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THE FIRST EXPERIENCE AND RESULTS IN THE APPLICATION OF THE GMS–92 GEOMECHANICAL MONITORING SYSTEM AT THE DOUBRAVA COLLIERY, THE OSTRAVA–KARVINA COALFIELD (THE CZECH REPUBLIC)

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ABSTRACT. The paper is subdivided into three main parts. The first chapter describes the interest field, in which the state of stress of rock mass are analysed by means of the geomechanical monitoring system, and under the support of a special software, the anomalous phenomena of state of stress are forecast.

The second chapter deals with the developed geomechanical sensors, e.g. convergometers, extensometers, pressure sensors and tensometric heads, and geomechanical monitoring system of the GMS–92 type.

The third chapter deals with the summary of the first results reached in the field of putting this geomechanical system into operation.

1. INTRODUCTION

In 1992, the staff of the Research Mining Institute of Ostrava–Radvanice finished the development of the GMS–92 monitoring system of an explosionproof type. It has been tested in the coal face No 43785 of the DOUBRAVA Colliery.

The fourth block of the DOUBRAVA Colliery, in which this above–mentioned coal face is situated, is bordered with the ELEONORA Fault in the North, with the HLUBINSKA Fault in the East, and with the Central Fault in the South. In the West, it is bordered with the shaft pillar. The 37 coal seam, in which the coal face No 43785–I is in operation, belongs to the saddle strata of the KARVINA Strata. The development of this 37 coal seam is irregular, i.e. its thickness varies under the influence of the erosive wash–out to a considerable boundary, i.e. about 2.5 up to 6.0 meters. Erosion has caused the changes in petrographic composition besides the local reduction of coal seam thickness. The dip is 4 degrees up to 5 degrees towards the North–East. Under the influence of this dip, the coal face is situated in the depth of about 900 meters under the surface.

The immediate roof (Fig.1) consists of 1.5 m thick stratum consisting of coal bads, claystones and siltstones. Higher, up to the distance of 45 meters up to 55 meters, there are strata of sandstones, less siltstones and conglomerates. Above them, there are two coal seams No 35 and No 36, which are unsuitable for coal extraction at all. Higher, up to the 34 coal seam, which is situated about 100 – 125 meters from the 37 coal seam, there are situated thick slices of sandstones of their total thickness of 65 meters. Above the 34 coal seam, to the 32b coal seam, there are situated sandstones of their thickness of 50 – 70 meters.

The immediate roof of the 37 coal seam consists of claystones, root siltstones, and the 38 coal seam is developed in two slices of their total thickness of about 25 cm and 65 cm, in some places up to 100 cm. Lower, there are situated strata of siltstones and sandstones up to the distance of 20 – 30 meters, the 39 coal seams is the main border. From the view–point of the structure and geology of these strata, the above–mentioned coal seam is characterized with the structure of a German type with prevailing fracture tectonics of a dip–slip fault character.

The coal face No 43785–I is led through the 37 coal seam, which will be mined in its full thickness. The coal face is being mined by means of a caving method. Life of face is about 170 meters. The coal face is connected to the mining area No 43765, finished in April 1986, mined in pneumatic stowing. The mining area No 43785–I is led through the gobs of the coal faces Nos 43765 and 43763. The nearest mined roof coal seam No 34 (in the distance of 100 120 meters) has been mined with left remaining non–extracted areas in 1970 – 1971 (mined by means of a caving method). In the higher roof, in the distance of 170 – 180 meters, the coal seam 32b was mined in 1962 – 1964. Both above–mentioned coal seams were not mined in their full area with regard to the shape of the coal face No 43785–I (there are solid pillars of coal seams No 32b and 34). The area of the adjacent coal face No 43765 showed the anomalous seismicity during its mining in 1983 – 1986, and there were many micro-rock bursts.

The above–mentioned coal face No 43785–I belongs to the working sites with the third degree of danger from the viewpoint of the origin of rock bursts with regard to the mentioned facts.

2. THE GMS–92 GEOMECHANICAL MONITORING SYSTEM

This geomechanical monitoring system serves for continuous monitoring of geomechanical parameters of rock mass by means of measuring of convergence of the entries/gates, longitudinal deformation of boreholes, pressures in stowing and boreholes, degree of gaseness, etc. There are many unique geomechanical sensors, measuring system of an intrinsically safe type, an explosionproof backup power supply, an explosionproof portable system, and the surface evaluation working site as well. The block diagram of the GMS–92 System is shown in the Figure 2, which also shows both connection of the particular parts of the system, and its position within the system of the explosionproof equipments. It is obvious that the power supply and the transmission system are of the ExdI type, and i.e. they can be placed in the area with increased danger of methane explosions (SNM2), and the other part of this system, it is the "ia" intrinsically safe equipment, i.e. it can be in operation in the areas with high danger of methane explosion (SNM3). The particular parts of this system incl.explosionproof enclosures, have the maximum weight up to 25 kg. To put this system into operation is too operative. The GMS–92 underground geomechanical monitoring system consists of these below–mentioned

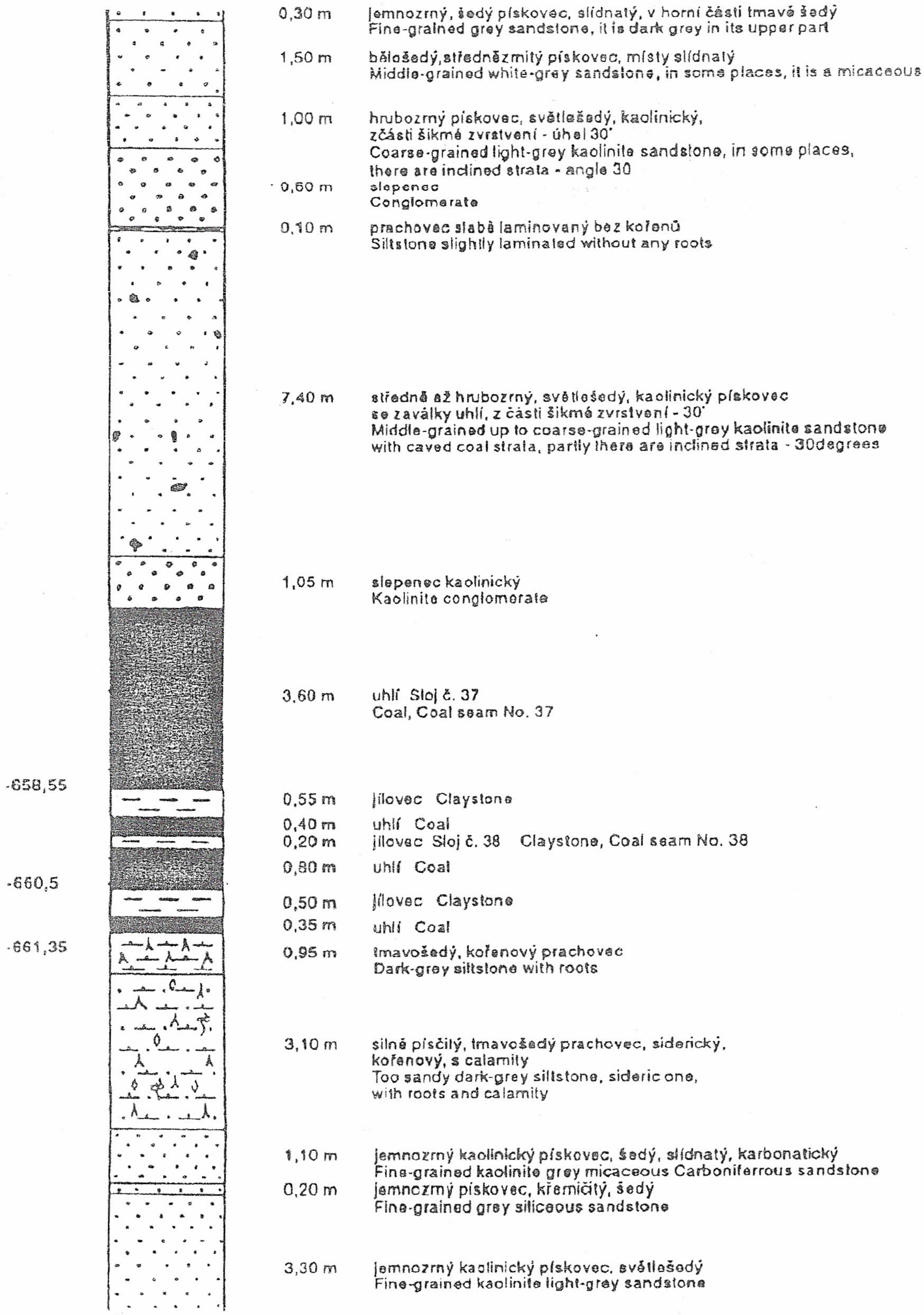


FIG. 1. Immediate roof and floor of the 37th coal seam

parts:

- Sensors (i.e. convergencemeters, extensometers, dynamometers, etc.),
- Analog buses, i.e. layout of cable distribution systems and connection boxes,
- The underground data outstation on base of one chip C–MOS microprocessor with programmable mode (and/or more underground data outstations),
- Intrinsically safe power supply (and/or with backup),
- Transmission system for data outstation's connection to the surface PC,
- The surface evaluation system.

Besides the GKD–92 data outstation's design, transmission system and surface evaluation part, the development of geomechanical sensors has been carried–out as well. These below–mentioned sensors have been developed for the environments with too high danger of methane explosion:

The KO–EL Convergencemeter serves for the measurement of deformations of the underground workings, and for the determination of movements of the particular parts of rock mass.

The KO–EL–Z Convergencemeter can be used esp. in stowing.

The EX–EL Extensometer is a measuring device serving for measurement of a displacement between two measuring points, usually between a preselected place of a borehole in rock mass (led from the side of a working) and the side of a working.

The EX–EL–V Extensometer is used for measurements in vertical boreholes.

The M168.1 Dynamometer enables to measure pressure in loosened rocks. It is used for the measurements of pressure phenomena of rock mass in caving, or stowing cushion in dependence upon the distance from the advancing coal face.

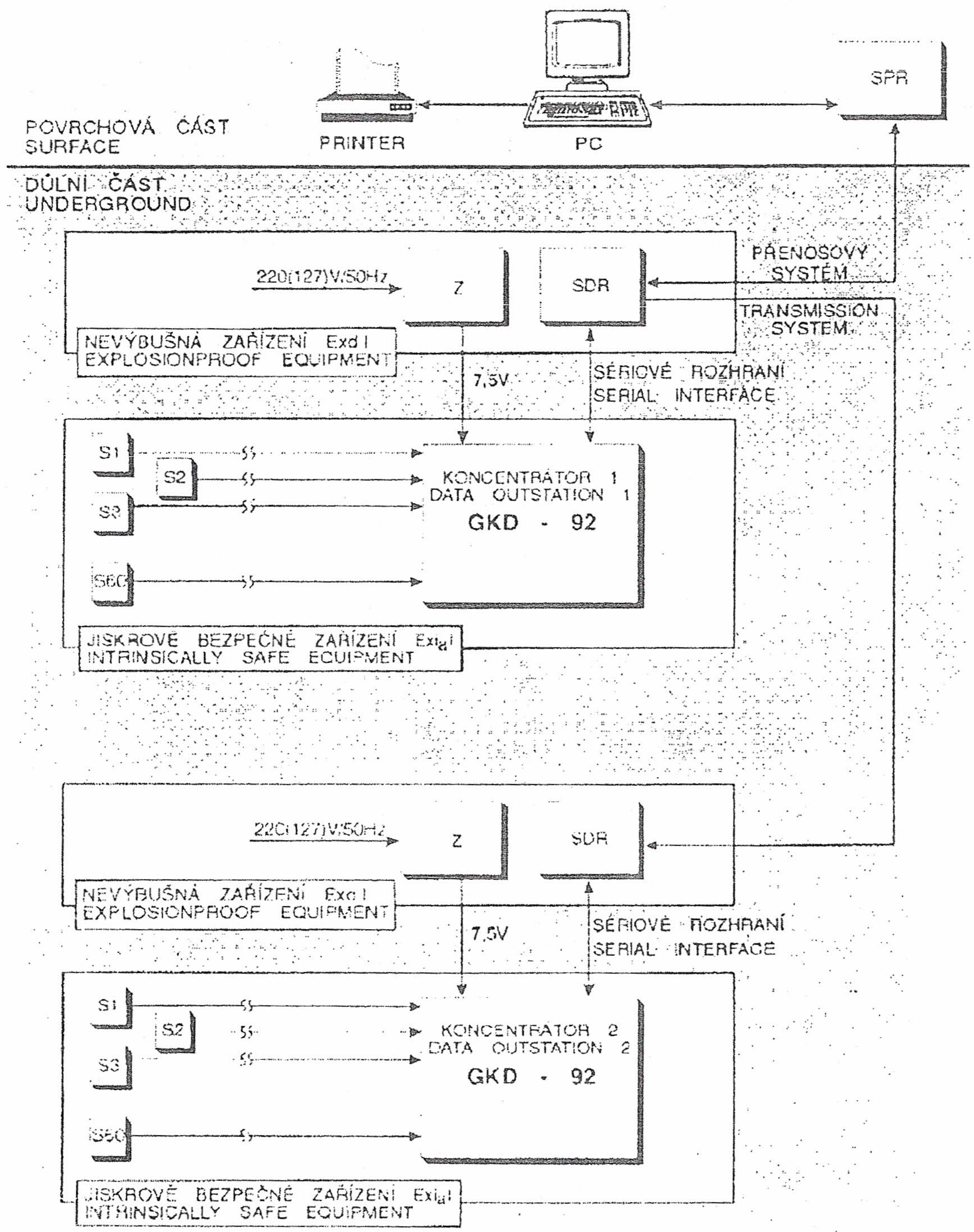
The below-mentioned TABLE gives the most important technical parameters of particular sensors:

TABLE

	KO–EL	**KO–EL–Z**	**EX–EL**	**EX–EL–V**	**M168.1**
construction	Exi_aI	Exi_aI	Exi_aI	Exi_aI	Exi_aI
measr.range*	400 [mm]	400 [mm]	100 [mm]	55 [mm]	50 [MPa]
dia.of a hole			42 [mm]	42 [mm]	
depth*			10 [m]	5 [m]	
resolution	0,5 [mm]	0,5 [mm]	0,5 [mm]	±1 % of range [mm]	0.2 [MPa]
weight	18 [kg]	5,5 [kg]	12 [kg]	3 [kg]	20 [kg]
protection	IP 67	IP 67	IP 54	IP 54	IP 65

* and/or in accordance with a customer's wishes and demands

The actual putting the GKD–92 geomechanical system into operation has been carried–out according to the worked–out draft by the research staff of the RE-



Legenda: / *Legend:*
- *Z* . . . . *JB zdroj - Intrinsically safe power supply*
- *SDR* . . . . *stanice důlního rozhraní - Station of underground interface*
- *SPR* . . . . *stanice povrchového rozhraní - Station of surface interface*
- *S1, S2, ... S60* . . . *snímače - Sensors*

FIG. 2. Block diagram of monitoring system

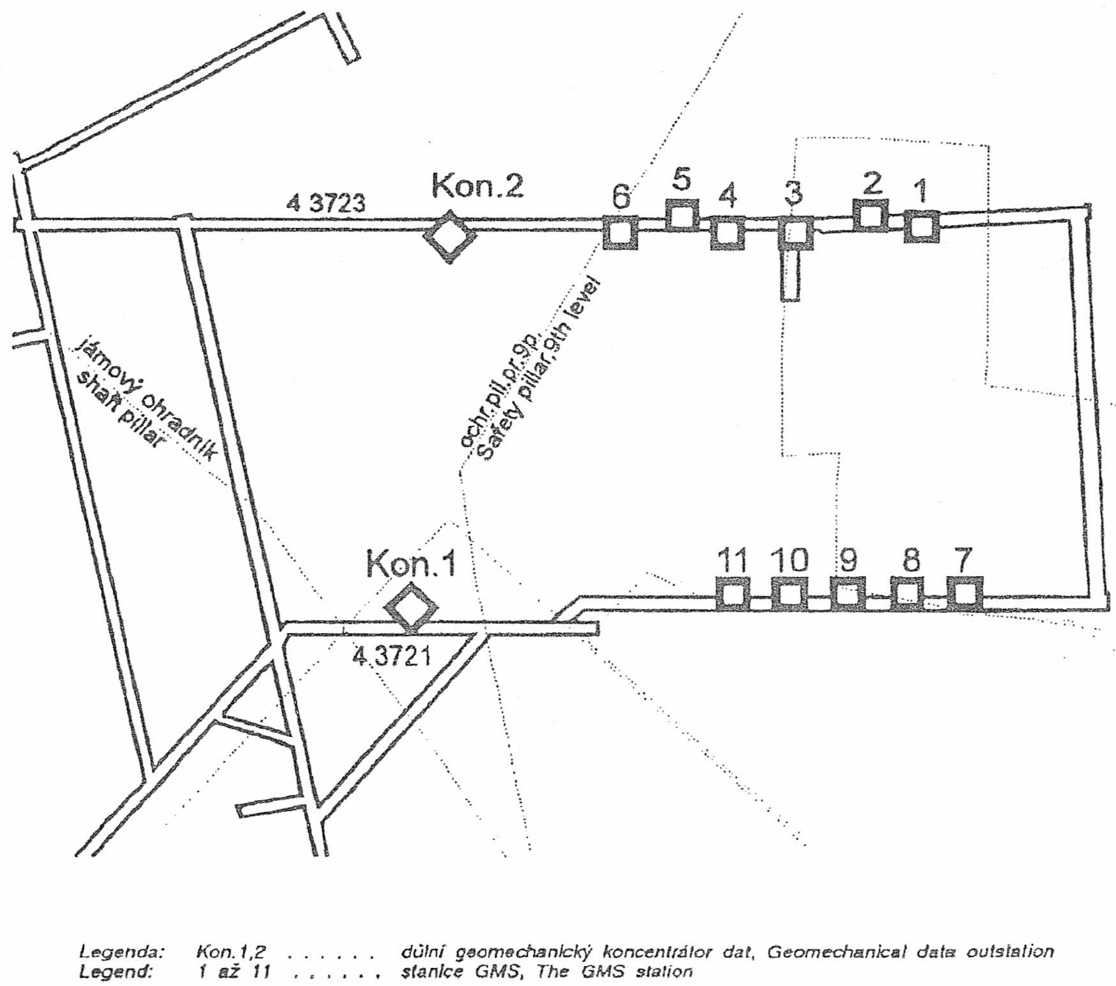


FIG.3. Layout of monitoring system in the coal face No. 43785

SEARCH MINING INSTITUTE OF OSTRAVA RADVANICE, Inc. In geomechanical stations, in forefield of the coal face No 43785–I, the convergencemeters and extensometers in the distance of about 50 meters from the connecting gate were installed. The distance between the particular geomechanical stations were set for 20 meters by the prepared project. In the trunk road No 43723, the wall niches were built for the needs of geomechanical stations, in which in roof and floor short bore holes for the installation of one meter long bolts ended with M24–thread were bored so that the KO–EL convergencemeter could be fitted there. An eleven meters long bore hole of a dia. of 42 mm was bored in the pillar side for the extensometer. In the depth of 10 meters, an anchor of extensometer, connected to a resistant transmitter by means of a measuring set of rods, was installed. The same works have been carried–out in the entry(gate) No 43721–V with this following difference: the own sensors were installed direct in the entry as in the cross section of the entry No 43721–V, there are no stowing zones/areas. As soon as the coal face advances to the distance of about ten meters, the displacement of a geomechanical station to another position according to the project for the application of geomechanical system will be carried–out. Figure 3 shows the geomechanical system and the layout of geomechanical stations and data outstations.

The basic software and the algorithm draft of a forecast of the origin of geodynamic phenomena of the GKD–92 geomechanical monitoring system is described in works of researchers of the Research Mining Institute of OSTRAVA–Radvanice, Inc. [Žák, 1993, Tomáš, 1993, Krečmer, 1992]. The situation in the GMS individual geomechanical stations is given by the coefficient of safety, the values of which are the results of the analyses of the development of convergence changes and convergence expansion in accordance with the algorithm draft of forecasts of the origin of geodynamic phenomena.

3. The Evaluation of Results Having Been Reached in the Field of the Application of the GMS–92 Geomechanical Monitoring System

Coal extraction in the coal face No 43785–I was started on April 20, 1993. The GMS–92 geomechanical monitoring system has been put into operation since April 1, 1993. The regular evaluation and data storing in database, incl. sensors testing, was started on April 28, 1993. Since then, the coal face advance from the starting connecting gate in the main gate No 43723 was 1.5 meters, and in the tail gate No 43721–V, it was 4.5 meters. During the time period till May 6, 1993, (face advance has been interrupted), the total face advance in the main gate No 43723 was 2.5 meters, and in the tail gate No. 43721–V, it was ten meters. From May 6, 1993 till May 24, 1993, face advance was stopped due to the fact that a group of miners went to another working place. From May 24, 1993 till June 15, 1993, the total face advance in the main gate No 43723 was 19 meters, and in the tail gate No. 43721–V, it was 25 meters. During this short period of time, in which coal face was in operation, two seismological phenomena of a higher energy than ten to five J were recorded (taken–over from the databank of geomechanical service at the DOUBRAVA–Colliery). These seismological phenomena are shown in Fig.4, in which the course of convergence of a working and loosening of a coal seam (further convergence and expansion only) in a geomechanical station (further the GMS only) were recorded. This GMS-geomechanical station is situated in the tail gate No 43721–V in stationing of 140 meters. According to seismological phenomena and local examination, these geomechanical phenomena and many other phenomena of stress releasing in a given area, were concentrated in a stowing area of coal face No 43785–V. From the same reason, no anomalous phenomena of convergence and expansion of a working have been recorded before these above-mentioned seismological phenomena.

In the main gate No 43723, both convergence and expansion have been of no importance till May 29, 1993. After blasting, in five bore holes, 824 kg of explosive have been blasted, and after destressing blasting on June 9, 1993 in a coal seam (35 kg explosive) in stationing of 235 – 255 meters, an obvious increase of both convergence and especially expansion could be observed. These changes can be caused by stress shifting of rock mass in a caved area into forefield of a coal face, which was loosened after the above-mentioned works have been done. Figure 5

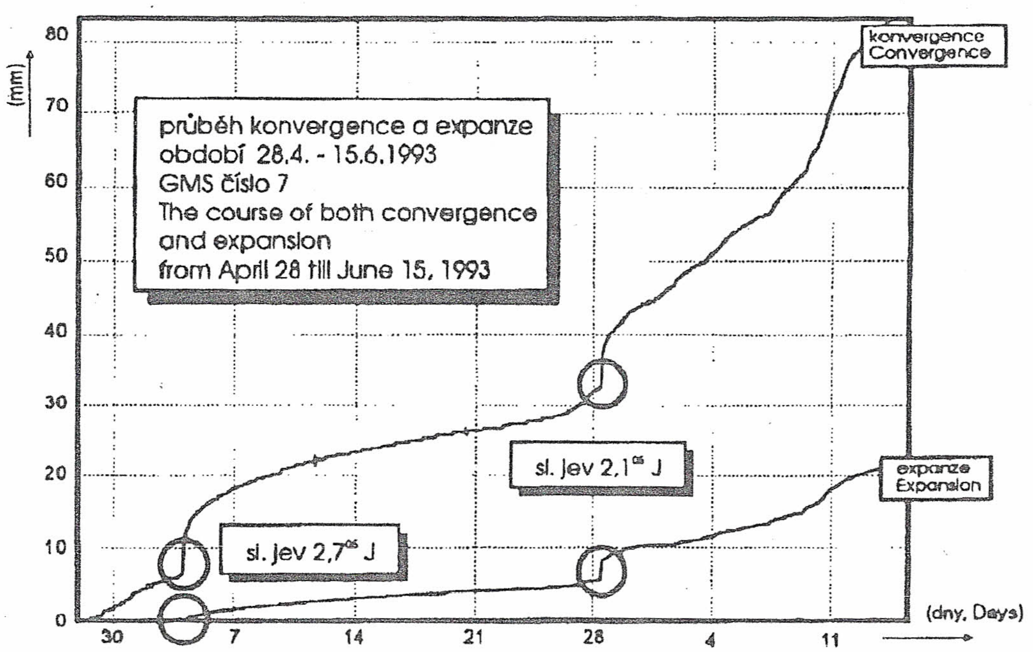


FIG.4. The course of both convergence and expansion from April 28 till June 15, 1993, GMS No. 7

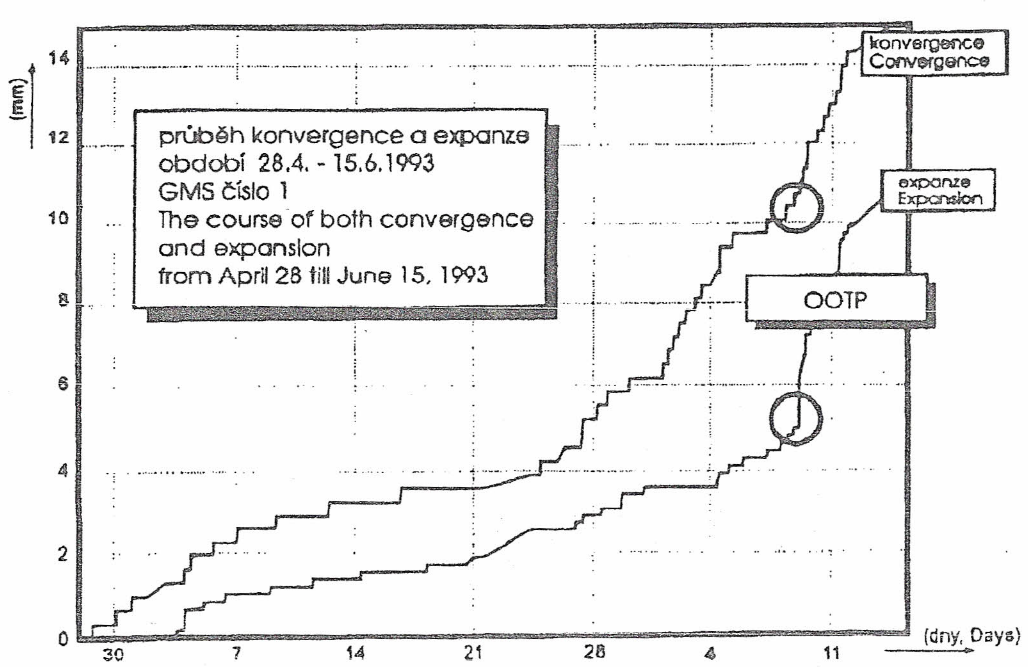


FIG.5. The course of both convergence and expansion from April 28 till June 15, 1993, GMS No. 1

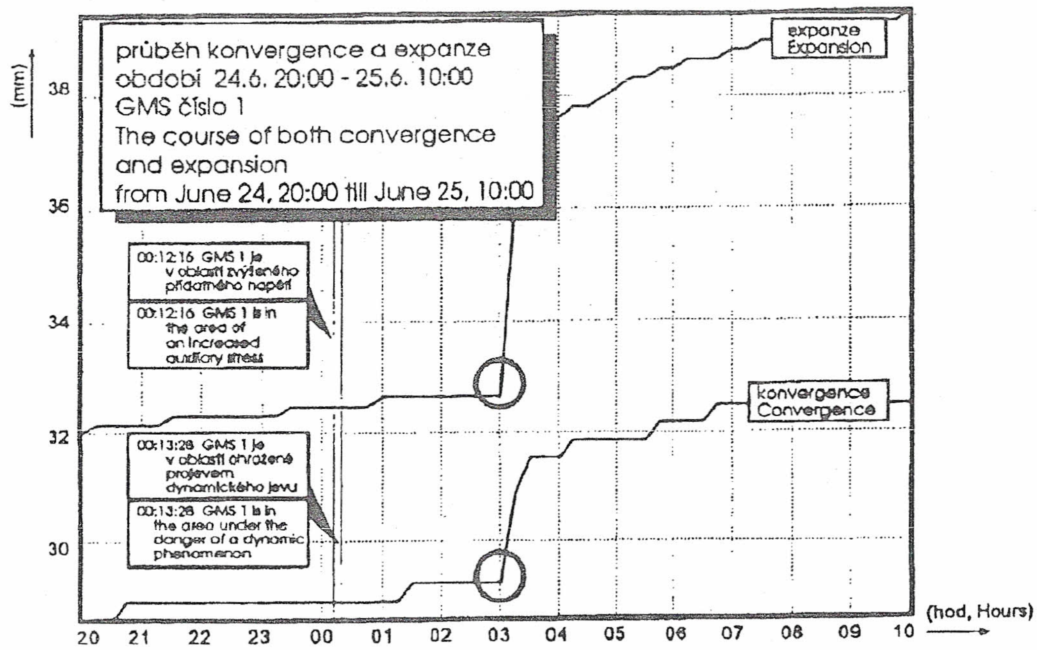


FIG. 6. The course of both convergence and expansion from June 24, 20:00 till June 25, 10:00, GMS No. 1

shows the graphic courses of these changes. On June 25, 1993, the seismological phenomenon of radiated energy of 6.10 to three J occurred. This phenomenon was located in the GMS1-area in the gate No 43723, and it confirms the algorithm of forecast of the origin of geodynamic phenomena. Figure 6 shows graphic course of these changes with signalling of these phenomena in advance.

4. CONCLUSION

As mentioned above, this geomechanical monitoring system can be used for forecasting the anomalous phenomena of state of stress of rock mass, and observing of the effectiveness of preventive measurements. With regard to the above–mentioned time of extraction and the total face advance (coal face No 43785–I), further anomalous phenomena of state of stress of rock mass can be expected. These results will be used in forecasting the anomalous phenomena of state of stress of rock mass, and during mining the coal face No 43767 at the DOUBRAVA–Colliery.

The GMS–92 geomechanical monitoring system records the changes of both convergence and expansion with a sensitivity of a tenth of millimeter. Such a sensitivity of sensors and surface evaluation device represent the improved works of a geomechanical service at the DOUBRAVA–Colliery, and it enables to compare the seismoacoustic observation and seismological observation with the above–mentioned deformometric methods serving for forecast of anomalous phenomena of state of stress of rock mass, and observation of the effectiveness of prevention and suppression.

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