A CONTEXTUAL ANALYSIS OF OCCUPATIONAL ACCIDENTS OCCURRED IN VALEA JIULUI COLLIERIES DURING THE LAST FOUR DECADES

Roland Iosif MORARU, Gabriel Bujor BĂBUȚ**

Abstract

An analysis of accident records provides a useful means for identifying patterns in the incidence of accidents in professional populations. Despite all precautions, underground coal mining is one of the dangerous industries leading to fatal occupational accidents. Accidents are complicated events to which many factors effect on their causation and preventing them is only possible by analyses of the events occurred in past and by proper interpretation of the statistical results. This paper synthesizes the analysis of accidents occurred in Valea Jiului collieries from 1972 to 2010. It is found that methane remains the main concern for the future, despite a favourable evolution trend in overall fatality rate. At last, it brought forward some conclusions and prospects for the improvement of safety levels in the collieries in Valea Jiului.

Keywords: statistics, events**,** methane, explosion, risk, occupational safety and health.

1. Introduction

Methane, entity present in worldwide coal mining industry, has represented along time the main risk factor and subject of major concern in research and ensuring higher safety levels [1, 2, 9]. Worldwide, thorough research aimed at deeper knowledge about the occurrence and prevention of hazards caused by methane gas, shows that no price is too high to reward achievements in possession and control of safety in underground environment.

Methane was continuously a maximum point of care in study and analysis for three main reasons, namely:

- methane is a natural product and appears frequently in underground excavations;
- methane is the cause of several accidents with catastrophic consequences, which resulted in casualties, more than other risk factors in the history of mining [3];
- the need for rational use of methane drainage technology [8].

Although the main reason for extracting methane from coal deposits continue to be the methane emissions reduction from mining operations, an important incentive was draining the gas and provide a source of fuel and the need to reduce emissions of greenhouse gases.

Black coal mining in Jiu Valley coal basin is being carried out in difficult geological-mining conditions, which creates many hazards to health and safety of underground personnel. The major mining risk factors are including the explosions of methane-air mixtures, which too often have been causes of mine disasters [6]. Practical materialization of scientific principles to prevent methane explosions has significantly contributed over time to the decrease of the explosion risk in coal mines [7, 11]. However, despite numerous scientific and technological achievements in this field, explosions continue to occur, remaining a potential threat to life and health of underground workers, contributing to generate considerable costs associated with fighting and rescue actions, asset damages, reserves immobilization and compensation granted.

2. Nature of methane gas impact on health and safety of underground workers

Methane associated with coal deposits in the Jiu Valley coal basin has been a constant concern, over time, both in terms of safety and health of workers, deposit, equipment and machinery used in underground protection and in terms of impact on the atmosphere.

Today, in the mines within the Jiu Valley basin are applied mining methods that have in common the downward removal of thick coal seams in slices, namely seam 3, with mining pressure release by the total overthrow of rocks [4]. In the specific case of method the mining method with undermined coal bank, the fragmentation and crumbling of rock massif is developed on a much larger area, creating the occurrence of exploitation gaps and remainder coal quantities in the caved goaf [14]. In this case, through the existing ventilation systems, increases the likelihood of large bodies of methane accumulation, which

* *Assoc.prof.eng.Ph.D University of Petroşani*

together with coal dust is the main source of potentially explosive atmospheres, with all the related adverse consequences on ensuring safety in underground and proper atmospheric underground environment for a normal course of mining activities.

Air inleakage through the space of caved goaf carries oxygen in the goaf and, meanwhile, discharges methane stucked in gaps between collapsed rocks and the heat of oxidation of the material. Depending on the intensity ratio of involved processes, air leakage through the exploited space can lead to self-heating and spontaneous combustion of coal left after mining operations. Research conducted worldwide have shown that the self-heating and spontaneous combustion intensity is even lower with higher methane content in the exploited area, namely in the goaf [10, 12]. In recent years in the Jiu Valley the collective accidents recorded were caused by accumulations of methane in the goaf area.

Technical and organizational measures aimed at reducing methane concentrations in underground environment and quantities of methane released into the atmosphere through the main ventilation stations are targeted, directly or implicitly, to the accomplishment of the following objectives:

- increased safety and protection of the coal deposit;
- ensuring continuity of coal extraction;
- increased safety of workers in the extraction of coal;
- reduction of the reserve immobilization;
- reduction of explosive mixture formation risk and reduction of the probability of endogenous fires occurrence;
- improving working conditions and safety by decreasing risk factors generated by spontaneous combustion and explosions of methane;
- decrease in technical and human accidents due to dynamic phenomena;
- the increase of safety and comfort of staff directly involved in the exploitation of coal;
- minimizing the environmental impact.

3. Analysis of accident statistics collective mines in the Jiu Valley

A statistical record, including collective accidents occurred in the last 33 years in coal mines in the Jiu Valley, presented in Table 1 [16], is particularly indicative of risk associated with explosive mixtures formation while the means to prevent accumulation methane de not have the expected effectiveness [5, 15].

Insufficient dispersion of methane in the ventilation currents, associated with technical failure and/or human error have generated numerous events with extremely severe consequences on human and economic plan.

Table 1. *Statistics on collective accidents occurred between 1972-2004 in collieries within Jiu Valley coal basin*

DATE	OCCURRENCE LOCATION	EVENT CHARACTERIZATION AND EFFECTS	CAUSES OF EVENT'S OCCURRENCE
02.11.1972	**E.M. Uricani,** Chamber face, seam. 3, bl. III	**Methane explosion** • 53 injured (43 mortal,10 ITM); • 2 hours no ventilation in bl. III area.	• inadequate selected mining technology; • inadequate ventilation; • faulty AG 25 switch-gear; • other organizational causes.
16.01.1980	**E.M. Petrila** Frontal face seam 13, panel B3, bl. I	**Methane ignition** • 7 injured ITM.	• failure to respect working technology; • inadequate ventilation; • other organizational causes.
29.11.1980	**E.M. Livezeni,** Frontal face, seam 5, bl. VI	**Methane explosion** • 77 injured (53 mortal, 24 ITM).	• inadequate ventilation; • un-proper operation and maintenance of electrical and mechanical equipment; • other organizational causes.
18.02.1982	**E.M. Petrila** Chamber face no. 331, seam 3, bl. II	**Coal dust explosion** • 29 injured (14 mortal, 15 ITM).	• inadequate selected mining technology; • other organizational causes.
09.09.1982	**E.M. Paroşeni** Head gallery, level 360, frontal face panel 1,seam 5, bl. V	**Methane explosion** • 24 injured (17 mortal, 7 ITM).	• error in developing the automated release system of electrical energy; • other organizational causes.
26.06.1985	**E.M. Aninoasa** Frontal face no. 4, seam. 3, bl. V, level X	**Hydrogen explosion** • 4 injured mortal.	• inadequate endogenous fire suppression technique, resulting in thermal dissociation of water in hydrogen and oxygen; • inadequate ventilation; • other organizational causes.

DATE	OCCURRENCE LOCATION	EVENT CHARACTERIZATION AND EFFECTS	CAUSES OF EVENT'S OCCURRENCE
21.03.1986	**E.M. Vulcan** Seam 7, bl. 0, level 420	**Methane explosion** • 19 injured (17 mortal, 2 ITM).	• inadequately selected blasting technology; • failure to reinforcement monograph compliance, respectively lack of old mining area closure; • inadequate ventilation; • erroneous placement of methane detectors.
22.03.1986	**E.M. Vulcan** Seam 7, bl. 0, level 420	**Methane explosion** • 17 injured (8 mortal, 9 ITM).	• other organizational causes, respectively granting permitting to access an area with explosive methane concentration.
18.09.1989	**E.M. Vulcan** Preparation gallery panel 1, seam 5, bl. 0	**Methane explosion** • 39 injured (29 mortal, 10 ITM).	• failure to apply correctly the methane and coal dust mitigation systems; • use of open fire, without appropriate safety measures; • inadequate ventilation; • erroneous placement of methane detectors.
13-14.11. 1991	**E.M. Uricani** Frontal face, panel 1, seam 3	**Methane ignition**	• methane concentration build-up; • spontaneous combustion development.
17.06.1993	**E.M. Paroşeni** Frontal face, seam 5, bl. V	**Methane ignition**	• methane concentration build-up; • blasting operation.
21.06.1993	**E.M. Vulcan** Mine workings at seam 3, bl. II	**Carbon monoxyde intoxication**	• inadequate dam insulation methods and materials.
12.08.1994	**E.M. Câmpu lui Neag** Chamber face, seam 17/18, bl. VI.S	**Methane ignition**	• methane concentration build-up; • electrical short-circuit.
30.03.1995	**E.M. Paroşeni** Longwall face, panel 1, seam 5, bl. 0	**Methane ignition**	• methane concentration build-up; • self-heating process.
12.09.1996	**E.M. Petrila** SCRI face no. 332, seam 3, bl. II, Level O	**Methane ignition** • 5 injured (4 mortal, 1 ITM).	• failure to comply with regulation on breaking oversized blocks technology; • other organizational causes.
25.07.1996	**E.M. Petrila Sud** Auxiliary Shaft	**Technical accident** • 3 injured mortal.	• wrong handling of the winch driving the working bridge; • other organizational causes.
08.11.1996	**E.M. Uricani** Gallery of return ventilation seam 8/9, bl. VI S, level 400	**Carbon monoxide intoxication** • 5 injured mortal.	• failure to comply with the regulation of mining rescue.
18.11.1996	**E.M. Vulcan** SCRI face no. 3, seam 3, bl. VI	**Methane ignition** • 3 injured (1 mortal, 2 ITM).	• failure to comply with framework mining method; • entering a fire zone, where methane concentrations were above the lower explosion limit; • other organizational causes.
30.01.1997	**E.M. Petrila** Directional opening-out on floor of coal seam no. 355 E - 334, seam 3, bl. II	**Caving** 4 injured (2 deceased, 2 ITM).	• failure to respect working technology; • no correlation of the distance of the front face entries and roads front of top slice; • other organizational causes.
19.05.1997	**E.M. Dâlja** Workings of short-wall face no. 2311, seam 3, bl. II	**Methane explosion** • 12 injured (7deceased, 5 ITM).	• inadequate ventilation; • technical noncompliance with requirements on how to conduct blasting operation; • erroneous placement of methane detectors; • other organizational causes.

DATE	OCCURRENCE LOCATION	EVENT CHARACTERIZATION AND EFFECTS	CAUSES OF EVENT'S OCCURRENCE
22.07.1997	**E.M. Vulcan** SCRI face no. 6, seam.3, bl. IX	**Methane ignition** • 8 injured (2 deceased, 6 ITM).	• changes and improvised electrical equipment enclosure constituting the power switch type electric motor scraper conveyor in cross-entry no. 2, that canceled intrinsic safety protection type of the control circuit of the scraper conveyor; • inadequate ventilation.
28.04.1998	**E.M. Dâlja**, SCRI face no. 331, seam 3, bl. III	**Methane ignition**	• methane concentration build-up; • blasting operation.
29.04.1999	**E.M. Paroşeni** Longwall face panel 2, seam 5, bl.0	**Methane explosion** • 2 injured ITM.	• unfit mining method; • technical noncompliance with requirements to prevent and suppress fires and spontaneous combustions; • other organizational causes.
02.11.1999	**E.M. Lupeni** Longwall face with undermined coal bench panel 3, seam 3, bl. V	**Caving** • 1 injured deceased.	• failure to respect working technology; • noncompliance with reinforcement monograph; • other organizational causes.
17.01.2000	**E.M. Lupeni** Ventilation raise SABO	**Methane explosion**	• methane concentration build-up; • open flame.
14.09.2000	**E.M. Uricani** Frontal face panel 4, seam 3, bl. III North	**Caving** • 2 injured deceased.	• lack of knowledge on geological and geo-mechanical characteristics of the coal and surrounding rock; • the presence of numerous excavations around face area, state of intense secondary and variable stresses; • the seismic waves generated by explosion loads.
30.09.2000	**E.M. Valea de Brazi** Frontal face panel 2 S, seam 17-18, bl. VIII	**Methane ignition** • 2 injured ITM.	• mechanical sparks; • failure to respect working technology.
07.08.2001	**E.M. Vulcan** SCRI face no. 1-4, seam 3, bl. VIII	**Methane explosion, with coal dust fines participation** • 7 injured (1 dead, 6 ITM).	• un-properly performed blasting operations; • inadequate ventilation; • other organizational causes.
30.08.2001	**E.M. Bărbăteni** Longwall undermined face no. 8 E, seam 3, bl. XI, under level 615	**Methane explosion in closed area with insulating dams**	• methane concentration build-up in insulated area.
12.06.2002	**E.M. Vulcan** SCRI face no. 3, seam 3, bl. VI	**Flammable gasses mixture explosion** • 14 injured (10 deceased, 4 ITM).	• unfit mining method; • technical noncompliance with requirements to prevent and suppress fires and spontaneous combustions; • other organizational causes.
31.07.2002	**E.M. Petrila** Closed area of face SCRI no. 138, seam 3, bl. 0	**Flammable gasses mixture explosion** • 7 injured (1 deceased, 6 ITM).	• technical noncompliance with requirements to prevent and suppress fires and spontaneous combustions; • other organizational causes.
22.12.2002	**E.M. Lonea** SCRI face no. 74, seam 3, bl. VII	**Methane ignition**	• methane concentration build-up; • blasting operation.
05.07. 2003	**E.M. Lonea** SCRI face no. 74, seam 3, bl. VII	**Methane ignition**	• methane concentration build-up; • mechanical friction spark.
18.04.2004	**E.M. Petrila** Skip shaft	**Exogenous mine fire**	• coal behind supporting system; • welding operation.
22.05.2004	**E.M. Uricani** Frontal face BS, panel 5, seam 3, bl. III-IV	**Methane ignition**	• methane concentration build-up; • blasting operation.

Overall analysis of the available statistics allowed highlighting the following issues:

- from the total of 35 events classified as collective occupational accidents, 13 are explosions of methane, 13 ignitions of methane, 3 cavings (collapse), 2 carbon monoxide intoxication, an explosion of hydrogen from thermal dissociation of water into hydrogen and oxygen, an explosion of coal dust, a technical fault by incorrect handling winch drive and an exogenous fire; we considered the fact that is unlikely to achieve the minimum explosive concentration of coal dust without prior methane explosion in a state of suspension raising coal dust deposited and - consequently - we considered the event in 18/02/1982 as having the presence of methane as a primary cause;
- from the total number of 344 victims of these dynamic phenomena, 239 have died (69,48 %) and the other 105 have suffered temporary work disability (30,52 %);
- the 13 methane explosions have resulted in 200 deaths (83,68 % of all deaths) and 87 cases of temporary disability;
- the 13 ignitions of methane resulted in 5 deaths (2,09 % of all deaths) and 18 cases of temporary disability;
- the event framed according to the research as *„coal dust explosion"* had the effect of 14 human deaths (5,86 % of all deaths) and 15 people who have had varying periods of temporary disability.

We can say therefore that 91,63 % of deaths resulting from accidents investigated were due to collective events leading as one of the primary causes accumulation of methane in underground mine openings. To them were added other causes that created the conditions for propagation of accident causation scenarios for the worker staff [13].

4. Statistical analysis of occupational accidents and safety indicators during 1981-2010

In order to establish the necessary measures and find solutions for increasing occupational safety and health at mines in the National Hardcoal Company, it is required an analysis of accidents evolution and the development of indicators of health and safety at work. Statistically, the situation of events occurrence in the past two decades is shown in Table 2.

Table 2. *Occupational injuries and specific indicators evolution in Valea Jiului collieries*

Year	Number of occupational injuries				$I_{frequency}$	$I_{gravity}$	$I_{average\ duration}$	No. acidents/ 1000 t
	ITM Temporary Work Disability	Invalidity	Fatalities	Total				
1981	1002	14	21	**1037**	34.5	1259.3	32.8	0.11
1982	926	25	56	**1007**	39.5	1139.3	33.6	0.10
1983	907	10	17	**934**	35.6	1176.2	37.9	0.09
1984	826	23	25	**874**	34.5	991.4	33.5	0.08
1985	731	22	28	**781**	30.3	987.5	41.3	0.07
1986	751	15	45	**811**	27.3	752.4	33.3	0.07
1987	948	18	31	**997**	43.9	661.0	26.5	0.09
1988	1377	13	42	**1432**	52.8	927.2	30.7	0.13
1989	1625	24	77	**1726**	51.8	947.2	32.2	0.16
1990	1368	5	17	**1390**	34.7	925.7	26.1	0.26
1991	1337	2	23	**1362**	34.0	1042.5	31.9	0.28
1992	1489	7	23	**1519**	36.5	1539.3	39.3	0.29
1993	1646	3	24	**1673**	40.5	1237.6	32.5	0.33
1994	1669	0	21	**1690**	38.7	1243.8	34.7	0.30
1995	1506	0	16	**1522**	37.0	1433.1	39.4	0.27
1996	1940	0	43	**1983**	48.0	1782.8	35.9	0.32
1997	1413	0	28	**1441**	38.1	1543.2	40.6	0.28
1998	1136	0	6	**1142**	49.0	1709.2	35.6	0.28
1999	1131	0	10	**1141**	57.2	2043.0	36.7	0.31
2000	1278	0	12	**1290**	70.7	1399.6	30.2	0.34
2001	1338	0	18	**1356**	75.7	2657.1	35.5	0.33
2002	1165	0	17	**1182**	68.5	2328.3	34.6	0.29
2003	962	0	6	**968**	59.0	1966.1	35.4	0.28
2004	575	0	7	**582**	39.7	1402.8	37.9	0.19
2005	319	0	7	**326**	24.5	1096.4	45.4	0.10
2006	291	0	2	**293**	24.5	1261.7	51.7	0.11
2007	251	0	1	**252**	21.4	1154.7	53.4	0.09
2008	220	1	15	**236**	20.5	1036.1	52.6	0.08
2009	267	0	2	**269**	25.1	1356.8	52.1	0.12
2010	216	0	1	**217**	23.5	1066.9	45.4	0.09

It can be noticed from Table 2 that the worst period in terms of safety and health was recorded from 1988 to 2002. The highest number of accidents occurred in 1996, respectively in 1983, representing over 25 % of the total number of accidents occurred in Romania. The highest number of deaths registered in 1989, 77 fatalities respectively. The accidents frequency index, reported as the number of accidents per thousand workers had the highest value in 2001 being 75.7. In the same year 2001 was recorded also the highest severity index, respectively 2657.1. In year 2000 there were the highest number of occupational injuries reported in the 1000 tons extracted, namely 0.34. From the analysis driven on the evolution of occupational injuries in the last decade, we may find the following:

- it significantly decreased the number of accidents involving deaths and disability;
- the number of fatalities was influenced by collective accidents occurrence; this is shown from the fact that the number of fatal accidents in years when there were no casualties, is very low, 1-2 fatalities/year;
- the reduction, in real terms, of the number and severity of accidents is also highlighted by the evolution of the occupational safety and health indicators; frequency index fell from 75.7 to 23.5, the severity index decreased from 2657.1 to 1066.9, while the index which relates to the production extracted (coal output) fell from 0.33 to 0.09;
- although the frequency index fell from 75.7 to 23.5, yet he is the highest in Romania; but if we analyze the frequency and severity index in different industries and activities, we find high severity indexes in fields with low-frequency index; from this analysis we can conclude that in other areas are declared only casualties; the fact that the National Hardcoal Company declares all accidents at work (last year being reported and investigated also the slight injuries) is a positive remark;
- the only indicator that increased in the last 10 years is the average duration index from 35.5 to 45.4; this increase indicates that mining workers are having ever lower resilience; the number of days to recover work capacity after an event is becoming bigger; this is mainly due to the increasing average age in the National Hardcoal Company personnel, poor health state of staff, lack of younger workers to perform work requiring high physical intensity work;
- between 2000-2010 it increased significantly the number of fatalities at work that can not be classified as occupational injuries: heart attacks, strokes and even suicides, events that occur due to exacerbation of psychosocial risk factors.

5. Conclusions

The statistic analysis of events occurred, accidents, occupational diseases, hazardous incidents, mine fires, self-heating and spontaneous combustion, the analysis of safety indices, non-safety related costs and loss of production and, especially, the causes that led to these events must underpin any policy setting in the field of occupational health and safety in Valea Jiului collieries.

The increase in average age of staff employed in the National Hardcoal Company, the specific conditions of underground activity, the layoffs and employment cessation in mining has led to damage of employees health, this in turn generating the following consequences:

- lower resilience and physical recovery capacity;
- diminished responsiveness, respectively predisposition to injury;
- reduced attention levels and predisposition to stress;
- occurrence at higher rate of events likely to be favored by stress causes (cardiovascular accidents, suicide, alcoholism);
- emergence of unfitness to perform certain activities;
- reduced ability to physical loads;
- the emergence in recent years, of new occupational diseases, mostly related to manual handling of loads and noise.

Not covering certain jobs or work stations, on which health and safety of employees highly depends, or covering them with workers who do not have the necessary competence or skills or medically they are unfitted, the impossibility to sanction through demotion or dismissal, all these are contextual elements that are conducive to an inadequate safety climate.

Since 2006 the focus was legally put on risk assessment to reduce or avoid the risk of major events, especially the methane explosion risk, since the occupational accident statistics and the statistics of non-safety related costs are confirming that these events most influenced the safety status of the National Hardcoal Company.

Unfortunately, quite often this fundamental process has a formal character, of exclusive legislative compliance. When undertaking a risk assessment it is of importance to consider the range of hazards proposed by personnel of all disciplines present in the affected area. This may include the mine manager, with whom ultimate responsibility lies, electrical and mechanical engineers, mine safety personnel and worker's representatives. Depending on the perceived severity of the hazard difficulty in fire fighting or the length of the escape

route, it may also be prudent to consult the Mine Rescue Service, or other emergency service who may attempt to undertake rescue or fire fighting underground.

Despite the positively evolving picture painted by the statistics above, the reality may be even worse. A chronic lack of accurate information, at many levels, combined with poor statistical measures probably underestimates the severity of coal mining safety challenges. Closing mines without careful consideration has other negative consequences. A failure to sufficiently fund other aspects of the coal mining industry also contributes to unsafe mining conditions.

Fundamentally, solving the coal industry's problems will require appropriate statistical measures and accurate information. To this end, the use of intensity based measures standards for safety improvement must be adjusted to include quantity-based safety targets. The former, while important, is merely a measure of fatalities relative to coal production and thus an abstract statistic. A reduction in this rate may be offset by higher absolute numbers as a result of increased production levels.

By using quantity-based standards, on the other hand, the industry is forced to reduce absolute numbers of coal mining injuries and deaths. This also places greater emphasis on the individuals and their tragedy and loss resulting from coal mining accidents. Aggressive quantity-based targets are achievable if supplemented with effective enforcement. Gathering and publicizing accurate information is also basic to any solution for coal mining safety. In addition, the government must focus on adequate mine capacity in order to meet both the national coal demand as well as ensure safe working conditions. For this to happen, investment in mining technology, safety equipment and adequate enforcement of safety measures are all imperative. Sufficient funding to ensure appropriate safety measures for Romanian coal enterprises has been chronically neglected. Romania's coal mining industry and its safety record also raises deeper issues about the nation's modern social, economic and political life. What is the balance between the country's needs for rapid economic growth versus the wellbeing of society? How should the overall progress of the nation be measured against the rights of the citizens that comprise it? Fundamentally, these are the thorny questions behind the relations between state and society and the widening gaps that we must address as it moves relentlessly forward.

References

1. **Anon, W.E.**
Mine disaster pushes safety to top of political agenda, 1995 (available www.mg.co.za; accessed: 06.08.2012)
2. **Baleni, F.**
A silent Crime in the Mines, NUM News, 2007 (available at: www.num.org.za; accessed: 06.08.2012)
3. **Battersby, J.D.**
30 South African Miners Killed, 1987 (available at: www.nytimes.com; accessed: 03.08.2012)
4. **Cozma, E.**
Optimizarea parametrilor de exploatare a zăcămintelor stratiforme, Editura Focus, Petroşani, 2002
5. **Davies, A.W., Isaac, A.K., Cook, P.M.**
Investigation of a coal mine explosion and relevance of risk assessment, Vol. 109, Number 2, pp. 61-69, 2000.
6. **Kissell, F.N.**
Handbook for Methane Control in Mining (IC 9486), Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Pittsburgh Research Laboratory, Pittsburgh, USA, 2006
7. **Kucuker, H.**
Occupational fatalities among coal mine workers in Zonguldak, Turkey, 1994-2003, Occupational Medicine, Volume 56, Issue 2, pp. 144-146, 2006 (avalable at: http://occmed.oxfordjournals.org/content/56/2/144.full.pdf+html; accessed: 06.08.2012)
8. **Lupu, C.**
Metanul din minele de cărbune, Editura INSEMEX, Petroşani, 2007
9. **McPherson, M.J.**
The Westray mine disaster. In: De Souza E, ed. Proceedings of the North American/Ninth U.S. Mine Ventilation Symposium (Kingston, Ontario, Canada, June 8-12, 2002). Lisse, Netherlands: Balkema, pp. 3–12
10. **Mitchell, D.W.**
Mine Fires: Prevention Detection and Fighting, Third Edition, Intertec Publishing, Chicago, pp.82-83,1996
11. **Moraru, R., Băbuț, G., Cioca, L.I.**
Human Reliability Model and Application for Mine Dispatchers in Valea Jiului Coal Basin, Proceedings of the International Conference on Risk Management, Assessment And Mitigation (RIMA '10), pp. 45-50, Bucharest, 20-22.04.2010, WSEAS Press, 2010
12. **Moraru, R., Băbuț, G.**
Oxygen deficiencies interpretation for use in ratios assessing spontaneous combustion activity, Revista Minelor, vol. 16, nr. 3/2010, pag. 15-19
13. **Moraru, R., Băbuț, G.**
Risk evaluation and participative management: practical guide, Editura Focus, Petroşani, 2010
14. **Onica, I., Chiril, G.**
The undermined bench exploitation of coal in front works, Editura AGIR, Bucureşti, 2005
15. **Terazawa, K, Takatori, T, Tomii, S, Nakano, K.**
Methane asphyxia. Coal mine accident investigation of distribution of gas, The American Journal of Forensic Medicine and Pathology Vol. 6 (3), pp. 211-214,1985
16. *Technical expertise reports on causes for accidents, events and damages during 1991-2008*, S.C. INSEMEX S.A. Petroşani.