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POLARIZATION DIAGRAMS OF ROCKBURSTS FROM THE OSTRAVA – KARVINÁ DISTRICT

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ABSTRACT. Local network denoted as Seismic Polygon Frenštát records intensive rockbursts from Ostrava – Karviná District also (distance about 30 km). The overall evaluation of these wave patterns can be summed up as follows: the rockbursts are easy–to–identify in the set of records, a wave pattern is developed, phases of P and S wave group are separable (S–P time ranges between 3 to 8 s) and their first arrivals are usually marked. First analysis of polarization diagrams is presented in this contribution.

1. INTRODUCTION

Intensive rockbursts (i.e. seismic events induced by mining activity) from the Ostrava – Karviná District (henceforth referred to as OKR) in the southern part of the Upper Silesian Basin are recorded also through the local network Seismic Polygon Frenštát (SPF network) that came into permanent operation in 1992. The stations of SPF network are situated in the distances from 30 to 50 km from the Karviná part of the OKR, where mining activity is concentrated today together with most of rockbursts. This distance and parameters of recording, especially the frequency and the dynamic range, ensure undistorted records of wave patterns of these events.

In the submitted paper the first results of polarization analysis that was made with the aim of analyzing the wave pattern of these events in the particular SPF stations, are presented. It is known from previous studies that onsets of P and S wave groups are easy–to–identify, e.g. [Kaláb 1995]. In addition, a description of functions of the POLAR program used forms a part of this contribution.

2. SEISMIC POLYGON FRENŠTÁT

The Seismic Polygon Frenštát is a five–station local network (stations TROjanovice, ČELadná, PALkovické Hůrky, PSTruží, VYŠné Lhoty) placed in the surroundings of the mining area of the preserved Frenštát Mine in the southern part of the OKR. The frequency range of three–component recording is from 2 to 30 Hz, digital recording of velocity taken in the dynamic range is 90 dB (LSB/MSB).

Recording is carried out only under triggered regime. Instruments of the SPF network was detailed in the paper by Knejzlík and Zamazal (1992).

In the SPF network, i.e. with distances of several kilometers from the rockburst foci, a seismic signal is recorded as the velocity of soil movement. By deriving, or integrating, acceleration can be obtained, or a soil movement. In addition to this, the record of soil velocity provides, at the minimum demands for dynamics of the digital recording equipment, the maximum dynamics of recorded seismic information [Klíma et al. 1986]. This is necessary for ensuring the sufficient sensitivity of apparatus not only to monitoring rather slight induced seismicity but also to recording undistorted records, including the most intensive rockbursts. An approach like that was used in designing the local network of the Seismic Polygon Frenštát.

An overview of events recorded by the SPF network as well as an existing manner of data processing is given, e.g. in [Kaláb, Rušajová 1995]. It has followed from subject analysis that, by means of the SPF network, all the rockbursts with energy more than $3 \cdot 10^4$ J (according to the energy scale used in the OKR) of the OKR are reliably recorded. Recording of energetically weaker rockbursts depends upon a current value of seismic noise because for launching the record, a criterion STA/LTA is used.

3. POLAR PROGRAM

When processing underlying data for this contribution, the POLAR program was used that is a part of the seismological software WAVE. It was developed in the Institute of Geonics of the Academy of Sciences of the Czech Republic (Mgr.Gruntorád) and has been used with computers of the PC type using WINDOWS.

These days, the POLAR program makes it possible to:

- display polarization diagrams in one optional section after another in three planes given by the registration directions (W, N–S, E–W),
- gradually elongate or shorten the section used for polarization diagrams,
- calculate polarization diagrams using the records of velocity or movement,
- determine an apparent azimuth of the wave arrival and an apparent angle of the wave emergence.

The program has not allowed yet the transformation of horizontal geographic components N–S and E–W into the rotated coordinate system R and T, i.e. the radial and the transversal component, from which the component products are calculated to distinguish individual wave groups.

A graphic icon of the program is divided into four square fields. In the right upper one, three components of the seismic signal of the relevant station, velocity or movement are displayed. This interval is chosen when operating with a wave pattern in the WAVE program. Further, there are two cursors manipulated by an operator there, through which the analyzed section chosen for displaying polarization diagrams is setup and a cursor determining the current position of the interval end when lengthening or shortening the analyzed section. In the remaining three windows, particle motions in three normal planes are displayed:

- in the left bottom square, motion in the horizontal plane is plotted,
- the left upper square is the display of the vertical plane motion in the W–E direction,
- the right bottom square displays the vertical plane motion in the N–S direction.

In these three windows mentioned above, the angle cursor is controllable, by which the apparent azimuth of the wave arrival as well as the apparent angle of the wave emergence can be manually assessed. Both these angles may also be derived by means of the calculation using nonlinear algebra. Below the graphic field, there is information on time of the beginning of the selected interval (local time), duration of the selected interval and the values of both these angles according to the angle cursor position.

The POLAR program is used for distinguishing P and S, or SV, SH and LR wave groups, contributes to the determination of "non–interfered" parts of the wave groups for spectral analysis or to the determination of longitudinal or transversal polarized parts of the record. The POLAR program communicates with the WAVE program and makes it possible to pick onsets of P and S wave groups. This is carried out through a serving icon which helps in the control of functions described above. The main advantage of the program is easy handling, fast processing of the record and calculation of polarization diagrams.

4. ANALYSIS OF POLARIZATION DIAGRAMS

For the purpose of analyses of polarization diagrams, the most intensive rockbursts recorded by the SPF network in 1993 – 1995 were utilized. To present the results, two rockbursts from 1993 are used as an example. The first of them with the energy of $5 \cdot 10^4$ J originated in the Doubrava Mine at 17:23 on the 26th of July, 1993, the second occurred in the Lazy Mine with the energy of $2 \cdot 10^5$ J at 18:42 on the 9th of September, 1993. Epicentral distances and azimuths of both these rockbursts to particular stations are given in the following table (km/angle degree).

	TRO	CEL	PAL	PST	VYS
July 26, 1993	39/34	36/19	24/34	28/23	20/3
Sept. 9, 1993	42/36	40/18	27/36	38/23	24/357

Examples of polarization diagrams obtained by the POLAR program are illustrated in Figs. 1 and 2 for the group of P wave groups and in Figs. 3 and 4 for the group of S wave groups. While parts above show the initial part of the analyzed group, parts down present its longer time section, integration offset is summarized in polarization diagrams. The angle cursor is set according to the visual judgement of azimuths and angles of emerging the initial phase of the analyzed part of the record.

The analysis of velocity seismograms and polarization diagrams of movement has proved a marked onset of the group of P waves in most of the processed rockbursts. Therefore, the time of picking the phase and the direction of the first picking can

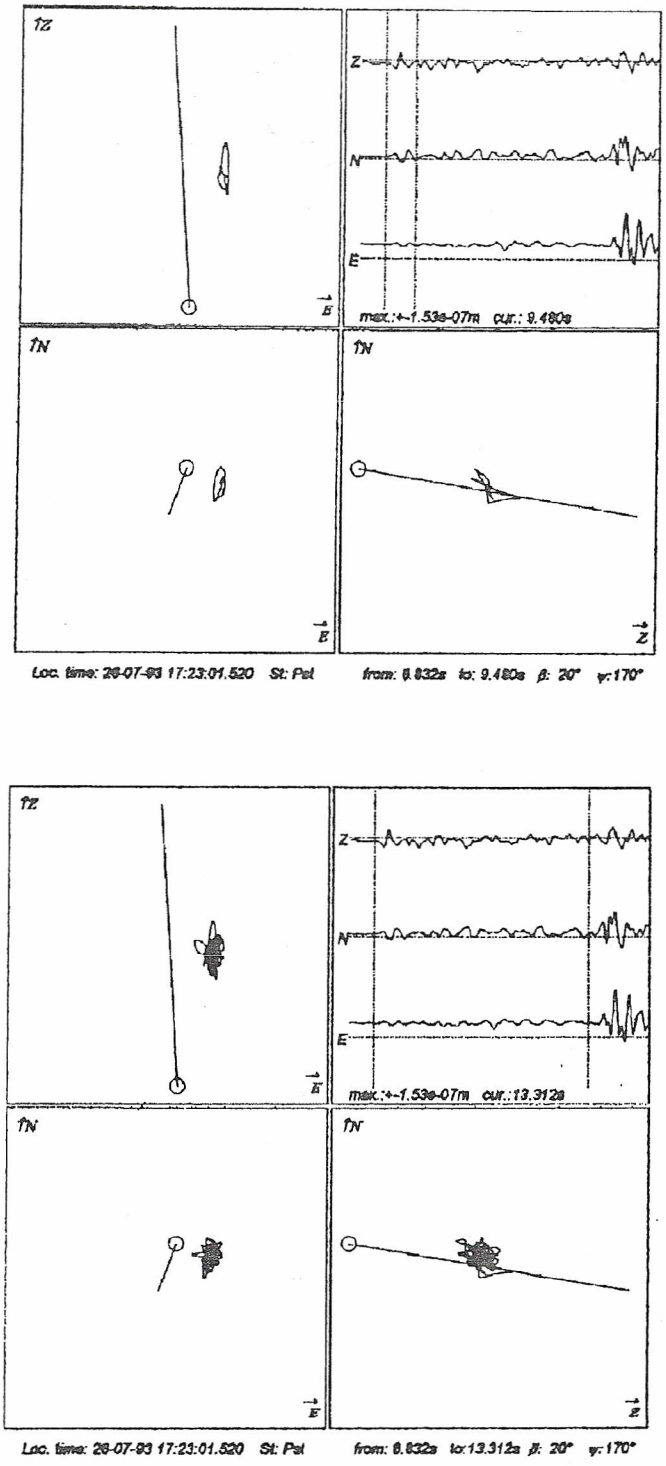


FIG. 1. The polarisation diagrams of P wave group of July 26, 1993 rockburst from Pstruží station (part above – the initial part, part down – whole analysed interval)

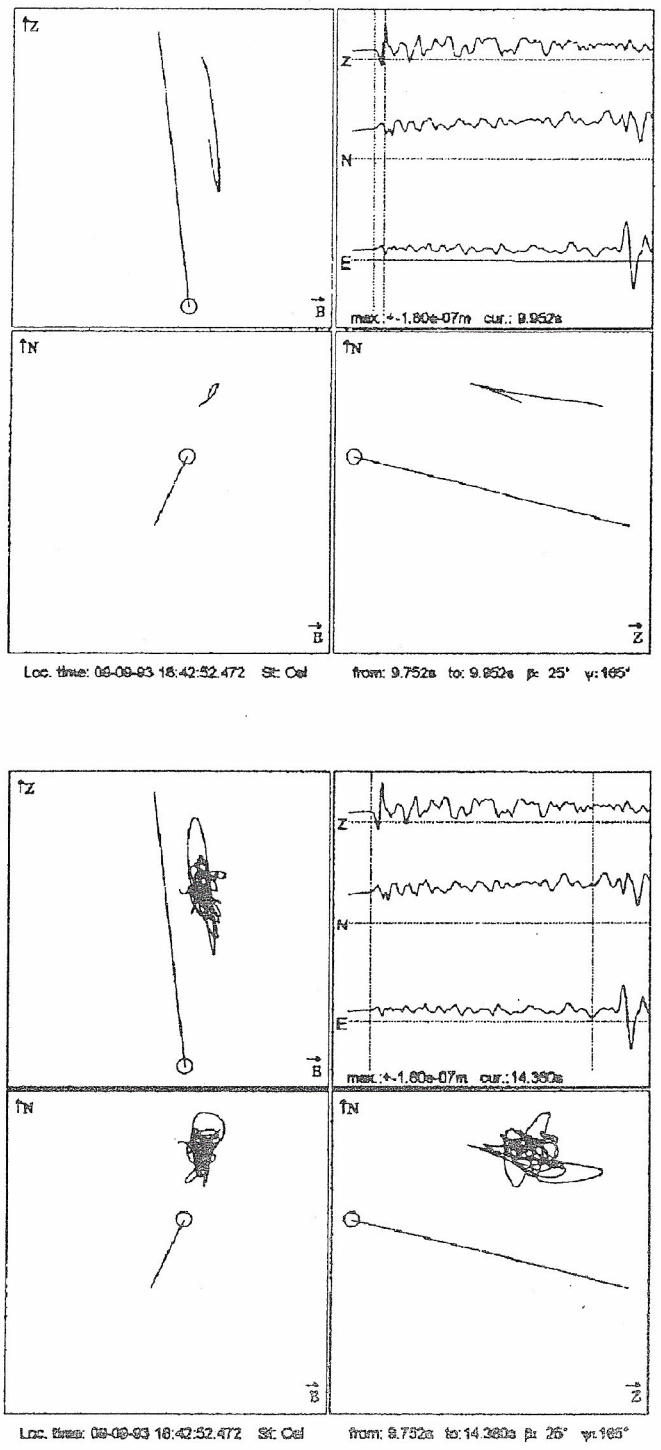


FIG. 2. The polarisation diagrams of P wave group of Sept. 9, 1993 rockburst from Čeladná station (part above – the initial part, part down – whole analysed interval)

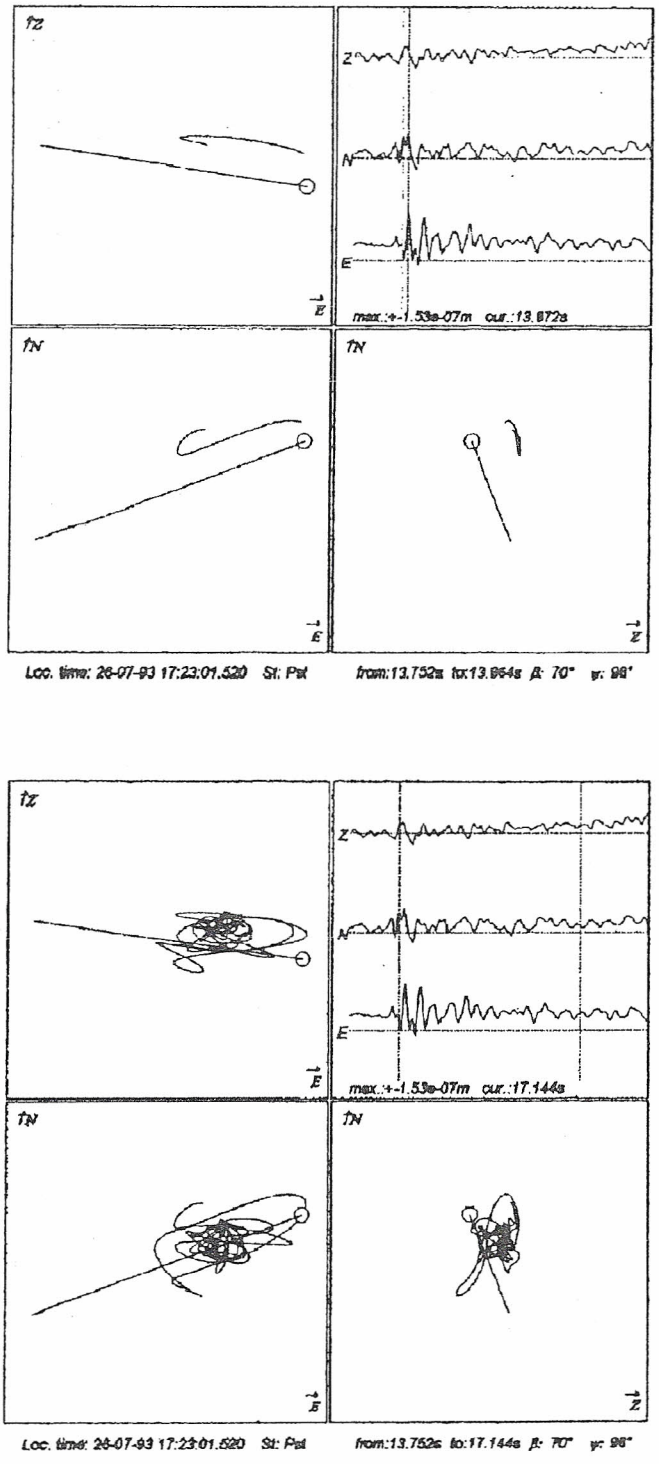
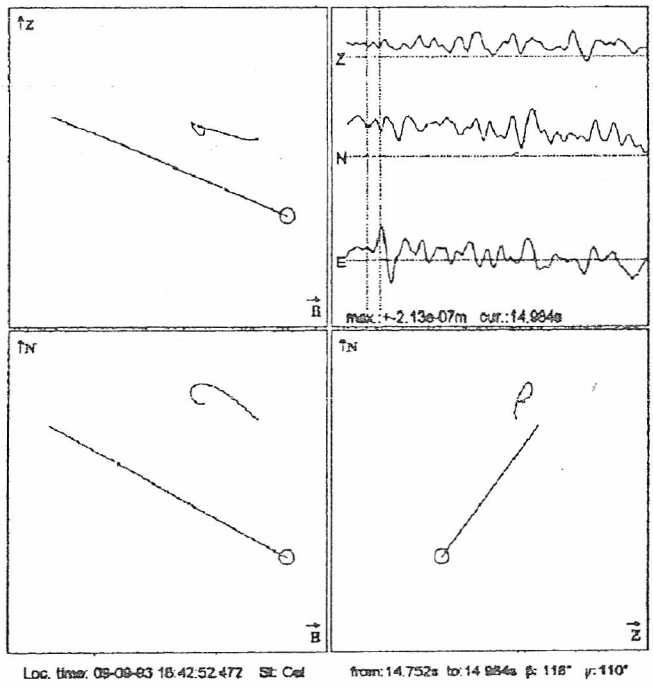


FIG. 3. The polarisation diagrams of S wave group of July 26, 1993 rockburst from Pstruží station (part above – the initial part, part down – whole analysed interval)



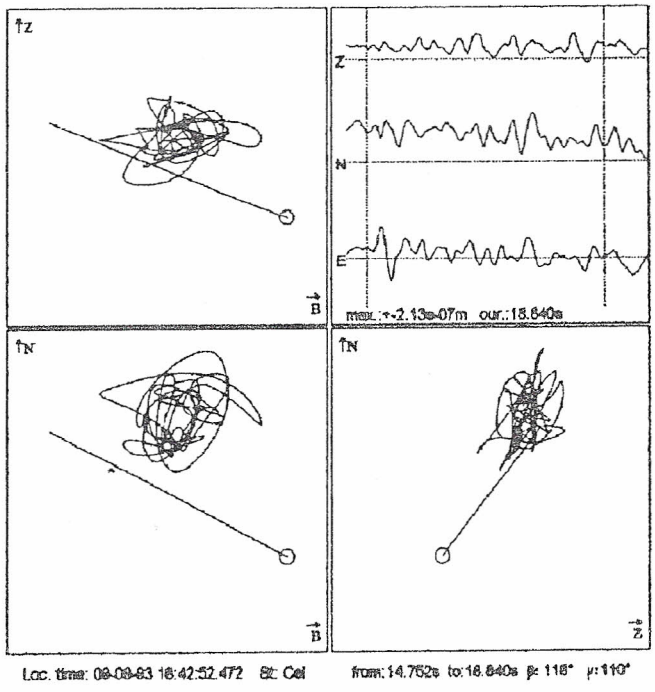


FIG. 4. The polarisation diagrams of S wave group of July 26, 1993 rockburst from Čeladná station (part above – the initial part, part down – whole analysed interval)

be identified well. Determining the azimuth of the wave arrival at the recorded position is usually rather difficult, because the values of the emergence angle are very low, which testifies the wave arrival almost normal to the surface. In spite of this, a value of azimuth can be mostly assessed. No systematic deviation between the determined wave arrival and the direction to the rockburst focus has been found during these analyses.

A "non–interfered" part of the P wave group takes only 0.2 to 0.4 s, then another phases appear with various polarizations. According to their amplitudes, the initial direction of vibration is more slowly or quickly prevailed by a chaotic motion, which is probably the result of existence of non–homogeneities in the vicinity of the station. The existence of significant secondary waves in the wave pattern caused by a marked geological structure in the vicinity of the station has not been however documented.

The onset of the S wave group manifests itself in changes in magnitude of amplitude or period or in both of them simultaneously. In spite of this, unambiguous identification of the onset is not always possible and so auxiliary criteria, e.g. type analysis, is used to determine onsets. The time interval t_{S-P} varies in the range of 3–8 s depending upon the epicentral distance. The depth of foci does not vary significantly on the basis of present knowledge and corresponds to the level of mining and to the adjacent overburden. The initial section of the group of S waves is just after some samples overlapped with subsequent secondary groups with various polarizations. Polarization diagrams of longer time sections thus remind one of chaotic motion and are, in this shape, uninterpretable.

It is necessary to bring back that seismometers in the SPF stations are placed in the probes that are lowered into the 30 m boreholes completed with casing. Experimental measuring the influence of placement of seismometers under these conditions has not shown any more significant deformations in the spectral pattern in the frequency range of 2–30 Hz. The casing acts as a rigid element vibrating in the vertical direction, distortions in polarization diagrams and angle values under determination can be supposed. This impact of the casing will be further analyzed.

5. CONCLUSIONS

For the purpose of both analyzing wave patterns from the standpoint of identification of basic wave groups and judging structuro–geological elements in the vicinity of the station, polarization analysis is used. Therefore, in the Institute of Geonics, the program POLAR was developed being a part of the WAVE interpreting seismological software generated previously. Its main advantage is a fast interactive construction of polarization diagrams and subsequent analysis using PC computers.

For analyses presented, polarization diagrams were constructed of intensive rockbursts of the OKR that had been recorded by the network Seismic Polygon Frenštát. It follows from them that it is necessary to approach very carefully some interpretations, especially when using spectral analysis, because seismic records are very complicated and contain only a small part of "non–interfered" onsets of P and S wave groups. On the other hand, no more marked geological structure has been

found yet in the vicinity of the station, where intensive secondary waves could originate and manifest themselves in the seismogram or polarization diagrams.

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REFERENCES

Kaláb Z. (1995), *Monitoring seismic activity in Northern Moravia by means of the Seismic Polygon Frenštát*, EGRSE, in print.

Kaláb Z., Rušajová J. (1995), *Present situation of data processing from the Seismic Polygon Frenštát*, In: Kaláb Z. (ed.): New knowledge in seismology and engineering geophysics, Proceedings, Institute of Geonics of the AS CR, Ostrava, pp. 85–91. (in Czech)

Klíma K., Plešinger A., Vaněk J. (1986), *Seismological outputs of Regional Diagnostic Polygon*, MS, Geophysical Institute of the CSAS, Prague. (in Czech)

Knejzlík J., Zamazal R. (1992), *Local seismic network in southern part of the Ostrava–Karviná Coalfield*, Acta Montana **A2**(88), 211–220.