust generator were turned off and the particle concentrations variation was monitored (especially for the two beds' places).

Also, the least squares method was used, for the fitting of data (R^2 values are given below).

The effective AER of PAC, Q_{PAC}/V was estimated one more time, for different locations (as presented in table 8 - the mean effective AER).

Table 8. Third and fourth experiment series - results

Patient location	**PM tipe**	**Q_{HVAC}/V (AER, h^{-1})**	**Q_{in}/V (AER, h^{-1})**	**K (h^{-1})**	**Q_{PAC}/V (AER, h^{-1})**	**R^2**
Bed no. 1	PM_1	7	0.031	5.42	12.4	0.35
	$PM_{2.5-1}$			1.23	10.2	0.46
	$PM_{10-2.5}$			0.70	10.7	0.62
	PM_{30-10}			0.09	12.0	0.84
Bed no. 2	PM_1	7	0.031	5.42	5.4	0.39
	$PM_{2.5-1}$			1.23	2.3	0.68
	$PM_{10-2.5}$			0.70	2.7	0.78
	PM_{30-10}			0.09	5.1	0.93

The noise level increased (as expected) when the PAC level was increased. Also, the noise level seemed to have approximately the same values inside the room (even if it is almost twice louder right next to the source).

Using a more quiet PAC will be considered in the future work involving a "fan-in-center" design. This will place the fan motor between sound-attenuating filters (and a double-walled case will successfully reduce noise transmission) while a rubber suspension pads steadily isolate the motor vibration from the PAC case.

In Figure 4 is presented HVAC system air pattern (when the PAC is off). In Figure 5 is presented the air pattern from both devices (the HVAC and the PAC) [17].

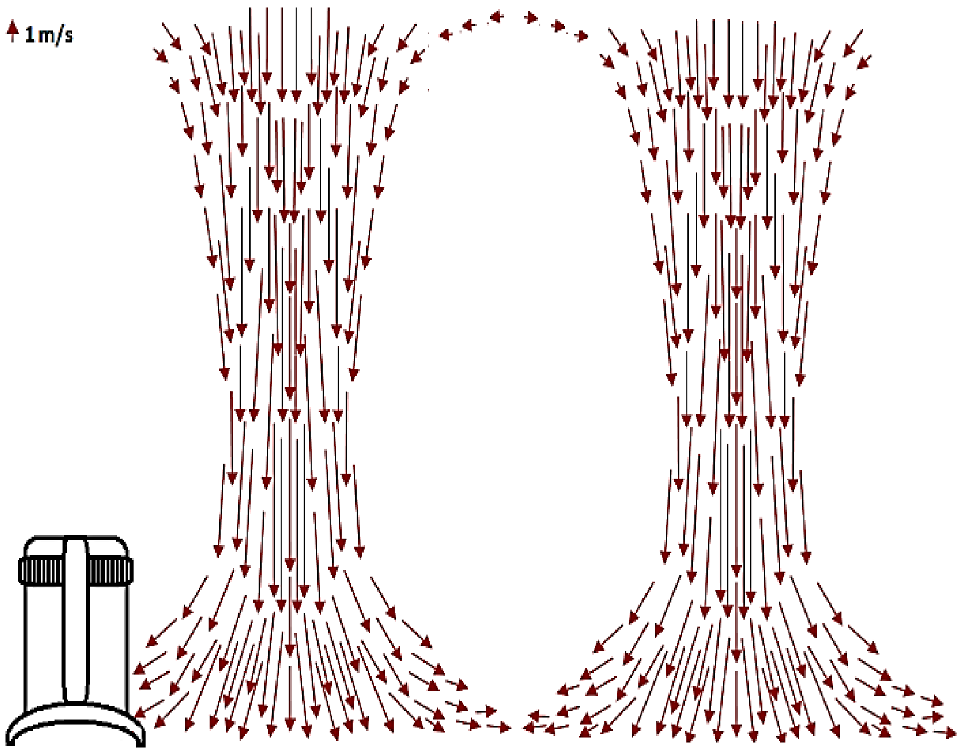

Fig.4. The air pattern with HVAC on and PAC off
(velocities less than 0.5 m/s being were not included)

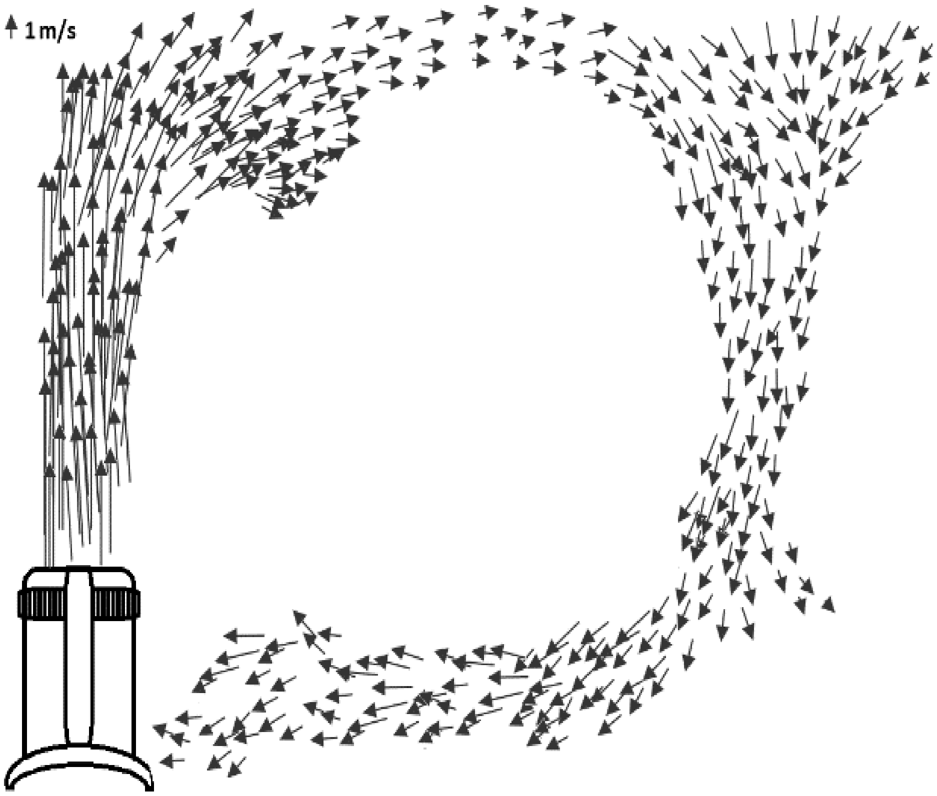

Fig.5. The air pattern with both units on (HVAC and PAC) – velocities less than 0.5 m/s were not included

4. CONCLUSIONS

This paper represents an important example of using engineering to solve new issues in different fields.

By this study, a specific solution was indicated in order to solve a problem (identifying a possibility to prevent, as much as possible, the spreading of respiratory infections in a hospital chamber).

As expected, the results have shown that the air (in the hospital chamber) was better mixed in case the portable air cleaner was on.

Such kind of studies become more important, as a result of the health crisis we have experienced.

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CONSIDERATIONS REGARDING THE OPENING, PREPARATION AND EXPLOITATION OF ORES IN THE BAIA MARE MINING REGION IN RELATION TO CLOSURE WORKS

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Abstract: *The paper addresses the issue of how to open and exploit the vein deposits in the Baia Mare mining region, which should have been analyzed when the projects and the execution of the closure works were carried out. The design of the closure works did not take into account the complexity of the mine structure of polymetallic vein deposits. It was also necessary to understand the circuit and accumulation of water in the mining works, namely their evacuation, the type and quantities of minerals, especially sulphides that become reactive on contact with water and free oxygen. Currently, these deficiencies with a strong environmental impact stand out. The analysis carried out in the paper allows a reflection on the possibilities of remedying the deficiencies of the past.*

1. INTRODUCTION

The manner of opening, preparation and exploitation of polymetallic sulphide deposits will significantly influence the environmental impact during the works, but especially after their closure. If the closure projects did not take into account the sequence of opening, preparation and exploitation works, the exploitation methods used, the observance of exploitation projects, etc., then the consequences of the generation of acid drainage are devastating. All mining perimeters are in this situation due to non-compliance with the rules of good practice in the design and execution of closure works. A typical example is the case of the opening works carried out through connection works, generically called a tunnel, between the Roata – Bolduț mine (Cavnic) and the Șuior mine and the outlet on the slope upstream of the town of Baia Sprie (Cavnic – Șuior – Baia Sprie transport tunnel) . The faulty closure of these works has led to numerous mine water management problems to date, while also posing a major risk in the future through surprises along its route. In the paper, references were made to the environmental problems due to these connection works between the 3 mining perimeters and the surface today.

In order to understand the current problems regarding the sources of mine water (acid drainage), numerous technical documentations for the opening - preparation and exploitation of deposits in the Baia Mare mining region, developed by research institutes and universities (Baia Mare Research Institute, Institute of Sub-engineers Baia Mare –

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University of North Baia Mare, Petroșani Mining Institute, etc.). These analyzes of the mining projects and documentation correlated with the closure projects and the monitored situation of the mining perimeters show the deficiencies that led to the current situation. Correlations between the exploitation works and the closure works allow the identification of technical solutions to remedy the problems generated.

The deposits of polymetallic sulfides in the Baia Mare region are developed in vein systems with variable thicknesses of the order of decimeters, meters and tens of meters (with the exception of a few cases from the Baia Borșa mineralization structure). The deposits that were the object of the exploitations were identified in relief forms of the type of slopes that allowed the opening on different horizons with coastal galleries connected to each other by vertical mining works (shafts, followers), and in depth by shafts executed from horizontal mining works – coastal galleries located at a base horizon. Wells that are run underground and are not connected to the surface have been called blind wells. From the point of view of the opening system in relation to a base horizon, 2 distinct situations are identified given the way mine waters are managed: above the base horizon where the waters drain by gravity and in a continuous form and below the base horizon in which were pumped during mining activity and accumulate in the workings below this horizon after mine closure. These situations have been described in later chapters in connection with the problem of acid drainage.

The horizontal or vertical mining works were defined in relation to the elevation of the level at which they were executed in relation to the elevation of the sea level, defining in this way the respective horizon, either for the horizontal mining works with connection to day, called coastal galleries, either for underground mining works. The data regarding the opening, preparation and exploitation methods were processed according to the technical documentation of Remin S.A., specialized literature, projects of the Baia Mare Research Institute and the Baia Mare Subengineering Institute. [1],[2],[4],[5],[6].

2. ANALYSIS OF THE OPENING AND EXPLOITATION OF THE ŞUIOR, CAVNIC, BAIA SPRIE AND HERJA DEPOSITS

2.1. The Șuior *deposit is represented by a main vein that surfaced and was exploited in the first stage in the quarry and later underground.*

The field opening works were through coastal galleries at the +1000 m, +950 m, +900 m, +850 m and +800 m horizons. These galleries were opened from a slope with the connection in several flanks: eastern , western and southern. The opening in depth was made through a shaft from the elevation +800 m to the elevation +462 m (called the central blind shaft), where the connection is made with the Baia Sprie – Șuior – Cavnic tunnel. This opening scheme shows that the entire deposit with all opening works - preparation and exploitation, at a depth of approximately 500 m, connects to the surface through the tunnel to Baia Sprie with a considerable length of 6.3 km. If a leak occurs in this tunnel, the possibility of draining the water that drains on the entire deposit is blocked, to which is added the water that comes from Cavnic. The closing works did not provide for ensuring the stability of the tunnel, its control and monitoring. The water accumulated at the base of the quarry infiltrates into the excavated spaces, the mining works, percolating the entire excavated space and deposit up to the horizon +462 m from where it is evacuated to the surface. Due to the high contents of pyrite and marcasite in the deposit, this space can be assimilated to a "chemical reactor", a fact noted both by the evacuated mine waters and by the gases released at the level of the ventilation shaft. For mine aeration, 2 wells were executed, one on the western flank and another on the eastern flank. Also, an inclined plan for car access from +800 m elevation with a total length of 5 km was executed. The Șuior deposit has variable thicknesses between 5 and 50 m and is developed along a length of 600 m.

Several underground mining methods have been devised for the exploitation of the deposit over time: the storage mining method, the mining method in ascending horizontal slices with support and backfilling, the mining methods in descending horizontal slices with support and backfilling and the method of mining with surfacing in underpasses [69]. The use of several exploitation methods led to a complex situation regarding the exploited space and the control of overburden from the underburden overburden exploitation method used predominantly in the last period of activity.

The Șuior deposit surfaced at an elevation of 1052 m and was identified at a depth of 1 200 m at an elevation of -150 m. The mineralization between elevation 1052 and 800 was gold-argentiferous. Lead, zinc and copper minerals have been identified at depth. Exploitation in the quarry was carried out up to +920 m elevation. From this elevation up to +850 m a safety pillar was left. Below the elevation of +650 m, the mining method was used with surfacing in underground tunnels. Pyrite has a very high content that can reach up to 35%. During mine activity, waters with a pH of 1.3 - 2.3 were identified. The vein is buried in altered and mineralized andesites above the +590 m elevation. Below the +500 m elevation, the vein is buried in marl.

Due to the mineralization in the surrounding rocks and the 70 m protective pillar in the deposit, to which is added the unexploited mineralization up to the level of the tunnel, it shows the presence of a significant amount of polymetallic sulphides with pyrite, marcasite and arsenopyrite and under the conditions of water infiltration in the deposit area all the conditions for the production of acid drainage are created.

These geomining conditions involve a major risk that will be difficult to manage in the future if this deposit is left at this stage.

The analysis of the works carried out both for the exploitation of the deposit and its closure leads to the conclusion of a large environmental impact and the need to reanalyze the possibilities for remedying the created situation.

2.2. The Cavnic deposit is linked from the point of view of mine water evacuation with the Șuior deposit through the previously described tunnel (Cavnic – Șuior – Baia Sprie). The closure project provided for the drainage of the waters from the Roata mine into the Bolduț mine, later into the Șuior mine with an outlet into Baia Sprie, but the execution and design deficiencies have lately determined the routing of the waters from Roata through the Ferdinand gallery into the Cavnic river. The exploitation of the Cavnic deposit has a tradition of over 650 years.

The opening of the Cavnic veins was achieved through coastal galleries and wells. There are 26 horizons with mining operations for opening and preparation totaling over 440 km. The maximum capacity of the Cavnic mine was 834 000 tons in 1984.

Mineralization was identified in 22 main and 75 secondary veins with a length of over 300 m to 2 200 m per direction and 350...900 m per dip. At the Bolduț mine, the known mineralization is 840 m deep, and at the Roata mine 450 m. Over 150 minerals have been described within the deposit. The predominant sulfides are pyrite, blende, galena, chalcopyrite, arsenopyrite.

The opening at the Bolduț mine was carried out from +800 m to +80 m elevation, and the opening and exploitation was planned up to -120 m elevation (approximately 900 m surface). The opening at the Roata mine was up to +590 m elevation (a depth of about 450 m from the surface).

The mining method applied at Cavnic was to store the ore in the mined area. The deposit conditions, the opening and preparation of the two mines (Bolduț and Roata) present distinct particularities. The Roata deposit is located above the base horizon, a fact that generates serious environmental problems. This situation, which actually represents a danger, allows the deposit to be reopened without the need to pump water, instead, the Bolduț deposit is opened and prepared mostly below the level of the base horizon. For the exploitation of the reserve opened and prepared in the last years of activity at the lower horizons, it is necessary to pump the water accumulated underground.

The Cavnic – Baia Sprie tunnel is located at the level of horizon +480 m in the Bolduț field, intersecting blind shaft number 2 and blind shaft number 1. The horizon +580 m named Ferdinand connects to the Roata mine and the exit to Cavnic Flotation. Below the horizon +480 m to the open horizon +80 m, in the Bolduț mine there is a complex network of mining works at a depth of 400 m in which the mine water accumulates. Between the +780m horizon and the +480m horizon is a network of mine workings above the tunnel elevation. The storage mining method was used starting in 1964 at the Cavnic mine.

2.3. The Herja deposit represents another case of non-compliance with geomining conditions in the design and execution of closure works by adopting the solution of blocking the Herja - Flotația Centrală tunnel and the accumulation of water in the exploited space up to the level of the base horizon. More than 220 veins and their branches with lengths between 300 and 1,300 m have been identified in this deposit (the branches have lengths between 50 and 300 m). The Herja mine was opened through the Ioachim gallery with a length of 1,000 m at an elevation of +380 m. The horizons below the level of this gallery were opened through a blind shaft. The opening of the field in terms of environmental impact is divided into two areas:

- above the elevation +380 m to the horizon +560 m with a height of 180 m, in which the ore and mine waters were transported and collected at the level of the base horizon;
- the area below the +380 m horizon to the +34 m horizon from where a tunnel was executed to the Central Flotation yard for the transport of ore starting in 1993. The area below the base horizon has a depth of 346 m. From this area mine waters were pumped during mining to the base horizon, (+380 m) from where they were directed to the treatment plant located in the mine yard. The closure project was based on the principle of accumulating mine water from the lower horizon level to the base horizon level to discharge the water from the elevation +380 m to the treatment plant (from the mine

premises). Ignoring some rules regarding the type of concrete used for the closing walls, the geological structure of the surrounding rocks, the presence of significant amounts of polymetallic sulphides in the exploited space led to the unfortunate failure of this project. The mining methods used at Herja were: with ore stockpiling, with horizontal strips and backfill and in the undergrounds.

These mining methods determined the leaving of some pillars or deviated ore that could not be evacuated, in this way important quantities of polymetallic sulphides remained, which in the presence of water from the precipitation through the percolation of the entire mining structure, leading to oxidation reactions and formation of acid drainage.

In this perimeter located vertically between the horizons +560 m and +40 m (14 horizons) large volumes of ore were excavated, which can be approximated by the productions extracted at over 100 000 mc per year, especially before 1989 (in 1989 production was 386,000 tons).

2.4. The Baia Sprie deposit was opened by coastal galleries, blind shafts or up to date with a network of 3000 m of shafts and 24 000 m of galleries. Blind well number 5 has a depth of over 450 m, executed between the coastal gallery at +523 m elevation and the XV horizon at -18.4 m elevation. Well number 4 was executed between the surface at +520 m elevation and the XV horizon at elevation -19.2 m, with a depth of approximately 513 m. Blind shaft number 3 was executed between the Limpedea coastal gallery, elevation +454 m and horizon XVII at an elevation of -116.9 m, with a depth of approximately 600 m. This deposit is opened, prepared and exploited for the most part below the level of a basic horizon (Leveși and Limpedea horizon) at +454 m elevation – ore transport horizon at flotation. The blind shaft number 1 was executed between the Leveși gallery and the XV horizon at an elevation of -23 m with a depth of over 450 m. The existing data show the extent of these underground mining works where mine waters accumulate, without having a connection to the surface through through mining works.

The mine water problem at Baia Sprie was studied in 1979 to analyze the possibility of recovering copper, zinc and other metals [3]. They were made experimentally in 3 cells located in panels at horizons XIV and XV and in the ramp of the Terezia well, horizon XV. The pH of the water was between 2.2 and 2.9, with copper contents between 70 and 240 mg/l. In these cells, during 6 months, the total amount of metallic copper recovered was 3,431 tons. The conclusion and recommendation of the study was to continue the recovery of copper and zinc precipitates, as well as rare and dispersed metals. In this study [3] metals such as gallium and cadmium were identified. Given the importance of gallium, copper and other metals and their current prices, their recovery is important. The lack of recovery of these metals causes an environmental impact problem.

3. CONCLUSIONS

These examples of open, prepared and exploited mine perimeters show the extent of the works carried out over time, the geomining conditions, the quantities of polymetallic sulphides remaining in the excavated space, the lack of backfilling with buffering material, the recovery of open and prepared or abandoned reserves, etc. The deposit opening was divided into two zones: above a base level through which rainwater will percolate and drain to its base without accumulating in underground excavations, and below a base horizon where mine waters accumulate. The projects and works executed to close these perimeters ignored the rules and the possibilities to reduce the environmental impact of the mine waters.

Another deficiency in the design and execution of the closing works of the coastal galleries on the portion from the slope (the entrance to the mine) is the creation of plugs consisting of a dike located at a certain distance from the entrance (depending on the topography of the land - up to the point in which the height of the covering formations is 50 m) and a pier at the mouth of the gallery. Between the two dikes, the gallery was filled in, leaving a water drainage channel (work carried out with numerous deficiencies). This construction created all the conditions for the clogging of the drainage channel by the deposition of precipitation and the accumulation behind the dike of a large amount of water. When a critical pressure is reached, the accumulated water and precipitate are released, called untimely vents.

The closure projects were carried out in a short period of time without analyzing the possibilities of using underground spaces for different purposes: tourism, scientific research, recovery of mine flowers, recovery of metals from mine waters or abandoned reserves, storage spaces , refuges in extreme cases, the exploitation of thermal energy identified especially at Cavnic and Baia Sprie, where the temperature of the rock in depth was high.

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THE ECONOMY OF NATURAL RESOURCES – A CHALLENGE OF ECONOMIC SCIENCE

SORIN-IULIU MANGU[1]

Abstract: *The concept of "natural resource" is a complex and dynamic one, whose evolution is conditioned by the states of interaction of the three fundamental elements: man, civilization (especially expressed through the level of scientific and technological development) and nature. The continuous development of human knowledge, science and technologies has led to an expansion of the physical, technical and economic limits of capitalizing the natural environment, thus contributing to the identification and putting into use of new natural resources, not considered as such in previous periods. These aspects may cause, at a certain moment, due to economic and/or technical considerations, some components of the natural environment to be excluded from the notion of "natural resources". Hence, the need for a scientific definition of the concept, which eliminates any tendency to absolutize or overestimate some components of the environment and to underestimate or ignore others.*

Keywords: *natural resource, mineral resource.*

1. THE CONCEPT OF NATURAL RESOURCES

Of French origin, the word "resources" (ressources) originally had the meaning of ways or ways out of difficult situations, but, gradually, it acquired the meaning of means of existence. Related to the natural environment, this concept created two separate currents of opinion. Thus, some specialists put the sign of equality between "natural resources" and "natural conditions", while others make a clear distinction between the two categories. The truth seems to belong to the latter, since, an analysis through the prism of the possibilities of putting it into use, shows that the first notion, that of "natural resources", has a narrower scope, referring only to those "substances and energies of nature that can be drawn into economic activities, as production factors" [1].

In general, the resource is defined as something that "is useful and evaluable under the conditions in which it is found" [4]. Compared to "natural conditions", the scope of the notion of "natural resource" is therefore narrower, being organically linked to the concept of rarity (which denotes the relative limitation of the supply of a certain resource of the natural environment, compared to the demand). The scarcity of natural resources means that their use as factors of production is not done at zero cost (natural resources, in their capacity as a factor of production, have real positive prices, so they must be remunerated, just like any other factor of production) . Regarding the second

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side of the definition, the evaluation (whose results are a direct consequence of the degree of knowledge of the resources), it must be viewed from a triple perspective: quantitative, qualitative and value.

Moreover, in addition to the fact that the correct foundation of natural resource valorization strategies depends on the most accurate definition of the concept, it is widely used by a wide range of specialists (biologists, ecologists, geographers, geologists, oceanographers, mining engineers, economists, energy scientists, etc.), each trying to outline their own definition, from the perspective of their particular field of activity. Thus, from a geographical point of view, natural resources represent "the means of existence offered to man by the environment" [2]. From the perspective of ecology, the definition of natural resources is simpler and more comprehensive: "by resources we mean any element of the natural environment that can be exploited by man to satisfy his needs" [3]. In economics, defining the concept of natural resources starts from the existing relationship between man and the natural environment, a relationship generated by the expression of social need and which takes the form of a permanent exchange, in both directions, of substance and energy. Through the transformative effect of work, substances extracted from nature become use values (which satisfy expressed needs of individuals and/or communities), but at the same time, the natural environment undergoes changes, positive (harmonious, sustainable development) or negative (pollution, imbalance). Therefore, a definition of natural resources from an economic point of view requires "a realistic and integrative vision, which expresses the dynamic exchange of matter, energy and information between the natural system and the system of economic activities" [1]. In such circumstances, the only possible solution consists in the systemic approach to the notion, only in this way possible parallelisms or omissions can be avoided.

In a systemic view, "natural resources are those substances-matter, energy fields or potentials and informational elements existing in the natural environment (biotic and abiotic) which, at a certain stage of economic, scientific, technical and technological development, under the conditions of a need and manifested demands, are likely to be attracted, transformed and used as natural factors of production" [1].

As a general conclusion, it can be stated that natural resources are involved in any economic activity, in the form of natural factors of production. No economic activity can be imagined and developed outside the natural environment. Moreover, there are activities directly related to the use or transformation of the elements of nature into production factors, activities which, in order to be characterized from an economic point of view by efficiency and effectiveness, need, first of all, clarifications at the conceptual and methodological level. Thus, the emergence of a new field of knowledge, a new frontier science, the economics of natural resources, whose object of study is "determining the economic implications of identifying, attracting into the economic circuit, exploiting and using the natural resources of the soil and subsoil" [8].

2. THE TRADITIONAL CLASSIFICATION OF NATURAL RESOURCES

The classification of natural resources has a double importance, theoretical and practical, serving to establish the norms of economic and ecological behavior in their exploitation. The realization of the classification is based on certain criteria, the rigor of which depends, to a certain extent, on the adoption of the most suitable methods of valorization and putting into use the components of the natural environment.

In the works devoted to the issue of natural resources economy, a multitude of classification criteria can be identified, the most important being presented in the following.

The criterion of social-economic utility. In relation to this criterion, we can distinguish between natural resources that represent means of subsistence (air, water, soil fertility, agricultural vegetation, fauna) and natural resources that are sources of means of work (mineral resources, energy resources, forest vegetation). Also based on this criterion, natural resources can be classified into fundamental (air, water, soil, mineral resources, energy resources) and auxiliary or secondary (vegetation, fauna).

The criterion of the mode of use. In relation to this criterion, natural energy production resources (mineral fuels, non-conventional energies), natural resources of industrial raw materials (mineral resources other than fuel, forest vegetation) and natural food resources (water, fauna, agricultural vegetation).

The criterion of the natural ability to restore and/or renew itself over time. In relation to this criterion, natural resources can be divided into renewable and non-renewable. Renewable resources are characterized by their ability to renew themselves naturally, with or without human intervention (agricultural and forestry plant resources), while non-renewable resources are those that, once consumed, no longer reproduce naturally or reproduce at a pace and in insignificant quantities for the world economy (mineral resources). In some works, renewable resources are classified, in turn, into non-perishable resources and agroforestry resources, and in others it is specified that some natural resources are regenerated in terms of surface, and others in terms of volume. In general, renewable resources are inexhaustible, but this depends, to a large extent, on human activities (in this sense, it is necessary to respect the laws of natural reproduction). Under the influence of external factors (which sometimes produce irreversible transformations on their existential framework), the stock of renewable natural resources existing (available) at a given moment can remain stable or change (either in the sense of increase or in the sense of decrease). However, in order for the resource to exist in the future, it is necessary to have a minimum stock in the present. If the current stock is less than the minimum value, the future of the resource is uncertain, and resource depletion will occur at some future time. In this sense, the characteristic of natural ecosystems to ensure a maximum sustainable present available stock, corresponding to the minimum regeneration capacity, must be taken into account. Non-renewable resources are the ones that determined the introduction of the concept of depletion into the economy, according to which no non-renewable natural resource can be created artificially, hence the conclusion that through exploitation, the available stock of the resource diminishes continuously, until it reaches zero. However, the zero value of the available stock of the resource does not necessarily imply its physical exhaustion. The concept of exhaustion has an economic character, showing that the available stock of the resource can be zero even when the unit cost of putting the resource into use is higher than its price, and any technological development followed by a reduction in cost is followed by an increase in the stock available resource (when there are no physical quantitative limitations). This aspect becomes obvious when the historical evolution of the problem of depletion of reserves of useful mineral substances (and, especially, those of mineral fuels) is analyzed.

The criterion of useful substance content. In relation to this criterion, natural resources are divided into resources rich in useful substances and resources poor in useful substances. If for the deposits of useful mineral substances, the operationalization of this criterion does not raise any kind of problems, in the case of other types of resources, certain particular characteristics of them must be taken into account (for example, the humus content - when we refer to the soil or the variety of plants, respectively the breed of animals - when we refer to agroforestry resources). The history of the exploitation of deposits of useful mineral substances highlights a continuous decrease, over time, of the contents of useful components, a decrease compensated by the progress made in terms of exploitation and preparation technologies.

The technical-economic criterion. According to this criterion, natural resources are divided into two categories: identified and unidentified. In their turn, the identified ones are divided into exploitable (those that can be exploited economically under the current level of technological development) and conditional (which cannot be exploited under the current technical-economic conditions), and the unidentified ones into predictable ones (being in known but insufficiently researched areas) and hypothetical (possible to be in areas not yet researched).

The property criterion. In relation to this criterion, natural resources whose supply is limited can be divided into privately owned resources and publicly owned resources, while natural resources characterized by an excess supply take the form of common free resources. Related to this criterion, two aspects are worth considering. First of all, the fact that the increase of natural resources subject to property takes place, especially, through public property, while their exploitation takes place through private property. Secondly, the continuous development of economic activities, which led to the acquisition of the economic content and the object quality of the sale-purchase transactions for a series of common free natural resources.

3. LANDMARKS OF ECONOMIC THINKING REGARDING THE USE OF NATURAL RESOURCES

In the history of economic thought, the use of natural resources is a relatively recent topic, the first discussions appearing only in the 18th century. However, since "most of our thoughts are influenced by the problems of our time" [5], the problem of the use of natural resources has found different ways of solving it in the view of economic schools and thinkers in the field.

Thus, a first thinker who focused on the use of natural resources was Malthus, whose conception of the evolution of the economy (and of humanity in general) was influenced by the events that took place during his life (a deep structural change of English society, under the influence of the industrial revolution, when, for the first time, as a result of the use of new agricultural and industrial technologies, as well as advances and discoveries in numerous branches of science, a sufficiency of food is found, followed by the reduction mortality and increased life expectancy). Analyzing the demographic phenomena, in parallel with the possibilities of the soil to provide food (the law of diminishing returns was known), Malthus identified two conflicting elements, the power of the population and the power of the land to produce the necessary food, the effects produced by these two unequal forces, with intensities of different manifestations, being controlled, mainly, by the population and its lack of food. Malthus developed a complex theory, in which he appreciated that an increase in the supply of food is followed by an increase in the population, which, in turn, causes an increase in the number of agricultural workers. However, the lower yield of the new agricultural lands that will be cultivated will lead to a lower rate of increase in the quantities of available food (compared to the rate of population growth), which will make the incompatibilities of the two conflicting forces manifest acutely. Thus, Malthus managed to identify the limits of the current world, represented, at that time, by the capacity of agricultural land to feed an ever-growing population, believing that humanity will reach a gloomy state of its existence, from which it will not be able to escape. However, Malthus omitted the evolution of agricultural technologies, as well as the changes that the increase in incomes and raising the level of education of the population have on the size of families. Nevertheless, his theory constituted, for more than 200 years, a field of debate between politicians and economists, its shadow continuing to hover over a significant part of the world even today.

Contemporary with Malthus, David Ricardo also had a pessimistic view on natural resources, appreciating that a state of stable equilibrium between natural resources and the environment cannot exist for a long time. Although he agreed with Malthus on the basic principles governing the population-income ratio, in his theory, Ricardo showed that profits are the engine of economic growth, and wages that of population growth, so that an increase in wages above the subsistence level causes an increase of the number of the population (through the birth of more children), followed by a reduction in the standard of living, which slows down the further growth of the population and demands new salary increases, the cycle repeating itself continuously. Ricardo's fundamental contribution was the connection of the concept of economic growth to the concept of the scarcity of natural resources. Ricardo considered the world a farm of fixed dimensions, where capital and labor were used to produce food, and the existence of profit and the stationary functioning of the system allowed the maintenance of subsistence wages, and implicitly a constant level of the population, all this as a result of resource scarcity.

Under the influence of the writings of Malthus and Ricardo, John Stuart Mill believed that any growth, including economic growth, must eventually reach a state of equilibrium. Mill was a follower of a world in which every square meter of land was cultivated, and every plant or wild animal, rivals of man, were exterminated.

In the writings of one of the pioneers of neoclassicism, William Stanley Jevons (who lived in England during the industrial revolution and whose ideas are totally different from those of Malthus and Ricardo, contemporaries of an eminently agricultural society), references are made, for the first time, to the relationship between the deposits of useful mineral substances and the development of the economy. The fundamental problem that Jevons pursued was that of the exploitation of coal deposits, whose insufficiency he considered the main obstacle to the industrial development of the British economy. Inspired by the rapid depletion of deposits with easy geological and mining conditions, in the conditions of a constant increase in coal production, Jevons had a fatalistic view, considering that the gradual depletion of deposits will cause an increase in operating costs to a level where industrial branches they won't be able to resist anymore.

In the first part of the 20th century, the French economist A.C. Pigou, also starting from the problem of the insufficiency of natural resources and concerned with sharing the advantages of their exploitation between generations, ended up formulating radical recommendations, according to which governments should pursue an active policy of defending exhaustible resources, promoting strict legislation, which would prevent their irrational exploitation, and to provide incentives for investments in regeneration actions of inexhaustible resources.

The problem of the insufficiency of natural resources and the harmful effects on the future development of mankind also appear in the writings of the end of the 20th century by A. Huxley. Expressed at a time when communism still appeared, for many, as invincible, its predictions regarding the diminishing reserves of useful mineral substances, the expansion of dictatorial political regimes, the decline of the population's health and the decrease of its level of intelligence could not convince the scientific community, all the more so since the last decade of the last century was marked by huge efforts to restore freedoms in countries that lived decades under dictatorship.

4. THE SCARCITY AND POTENTIAL CRISIS IN THE USE OF NATURAL RESOURCES

The common point of thinking of all the economists mentioned above resides in the insufficiency, rarity and limited nature of natural resources, manifested by a possible future crisis in their use. In the last century, extensive studies were devoted to this aspect, almost all of them trying to prove that the scarcity of natural resources did not increase with their increasingly intensive exploitation.

Although the research results are reassuring regarding the scarcity of resources, there are still many researchers who doubt their validity, especially since there are two more problems (how the new factors of production will influence the future supply of resources, respectively the effects that the potential technological developments will have on the possibilities of substitution of some resources) whose solution is still a desideratum for economic research. Government officials (The United States Bureau of Mines) got involved in the problem and showed that the existing stocks of resources, as well as the terms of their exhaustion, should be estimated on the basis of data sources with greater credibility. For this purpose, it was recommended not only to use the data provided by the classical geological research, but also to resort to special prospecting methods (scanning the earth's crust with the help of satellites seems to be the most suitable).

As a general conclusion, it can be stated that the problem of resource scarcity has not yet been solved and probably never will be. For mineral resources, the problem is even more delicate. Reserves of useful mineral substances become known accurately (quantitatively, qualitatively and from the point of view of deposit conditions) only when they are fully exploited, and their uneven distribution in the earth's crust will probably give rise to many more and more heated debates, both on the way of putting it into use, and on national property rights, in the conditions where the globalization of the world economy has become a reality of our days.

5. CONCLUSIONS

The development of human civilization cannot be imagined without natural resources. A simple overview of the productive cycle, on the technological chains of obtaining basic products, illustrates the importance of natural resources.

Natural resources (represented, originally, by the wealth of the subsoil, of the soil, virgin biomass and scrub) are subject to primary productive activities (agriculture, forestry, fishing, hunting, mining), with the aim of being transformed into raw materials (which, rarely are used as such to satisfy human needs, most often entering a productive process of transformation, the specificity of which is imposed by the type of resource). For raw materials that are intended, as a final goal, for consumption as food, the transformations take place within the food sector, which in all developed countries, has led to the increase of the "distance" between the producer and the final consumer.

For raw materials of mineral origin, between exploitation and manufacturing there is an important phase, that of primary processing, in which chemical and metallurgical transformations take place, necessary to obtain the basic materials, which, in turn, allow the further development of activities in the processing branches.

In the end, the needs of society are met, through several categories of final products: food, manufactured products, constructions, infrastructure and final energy. The productive cycle ends with the elimination of waste (results from both productive consumption and that of the population), which are either recycled and return to the various processing phases, or are stored within natural ecosystems.

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CONSIDERATIONS ON THE CLASSIFICATION SYSTEMS OF MINERAL RESOURCES

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Abstract: *Even if the problem of establishing certain levels of exploitation of mineral resources in order to ensure the sufficiency necessary for the perpetuation of human civilization has been analyzed by numerous economists, the crisis triggered by the oil shock (in 1973), sharpened and focused the debates, especially in the direction of establishing a certain level exploitation of national energy resources. Thus, a problem that was treated at the beginning as a simple geological curiosity became of the greatest importance, especially when, for its solution, it was necessary to integrate concepts and information of geological nature (resources, reserves, content in useful components) with those of technical and economic nature (cost of exploitation, economic efficiency of exploitation). Regarding the classification of resources/reserves of useful mineral substances, in Romania, until 1998, it was used a Soviet-inspired classification. However, the promulgation of the Mines Law established another classification, in accordance with the methodologies promoted by the United Nations Organization*.

Keywords: *mineral resources, classification.*

1. ATTEMPTS TO DEVELOP A CLASSIFICATION WITH GLOBAL ACCEPTANCE

Converging on this approach and not ignoring the importance of mineral resources for national wealth, several Romanian researchers focused on some conceptual and methodological clarifications, reaching the conclusion that it is necessary to group mineral resources into three distinct categories, according to the possibilities of attracting them in the economic circuit, namely: "useful mineral substances existing in deposits, useful mineral substances recoverable from deposits, useful mineral substances that can be exploited as raw raw materials" [5].

The use of the criterion of economic efficiency of exploitation in order to distinguish between the concepts of resources and reserves introduces the influence of the mineral raw materials market into the classification, and, implicitly, into the drawing of the border between the two categories. As rich deposits and/or characterized by easy geological and mining conditions are exhausted, the level of the criterion is reduced (as a result of the increase in marginal costs), while the action of factors related to technical progress (which lead to a decrease in marginal costs) has an inverse influence.

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Taking into account all the recommendations and classifications used, starting from the 6th Session, the Natural Resources Committee adopted an international classification of mineral resources, in identified (economic and sub-economic) and estimated (economic, sub-economic and marginal), through which it tried to unify the methods of quantitative evaluation of the potential of mineral resources.

Regarding the classification of geological reserves by groups and categories, in the specialized works it is appreciated that it is necessary to take into account some criteria related to the degree of knowledge of the reserves in terms of quantity, quality and deposit conditions, the technical possibilities and economic exploitation on an industrial scale of the respective deposits and the average or minimum content of useful substances. Regarding the level of economic indicators that characterize the exploitation of mineral resources, practice has shown that there are four main groups of influencing factors: geomining conditions, the volume of geological reserves, the content of useful substances, the level of development of exploitation and preparation technologies.

2. THE OLD CLASSIFICATION OF RESERVES OF USEFUL MINERAL SUBSTANCES

In the practical activity and specialized literature in Romania, the reserves of useful mineral substances of a deposit have been classified according to the following criteria: degree of knowledge; geological-mining, tectonic and natural conditions; the technical and economic conditions for capitalization; degree of preparation.

In relation to the degree of knowledge, geological reserves are classified into five categories: A, B, C1, C2, D. The amount of reserves in categories A, B and C1 is determined based on measured parameters, that of category C2 based on inferred parameters or indicate, and the one in category D based on assumed or hypothetical parameters [6].

In relation to the geological-mining, tectonic and natural conditions in which the reserves of a deposit are concentrated, the following were identified: class I deposits (they have irregular shapes and contours, a relatively small variation in the distribution of useful components and are of medium size), deposits from class II (they have irregular shapes and contours, a relatively small variation in the distribution of useful components and are small in size), class III deposits (they have irregular shapes and contours, a relatively large variation in the distribution of useful components and are of various sizes). The inclusion of a reserve in one of the categories of reserves classified according to the degree of knowledge depends on: the class in which the deposit is classified, the type of exploration works and the dimensions of the geological research network [6].

In relation to the possibilities of capitalization, geological reserves are classified into balance sheet geological reserves (which include those reserves that from a technical and economic point of view can be capitalized in the current conditions of the national economy) and off-balance sheet geological reserves (which include those reserves that cannot be capitalized in the current technical and economic conditions, but whose capitalization may become possible due to the action of technical progress or the change in economic conditions) [6].

In relation to the degree of preparation, the reserves are classified as follows: open reserves (for which all the necessary conditions have been created for the start of preparatory works for exploitation), prepared reserves (where exploitation works can already begin), reserves in progress of exploitation (located in the panels already in operation).

3. THE FRAMEWORK CLASSIFICATION OF GEOLOGICAL RESERVES PROPOSED BY THE UNITED NATIONS ORGANIZATION

To facilitate international communications, starting from a proposal by the German government, the United Nations, through the Economic and Social Council, developed its own classification of reserves/resources of solid fuels and mineral products, based on market economy criteria.

This classification provides information about reserves/resources according to three elements: geological assessment, feasibility assessment and degree of economic viability. Each of these three criteria has its own terminology and particular definitions.

The geological evaluation phase involves the following stages:

-recognition: the stage in which it is identified, on a regional scale, through a recognition study (based on the results of regional studies, regional geological maps, preliminary maps on the ground, aerial methods, indirect methods, geological assumptions and extrapolation), areas with a strong mineralized potential, the objective being to locate mineralized areas that justify a more thorough study;

-prospecting: the stage that consists in the systematic research of a deposit by delimiting promising areas, using direct (identification of outcrops, geological mapping) and indirect (geophysical and geochemical studies) methods to determine the quantities of reserves/resources, the objective being to identify a deposit to be the subject of more advanced exploration;

- general exploration: the stage in which the initial delimitation of a deposit is carried out, using specific methods (surface mapping, three-dimensional sampling, trenching and drilling for the qualitative and quantitative assessment of mineralization, with processing of mineralogical samples in the laboratory, if is the case, and limited interpolation), the objective being to establish its main geological characteristics, so as to result in reasonable indications regarding continuity, dimensions, configuration, structure and contents in useful components, the degree of precision of the determinations being sufficient for correct substantiation of the decision to develop a pre-feasibility study and continue with the detailed exploration;

- detailed exploration: the stage in which the deposit is perfectly delimited (in detail, on the three dimensions), proceeding to the systematic sampling of samples, the objective being to establish with a high degree of certainty the values of the geometric parameters, shape, structure, the contents and other characteristics of the deposit, so that the decision-maker can decide on the appropriateness of developing a feasibility study.

The feasibility assessment phase involves the preparation of the following documentation:

- the geological study: the documentation in which an initial assessment of the economic viability is carried out (presenting the content threshold values, the depth, the thickness and the exploitation cost, estimated by reference to comparable deposits), the objectives being to specify the mineralization, verify the continuity and determine the quantity and quality of the reserves, so that the investment possibilities can already be estimated (the geological study is not so precise as to allow defining the categories of economic viability, the estimated quantities may indicate a deposit of intrinsic economic interest, which can be qualified as " economic that tends towards economic potential");

- the pre-feasibility study: the documentation in which a preliminary estimate of the economic viability of the deposit is made, based on the final results of a conclusive exploration campaign (which allows summarizing all the geological, technical, environmental, legal and economic information), the objective being to ensure the necessary information to substantiate the decision to continue research or not (for relatively advanced projects, the margin of error of the pre-feasibility study must not exceed 25%, the data associated with this precision being the quantities of reserves/resources from general exploration and detail, results of technical laboratory tests, estimation of relevant costs);

- the feasibility study: the documentation that evaluates the technical quality and economic viability of the deposit development project (allowing the relative verification of all geological, technical, legal, economic and environmental protection information related to the project), being drawn up in - a form that allows the transition to solving the aspects related to securing the financing sources of the project;

-exploitation report: the documentation developed by the mining company, which includes the exploitation plans of the deposit and which presents the state of development of the exploitation of the deposit during its exploitation (the quantity and quality of the useful mineral substance extracted from the deposit, the changes in the categories of economic viability and which may lead to variations in prices or costs, the degree of completion of relevant technologies of exploitation, the new regulations imposed, especially in the field of environmental protection, the relative data of the exploration carried out during the exploitation of the deposit), providing a detailed, faithful situation and day of unexploited reserves.

The degree of economic viability is determined based on highlighting the following categories of reserves/resources:

-economic reserves/resources: from a quantitative and qualitative point of view, they are highlighted, in increasing order of accuracy, in a pre-feasibility study, feasibility study or in an exploitation report, justifying the exploitation in the technical, economic, the environment and others admitted as a realistic hypothesis at the time of the evaluation; they can be normal (those that can be exploited under the conditions of a competitive economy, the value of the average annual production having to be sufficient to reach the efficiency parameters of the investment) and exceptional (those that cannot be exploited under the conditions of a competitive market, requiring subsidies from the state or other support measures);

-potentially economic reserves/resources: from a quantitative and qualitative point of view, they are highlighted, in increasing order of accuracy, in a pre-feasibility, feasibility study or in an exploitation report, not justifying the exploitation in the technical, economic conditions, of the environment and others admitted as a realistic hypothesis at the time of evaluation; they can be marginal (those located at the limit of economic efficiency, which could become economic in the near future, in case of a change in technical, economic, environmental or other conditions) and submarginal (those that can become economic in case of an increase in the price of mining products or according to the development of technical progress);

-intrinsically economic reserves/resources: tend towards economic potential (quantities established in terms of volume and contents and which may present an intrinsic economic interest at the end of a geological study).

Based on the three criteria, transposed in the form of three axes (economic axis, feasibility axis, geological axis), a codification of the different categories of reserves/resources was made. This coding uses three-digit codes, the number "1" indicating the highest degree of economic viability (on the economic axis) and at the same time the highest degree of certainty (on the geological and feasibility axis).

3. CONCLUSIONS

In the different national classification systems that have been used for a very long time, the terms "reserves" and "resources" have different meanings. Due to the ever-increasing needs for communication in the context of the globalization of economic relations, a unification of the concepts and notions related to this issue has been attempted worldwide. Thus, because the terminologies and definitions developed by the "Council of Mining and Metallurgical Institutes" have come to be widely used by numerous investors, shareholders and credit institutions from Anglo-Saxon countries, they have been incorporated into the English version of the framework classification proposed by Economic and Social Council of the United Nations.

In the framework classification of the United Nations Organization, the following terminology was used for reserves and resources:

- total mineral resource (which designates the natural concentrations of mineral raw materials of economic interest, characterized by a determined degree of geological certainty);

-mineral reserve (denoting the economically exploitable part of the total mineral resource, as highlighted by the feasibility study);

-remaining mineral resource (denoting the remainder of the total mineral resource, which has not been identified as a mineral reserve).

If one intervenes in the different assessment phases, the mineral reserve and the mineral resource are subdivided, in total, into eight classes.

The current stage of development that Romania is going through requires that the terminologies used in the preparation of documents and documentation, from any field of activity, allow easy communication not only domestically but also internationally.

Considering the conditions imposed in the definitions of the concepts of "mineral resources" and "geological reserves", it can be considered that the limit between reserves and resources is given by the knowledge and establishment of the geological, technical, economic and legal conditions for their exploitation. As a result, the names of "reserves, for those mineral resources that have been analyzed through pre-feasibility studies, feasibility studies, mining reports, establishing the categories of economic, marginal-economic and sub-economic" and "resources, for those mineral resources" can be assigned which were analyzed through feasibility, geological or opportunity studies, through which the exploitation conditions could not be known and established" [6].

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THE EFFECTS OF COVID - 19 PANDEMIC ON THE WORLD ENERGY INDUSTRY

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Abstract: *The importance of the energy sector in the global economy is obvious and this is the reason why the main objective of this paper is to provide a broad overview of the COVID-19 pandemic impact on the world energy industry highlighting the effects on the fossil fuel, renewable energy sectors and energy demands.*
The price of oil has served as an additional indicator of the pandemic impact on the global economy. The reduced return on capital and the increased volatility in fossil fuel prices is making many investors look at these assets in the post-COVID World with a greater degree of caution.

Keywords: *energy demand, fossil fuels, renewable energy, COVID-19 pandemic.*

1. INTRODUCTION

The world has changed. The new coronavirus has managed to do that. Safeguarding and stabilizing operations, liquidity, people, supply chains and markets have been the overwhelming first priority. Now, companies must start thinking strategically about how they will adapt as the pandemic and markets evolve. COVID-19 has reminded the World of its vulnerability and heightened the awareness of the public and wider society to global risks. This could have an impact on discussions about other threats such as climate change. Across the board, companies will want to examine their approach to risk with a fresh eye and consider what measures are needed to low the risk of their business.

The coronavirus pandemic will have a dramatic impact on energy supply and demand in the short term and will have lasting impacts once the pandemic dissipates. However, that will in itself do little to advance the world's progress towards the Paris climate ambitions.

Energy use is strongly linked to economic activity, which has and will continue to be, significantly impacted by the new coronavirus pandemic. The energy forecast is predicated on IMF's longer outbreak scenario, where World GDP will shrink 6% in 2020. The lingering effects of the pandemic will take the wind out of the sails of the world economy for many years – reducing World GDP in 2050 by 9%, relative to pre-pandemic forecasts.

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Even with slower growth, however, by mid-century the world economy will still be twice its size today. In contrast, energy demand will not grow. In 2050, it will be about the same as it is today, in spite of a larger population and world economy. This is largely due to significant improvements in energy intensity, but also due to the effects of COVID-19.

2. THE PANDEMIC IMPACT ON FOSSIL FUELS ENERGY DEMAND

The importance of the energy sector in the global economy is readily evident. As of August 2020, six of the eleven largest companies in the world by revenue are in the oil and gas sector: Sinopec Group (China), China National Petroleum (China), Royal Dutch Shell (Netherlands), Saudi Aramco (Saudi Arabia), BP (United Kingdom) and Exxon Mobile (United States). [3]

Before the pandemic, it was predicted the total global energy demand in 2050 at 456 exajoules (EJ), (Global energy demand using the latest historical figures was at 424 EJ in 2018.) The modeling shows that the pandemic will reduce energy demand through to 2050 by 8%, resulting in energy demand in 2050 at almost exactly the level it was in 2018, as it is shown in figure 1.

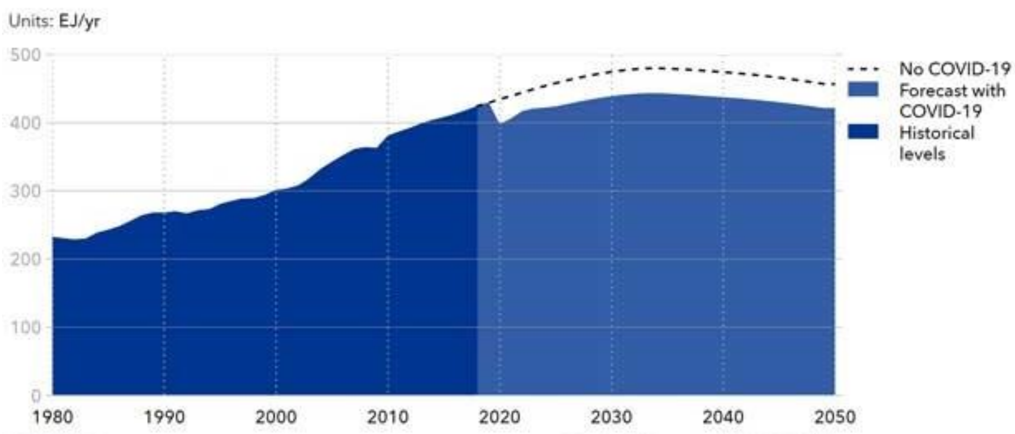

Fig. 1. *Global energy demand 1980 - 2050*

This appears to be good news for decarbonisation, but transport remains dependent on oil and iron and steel is one of the key so-called ”hard to abate” sectors, relying as it does to a large degree on hydrocarbons to supply high-heat processes. Declining demand in these sectors is one of the main reasons for the price weakness in hydrocarbons, with widespread write-downs in oil and gas assets. It appears likely that oil has already reached a supply plateau in 2022, prior to factoring in the effects of the pandemic.

It is certainly not game over for hydrocarbons and especially not so for natural gas, which it is forecasted to take over from oil as the largest energy source in this decade. However, the reduced return on capital and the increased volatility in fossil fuel prices is making many investors look at these assets in the post-COVID world with a greater degree of caution; they may also now regard renewable energies assets more favorably, even though the pandemic is placing a temporary check on the expansion of renewable sources of energy. Renewable energies have first place in the merit order of the power mix due to their very low operating costs and short design and construction times. [4] These assets are therefore more robust and researchers predict a slightly faster recovery of the non-fossil capital expenditure in the next couple of years than will be the case for fossil energy.

The price of oil has served as an additional indicator of the impact of the pandemic on the global economy. As global economic activity fell in March and April 2020, demand for oil also fell, resulting in rising inventories and falling prices. In response, oil producers reduced oil production, only slowly restoring output as the global economic activity recovered. As financial market indexes declined in 2020 and the dollar appreciated, the price of Brent crude oil dropped close to 20 $ per barrel on March 20, as indicated in figure 2.

Fig. 2. *Brent crude oil price per barrel in US Dollars (source: Markets Insider, 2021)*

As a result of the steep drop in oil prices, oil producers agreed in April, 2020 to reduce global supply by 10%, or 9.6 million barrels per day. Since the low prices recorded in April, the price of Brent crude oil generally moved within a range of $40 to 44 $ per barrel through late November 2020, when it began edging above $50 per barrel. In trading December 10, 2020, the price of Brent crude oil breached the $50 per barrel mark for the first time since March 2020. As energy demand showed signs of recovering in 2021, the cuts in oil production that began in April were trimmed to 7.7 million barrels per day and were trimmed by an additional 2 million barrels per day starting in January 2021. On February 23, 2021, the price of Brent crude oil rose above $67 per barrel, the highest price since January 9, 2020, but dropped to 64 $ per barrel by March 3, 2021.

On March 5, 2021, the Brent crude price of an oil barrel rose to 69 $ per barrel, the highest since January 2020, as OPEC and Russia decided against increasing petroleum output. [5] By the end of June 2021 the price of Brent crude oil pushed above 75 $ per barrel. In meetings in early July 2021, OPEC members agreed to increase production as the international price of crude oil reached nearly 78 $ per barrel, but objections by the United Arab Emirates (UAE) over the calculation used to increase production targets held up the agreement. On July18, 2021, OPEC and Russia agreed to increase crude oil production by an additional 400,000 barrels a day into 2022. [6].

The global coal industry will never recover from the Covid-19 pandemic, industry observers predict, because the crisis has proved renewable energy is cheaper for consumers and a safer bet for investors. A long-term shift away from fossil fuels has accelerated during the lockdown, bringing forward power plant closures in several countries and providing new evidence that humanity's coal use may finally have peaked after more than 200 years. As demand for electricity has fallen, many utilities have cut back on coal first, because it is more expensive than gas, wind and solar. In the European Union imports of coal for thermal power plants plunged by almost two-thirds in recent months, to reach lows not seen in 30 years. The consequences have been felt around the world as well.

3. THE PANDEMIC IMPACT ON RENEWABLE ENERGY

In some countries, strict measures implemented to prevent the spread of COVID-19 have caused delays in the export of materials and components for the development of renewable energy projects. It was a high impact on manufacturing and procurement, transport and logistics, construction, installation and a low impact on project planning, operation and maintenance. Concerning the solar energy sector, materials and components used in the construction of solar arrays and panels have slowed down, as most of the manufacturing companies are located in China, South Korea, Vietnam, Singapore, Malaysia and Thailand, countries that were strongly affected by COVID-19.

The wind industry was also interjected due to the outbreak of COVID-19. In India, due to problems as lack of project financing and bottlenecks in the supply chain, Siemens Gamesa, Vestas, and LM Wind Power - three of the main competitors in the wind energy market in India-halted production, which would cause a delay in the construction of 600 MW of wind power by 2022. [9] The situation was different in Europe, where 96% of manufacturing plants continued production despite the crisis, and only 18 of the most affected factories, mainly located in Italy and Spain, closed.

The impact of the pandemic on the environment and renewable energy sector in the general and solar energy sector has been also reported in the literature. It has been indicated that there are some contradictory impacts of the pandemic on the renewable energy sector. The renewable energy sector is expected to witness a significant reduction in allocated investment due to economic turndown, holding up many renewable projects. [8] In addition, with the significantly dropped prices of fossil fuel commodities, the competition is not in favor of renewable. Meanwhile, due to the problems with the supply chain, many projects have been lacking critical components. On the other hand, the pandemic has indicated the need for reliable localized energy supply, with renewable in the forefront, due to the drop in maritime trade restricting gas, oil and coal supplies.

Before the COVID-19 outbreak, renewable energy made significant progress in several countries with accelerated growth. The cost of renewable energy became more affordable because of overwhelming research activities, technology advancements and supporting policies in the sector (figure 3). In terms of policies, most countries formulated strategies to ensure the accelerated development of the sector globally.

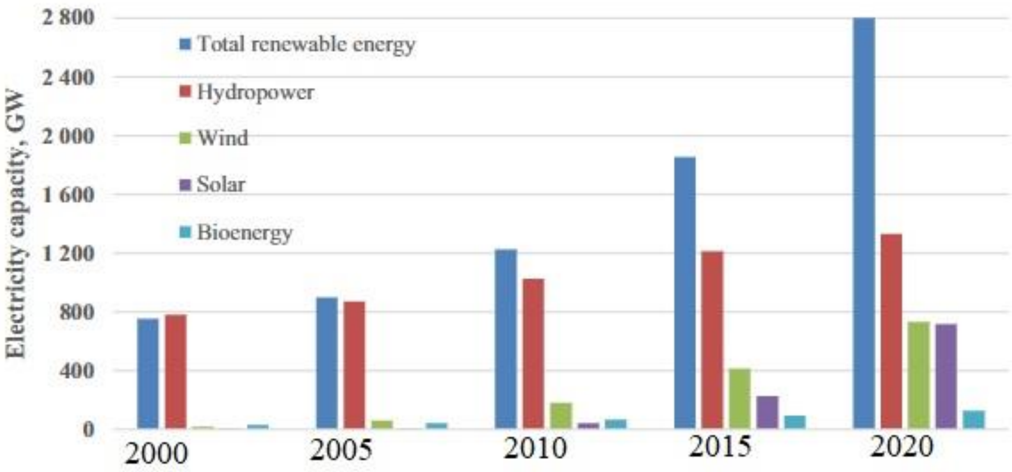

Fig. 3. *Evolution of renewable energy resources worldwide, over the period 2000-2020*

For instance, in terms of cost, solar and wind energy was in good competition with fossil commodities before the pandemic. When a barrel of oil was pegged at 60 $, most oil-related companies championed several programs aimed at carbon emission reduction. These programs cushioned and sustained renewable energy immensely, but the inception of the COVID-19 pandemic has stalled investments into this renewable energy - related programs. Suncor Energy Inc. reduced its 2020 budget to the tune of 1.5 billion $. This budget allocation was to be used to develop two cogeneration units, mainly to curb carbon emissions, and a wind-powered plant in Canada. However, note that the renewable energy sector saw accelerated development because money harnessed for the sector was obtained from the fossil-related sector.

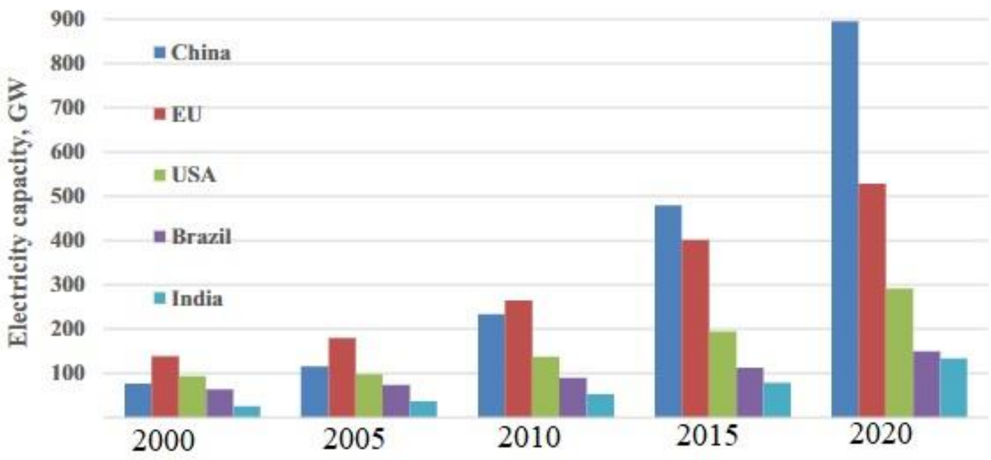

Fig. 4. *Renewable energy capacity distribution by countries over 2000–2020*

The USA, UK, Spain, China and India were the countries with the highest installation capacities in 2019. During the pandemic, most of these countries have been compelled to cut their spending in the renewable energy sector and redirect the funds to other sectors, mainly medical and social support, subject to their needs (figure 4). According to the Global Wind Energy Council, these obstructions regarding the supply chain as a result of the negative impact of the COVID-19 pandemic on the renewable energy sector were likely to affect the development of wind energy projects in the next two years.

In the European Union, the decrease in energy demand, as well as the higher demand for energy from renewable sources, has caused a sharp decline in energy harnessed from non-renewable sources. From February to July 2020, energy generation from renewable sources increased compared to that from fossil products. Energy harnessed from natural gas has also seen a sudden surge due to lower gas prices. From January to August 2020, nuclear generation has dropped. Nuclear power share saw a marginal increase after September. Production of coal also dropped within the same time frame but increased with respect to demand. There were, however, sporadic peaks in weekly renewable generation in the fourth quarter of 2020.

4. RELATIONS BETWEEN ENERGY DEMAND AND PANDEMIC

Several researches have shown that the stricter the containment measures, the more significant the reduction in energy consumption. A study compared the impact of different containment measures taken by European countries in response to COVID-19 on the electricity consumption profiles. The data highlighted that in countries with severe restrictions like Spain, Italy, Belgium and the U.K., the weekday consumption was considerably reduced and energy consumption profiles were similar to pre-pandemic weekend profiles for the same period in 2019.

In the course of a week, the demand reduction is not the same on working days as on weekends across the countries due to differences in work from home policies and differences in the severity of weekday versus weekend confinement measures. In Spain, the electricity demand was reduced on working days by 14.53%, while on weekends, electricity consumption was reduced by 10.62% in the period from March 14 to April 30 in 2020 compared with an average value for the same period in the previous five years. [7]

For countries with less restrictive measures, the decrease in power consumption was lower. In fact, for Sweden, where a lockdown was never imposed, the consumption even increased at particular points compared to the same period in 2019.

This relationship between the severity of the confinement and demand reduction is evidenced by Kuwait, where the stay-at-home phase (March 13–March 21) recorded a 2.2% reduction in power generation while the partial curfew (March 22–May 10) and full lockdown (May 11–May 30) phases showed 13.7% and 17.6% reductions respectively, relative to the 2020 forecasted values. [1]

5. CONCLUSIONS

The economic impact of the COVID–19 pandemic can be separated into short-term and long-term. These negative shocks affect global supply and demand, including the level of global trade. This phenomenon is not only limited to today's global economies but also those into the future. While the short-term impact decays over time, permanent long-term negative effects exist to the income level and growth gradient.

Energy is the lifeblood of the global economy and all economic activities require energy. Previous researches have confirmed that slower economic growth reduces the demand for energy and, in turn, reduced energy consumption restrains further economic growth. The same relationship has also been found for oil demand and economic growth, consistent with the fact that oil remains a driver of the energy sector.

Many studies indicate that oil price shocks have an adverse effect on real output and, hence, an adverse effect on corporate profits where oil is used as a key input.

The research indicates that oil price rises have a negative impact on equity returns for all sectors except mining and oil and gas industries. Generally, these results are consistent with economic theory and evidence provided by previous empirical studies. Little evidence of any asymmetry is detected in the oil price sensitivities. In light of our findings, it is recommended that international portfolio investors consider hedging oil price risk.

The impact of the pandemic stems from the manufacturing facilities related to renewable energy as well as supply chains. Today, the world is compelled to evaluate some existing energy-related policies, especially those that negatively affect renewable energy related companies. Most budget allocation devoted to specific programs to sustain the economies of some countries globally is today being diverted to mitigate the current global challenge.

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THE LATEST WAR IN EUROPE AND THE ENERGY CRISIS IT GENERATED

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Abstract: *Since February 2022, the conflict between Russia and Ukraine has gradually escalated and deepened the concerns the world about energy security. To understand the situation today, we must understand the importance of Russia in the global energy landscape and especially in Europe since this is the region of the world which is the most dependent on the energy supply from Russia. In Europe, fossil fuels represent approximately 70% of the final energy consumption and the European Union is the largest importer of natural gas in the world.*
That strong dependence is now forcing European countries to find alternatives to maintain the security of supply in the region. The diversification of the energy sourcing will be the key to energy security.

Keywords: *fossil fuels, oil, gas, coal, energy, Russia, Ukraine.*

1. INTRODUCTION

As the world's largest exporter of natural gas and second largest exporter of oil, Russia plays an important role in the global energy supply system. In 2021 exported 230 million tons of oil and 252 billion cubic meters (bcm) of natural gas, accounting for 11% and 16% of the world's total export volume respectively. The crude oil from Russia mostly flowed to European countries (57%), especially Germany, the Netherlands and Poland. China was the largest importer of Russian crude oil and condensate (31%). 89% of Russian natural gas exports went to Europe, mainly to Germany, Italy and France and Ukraine is an important energy transportation route for Europe. 40 billion out of the 155 bcm of pipeline natural gas imported from Russia in 2021 went through Ukraine. As of the end of January 2022, the total gas reserves of Europe hit a record low of 42 bcm, accounting for only 37.5% of the stock. Any disruption in the flow of Russian gas to Europe through Ukraine would affect trading prices and LNG import demand. [5]

Since February 2022, the conflict between Russia and Ukraine has gradually escalated and deepened the concerns the world about energy security. This isn't the first time that Russian military aggression has prompted world leaders to fret about energy security. Similar concerns arose when Russia invaded Georgia in 2008 and in 2014 when it invaded and then annexed the Ukrainian territory of Crimea.

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The energy consumption worldwide is still dependent on fossil fuels as the decarbonization policies implemented here and there are too recent to have an impact on the energy mix today. [6]

2. THE ENERGY CRISIS IN EUROPEAN UNION

In Europe, fossil fuels represent approximately 70% of the final energy consumption (22% gas and 43% oil) and the electricity which represents roughly 22% of the energy consumption, is largely generated from fossil fuel as well, mainly gas and coal. Over the recent years we have had an increase in gas consumption, as the gas was seen as an energy transition as considered cleaner than oil and coal and more acceptable by the population than other power generations such as nuclear. As it relates to natural gas, the European economy is overly dependent on Russia with situations which vary from country to country (with some countries notably in the Baltic countries which are 100% supplied by Russia). [4]

In December 2021 Russia exported 5 mb/d of crude oil and 2.8 mb/d of oil products, including 1.1 mb/d gasoil/diesel, 0.6 mb/d fuel oil, and 0.5 mb/d. In 2020, total crude exports to Europe were 2.8 mb/d, of which around 0.7 mb/d was by pipeline, with the remainder by sea. Total crude exports to Asia were 2.1 mb/d, with 0.8 mb/d directly to China via pipeline. Over 70% of Russia's oil product exports went to the European and US markets (figure 1).

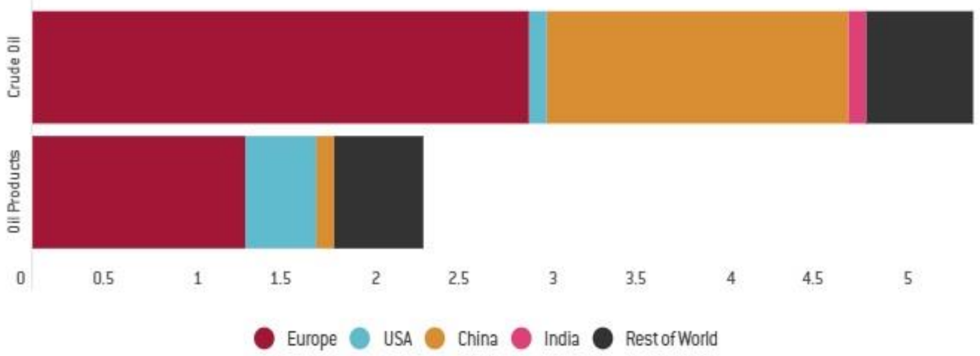

Fig. 1. Russian oil exports, mb/day (source: Eurostat, 2021)

In 2020, the European Union imported 9.3 mb/d crude oil and 5.6 mb/d of refined oil products, according to Eurostat. Around 8 mb/d of imported or domestically refined products (Figure 2) is used for transport (diesel, gasoline, kerosene), around 3.5 mb/d for heating (gasoil, fuel oil), and 2 mb/d as a chemical industry feedstock (naphtha, LPG). Some of these fuels are re-exported to markets such as the US and Switzerland.

The European Union is the largest importer of natural gas in the world. The European Union imports 90% of its needs in natural gas are mainly from Russia (41%) and the rest primarily comes from Norway (24%) and Algeria (11%). The European Union is also dependent on Russia for its imports of oil and coal: 27% of oil imports and 46% of coal imports. On the demand side, Europe's dependence on imports of crude oil and natural gas in 2020 was about 95% and 83% respectively, with 27% of oil and 45% of natural gas from Russia. Russia accounts for 15% of crude oil, 8% of liquefied natural gas (LNG) and 9% of piped gas among China's imports. [3]

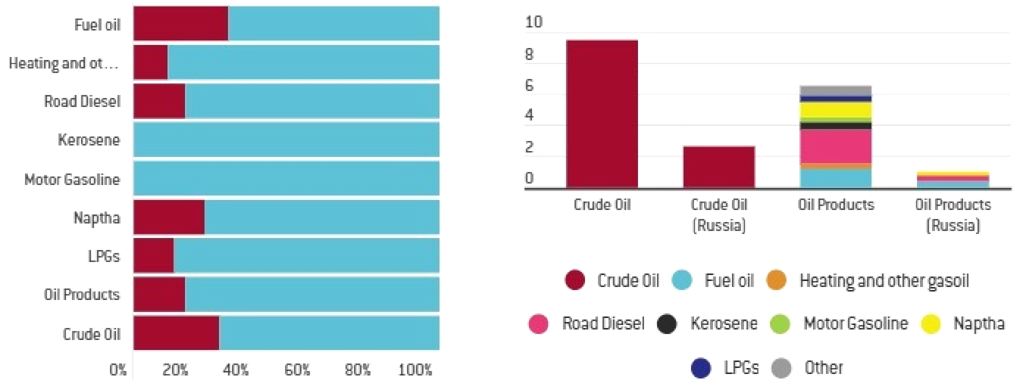

Fig.2. *E.U. imports and demand* (source: Eurostat, 2021)

The European Union has been gradually phasing out solid fossil fuels, bringing down consumption from 1,200 to 427 million tons over three decades (1990-2020). We must focus on hard coal, as lignite is produced and consumed domestically. Hard coal consumption and production in the EU has declined, especially in the past few years (figure 3). In the process, imports have become more significant, from 30% to more than 60% of domestic consumption, raising questions about the availability of hard coal for the EU in case of a major disruption, such as an energy embargo on Russia.

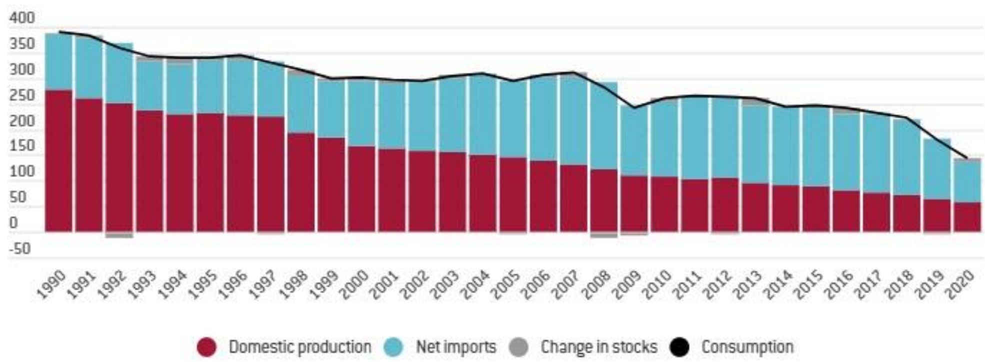

Fig.3. *E.U. hard coal supply and demand in million tonnes* (source: Eurostat, 2021)

Russia has played a major role in filling the gap between the EU's consumption of hard coal and domestic production, with EU hard coal imports from Russia rising from 8 million tonnes (7% of total EU imports) in 1990 to 43 MT (54%) in 2020. [7]

It is important to distinguish between thermal coal, also known as "steam coal", that is used to generate electricity and metallurgical coal used in iron and steel making. Russian metallurgical coal accounts for between 20% and 30% of the EU's coal imports, while the Russian share of the EU's imports of thermal coal is almost 70%. Germany and Poland are particularly reliant on thermal coal from Russia.

For now, the biggest question facing world leaders is how to sever their energy dependence on Russia. The United States and the United Kingdom were the first major countries to ban Russian oil, but neither depends heavily on these imports. If we look at the United States of America, the situation is very different as the country is a net exporter of fossil fuels and has barely any imports from Russia. As such, the decision of the United States to ban the energy imports from Russia does not really impact the economy of its own country, nor does it has real effects on the Russian economy.

3. DIVERSIFYING THE ENERGY SOURCES

In the very short term, Europe has no other choice than acting rapidly to avoid any disruption in energy supply during this winter which would be clearly detrimental to its economy as well as an additional factor of instability. Though the options are somehow limited as it relates to gas and thus pressure on energy prices will remain high.

The first one is to work on the diversification of suppliers of gas and there are two possibilities:

- an increase in pipeline imports from non- Russian suppliers of gas: Azerbaijan for instance, but this will be limited, combined with.

- higher LNG imports, which will be very costly, there will be indeed incremental cost given that globally traded LNG cargoes typically ship wherever prices are highest, the demand from Asia is strong and spot prices are extremely high. Drawing more LNG would leave European Union with a 70 billion euro (78 billion dollars) bill to refill gas storage facilities this summer which is six times the price in previous years; [1]

- European countries have agreed to fill up their existing storage capacities by at least 80% before the beginning of the winter season.

The second one is the revival of some coal power plants: with the increase in the energy prices and the will to maintain energy affordability for the population, the temptation will be extremely high to revive some coal power plants which have been closed on environmental grounds, which would imply that the net zero ambitions set would be temporary put on hold.

The possible life extension of nuclear power plants on the European territory: for instance, Belgium which had initially planned to exit nuclear power generation by 2025 has recently announced it would postpone that deadline by 10 years. [9]

Alternative gas supply, in particular, may pose an issue. There is hardly any more gas to come from either North Africa (mainly Algeria) or Norway in the short-term. The beginning of Black Sea production from Turkey's Sakarya field and Romania's Neptun field could help, but not until 2024 and 2025. Expansions from existing suppliers could take five years or more. East Med looks like it might come to the battle too late, while an increase in production from the Groningen gas field would be possible but politically difficult. The LNG spot market is an option, but that means competition from Asia for the now very fungible, crude oil-like commodity. [8]

Caspian producers are in a position to supply as much as 10 additional bcm within a matter of months; a volume which no other sources of pipeline gas can match. There are three ways in which gas from currently operating fields in the Caspian can contribute to Europe’s gas balance in the short term. All are predicated on the concept that if the gas can reach Turkey, then LNG going into Turkey can be freed up for competitive sale to the rest of Europe, where there is a comfortable surplus of LNG regasification capacity.

The three options are:

- capture of 5 bcm of gas produced by Petronas in Turkmenistan’s sector of the Caspian, most of which is being flared and transporting it to Azerbaijan;
- increased volumes via the Turkmenistan-Iran-Azerbaijan 2 bcm swap arrangement, active since January 2022. This could raise deliveries to Azerbaijan by another 2-3 bcm, freeing up a comparable volume of Azerbaijani gas for delivery to Turkey;
- organization of a new Turkmenistan-Iran-Turkey swap arrangement to make use of spare capacity in the existing 48” Iran-Turkey pipeline.

As for the final part of the arrangement, the Southern Gas Corridor is the system that carries Azerbaijani gas across Turkey to Italy, with the Trans-Adriatic Pipeline, the final section from Turkey to Italy, already operating near its current 10 bcm capacity. Additional piped gas through Turkey to Europe will be exceedingly hard to come by [2].

This is why Turkey’s political cooperation is a crucial component in importing Caspian gas into Turkish markets and making would-be Turkish LNG available for the EU in the short term.

4. CONCLUSIONS

While the United States, Canada and the United Kingdom have announced embargoes or phase-out measures for Russian energy in the wake of the war in Ukraine, the European Union has held back, instead launching a new energy strategy.

Replacing current volumes of Russian coal (>40 MT) might only be part of the challenge. If Russian gas and oil supplies are also stopped, the EU might want to import more coal to produce electricity. In fact, in terms of electricity, the EU has enough spare capacity to drastically increase power generation from coal in case of an emergency. Had all hard coal power plants in Germany operated at full capacity in 2021 they would have produced around 140 TWh more of electricity, consuming about 40 MT of additional coal.

While stopping Russian gas imports would be difficult and costly, but feasible, it will likely be less painful for the EU to manage a complete interruption of Russian oil and coal imports. Oil and coal are more global and liquid markets than gas and rely less on rigid infrastructure like Europe’s gas import pipelines.

This aims to reduce by nearly two thirds the EU’s gas imports from Russia by the end of 2022 and to make Europe independent from all Russian fossil fuels well before 2030. Renewable energy will only be able to play a significant additional role in EU energy independence in the medium term: in the coming months alternatives will need to do the heavy-lifting.

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AIR QUALITY ANALYSIS DURING THE MINING ACTIVITY IN TISMANA COAL PIT, ROMANIA

CIPRIAN NIMARĂ[1]

Abstract: *Several hundreds of large, medium and small coal pits operate in Romania, whose objective is the extraction of useful rocks and construction materials. Many of them cannot be considered as factors of obvious aggression towards the environment, since the changes in the area are minor. The purpose of the current paper is to present the impact of the exploitation activity from Tismana coal pit on the atmosphere as well as the quality assessment in the human settlements located near the coal pit. In order to evaluate the air quality, air samples were collected from significant points and the indicators were determined.*

Keywords: *mining, coal pit, air quality, air pollution, Tismana.*

1. INTRODUCTION

The perimeter of Tismana coal pit is located in the north of Oltenia historical region, south of the Targu Jiu city, on the right bank of the Jiu River in a hilly area [2], being delimited as follows:

- to the South, by the Timişeni - Pinoasa coal pit;
- to the North, the Şomanesti mining perimeter;
- to the East, from the 66 National Road, Rail lane line no. 221 Filiaşi - Rovinari - Tg. Jiu, respectively Vârţ village;
- to the West, by the TismanaI coal pit (figure 1.1.).

The opening works at the Tismana I coal pit began in 1969. The useful mineral substance extracted is energy coal (lignite), which is delivered in small grades for consumption in thermal power plants, respectively in lumps for consumption by the population.

The town of Rovinari and the Rovinari thermal power plant can be found near the mining perimeter.

Morphologically, the Tismana I mining perimeter is characterized by a hilly area with low relief energy. The average slope is 10°-12° towards the base and 35°-40° in places in the upper part and the average height of the slopes reaches elevations between 290-310 m. The floor of the coal pit is established at the bed of the Vs layer of lignite, elevation +145m, resulting in an average depth of the coal pit of 105 m, with frequent oscillations between 75-155 m.

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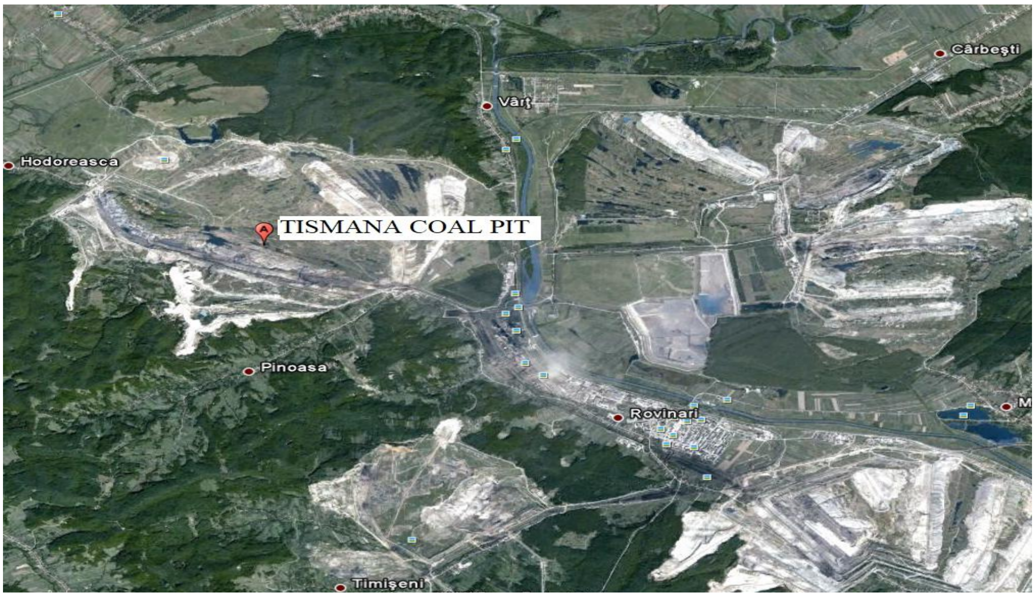

Fig.1. Location and boundaries of the Tismana coal pit (source: Google Earth)

The studied area has a temperate continental climate with typical hill climate aspects. Regarding the temperature, the averages of the warmest month (July) reach 21.6°C, and the coldest (January) reach -5.8°C.

Atmospheric precipitation is very different as a result of the installation of the microclimate due to the adjacent coal pits (annual average is 753mm). Winds are strongly influenced by relief, in terms of frequency, direction and speed. The average annual frequency of calm is particularly high in the sheltering conditions achieved by the coal pit.

2. ASSESSMENT OF AIR QUALITY

Several hundred of coal pits operate in Romania, which objective is the extraction of useful rocks and construction materials. Many of them cannot be considered as factors of obvious aggression on the environment, since the changes in the area are minor. [4] The monitoring of the sources of atmospheric emissions was carried out from significant points and the main indicators were determined: suspended dust and sediment dust, in the approved methodological norms, threshold values and evaluation criteria and methods for sulphur dioxide, nitrogen dioxide and nitrogen oxides, suspended dust (PM 10 and PM 2.5), lead, benzene, carbon monoxide and ozone in the surrounding air.

The analyzed quality indicators were:

a) **suspended dust (PM10)** with an aerodynamic diameter of 10 µm, passing through a size-selective orifice with a separation efficiency of 50%.

- were collected in the field, with the suction pump left in the same spot for 24 hours to capture the sample;

- the suspended dust sampling stations aimed at the protection of human health were located near the MAN type distribution equipment at the Tismana coal pit premises (so as to provide data on the air quality in that area where the highest concentrations occur the population is exposed, directly or indirectly, for a period of 24 hours, period of averaging the limit values);

- measuring point 65 m from the distribution node, near the Tismana coal pit site (the suction pump could be safely left there for 24 hours for sampling);

- measured value = 195.91 µg / m^3;

- allowed limit value = 50 µg / m^3;

b) **sediment powders** were carried out by placing the laboratory containers in the field, at the most representative polluted sampling point, for a period of 15 days. The measurement points for sediment powders were the following:

- Pinoasa village residential area limit;

- limit of the inhabited area of the village of Arderea;

- Pinoasa village residential area limit (Tismana coal pit):

» measured value = 9.6 g/m^2 / month

» allowed limit value = 17 g / m^2 / month

It is observed that these values are extremely small, with a strictly local effect inside the coal pit, the impact of emissions from the coal pit vehicles is negligible on the atmosphere of the populated areas adjacent to the coal pit, compared to the impact of the actual activity of the coal pit. Overruns for the Tismana coal pit are recorded at:

- limit of the inhabited area of the village of Arderea (Tismana coal pit)

» measured value = 69.4 g /m^2/month

» allowed limit value = 17 g / m^2 / month

- excess level was recorded for sediment powders = 408.2% (this area is near highways and warehouse equipment).

Table 1. The sediment powders analyzed in Tismana

SAMPLING POINT	**CONCENTRATION [g/m^2/month]**	**MAXIMUM CONCENTRATIONS ALLOWED (M.C.A.) [g/m^2/month]**
Tismana - head office P_1	9,6	**17**
Tismana I - coal pit head office P_2	5,73	
Gârla P_3	7,45	
Rovinari East (Arderea coal deposit) P_4	**69,4**	

The air samples were collected from 4 significant polluted points with sediment dusts (P1 - Tismana - coal pit head office, P2 - Tismana I - coal pit head office, P3 - Gârla, P4 - Rovinari East (Arderea coal deposit) and from two significant polluted points with suspended dust (P5 - Rovinari- limit Tismana I coal pit, P6 - Rovinari- limit Tismana coal pit) and the "sediment dust" and "suspended dust" indicators were determined and the values obtained were compared with the standards (table 1 and 2).

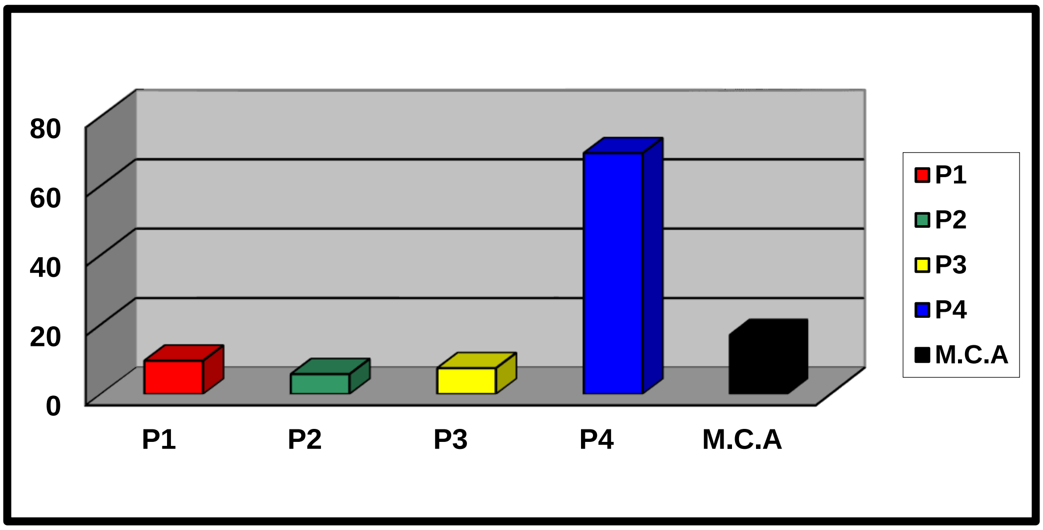

Fig.2. Variation in the concentration of sediment powders

The graphic representation of the variation in the concentration of sediment powders in the 4 points is shown in figure 2 and the graphic representation of the concentration of suspended powders is shown in figure 3.

Table 2. The suspended powders analyzed

SAMPLING POINT	CONCENTRATION [g/m²/month] [µg/m³]	MAXIMUM CONCENTRATIONS ALLOWED (M.C.A.) [µg/m³]
Rovinari - limit of the Tismana coal pit	**185,49**	**50**
Rovinari - limit of the Tismana coal pit	**195,91**	

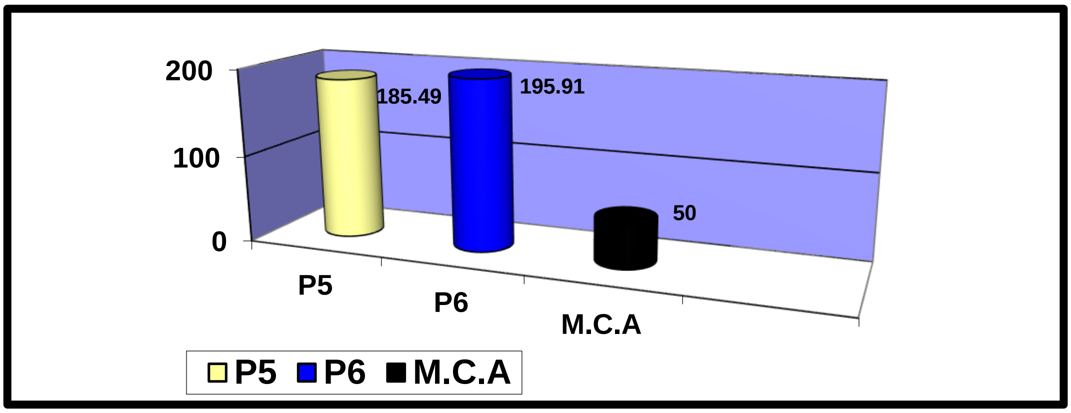

Fig.3. Variation of the powders in suspensions

The air samples were collected from four representative points (P1 - Poiana, P2 - TismanaI, P3 - Tismana, P4 - Pinoasa) and the quality indicator "sediment powders" was monthly determined, between January and September. The obtained values were compared with M.C.A.=17g/m^2/month.

Analyzing the data in the table 3, it appears that the maximum allowed concentration was exceeded, as follows: Pinoasa in the months: April, May, July and August, Tismana in the following months: March, July and August.

Table 3. The sediment powders determined monthly in 2021 between January to September

SAMPLING POINT	MONTH / 2021								
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**
P_1-Poiana	16,71	-	-	-	-	-	-	-	-
P_2-Tismana I	6,53	6,84	**43,5**	11,65	14,42	15,69	**22,7**	15,12	7,61
P_3-Tismana	2,61	6,82	4,48	8,61	15,71	6,04	6,56	**17,4**	9,096
P_4-Pinoasa	-	-	2,4	**23,60**	**54,2**	16,63	**40**	**29,4**	16,70

Around the Tismana coal pit there is a residential area less than 350 m from the mining equipment. The village of Pinoasa is in the southern area of the Tismana mining perimeter, near the main transporters and the village of Arderea is near the coal deposit. Noise measurements were carried out with the mining equipment turned on and it was found that the villages are not polluted by noise.

Due to the fact that the activity in the coal pit is carried out below the land level, the propagation of noises is reduced.

3. CONCLUSIONS

In order to evaluate the air quality, air samples were collected from significant points and the indicators were determined: suspended dust and sediment dust. The suspended dust was measured 65 m away from the distribution node, near the Tismana coal pit premises and the value of 195.91 µg/m^2/month was determined but the allowed value is 50 µg/m^2/month.

For sediment powders, analyzes were carried out at the limit of the inhabited area, Pinoasa village (the measurement value was 9.6g/m^2/month) and at the limit of the inhabited area, Arderea village, (the measurement value was 69.4g/m^2/month) and the allowed value is 17g /m^2/month. A 408.2% exceeding was recorded for sediment powders because this area is located near the conveyor belts and storage equipment. Also, samples were collected from four representative points and the sediment powders indicator was determined monthly and the values obtained were compared with the maximum concentration allowed, exceeding each month.

Air quality is modified by increasing the concentration of suspended dust, gases and smoke. The noise was determined by the vibrations coming from the machinery and was produced in a wide range of frequencies. Sound measurements were carried out and it was demonstrated that the noise level falls within the limit of 103 dB (A) near the mining equipment and for inhabited areas the level falls within the limit of 65 dB.

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EXPROPRIATION FOR REASONS OF PUBLIC UTILITY - THEORETICAL AND PRACTICAL IMPLICATIONS REGARDING THE NOTION OF PROPERTY RIGHT RELATED TO THE MINING LAW NO. 85 OF MARCH 18, 2003

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Abstract: *TThe ownership right implies the legal possibility of a person to enjoy and dispose of a thing exclusively and absolutely, within the limits determined by law. Depending on the owner and its characteristics, the property can be private or public. One of the legal limitations of the ownership right concerns the existence of some mineral resources related to the buildings where this right applies. In these conditions, the existence of civil right of property will be related to the pre-existence of a legal right of property, established in favor of the Romanian State over the mineral resources included or not in the buildings in question. Supplementary, in the conditions of exercising the option of prospecting/exploration/exploitation by the Romanian State, through entities with special competences established in this regard of mineral resources in question, the existence of the right of property can be censured by "forcing the transfer" of property ownership towards the Romanian State. The legal solution of this transfer of ownership is given by expropriation for reasons of public utility of national interest, a legal-administrative procedure with complex implications. The purpose of our scientific approach is to establish some theoretical and practical benchmarks related to the Mining Law with no. 85 of March 18, 2003*.

Keywords: *property right, expropriation, mineral resources, Mining Law, Romanian State, limits*

1. INTRODUCTION

In the content of the Mining Law with no. 85 of March 18, 2003 (hereinafter referred to as the Law[(1),] more precisely in Article 6 letter d)., it is noted that expropriation for the purpose of public utility is identified as a way of acquiring the right of "use" over the lands necessary to carry out mining activities in **the exploration/exploitation perimeter**. As a preliminary, we will note the fact that concerning this legal procedure, it is not effectively defined in the content of the Law, much less the concrete methods and legal steps that are going to be applied are not established, in which sense we appreciate that it is required to establish some correlations between the specificity of this legal approach, related to mining activities and the directly applicable national and the European legislation one.

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In what it follows, we will try to analyze this legal institution through the prism of theoretical and practical implications applicable to mining legislation in Romania.

2. THE NOTION OF OWNERSHIP

Expropriation for reasons of public utility implies the priority retention of the concept of property with the two variations – the private and, respectively, the public property one.

Related to the situation of the mining activity on which we focus on in the present study, it is necessary to note the fact that the concept of property is subordinated to the notion of **mineral resource.**

Practically, the right of ownership and respectively, the transfer of ownership carried out under the conditions of expropriation for public utility starts from the premise of the existence of some mineral resources on which the Romanian State decides according to **an opportunity study**, the fact that prospecting/exploration/exploitation proceedings must be started.

It will be remembered that as regards **the right of ownership over the mineral resources, it is assigned *ope legis* to the Romanian State exclusively**, meaning that the provisions of articles 1 and 2 of the Law are retained, as follows:

"Article 1 - The mineral resources found on the territory and in the subsoil of the country and of the continental plateau in the economic zone of Romania in the Black Sea, delimited according to the principles of international law and the regulations of the international conventions to which Romania is a party, they are exclusively the object of public property and belong to the Romanian state.

Art. 2 - (1) The mineral resources that constitute the object of this law are: coal, ferrous ores, non-ferrous, aluminum ores and aluminiferous rocks, noble metals, radioactive, rare and dispersed earths, haloid salts, useful non-metallic substances, useful rocks, precious and semi-precious stones, peat, therapeutic muds and peats, bituminous rocks, non-combustible gases, geothermal waters, gases that accompany them, natural mineral waters (gaseous and flat), therapeutic mineral waters, as well as the mining waste product from dumps and ponds of decantation.

(2) The provisions of this law also apply to potable and industrial groundwater for the activities of prospecting, exploration, determination and recording of reserves".

This explanation of extent of ownership on the mineral resources derives logically from the provisions of article 136 paragraph 3 of the Constitution of Romania, where it is mentioned that "Wealths of public interest of the subsoil, air space, waters with exploitable energy potential, of national interest, beaches, territorial sea, natural resources of the economic zone and of the continental plateau, as well as other goods established by the organic law constitute the exclusive object of public property".

In this context, the legislator's incongruity can be observed at the terminological level when he refers in the Law to the notion of mineral resources versus the constitutional notion of "wealth", but this aspect is not particularly important as long as the key concept of mineral resources is retained.

Starting from the premise of the fact that mineral resources are the exclusive property of the Romanian State, it must to be further analyzed what bears the property right against which the expropriation procedure is to be carried out.

From our point of view, logically by reference to the object of the analysis, we will have to remember the fact that it exhaustively **covers immovables to which the mineral resources in question are attached to.**

We prefer to use the terminology "attachment" in order to establish a more rigorous understanding of the relationship between physical content of expropriated right of property and the main reason of expropriation - mineral resource.

Thus, from our point of view, related to the provisions of articles 1 and 2 of the Law, the right of property that it is going to be expropriated concerns the surface of the buildings in question, this not existing in any way on the mineral resource, regardless of its proximity to the earth's crust.

At the same time, the right of property that may be expropriated must not perfectly overlap with physical location of the mineral resource(s) in question.

In short, we appreciate that in establishing buildings that can constitute a subject of the procedure of expropriation, at least, the idea of **perimeter of prospecting, exploration and exploitation of the mineral resource(s) in question** must be taken into account.

The contouring and materialization in land of **the prospecting, exploration and exploitation perimeter** is carried out through the prism of the definition found in article 3 point 21 of Law, essentially representing *"the area corresponding to projection on surface of the contour of the part from the crust of earth inside which, on a determined interval of depth, prospecting, exploration, respectively exploitation works are carried out, as well as the surfaces necessary for carrying out processing activities, preparation of mineral resources and storage of residual mining products"*.

Therefore, the property on which the procedure of expropriation can be carried out for reasons of public utility is not perfectly identified with the area where the mineral resources are located, but it extends over a possible area necessary for the proper development of the entire production and exploitation cycle of mineral resources.

As I mentioned, the premise of expropriation as a juridical-administrative operation concerns the existence of private and public property.

Concerning **the regime of private property**, it must to be remember the fact that in present(2), precisely by referring to the existence of this forced way to take goods into public ownership, the constitutional legislator wanted to emphasize its inviolable character in article 136 paragraph 5 of the Constitution - *"Private property is inviolable under the conditions of organic law"*.

A definition of right of private property can be found in article 555 paragraph 1 of the New Civil Code, entered into force on 01.10.2011(3), being in this case " the owner's right to possess, use and dispose of a property exclusively, absolutely and perpetually in limits established by law".

Starting from this normative text, characteristics of right of private property are noted, respectively: exclusivity (namely, holder of such a right holds a monopoly over his property), its absolutism (right has a full character) and its perpetuity [1] (it lasts for all time of existence or accessibility of good).

As can be seen from legal definition of right of private property, its exercise and even its existence are circumscribed by limits established by law, the absolute nature of the right being susceptible to limitations [2], one of these is the possibility of expropriation for public utility.

Regarding **the public property regime**, a definition can be found in article 554 paragraph 1 of the New Civil Code, as follows "The goods of state and of administrative-territorial units, which **by their nature or by declaration of law are for use or of public interest**, form the object of public property only if the goods were legally acquired by these".

From the content of the aforementioned legal norm, it is observed that right of public property derives either from **the nature of goods subject to it** (meaning that goods expressly mentioned in article 136 paragraph 3 of the Romanian Constitution and mutatis mutandis including those mentioned in articles 1 and 2 of the Law) will be retained, or from the *"declaration of law"* regarding their acquisition (which implies their acquisition in ways provided by the law, respectively in cases mentioned in article 863 of the New Civil Code(4)), the distinction between the two categories being the subject of some extensive doctrinal debates [3].

Concerning **the holders of public property rights**, they are nominated in article 136 paragraph 2 of the Romanian Constitution(5), being represented by **the Romanian State and the administrative-territorial units**.

Referred to article 9 of the Mines Law, a text with special applicability, it must be observed that expropriation for reasons of public utility must be **of national interest** and it is done under the terms of the law, under the coordination of the relevant ministry. Starting from this normative text, it will be noted that, in this case, through this way of acquiring the right of ownership, expropriated goods in the context of mining legislation can have only one owner, respectively only the Romanian State, a notable element of differentiation in the context of the provisions of article 136 paragraph 2 of the Romanian Constitution.

Finally, regarding **the nature of goods that are subject to expropriation**, it is noted that these are **immovable goods par excellence**. However, starting from the legal classification [4] found at the level of the New Civil Code, it is also observed that certain movable goods by anticipation or incorporated movable goods can follow the same legal fate [5] with the mention that in the conditions in which the movable goods they would not be able to be acquired by the expropriated, their value is going to be taken into account when establishing the fair price of expropriation(6).

At the same time, in doctrine and practice, with which we will also agree with, the idea was also circulated that real rights dismembered (for example the usufruct, the servitudes [6]), the right of lease [7], respectively all movable goods attached with character permanent or not, but the removal of which causes a major damage / depreciation [8] will be able to be subject to expropriation.

Related to the mining legislation, an aspect that draws attention and which derives from the content of article 6 which bears the marginal name **- The right to use** the lands necessary for the realization of mining activities..., refers to use of the phrase "right to use" in the conditions of the express mention of the concept of expropriation for reasons of public utility. We appreciate the fact that it is at least unfortunate to use this phrase in conditions where through expropriation the transfer of a property right is made and not a right of use.

In conclusion, it is imposed to remember the fact that, according to the Romanian mining legislation, immovable property, including movable property incorporated therein, found in prospecting perimeter, exploration and exploitation of the mineral resource/s owned ope legis by the Romanian State constitute a subject of the expropriation procedure [9] and of passing into the public domain of the Romanian State.

Obviously, the procedure of expropriation will be carried out under the conditions of the special legislation represented by Law no. 255 of December 14, 2010 regarding expropriation for reasons of public utility, necessary to achieve some objectives of national, county and local interest (7).

3. EXTENT OF RIGHTS OF PROPERTY THAT IT IS SUBJECT TO EXPROPRIATION IN MINING LEGISLATION – CASE STUDY

As I mentioned above, it is imposed to establish rigorously what the right that is a subject to expropriation in the case of mining operations entails.

Here, we propose for analysis the situation described in Decision no. 239 of June 29, 2022 issued by Craiova Court of Appeal(8) in the resolution of the recourse of the Appeal related to the Civil Sentence no. 319 of December 2, 2021 issued by Gorj Court on basis of the file no. 1293/95/2020 regarding expropriation.

Thus, *"the claimant S.M. sued the defendant Romanian State, through M.E. through S.C.E.O. S.A., requesting that the defendant be ordered to pay the counter value for the surface of 1421 m.p. urban land located in T 14, P 418, with neighbors to the East - C. I., to the west - G. D. and S. V., to the south - rest of property, to the north - DS 461 and C. I., land located in the expropriation corridor Annex 2 to Decision no. 1031/2018; requesting that the defendant be ordered to pay the counter value for the surface of 864 m.p., urban land located in T 14, P 424, with neighbors to the East – rest of property, to the west - G. D., to the south - DCI, to the north – rest of property, land located in the expropriation corridor Annex 2 to Decision no. 1031/2018; requesting that the defendant be ordered to pay the counter value for the surface of 490 m.p., urban land located in T 14, P 425, with neighbors to the East – rest of property, to the west – rest of property, to the south - DCI, to the north - remaining property, land located in the corridor of expropriation Annex 2 to Decision no. 1031/2018; requesting that the defendant be ordered to pay the counter value for the surface of 1099 m.p. urban land located in T 14, P 426, with neighbors to the East – L. P., to the west – G. D., to the south - rest of property, to the north - rest of property, land located in the corridor of expropriation Annex 2 to Decision no. 1031/2018; obliging the defendant to also purchase the area of 710 urban land located in T 14, P 427, with neighbors to the East - L.P., to the west - rest of property, to the south - DCI, to the north - west property, land located in the corridor of expropriation Annex 2 to Decision no. 1031/2018; obliging the defendant to pay the counter value for the re-establishment of the existing fruit tree plantations and vines on the expropriated lands and maintenance works until they return to fruition; obliging the defendant to pay the counter value of the production of which she is deprived during the period from the receipt of the lands until the date of the re-established crops coming into fruition and obliging the defendant to pay court costs".*

From the analysis of the object of the court's investiture, it must be noted that, in this case, claims are requested in relation to a **procedure of expropriation** ordered regarding the corridor of expropriation found in the Annex 2 to the Decision of Government no. 1031/2018[(9).]

What represents, however, the element of interest concerns the fact that in this case it is requested to establish the extension of expropriation also on some immovable property - agricultural land, which were not part of the area proposed for expropriation (the corridor of expropriation) issued in the Decision of Government in question, but which are part of the plots of land for which expropriation is requested to in part.

At the same time, it is requested to extend the counter value for the price of expropriation with regard to the agricultural plantations found on these lands (with the mention that it is a multi-year crop) and the counter value for the production for a certain period of time.

The appellate court considered the following factual and legal aspects:

"It was considered that, according to the expert report in the field of topography drawn up in the case, it was concluded that, from the real surface (existing on the land at the time of expropriation) of 2718 m.p. of plot A 418, a total area of 861 m.p. was not expropriated, which is located in the north of the corridor of expropriation for the Rosiuta quarry, finding out that the applicant only received money for the directly expropriated area of 436 m.p.

Relative to conclusions of the expert report, specialty real estate appraisals, the court held that their value amounts to 11116 lei for the area of 861 m.p. and the amount of 48028 lei, related to the area of 3,270 m.p., effectively expropriated by administrative decision. At the same time, the established value was calculated according to the legislation in force at the time of expropriation, by referring to the sale-purchase contracts actually concluded by other owners in the respective area.

Also, in this case, an expert report was drawn up in the agricultural specialty, the expert proceeding to the inventory of the vines and fruit trees found on the surface of land in dispute and it was found that there were 190 pieces of vine in the yard of the house, and on the land of 490 m.p. a number of 330 vines are planted; a number of 49 fruit trees were inventoried in the following structure: 7 pears, 21 cherries, 64 cork trees, 12 apples, 6 quinces, a cherry, 15 grafted plums, 363 indigenous plums and 2 walnuts; one hair, one cherry, 2 apple trees, 11 plums, and 10 cherry plum were excluded from the inventory because of their age,. The inventoried trees are planted without respecting a planting scheme with distances between trees, in rows and between rows, their arrangement being irregular.

Secondly, regarding the prematurity of this action, the court found that by decision no. 14/2019 issued by the High Court of Cassation and Justice of Romania on appeal in the interest of the law, the following were established with binding effect: "In interpretation and application of the provisions of article 22 paragraph (1) from Law no. 255/2010 on expropriation for some reasons of public utility, necessary to achieve objectives of national, county and local interest, with subsequent amendments and additions, the court is competent to resolve not only the appeal filed against the decision establishing the amount of compensation, but also the action by which the expropriated person contests the estimated compensations and requests both their determination by *the court and the obligation of the expropriator to pay to after the issuance of the expropriation decision and recording the amounts related to the compensations in the case of the unjustified absence of this decision."*

Therefore, it was held that we can no longer talk about prematurity, but about the full reparation of the damage, according to article 1357 of the Civil Code, considering that the lawful action also had as a result an expropriation in fact and the claim for compensation for the area that no longer had access to the public road, as well as for the related damage calculated by the experts, is justified, related to the principles of civil tort liability, respectively the article 1357 of the Civil Code: The one who causes damage to another through an illegal act, committed with guilt, is obliged to repair it; The author of the damage is responsible for the slightest fault. According to article 1385 paragraph 1 of the same normative act, the damage is repaired in full if the law does not provide otherwise.

In this context, it was noted that the expert in the agricultural specialty established the net value of the re-establishment works and the maintenance works until the fruiting of the vine and fruit tree plantation at the amount of 15.675 lei.

It was also noted that the payment of the counter value for the production cannot be granted for the period from the receipt of the land until the date of the re-established plantations coming into fruition and of the maintenance works until they come into fruition as it would reach to an unjust enrichment for the applicant considering that applicants are entitled to compensation for lands, depending on the category of use, at the value of circulation from the moment of direct and indirect expropriation and the mentioned amount includes precisely the costs for the re-establishment of the plantation and the works of maintenance until the fruit tree and vine plantation comes into fruition, noting that until now no re-establishment of those plantations has been carried out in order to establish compensation for a damage uncertain.

Thus, according to article 1385 paragraph 2 of the Civil Procedure Code, compensation may also be granted for a future damage if its occurrence is beyond doubt.

Consequently, based on article 22 of the Law no. 255/2010, the court partially admitted the summons and ordered the defendant to pay the applicant the sum of 11.116 lei, related to the surface of land of 861 m.p. and the amount of 48028 lei related to the surface of land of 3,270 m.p., representing the counter value of lands; obliged the defendant to pay the applicant the sum of 15675 lei, representing the value of the investment to re-establish the existing fruit tree and vine plantation on the expropriated lands; will reject the counts regarding the obligation to pay the counter value of the production during the period of receiving the lands and until the date of the re-established plantations coming into fruition and of the maintenance works until they come into fruition, as unfounded.

One of the principles that limit the rule of devolutive character of the appeal is tantum devolutum quantum apellatum, which is a requirement of the principle of availability applicable to the civil process, a principle that is also imposed before the courts of judicial review, therefore also before the court of appeal.

As such, according to the stated principle, the appellate court, as a reformation court, is called to examine the case only by reference to the reasons invoked in the appeal request, not being able to pronounce on other reasons for reformation not indicated in the content of the reasons of appeal, except the reasons of public order.

In this case, the Court did not identify the existence of the reasons of public order and analyzing the appellants' criticisms regarding the unfoundedness of the appealed sentence, it is noted that these are not founded.

Regarding the appeal filed by the appellant-defendant S. C.E.O. S.A. as the representative of the Romanian State, the Court notes the following:

Contrary to what was argued by the appellant, the first instance was noted that the judgment was held in contradiction with only one defendant, the Romanian State, citation in question of Ministry and C. E. O. not being made in their own name but as a representative of the defendant- the Romanian State.

The operative part of the sentence fully reproduces the defendant's name obliged to pay compensation, leaving no room for doubt regarding the obliged entity in question, being explicitly assigned the quality of defendant in the case exclusively to the Romanian State.

The applicant sued the Romanian State as a defendant, which is in process through the two representatives in whose charge no obligations have been established.

Therefore, the passive procedural quality belongs to the Romanian State and it is justified by the provisions of article 2 paragraph 1 letter e) of Law 255/2010 according to which mining works of national interest for exploitation of lignite deposits are declared to be of public utility which are carried out on the basis of an exploitation license by economic operators found under the authority of M.E., E. and M. de A., as responsible ministry.

In the sense of article 2 paragraph 2 of the law, for the objectives of national interest, the expropriator is the Romanian State, and in accordance with paragraph 3 letter d) the expropriator is represented by the Ministry E., E. and M. de A., through the economic operators for mining works of national interest for exploitation of lignite deposits which are executed on the basis of an exploitation license through the companies of project which have as shareholders national societies/national companies/other companies with majority state capital for works of national interest in the field of exploitation, processing and valorization of mineral energy resources: coal, uranium, oil, crude oil and natural gas.

Therefore, these legal provisions justify not only the summoning of the Romanian State as defendant, having the quality of expropriator, but also the summoning in the case of the two representatives expressly provided by article 2 paragraph 3 letter d) of Law 255/2010, namely M. E. and the commercial company with majority state capital that exploits the lignite resources, namely S. C. E. O. S.A.

The appellant's criticisms regarding the wrong assessment of the real state and the compensations due by the first instance cannot be retained either,

Compensations were established according to the expert report – specialty of agriculture drawn up in this case, the expert calculating the net value of the re-establishment works and the maintenance works until the vine and fruit tree plantations come into fruition. The lack of motivation of the appealed sentence invoked by the appellant is not verified.

In relation to dispositions of article 425 paragraph (1) lit. b) Civil Procedure Code, the Court notes that the obligation of the court to justify the pronounced sentence is considered fulfilled, the court clarifying all aspects deduced from the judgment.

The reasons for which the court admitted some petitions and rejected others are clearly specified in the sentence, the obligation of the court being to examine the essential arguments of the parties for judging the case, not to provide a detailed argumentation for each argument of the party. The motivation of the decision is not a generic, abstract one, but is specific to the present case. The court presented in a clear and coherent manner the arguments considered in adopting the solution, the considerations retained aimed at solving the legal issues brought to the judgment by reference to the arguments invoked by the parties to the administered evidence and also taking into account the applicable legal provisions concerned to. No considerations were identified in the content of the sentence, contradicting the solution given, the court taking into account the defenses invoked through the statement of defense.

Not least, pronouncement of a solution contrary to the party's conviction cannot mean that the court did not respect the standards of argumentation imposed by article 425 Civil Procedure Code and article 6 of the European Convention on Human Rights (ECHR).

Also, the rejection of the request regarding the carrying out of a new expertise was motivated by the first court, showing that it is not useful to the case because the court considers itself enlightened. The court approved the objections formulated by the parties, including the appellant-plaintiff and the expert gave a reasoned answer to all objections.

Regarding the appeal filed by the appellant-plaintiff S.M., the Court notes that she criticizes the decision of the first court regarding the rejection of the petition concerning the payment of the counter value of the production of which the plaintiff was deprived during the period from the receipt of the lands until the date of the re-established crops coming into fruition, respectively the sum of 76492 lei representing the production value.

In agreement with the first instance, the Court assesses that, as long as the appellant- plaintiff was compensated with the counter value of the expropriated lands and with the value of the investment to re-establish the plantation of fruit trees and vines existing on the expropriated lands, the damage caused to her was covered.

The damage was quantified in compliance with the provisions of article 26 of Law no. 33/1994 and granting the additional amount requested by the appellant would lead to a double compensation and therefore, to her unjust enrichment."[(10)]

Therefore, the solution issued by the trial court - Gorj Court was maintained and the appeals filed in the case were rejected in full.

From the analysis of this solution, the following conclusions must be retained regarding the right of property subject to expropriation under the conditions of the mining legislation:

First of all, it is noted that expropriation will aim not only buildings land that are part of prospecting, exploration and exploitation perimeter of mineral resource(s) in question, but also parts of land/lands considered *ut singuli* that reduce their economic value, respectively the possibility of normal exploitation according to the destination of the asset in question.

Thus, it is required that at the time of analyzing the opportunity of expropriation and drawing up the technical documentation to be analyzed both the situation of the mineral resource incorporated in that land and the situation of the neighboring lands or parts of a larger plot that are not actually part of the corridor of expropriation, but which under these conditions, it presents a decrease of the possibility of exploitation and implicitly in the market value. This aspect requires a complex understanding of the rights of property, as well as collaboration between the entity that carries out the documentation from a technical point of view and the legal or commercial component that supervises it.

In essence, it will be remembered that this situation circumscribes the idea of indirect / de facto expropriation, also retained by the European Court of Human Rights in its jurisprudence (11), to which we will lean in a future research.

Secondly, it is observed that the right of property, subject to expropriation, also extends to movable property by anticipation or perennial crops found on the land in question. In this case, when setting the price of expropriation, **the value of the investment to re-establish the existing fruit tree and vine plantation on the expropriated land** was taken into account which reflects the legal aspects mentioned above regarding the object of expropriation.

Finally, it must to note the fact that under conditions of initiation of the procedure of expropriation for reasons of public utility, the Romanian State is the entity that will grant the counter value for this operation.

4. CONCLUSIONS

Starting from the legal premise of the fact that the right of ownership over mineral resources is assigned exclusively ope legis to Romanian State, it is considered that it has the legal possibility to obtain the right of ownership over the buildings necessary for their exploitation, especially by resorting to the procedure of expropriation for the cause of public utility.

From this point of view, an important aspect is the outline of the right of property which is going to be expropriated, with a direct effect on the counter value of expropriation.

In this sense, we note the fact that the technical concept of prospecting, exploration and exploitation perimeter of the mineral resource(s) in question must be retained, which, however, is not definitive and complete in order to establish the right of private property, subject to a possible expropriation.

The importance of establishing the object of a procedure of expropriation depends on the use of public investments, acquisition of right of public property and retention of a complex procedure, both technical and legal in order to obtain the desired objective.

From this point of view, we appreciate that the existence of a complementary vision is necessary, both from a technical and legal point of view in order to establish the object of the procedure of expropriation, meaning that the present approach comes to offer a starting point in the analysis of the practitioners who are involved in the unfolding of such a procedure.

Notes:

(1) Published in Official Gazette Part I no. 197 of March 27, 2003. Based on historical evolution of mining legislation, it is noted that by article 69 of this, it is noted that *"On the date of entry into force of this law, Mining Law no. 61/1998, published in the Official Gazette of Romania, Part I, no. 113 of March 16, 1998, with subsequent amendments and additions, as well as any other contrary provisions is repealed".*

(2) The Constitution of 1866 regulated the right to inviolable private property according to article 20 with mention that the exception to this principle was represented by the expropriation established in article 19 as follows: *"Property of any nature, as well as all claims on the State are sacred and inviolable. No one can be expropriated except for the cause of legalized public utility, ascertained and after a fair and prior compensation. By reason of public utility, only communication and public sanitation, as well as land defense works are going to be understood. The existing laws regarding the alignment and widening of streets in the communes, as well as banks of waters that flow through or along them, remain in force. Special laws will regulate the procedure and manner of expropriation. The free and unhindered use of navigable and floating rivers, roads and other means of communication belongs to the public domain", text available at https://www.cdep.ro/pls/legis/legis_pck.htp_act_text?idt=37755, accessed on 15.01.2023;*

(3) The New Civil Code and the Implementation Law, 4th edition, rev., Hamangiu Publishing House, Bucharest, 2013, page 173;

(4) According to article 863 of the New Civil Code, "Right to public property is acquired: (a) through public acquisition, carried out under conditions of law; (b) by expropriation for reasons of public utility, under the law; (c) by donation or legacy, accepted under the law if the good, by its nature or by the disposer's will, becomes of use or of public interest; (d) by agreement with onerous title, if the good, by its nature or by the acquirer's will, becomes of use or of public interest; (e) by transferring an asset from the private domain of the state to its public domain or from the private domain of an administrative-territorial unit to its public domain, under the law; (f) by other means established by law".

(5) Text available at https://www.cdep.ro/pls/dic/site2015.page?id=339&idl=1 &par1=4, accessed on 15.01.2023;

(6) We will note that in such a hypothesis, the generally applicable rule aims to grant the expropriated person the possibility to take over the respective goods. In this sense, the provisions of article 31 paragraph 2 of Law no. 33/1934 are retained as examples.

(7) Published in Official Gazette no. 853 of 20.12.2010

(8) Text available at https://www.cdep.ro/pls/dic/site2015.page?id=339&idl=1 &par1=4, accessed on 15.01.2023;

(9) In case it is about Government Decision no. 1031/2018 regarding approval of location and initiation of procedures of expropriation of all privately owned buildings that constitute the corridor of expropriation located on the site of public utility work of national interest "Opening and commissioning of the Rosiuta Quarry, Gorj County with a capacity of 3.000. 000 tons/year" published in Official Gazette, Part I no. 1105 of December 27, 2018.

(10) Decision no. 239 of June 29, 2022 issued by Craiova Court of Appeal, pages 13-17.

(11) Judgment of January 27, 2009 in Burghelea case against Romania, text available at http://ier.gov.ro/wp-content/uploads/cedo/Cauza-Burghelea-%C3%AE mpotriva-Romaniei.pdf, accessed on 02.02.2023. An analysis of this jurisprudence can be analyzed in Chirita, R., Expropriation of fact. A commentary on the ECHR (European Court of Human Rights) judgment in Burghelea v. Romania case, text available on https://www.scribd.com/document/34115192/Exproprierea-de-fapt-Un-comentariu-al-hot %C4%83rarii-CEDO-in -Burghelea-c-Romania-Radu-Chirita, case accessed on 02.02.2023.

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INDEX OF AUTHORS

Annals of the University of Petrosani, Mining Engineering, edition (2022)

INSTRUCTIONS FOR AUTHORS
PAPER TITLE TNR 14p bold

Author 1 Surname, Name [1], Author 2 Surname Name[2] TNR 12p bold

Abstract: *5-15 lines, TNR 10p italic*

Keywords: *4-7 key words, TNR 10p italic*

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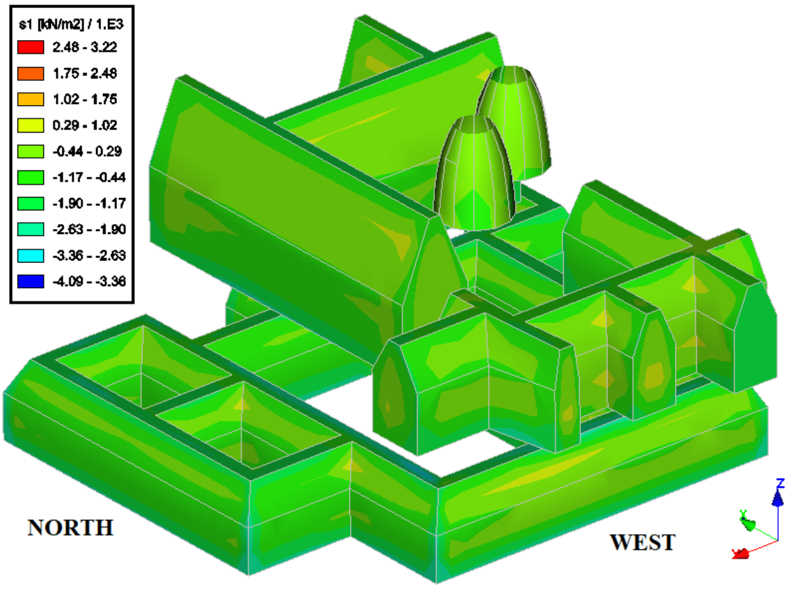

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3. CONCLUSIONS

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4. REFERENCES

[1]. Author, Paper title, Publisher (year) – TNR, 10p

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