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SAFETY IMPROVEMENT SOLUTIONS IN COAL MINES USING GIS

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Abstract: *Exploitation of coal from the Jiu Valley presents its own specific, in terms of coal mining deposit conditions, fact that required a continuous preoccupation for the monitoring of the work conditions, in order to ensure work-places safety. This paper intends to indicate a method of increasing the work environment safety using GIS technology, the analysis being completed at Lupeni Coal Mine, the largest Coal Mine in Jiu Valley, characterised by a low level of accidents that has taken place in there so far. It consists of an extension of accomplished studies in order to implement an intelligent dispatching system.*

Key words: GIS, safety, coal mines

Introduction

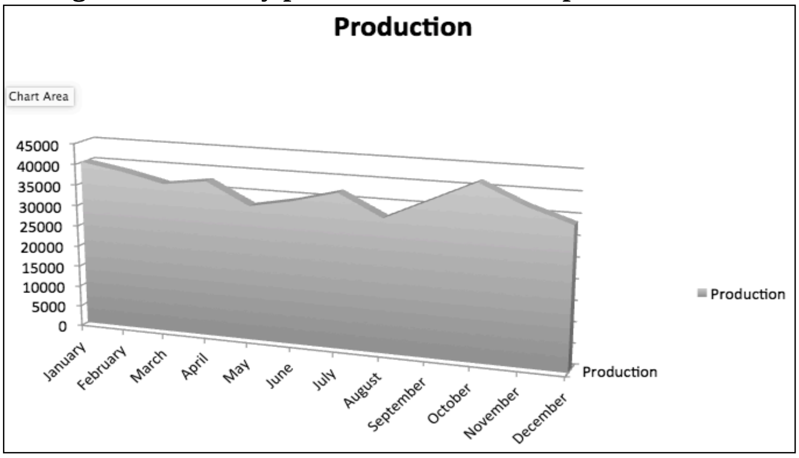
The coal extraction in Jiu Valley begins in 1840 (taking into account the information given on the webpage of the Complex Energetic Hunedoara) and over time the quantity of extracted coal increases or decreases and mines are opened or closed. Nowadays the coal exploiting is performed by two companies “Complexul Energetic Hunedoara” which currently owns 4 coal mines and “Societatea Nationala de Inchideri Mine”, which currently owns 3 coal mines.

Meaningful and relevant characteristics of mining in Jiu Valley, in connection with work environment safety, are the structure and the depth of the coal deposit taking into account that this has a firedamp characteristic.

2. The existing situation in a Jiu Valley coal mine

In the analysis performed by us, we have chosen to refer to the most representative coal mining from several reasons related to size, complexity and history in terms of accidents. The Lupeni coal mine is the largest mining in this area, not only in terms of number of employees, which is now 1392 but also in terms of coal production. It is found located in the western part of the mining area. In the last 35 years, Lupeni coal mine hasn’t experienced a significant number of accidents or casualties.

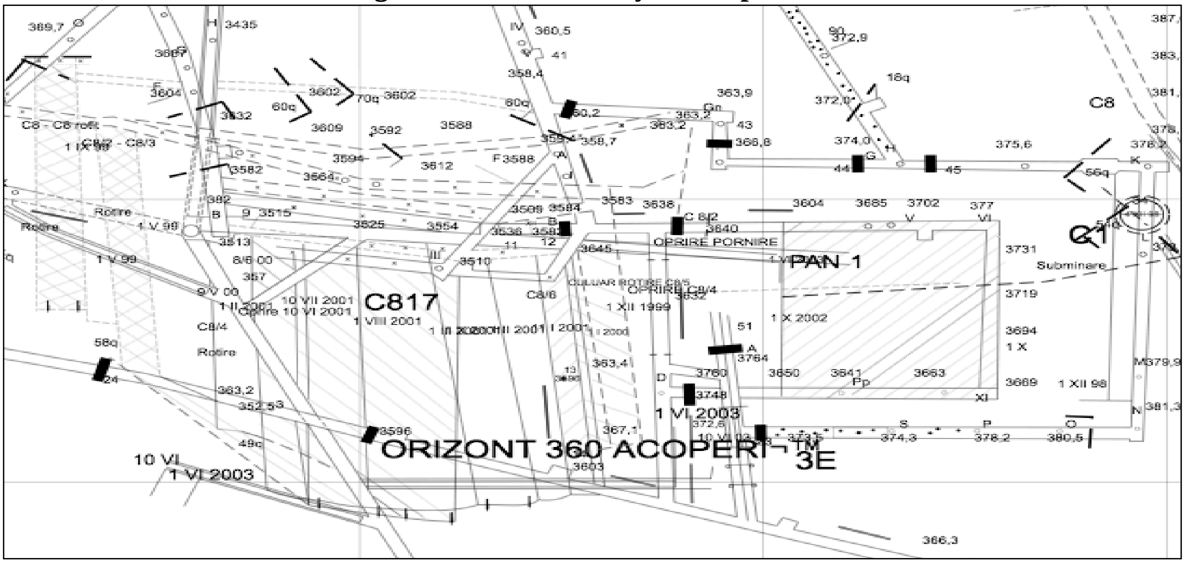
Figure 1: Monthly production of 2014 Lupeni Coal Mine



Source: Production documentation Lupeni Coal Mine

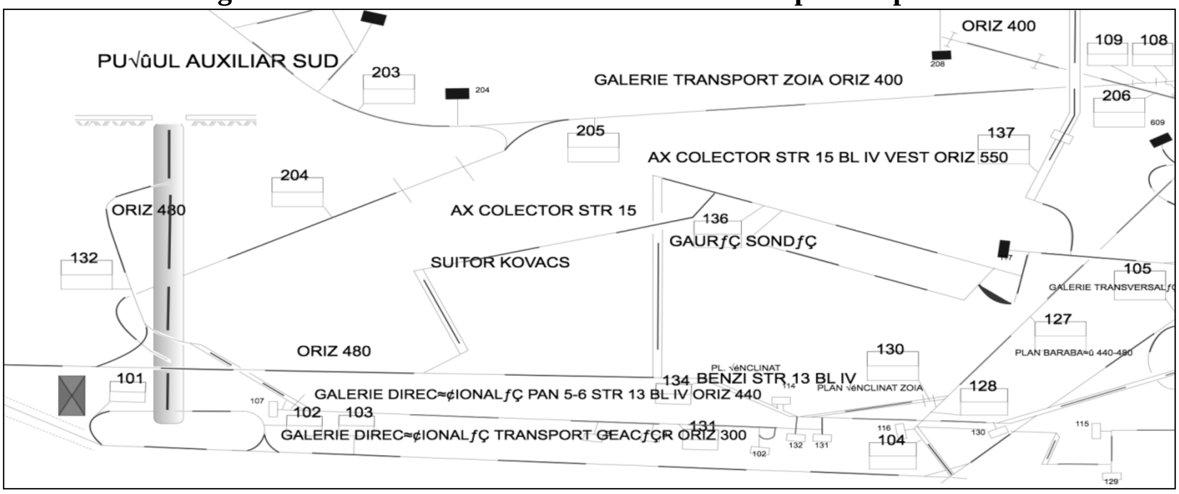
As shown in Figure 2, the complexity of coal mine is a special one and for this, there is a continuous concern regarding monitoring and ensuring the safety of work environment. Work place safety is seen in a complex way taking into account all possible components. As it is known, the Jiu Valley mines have a firedamp character and that contributes to an increase risk of coal exploitation. To maintain the correct parameters of the atmosphere from underground, ventilation systems exist. In Figure 3 the complexity of the mine ventilation system in Lupeni Coal Mine is shown.

Figure 2: Section of Layer 3 Lupeni Coal Mine



Source: Production documentation Lupeni Coal Mine

Figure 3: Part of the indicative mine ventilation plan Lupeni Coal Mine



Source: Production documentation Lupeni Coal Mine

Analysis of the methane concentration in Lupeni coal mine, shown that sometimes exceeding of the permissible values occurs. The causes are diverse. In Table 1 are presented two of such situations.

Table 1: Methane concentration measurements point 16, Sector 3, Ventilation Plan P2C, str. ¾, top, in the highest point

Data	**The hour of reading**	**Normal Value**	**Concentrations**	**Cause**
1st of September 2014	18:50	0,2%-0,3%	1,2%	Emanations from the dam located at ventilation canal P2 complex (CPX)
"	18:54	0,2%-0,3%	0,6%	
"	18:58	0,2%-0,3%	1,1%	
"	19:02	0,2%-0,3%	0,7%	
"	19:06	0,2%-0,3%	0,9%	
"	19:10	0,2%-0,3%	0,8%	
"	19:14	0,2%-0,3%	0,3%	Fixed
6th of September 2014	14:53	0,2%-0,3%	0,7%	Emanations from layer and blocked ventilation
"	14:57	0,2%-0,3%	1,9%	
"	15:01	0,2%-0,3%	1,4%	
"	15:05	0,2%-0,3%	0,7%	
"	15:09	0,2%-0,3%	1,7%	
"	15:13	0,2%-0,3%	2,0%	
"	15:17	0,2%-0,3%	2,2%	
"	15:21	0,2%-0,3%	1,0%	
"	15:25	0,2%-0,3%	0,3%	Fixed

Source: Register of methane concentration records Lupeni Coal Mine

The presence of methane in combination with coal dust, lead to meeting the risk conditions of underground explosion. Over time, in Jiu Valley Mines many events took place, some of them having been explosions that resulted in many causalities and life losses. Among these, we mention a few: 53 dead people in 1980 Livezeni Coal Mine, 25 dead people in 1986 Vulcan Coal Mine, 13 dead people in 2008 in Petrila Coal Mine. All of these speak without doubt about the importance of the safety of the underground work environment.

Monitoring the underground presence of methane, is currently accomplished in a tele firedamp detector system, which includes a system of head detections located underground, in points that are considered to be important. They are connected to a tele firedamp detector station that is usually located, at the dispatching point of coal mine. Lupeni Coal Mine uses CTT 63 / 40U stations of firedamp detector, having active a number of 40 heads of detection. The system is an old one, manufactured in the 70s and being characterised by the fact that the reading is fragmented from 4 to 4 minutes, as can be seen in Table 1.

Figure 4: Tele Firedamp Detector Station CTT 63/40

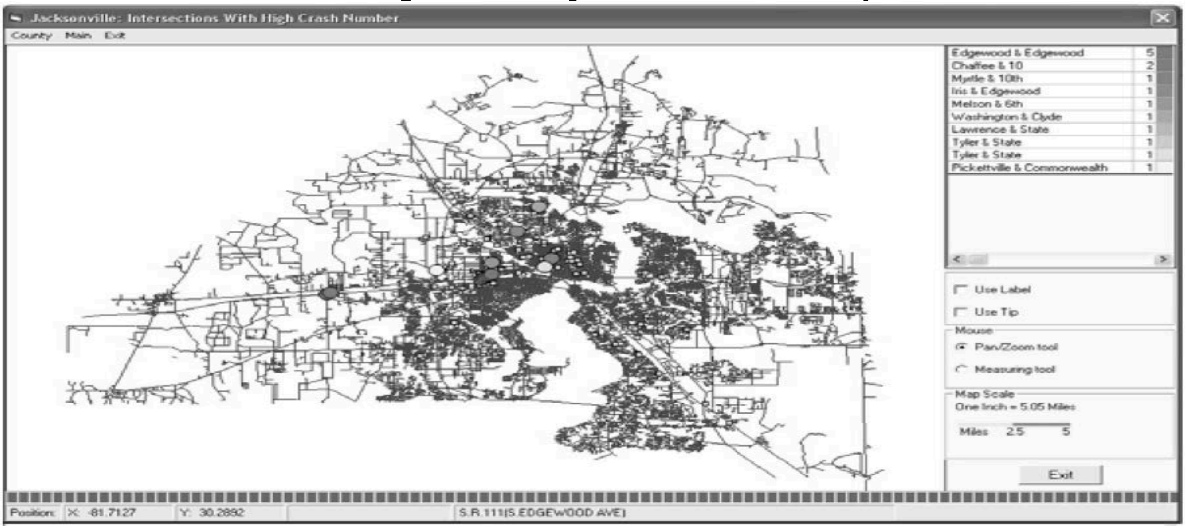
Source: Lupu, Constantin. Moraru, Roland. *Prevention of fire and explosion– course material,* Master – Occupational Health and Safety Management, 2014 – 2015

Note that at Livezeni Coal Mine operates a Firedamp Detector station produced by Carboautomatika SA Poland with CPC1 transducers that, being from a newer generation, has an exceptional characteristic: it has a continuous measurement system. At the same time, this system allows, besides the monitoring of methane concentrations, the monitoring of several other parameters.

3. Experiences in the use of GIS for monitoring and controlling of various environmental parameters

We concluded from the analysis we performed, that at international level, GIS is used in various situations. One situation is that of creating tools to increase safety of road traffic on highways, situation studied by Thobias Sando, and others in thesis ***A Cost-Effective GIS Safety Analysis Tool for Improving Highway Safety***, and that shows that by the usage of GIS, using models of accident localization, queries the database with data acquisition and having at disposal an access interface, analysis of intersections, of traffic, of accidents, and so on can be created. Figure 5 shows the example taken, for the part of intersections of highway sectors.

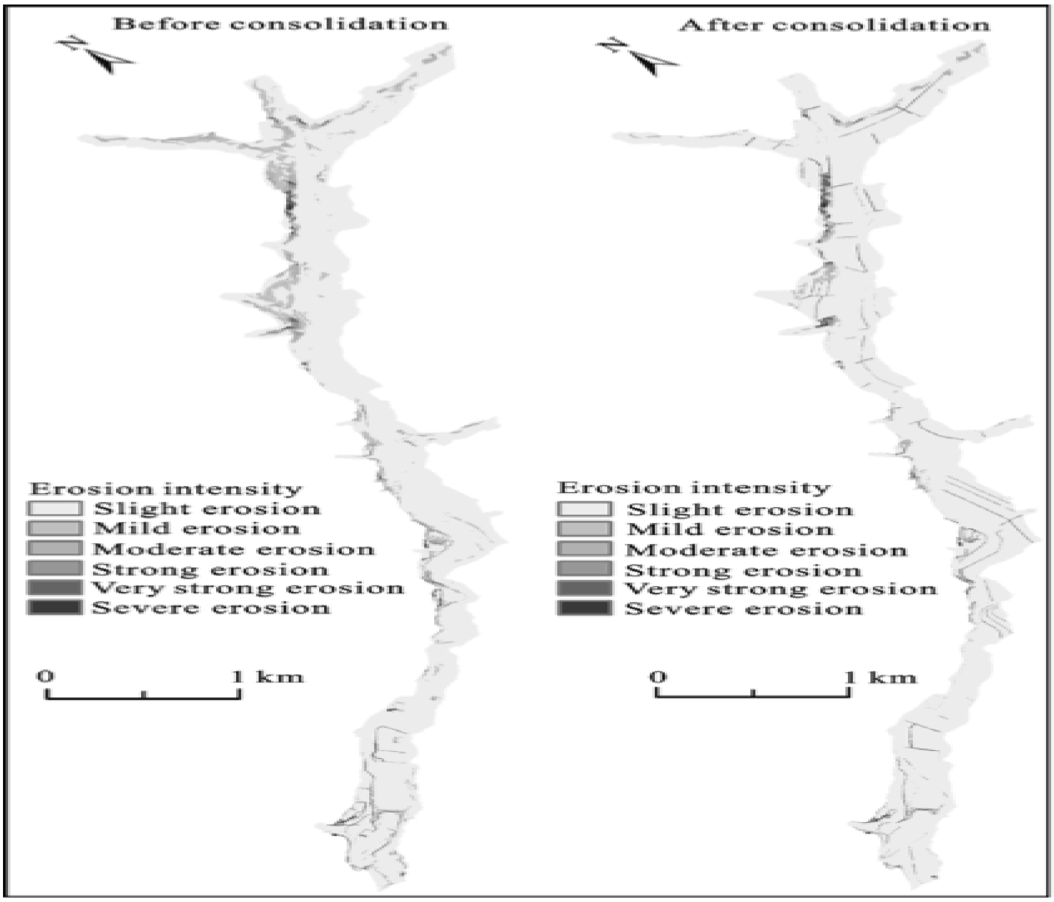
Figure 5: Example of Intersection Analysis



Source: Sando, T., Mussa, R., Wu, H., Sobanjo, J., and Spainhour, L. *A Cost-Effective GIS Safety Analysis Tool for Improving Highway Safety* Paper in Proceedings of ESRI International GIS User Conference, San Diego, California, August 2004

Another example of GIS use is in monitoring and controlling of soil erosion. In the paper written by Liu Yansui, and others, entitled ***GIS-based Effect Assessment of Soil Erosion Before and After Gully Land Consolidation: A Case Study of Wangjiagou Project Region, Loess Plateau***, the authors try to show how GIS can be used to evaluate the soil erosion. Using high density measurements, they succeed to assess soil erosion, providing comparatively the situation before and after the consolidation of the considered area. This is shown in Figure 6.

Figure 6: Soil erosion intensity before and after consolidation



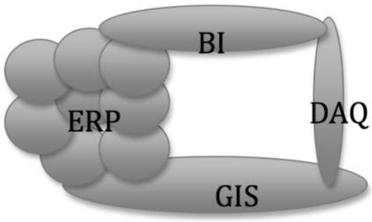
Source: Liu, Yansui. Guo, Yanjun. Li, Yurui. Li, Yuheng. *GIS-based Effect Assessment of Soil Erosion Before and After Gully Land Consolidation: A Case Study of Wangjiagou Project Region, Loess Plateau,* Chinese Geographical Science 2015 Vol. 25, No. 2, pp. 137–146

More examples can be given, but they can't lead to a different conclusion than the one that shows that the GIS usage is feasible in many domains and that it serves without difficulty in many areas of interests including for coal exploitation. GIS connectivity with other informatics systems, allows the monitoring of processes, the anticipation of situations, the management and running of activities.

4. Opportunities for control of safety in coal extraction

As shown in a paper that aims to bring to potential interested persons, the possibility of transforming the present time dispatching from coal mining of Jiu Valley in intelligent systems, based on 4 pols: GIS, ERP, DAQ and BI (as in Figure 7), the construction of systems that include software and hardware can lead to increased safety of work environment.

Figure 7: The structure of the informatics system "Intelligent Dispatching System"



Source: Lupu-Dima, Lucian. Leba, Monica. Ionica, Andreea. Edelhauser, Eduard. *Intelligent Dispatching, A Solution for Increasing Efficiency in Mining,* The 6th International Conference on Manufacturing Science and Education, MSE 2013, 12th - 15th of June, 2013, Sibiu, Romania, http://conferences.ulbsibiu.ro/mse/

By using the following set of actions:

1. Creating of GIS of coal exploitation:
    a. The base layer is the coal deposit;
    b. The upper layers are underground work structures and utilities infrastructure and transport;
2. The implementation of a complex system of monitoring for all the relevant indicators, from the methane concentrations, the carbon monoxide level, to the underground equipment functioning and the supply of water, electricity and also consumptions on various points of interest;
3. Implementing of a control system that allows the remote intervention, based on the collected information;
4. The integration of all of these elements in GIS, the connecting of the result with the ERP of the management activity and the propagation of the results in BI made available to the management of the organization, to the decisional levels of the existing hierarchical structure;

The premise for the safety of work places to be assured can be created by means of preventing the conditions that lead to accidents.

Considering that accidents can happen because of human errors, such a system can come to sustain the rescue activities required to be performed in case of the apparition of such event. Thus, an intelligent system would allow a safer coordination of interventions and the determination of places to mean the demarcation limits of the affected areas.

Conclusions

The existing situation in Jiu Valley coal mining, especially in Lupeni Coal Mine, shows that it is possible for the level of work place safety to be improved. This action, in the direction suggested by the present paper, brings a set of results, regarding the improvement of the management, of the capacity of simulating situations when production faces of workings advance in coal deposit and the activity is managed so that its efficiency to be improved. At the same time it is relevant to be mentioned that at a coal mine of such dimension and complexity, the benefits in terms of efficiency of exploitation can bring considerable effects, regarding the production costs.

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