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MECHANISM OF ROCKBURSTS FROM ČSA COLLIERY, OSTRAVA-KARVINÁ COAL BASIN (CZECHOSLOVAKIA)

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Abstract:

Exploitation of coal face 13933 on ČSA Colliery (Czechoslovakia) was started on the end of 1989. This is area where was rockbursts with catastrophe consequences. In this paper we are presented results of geophysical interpretation of the fifteen strongest rockbursts in period since January to June 1991. Primary data come from digital network called Seismic Polygon of Ostrava-Karviná Coal Basin. This network consists of ten of three-component digital registered stations. For determination of fault plane solution is used method of inverting P-wave first amplitudes; for determination of geometric and physical source parameters is used spectral analysis (Brune´s and Madariaga´s models). Numerical results are presented in tables.

Key words:

rockburst, fault plane solution, source parameters

1. INTRODUCTION

At obtaining of mineral raw materials by underground exploitation exist real danger of rockburst rises, what is consequence of rock massif failure process. It is especially in difficult mine-geological conditions. Such situation is also in Ostrava-Karviná Coal Basin (OKR), where at coal exploitation arise very much rockbursts. The strongest rockburst (March 27th, 1983) with local magnitude 5.1 - according determination of NEIS - comes from area of ČSA Colliery. Exploitation was again started in this area (coal face 13933) from the end of 1989.

It is documented by research that for complete evaluation of mining situation is necessary to confront geological, geomechanical and geophysical knowledge. Seismic research has in this evaluation basic importance as in sphere of local and time prognoses, as for determination of physical processes passing in rock massif foci of violation and for objective classification of rockbursts /RUDAJEV, 1986/.

There is interested in lot of countries of whole world by interpretation of seismicity induced by mining activity. In sphere of basic research was interested by this questions especially for example COOK /1976/, KISSLINGER /1976/, McGARR et al. /1981/, GIBOWICZ /1985/, GIBOWICZ /1989/, HASAGAWA et al. /1989/, KUHNT et al. /1989/, and from their results we come out.

2. APPARATUSES

Interpretation of rockbursts in OKR entered from 1988 to new stage, because was started operation of digital seismic network called Seismic Polygon of the OKR (SP). This network gives to OKR qualitative new data - three-component digital recorded seismic signal. Network is composed from 7 surface and 3 underground stations, from where are data telemetric transfer to the central recording station. Description of tasks and apparatus equipment of the SP is for example in KONEČNÝ, 1988 and KALÁB, 1991.

The digital registration by the SP gave also possibility for development of methods for rockburst source mechanism determination.

3. STARTING METHODOLOGICAL CONDITIONS

On base of provided analysis of rockburst source mechanism determination in world and geomechanic interpretation of conditions in OKR we can state:

- for determination of fault plane solution is necessary to come from models, which enable consideration of superposition of shear and non-shear component (shear forces with implosion or explosion components);
- for determination of rockburst spectral parameters we can use Fourier transformation (FFT) for calculations of spectra. In case of short distance between some stations from focus is necessary very careful application of FFT;
- for determination of geometric and physical parameters we can come from relations conscript for dislocation models. With point of view to fact, that source dimensions determinated according Brune´s relations there are maximum estimates of possible dimensions, there

is used Madariaga's model for interpretation of geometric focus parameters.

Recordings of digital data in OKR pas only for short time and since are not finished some methods for primary interpretation (determinations of rockburst origin time, localisation and radiate energy). Geological and tectonic patterns of OKR are very complicated. Determination of rock environment parameters (especially seismic velocity model and damping of seismic wave) also in not provide with needful quality. These facts have direct influence for quality of rockburst mechanism interpretation. That is why is now sufficient to develop for this sphere of interpretation only the simplest methods, which give good results also at ignorance of accurate basic parameters of rockbursts and rock environment.

4. DATA

Selective set for interpretation is composed from the most strong rockbursts, which were localised to area of coal face surrounding 13933 in ČSA Colliery (OKR) in period from January to June 1991. On beginning of followed period there was exploit about 320 m of direct length of coal face, on end of period about 490 m. Dimension of coal face was 220 m. About 18% rockbursts from whole OKR-area were recorded in above mentioned period from area of coal face 13933, but by energy about 69% of energy radiated from whole OKR-area /VESELÝ et al., 1991/. That are mentioned in Tab. I. the results of primary interpretation for rockbursts from selective set.

5. FAULT PLANE SOLUTION

For determination of fault plane solution of rockbursts that was selected method of inverting P-wave first amplitudes with possibility of non-shear component ratio determination /ŠÍLENÝ, 1987/. Methodical process and new developed software enable other research into solution problem /STAŠ, 1991/. Fault plane solution (strike, dip and rake angles of shear slip and ratio of non-shear and shear dislocations) for selective set is mentioned in Tab. II. Reliable results we obtained after accuracy of entrance calculation parameters (localisation, seismic velocity model and damping of seismic wave).

We provide complete evaluation of interpretation results of fault plane solution from selective set, after that are essential two conclusions:

Tab. I. Primary interpretation data (from ČSA Colliery Seismic Centre database)

Number	Origin time	Localisation	Energy
a001	4.1.1991 18:22:42	Q-61	9.0e5
a002	12.1.1991 20:53:22	Q-61	1.0e5
a003	18.1.1991 20:53:27	Q-61	1.1e5
a004	21.1.1991 21:01:37	Q-61	4.2e5
a005	30.1.1991 17:10:42	Q-61	5.1e5
a006	7.2.1991 03:46:37	Q-61	1.3e5
a007	16.2.1991 01:25:40	Q-61	1.1e5
a008	27.2.1991 08:16:06	Q-61	1.5e5
a009	5.3.1991 10:39:55	Q-61	3.8e5
a010	13.3.1991 15:25:49	Q-61	4.4e5
a011	16.3.1991 14:18:08	Q-61	2.2e5
a012	20.3.1991 20:17:20	P-61	4.2e5
a013	28.3.1991 04:37:12	P-61	1.5e5
a014	4.5.1991 01:26:22	Q-61	1.1e6
a015	16.5.1991 21:15:27	Q-61	2.0e5

Origin time - time from DCF signal
Localisation - mine localisation
Energy - mine scale of ČSA Colliery Seismic Centre

- The first is the fact, that is possible to divide rockbursts of selective set to four basic types according their fault plane solution. These types are not determinate only on base of statistic evaluation of geophysical interpretation results, but it is possible to include geologic-geophysical interpretation. For this interpretation there were use mine maps of separate seams, tectonic maps (including small tectonic map), evaluation of coal mining intensity and consultations with geomechanics. Results of this interpretation are also presented in this Proceedings /KONEČNÝ/.

The second conclusion is about evaluation of ratio of non-shear and shear dislocations. This ratio maximum is 30 % and from this arises that main cause of rockburst generation is shear dislocation. That is why we can come from relations, which are connected with presumption of this fact (dislocation models).

Tab. II. Fault plane solution

Number	DIP [°]	STRIKE [°]	RAKE [°]	V.C. [%]	Type
a001	53.2 38.6	57.0 216.3	102.7 73.6	-11.6	I
a002	83.3 77.7	240.2 331.6	-12.4 -173.	-2.6	IV
a003	18.1 77.0	252.4 27.6	133.4 77.3	-17.9	III
a004	40.4 52.1	202.6 46.1	71.7 105.0	-10.2	I
a005	80.2 29.2	20.6 128.6	-62.3 -159.	-30.0	III
a006	50.6 41.9	47.6 203.9	105.5 71.9	-10.1	I
a007	42.6 47.7	212.3 41.2	83.4 96.0	-4.8	I
a008	53.7 38.1	50.0 209.7	102.3 73.8	-10.8	I
a009	28.4 66.8	152.1 9.8	-124. -73.1	-0.5	III
a010	83.0 9.9	345.0 117.1	-82.6 -138.	-16.9	III
a011	44.7 46.0	80.2 272.8	81.0 98.8	-16.9	II
a012	64.2 27.2	98.9 299.2	80.9 108.2	-11.4	II
a013	88.0 59.5	223.2 132.0	30.5 177.6	-11.9	IV
a014	39.8 53.1	204.5 50.0	69.8 106.0	-10.6	I
a015	49.0 41.0	273.7 90.9	91.8 87.9	-12.7	II

6. GEOMETRICAL AND PHYSICAL SOURCE PARAMETERS

For determination of geometrical and physical source parameters we come from spectral analysis of wave patterns of Madariaga´s model reception. There was use for analysis a non-interference P-wave part. Spectra calculated for Z-components of separate stations by algorithm FFT are correct for distance and damping of signal on way station-focus and for free surface. There are after that spectra approximate by two straight lines and there are subtracted spectral parameters. Calculated geometrical and physical source parameters for rockbursts of selective set are mentioned in Tab. III. Achieved results by their values correspond with data presented in literature /for example GIBOWICZ, 1989/ and to ideas of geomechanics about course of activity in rockburst foci.

Tab. III. Geometrical and physical source parameters

Number	ro [m]	Mo [10^{12}Nm]	$\Delta\sigma_o$ [10^6Pa]	$\bar{D}_o$ [10^{-3}m]
a001	144	4.27	0.622	4.70
a002	144	2.57	0.375	2.83
a003	147	1.57	0.216	1.66
a004	137	5.21	0.893	6.39
a005	156	3.83	0.443	3.61
a006	150	2.32	0.302	2.37
a007	139	2.32	0.378	2.75
a008	142	2.26	0.348	2.60
a009	156	2.76	0.320	2.61
a010	142	3.07	0.474	3.51
a011	137	3.83	0.657	4.70
a012	162	5.02	0.514	4.37
a013	139	1.44	0.235	1.71
a014	139	6.90	1.120	8.17
a015	134	1.76	0.318	2.23

ro source radius from Madariaga´s model
Mo seismic moment
$\Delta\sigma_o$ stress drop
$\bar{D}_o$ average displacement across the fault plane

We can await more accurate results after elaboration of methods for interpretation of other types of waves, especially of S-wave. Also analysis of signals in transformed co-ordinate system (turn of coordinate system to geometry of ray) and/or analysis of complex amplitude of signal (that means not of separate components) will be good for more objective determination of source parameters.

7. CONCLUSION

On base of achieved results we can make following evaluation:

- for focus mechanism interpretation was determinate on base of provided tests these calculation methods
  - determination of fault plane solution by method of inverting P-wave first amplitude
  - determination of geometrical and physical source parameters by spectral analysis at presumption of Madariaga's model

- interpretation of rockbursts from selective set proved possibility of using achieved results for complete evaluation of rockburst and for evaluation of development of seismic activity (results of interpretation are good for more objective evaluation of rock massif failure process)
  - fault plane solution of rockbursts from selective set we can sort to four types, which have geomechanical interpretation
  - calculated geometrical and physical source parameters have values corresponding with presupposed mechanisms in foci.

Relations, according which we are calculated parameters of dislocated surface and geometrical and physical parameters, are deducted for ideal elastic surrounding. Because surrounding of OKR has features rather different from this approximation, was introduced corrects of non-elastic surrounding. But these above mentioned corrects come only from experiments not from special seismic measurements, which are necessary for determination of features of surrounding. It is also reason why are not used some prepared methods, which are developed for rockbursts.

By detail study of rockbursts according their activity by radiation seismic energy after their rise, is achieved qualitatively new information about presupposed activities, which pass in foci. These results are part of complete view on rockburst, what enable not only its complete interpretation from point of view of geomechanics, but also complete interpretation of development of seismic activity.

Achieved results proved importance of next basic research, and with this also application research on digital seismic data from OKR. One of the directions is analysis of rockburst as phenomenon, which first methodical processes and results we presented in this paper.

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