20th Meeting of the "Heads of State Mining Authorities" Dublin, Ireland - 9th & 10th of October 2014

Topic - "Lessons learned from Significant Mining Incidents"

Major Mining Accidents Occurred in Jiu Valley Coal Field between 1990-2014

National Institute for Research and Development in Mine Safety and Protection to Explosion

I N S E M E X

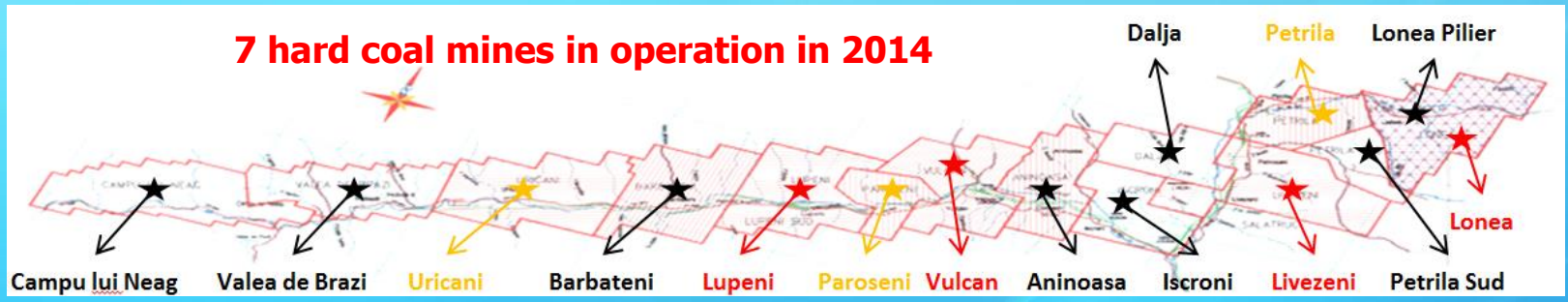
Authors:

George Artur GĂMAN - PhD., Eng.

Constantin LUPU – PhD., Eng.

Vlad Mihai PĂSCULESCU – Eng.

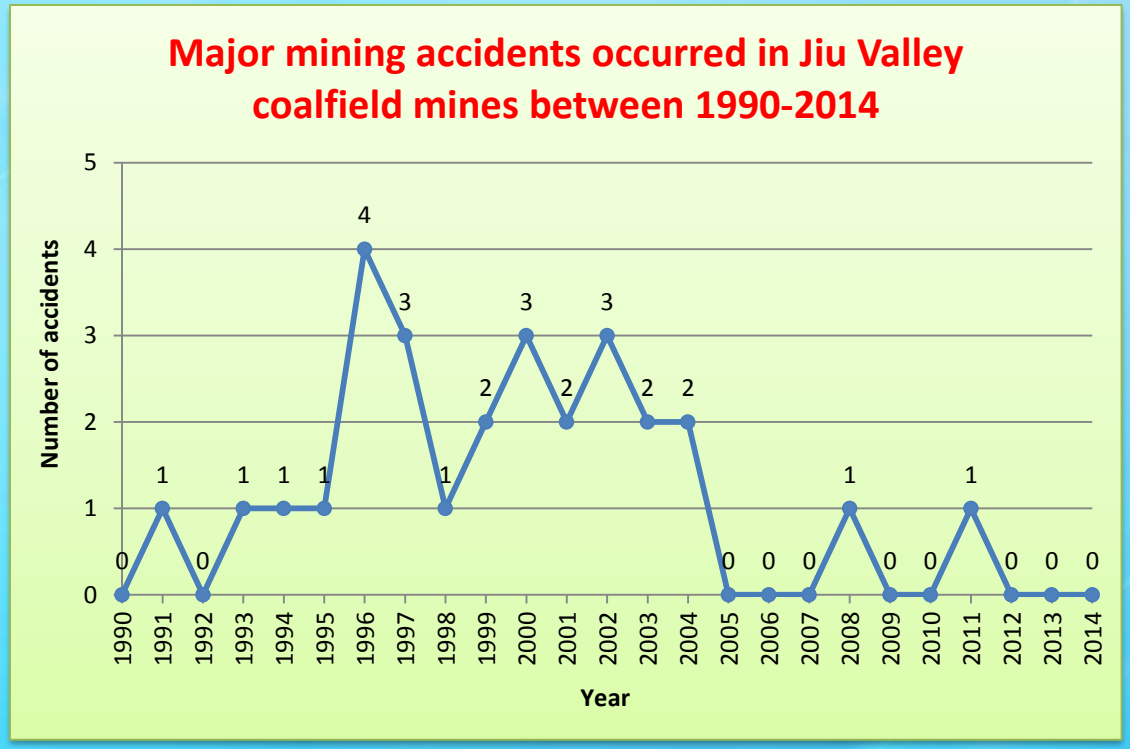
Location of Jiu Valley coalfield



- **4 mining units considered to be profitable (Lupeni, Vulcan, Livezeni, Lonea) are operating within the Hunedoara Energy Complex (CEH)**
- **3 mining units considered to be unprofitable (Uricani, Paroseni, Petrila) are operating within the Jiu Valley National Society for Mine Closure (SNIMVJ) and are to be closed until 2018**

Major accidents

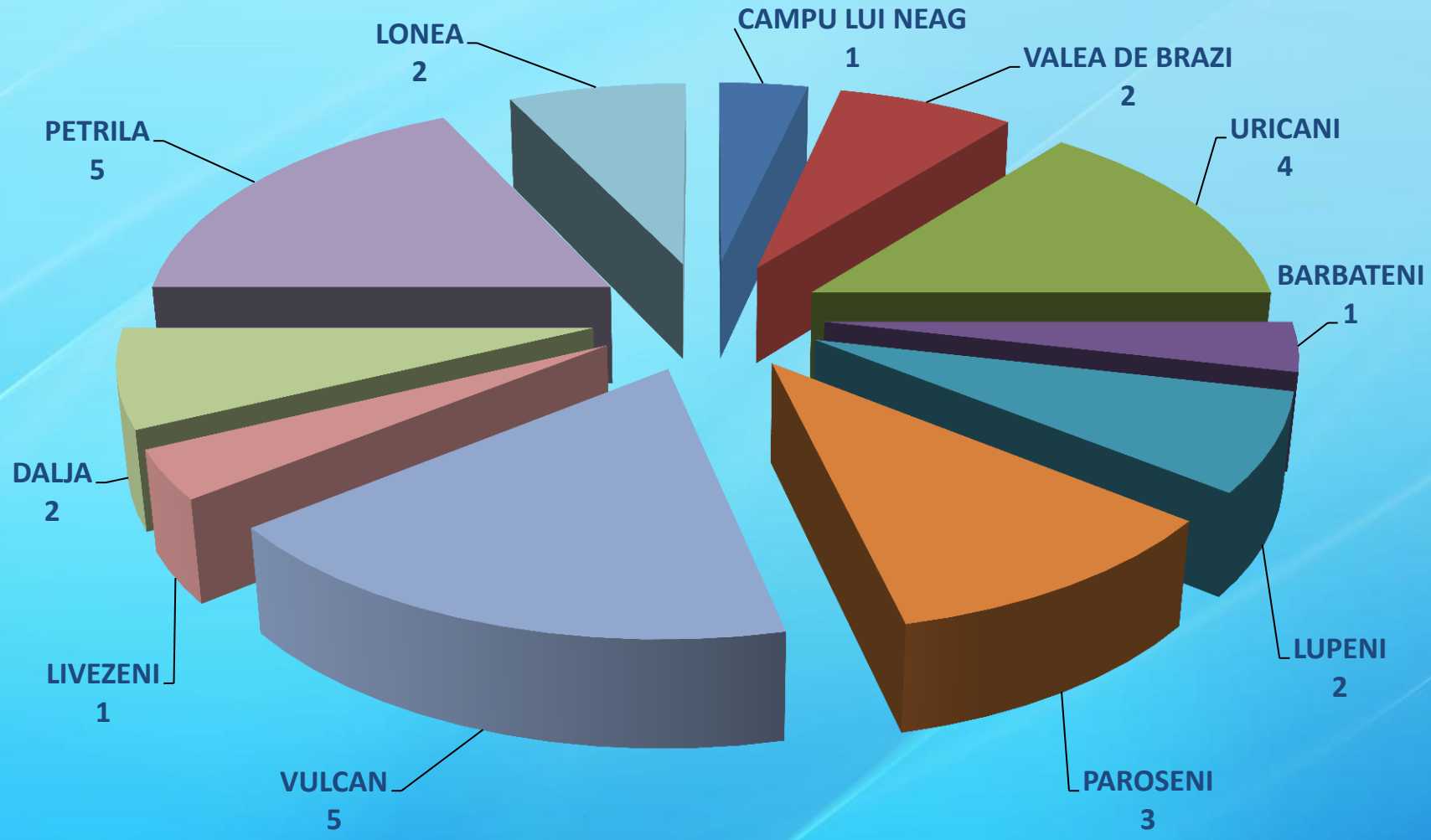
- **Between 1990 – 2014, in Jiu Valley hardcoal mines occurred 28 major accidents resulting in human losses and important material damages**



Main causes of accidents

- **Methane emissions and accumulations**
- **Spontaneous combustion and self-heating**
- **Blasting operations**
- **Electrical faults**

Number of accidents / Mining Unit between 1990-2014



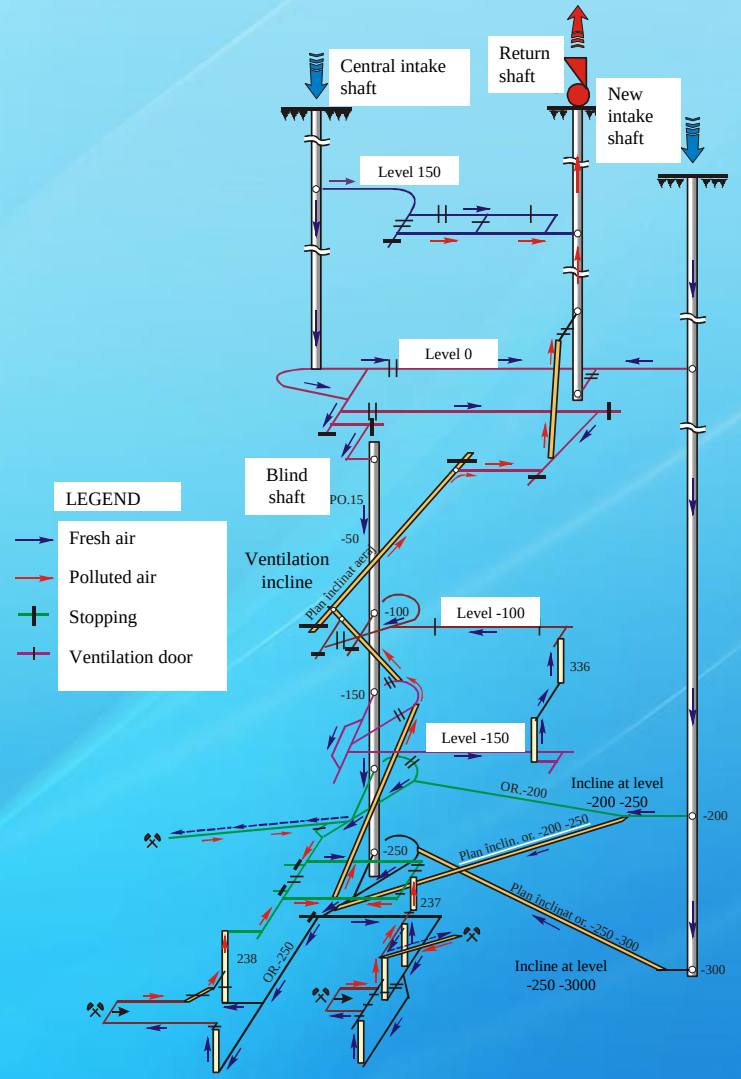
CAUSES WHICH LED TO THE EXPLOSIONS FROM PETRILA MINE UNIT DATED NOVEMBER 15TH 2008

Opening, preparatory and mining workings at Petrila mine

Petrila mine field was opened through a series of vertical shafts combined with horizontal and inclined mining workings.

Ventilation system of the mine
General ventilation

Main ventilation system is of the exhausting type created by the fan located at the return shaft



Preparatory and mining workings in the stope

Preparatory and mining workings at the face with undermined coal seam no. 431, where the two explosions occurred, are located at a 910 m depth from the surface of the mine (level –250). Sublevel IV includes:

- longitudinal mining way on the floor of the seam
- longitudinal mining way under the roof of the seam
- coal face

On **October 20th , 2008** the mining of the face was started from the longitudinal mining way, and on **November 06th , 2008** the stope was ventilated under the general depression.

Technical parameters designed for the stope with undetermined coal seam no. 431

- height of the base strip of the stope: 2.5 m;
- length of the base face: max. 43 m;
- longitudinal stope length: 225 m;
- support of the base strip in the stope: hydraulic props and special metallic beams;
- advancing pitch of the working face: 1.25 m;
- distance between two rows of beams: 0.8 m;
- width of the stope:
  - minimum: 2.5 m (length of two beams);
  - maximum: 3.75 m (length of three beams).

Events occurred at the stope with undermined coal seam no. 431

Two explosions occurred at the stope with undermined coal seam no. 431, sublevel IV, seam 3, block II, level -250 on November 15, 2008.

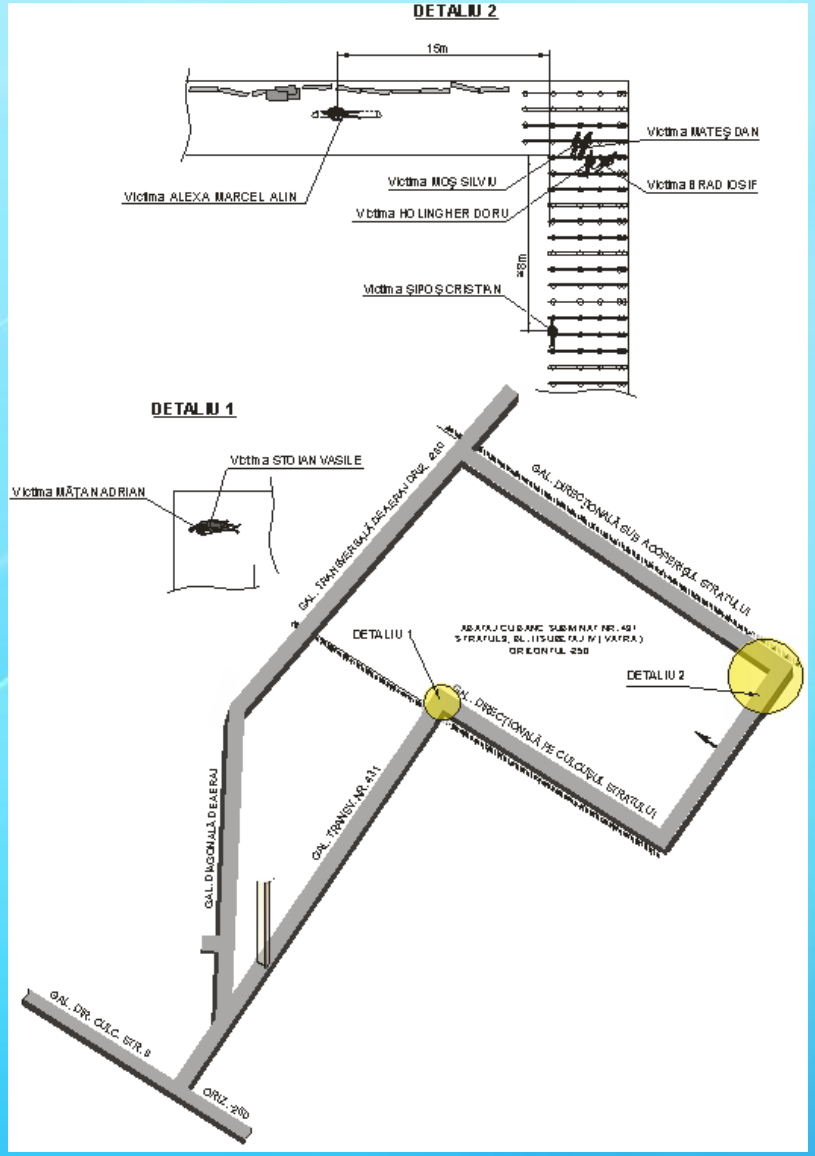
The first event occurred at **14^{49}** and it registered **17** victims of which **8** died. The rescue group of the mine which entered after the first event, performed the investigation of the area and started retrieving the dead victims.

During this action, a 2nd explosion occurred at **18^{40}**; there resulted **10** other victims of which **5** dead persons.

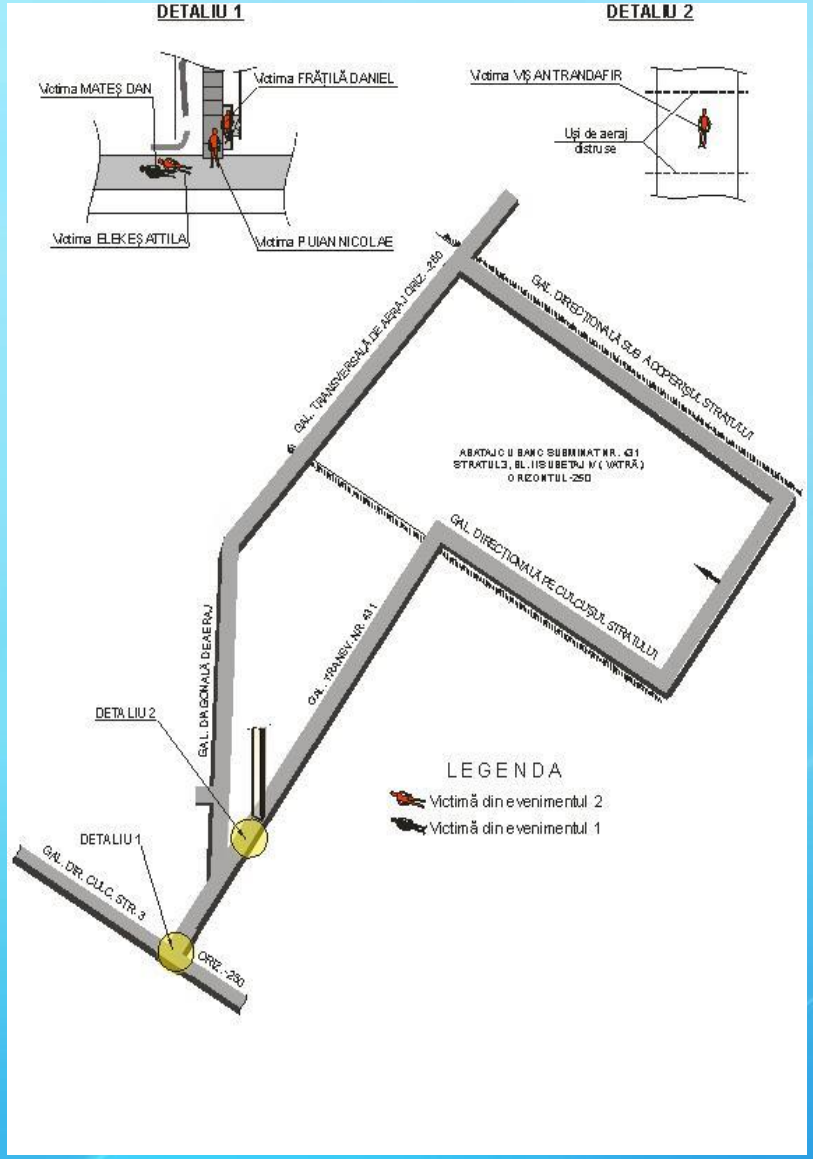
After the recovery of the dead bodies, the team for the management of incidents took the decision to close the damaged area due to the imminent hazard.

In order to determine the causes that triggered the two incidents, there have been used several models that focused on:

- the development of the explosion at the sublevel IV
- the ventilation both for the situations that existed before the occurrence of explosions and after
- the processes that occur when water comes into contact with the smouldering coal.



Position of dead bodies after the occurrence of the first explosion.



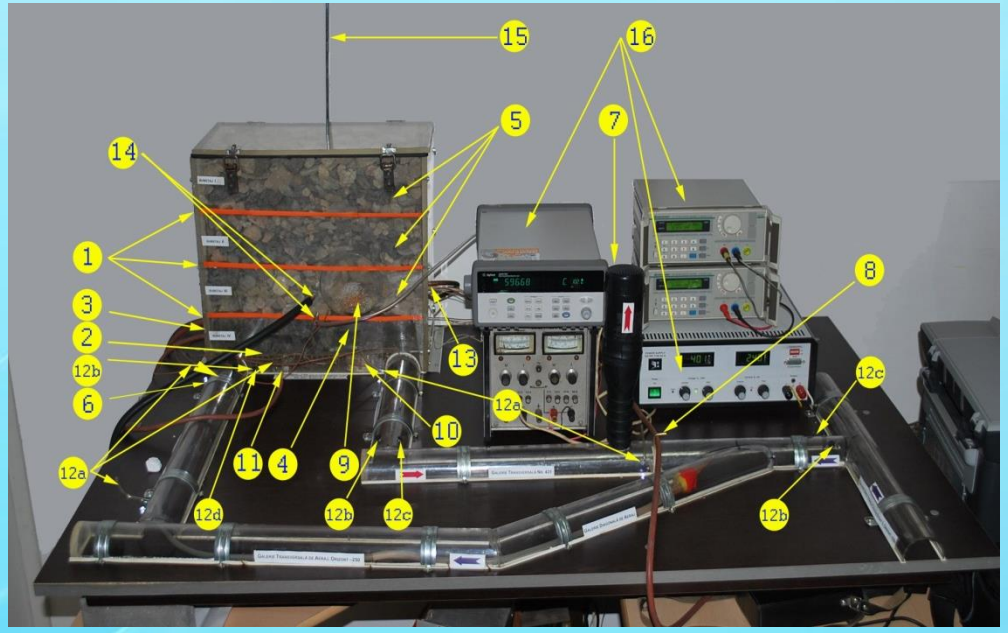
Position of dead bodies after the occurrence of the second explosion.

Modeling of the explosions developed at stope no. 431

Model of the stope with undemined coal bed no. 431

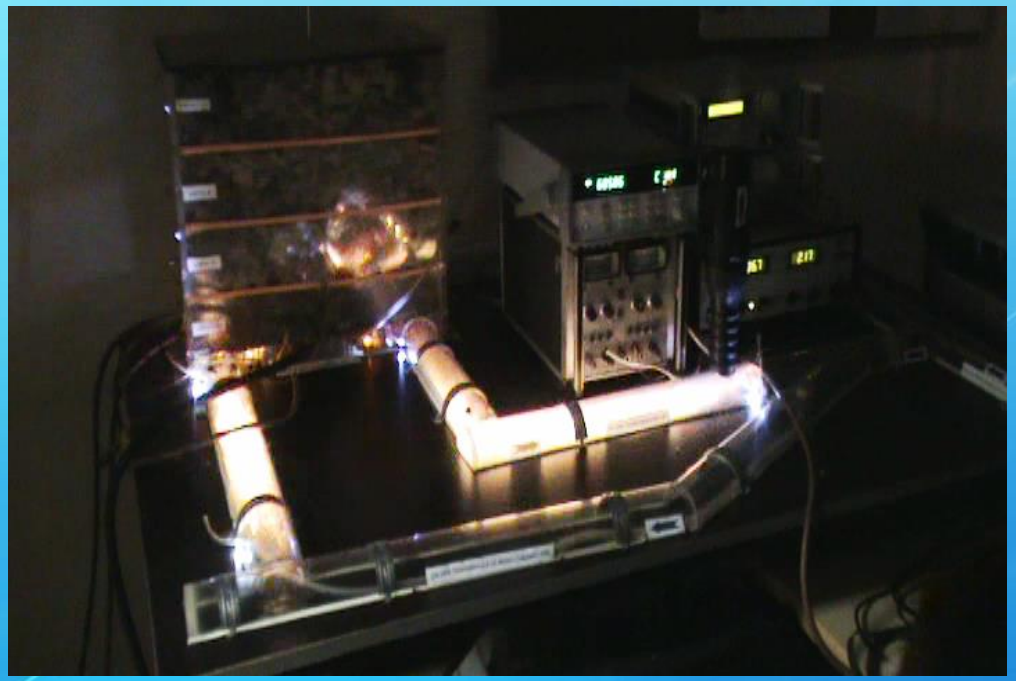
Technical parameters

- scale of the model: 1:100
- length of the stope: 42 cm
- length of the way on the floor: 36 cm
- length of the way on the roof: 58 cm
- length of the cross return way: 54 cm
- length of the cross way: 70 cm
- length of the diagonal return way: 45 cm
- start scarp of the stope accomplished at an angle of 70%
- cross section area of the ways: 9 cm^2
- cross section area of the ventilation raise: 2.5 cm^2
- cross section area of the stope: 10 cm^2
- height of the stope: 2.5 cm
- height of the undermined coal bed, sublevel IV: 10 cm
- height of the sublevel III, II, and I: 10 cm



Model of the stope with undermined coal bed no. 431

Simulation of an explosion developed at the stope 431, sublevel III



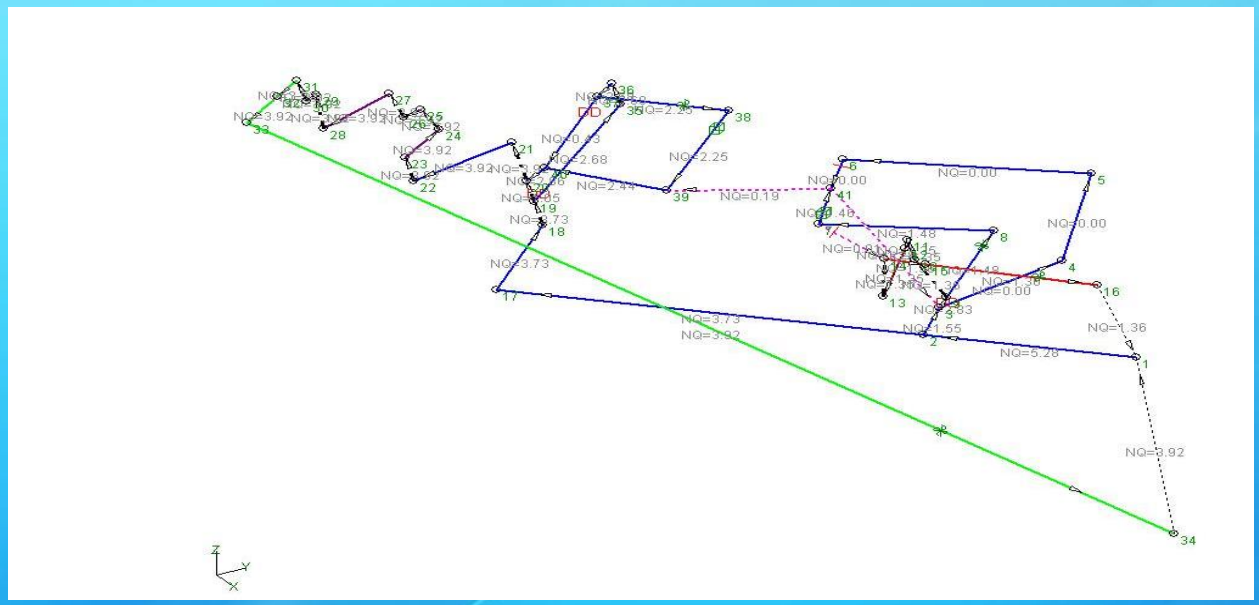
Simulating the ventilation system at the face with undermined coal seam no. 431

The simulations relied on the information and determinations made in the main ventilation system of the mine, settled and updated in November 2008.

If taking into consideration the diminished distance between the stope with undermined coal seam no. 431 and the stope with undermined coal seam no. 433, the simulations focused on the stopes when interconnected.

The simulations took into consideration the parameters that had been previously determined through in situ measurements for the opening and preparatory workings of the two stops and the mine workings at the sublevels were similar to the ones previously determined.

For exemplification, the following figure shows one of the models used for simulating the stope's ventilation system.



This simulations underlined the following aspects:

- short-circuiting the air flow on the cross way no. 431 directly to the ventilation raise
- reversal of the air flow along the route of the crossway no. 431 towards the floor, longitudinal mining way on the floor and the face line, with a significant increase of the intake air
- diminished air flow along the following route: diagonal way, crossway towards the roof, longitudinal mining way under the roof
- an increased value of the short-circuited air flow through the goaf, between stope with undermined coal seam no. 431 and stope with undermined coal seam no. 433.

Causes and circumstances that triggered the subsequent events

Classification of events occurred at Petrila Mine

Two events occurred at Petrila Mine in the undermined coal bed working, behind the face line no. 431, layer 3, block II, sublevel IV - floor on 15.11.2008:

A. The first event occurred at 14^{49} , and was determined by the occurrence of a deflagration-type explosion

B. The second event occurred at 18^{40}, and was determined by the occurrence of an explosion which was stronger than the one occurred at 14^{49}

Circumstances that triggered the occurrence of two explosions

- the existence of gaseous flammable substances, finely dispersed into the free space
- the concentration of certain gaseous flammable substances dispersed into the free space situated within the explosive limits;
- formation of explosive mixtures (explosive atmospheres) hazardous from a quantitative point of view;
- the existence of one / several initiation sources for the explosive atmospheres already formed.

Hypotheses on the place and mechanism that triggered the two explosions

Several hypotheses have been delivered and the following ones have been retained:

FIRST EVENT

Retained hypothesis: explosion inside goaf

A. Explosive mixture - supporting element of the explosion

The explosive mixture was made of methane and air and it occurred on the sublevel III. Methane accumulated inside the void of the undermined bed at the working that appeared after the production of scarp with regular holes (maximum 3 m) and the discharge of coal from the undermined bed, starting from the upper half of the working and up to the roof.

B. Underground fire at the sublevel III of the working no. 431 – initiating agent of the explosion

The breaking out of the underground fire at the sublevel III represents a consequence regarding the reactivation of coal spontaneous combustion found in the self-heating stage at this sublevel.

C. Location of the initiation source

The underground fire which broke out at the working no. 431, sublevel III was located at the starting point of the working at sublevel III.

D. Mechanism that triggered explosion:

The explosion initiated in the goaf at the sublevel III propagated downwards along the route of the free space of the discharge cone.

The oxidizing - combustible support of the explosion was the preformed methane-air mixture.

The explosion that was initiated and then developed into the goaf propagated through the holes located within the area of windows of props 15 - 17, in the working and its related areas.

As a consequence of explosion, CO at high concentrations (> 0.2% vol.) was registered in the mine areas related to the working in question. It was the result of CO repress, emitted by the underground fire existing at the sublevel III and the one formed during the occurrence of explosion within the goaf.

SECOND EVENT

Hypothesis taken into consideration - explosion at the sublevel III

A. Explosive mixture - the support of the explosion

The explosive mixture was made of air and flammable gases. These flammable gases were made of:

- Released methane
- H2 and CO resulted from coal pyrolysis / burning, as well from the secondary reactions (reduction of CO2 to CO; water - gas reaction that takes place when water or water vapors manes direct contact with the incandescent coal).

B. Initiation source

Underground fire from the sublevel III of stope no. 431

C. Location of the initiation source

The initiation source (the underground fire) located at the starting point of the working at sublevel III.

D. Mechanism that triggered explosion

The simultaneous occurrence in time and space of the explosive mixture formed with the fire triggered the explosion at the sublevel III of working no. 431.From there on, the explosion propagated towards the extremities of the working through the void existing at the level of windows 15 - 17. Then, the explosion pursued its route to the neighboring mine workings.

The dynamic effect generated by the pressure front propagated before the flame front and produced the violent death of miners located in the transverse gallery no. 431, as well within the area that crosses the directional gallery, floor, bed no. 3, level –250 (gallery with belt conveyors).

The cloud made of air - dust mixture didn't ignite, although it come into contact with the flame front due to water moistening and to the presence of water vapors (also emitted by hydrogen burning that participated in the explosion); consequently, coal dust didn't participated in the explosion.

CONCLUSIONS

Two events occurred at Petrila Mine in the undermined coal bed working, behind the face line no. 431, seam 3, block II, sublevel IV - floor on 15.11.2008:

The first event occurred at 14^{49};

The second event occurred at 18^{40}

13 persons died as a result of explosions occurred at Petrila Mine on November 15, 2008 (8 persons in the first explosion and 5 in the second one)1nd 15 persons were injured

The first incident occurred at Petrila mine on November 15th 2008, at 14^{49}, was determined by the occurrence of a deflagration-type explosion.

The second incident occurred at Petrila mine on November 15th 2008, at 18^{40}, was determined by the occurrence of an explosion which was stronger than the one occurred at 14^{49}.

MEASURES DISPOSED FOR PREVENTING SIMILAR EVENTS

- **Revising the Regulation on occupational health and safety concerning the following aspects:**
  - Measures for preventing and fighting against endogenous fires for each exploitation method applied within the National Hardcoal Company
  - Intervention in case of faults and major incidents with the establishment of clear action procedures
  - Establishment of clear procedures related to mining rescue operations.

- **When establishing rescue teams which have to intervene for rescuing victims, there shall be avoided the placement within the teams of rescuers which are related with the victims**

- **When using the undermined coal seam mining method, when starting the stopes, the undermined coal seam shall be blasted using the technology with long boreholes over the entire length of the stope, in order to avoid the occurrence of gaps and remaining coal in the console.**

- **Verification of the manner in which the communication and investigation of methane accumulations over admitted limits is performed**

- **Performing relative methane flow determinations for coal seams in exploitation**

Thank you for your attention!

National Institute For Research And Development In Mine Safety And Protection To Explosion

I N S E M E X

G-ral Vasile Milea Street, No. 32-34, Petroșani, Hunedoara County, ROMANIA
Phone: 0040 254 541 621 Fax: 0040 254 546 277
Email: insemex@insemex.ro Web: http://www.insemex.ro