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THE TESTING OF INPUT DATA FOR THE DETERMINATION OF ROCKBURST FOCAL MECHANISMS

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Abstract:

The program for the determination of rockbursts focal mechanism have been modify to comply with Ostrava - Karviná Coal Field conditions.

Input data from seismic network of Seismic Polygon Ostrava - Karviná Coal Field and local seismic network Lazy Colliery was tested to influence of accuracy of focus coordinates and input values of amplitude motion, seismic medium model, criterion of optimization.

Key words:

Ostrava - Karviná Coal Field, rockburst focal mechanism, amplitude inverse method.

1. INTRODUCTION

Last year we began to study the rockbursts focal mechanism generation method in eastern part of Ostrava - Karviná Coal Field (Kaláb, Staš, Veselá, 1992). Our methodology is based on experiences of research workers of Geotechnical Institute and Geophysical Institute of Czechoslovak Academy of Sciences. We used a computer program for amplitude inverse method (Šílený, 1987). We had to revise this program and we tested the rightness dependence of results on accuracy of input data.

The program for determination of the rockbursts focal mechanism, using amplitude inversion method have been created in Geophysical Institute of Czechoslovak Academy of Sciences, Prague. The theoretical model of the rockbursts focus supposing a superposition of shear and

volumetric component of focal mechanism is used (Šílený, 1987).

The calculation is performed from the P-wave firs extreme amplitude motion recorded on seismic stations and direct or head wave propagating along a seismic ray.

The original version of the program dealt only with two-layer seismic medium model (four-layer model could be used after the modification, its calculation was interrupted) and with input data from surface seismic stations. Owing to the complexity of the seismic medium in the east part of Ostrava - Karviná Coal Field and the presence of underground stations in the seismic network covered in this area, the program was completely revised. Update version of this program deals with maximum ten-layer seismic medium model and enables to use data from underground moreover surface seismic stations.

Numerical characteristics of the rockburst focal mechanism (dip, strike, rake, volumetric comp.) and drawing of the projection of nodal surface and position of the station to lower hemisphere of unit sphere are the outputs for this program. The output can be added then by basic description data of seismic event (name, date and time, energy, etc.) and other supplementary information about the seismic event in a form of the table. Now table contains the following data: stan - name of the station, chs - characteristic of the station (underground, surface), Ax, Ay, Az, At -chartered components of amplitudes, cha - way of calculation to standard amplitude Ared, kh - type of wave (0 - direct, head) δ - angle deviation between real and calculated direction of ray, βxf, βzf - angle of wave propagating from focus, xysf - epicentral distance of focus, dt - hypocentral distance of focus, Σl - total ray path, rl - path of wave on boundary line, time - time of propagating, csn - cosinus of ray direction to the station, Π.utl - used attenuation, ?xxx? - value of square theoretic and standard measured amplitudes difference after finish calculation (See Fig.1), (Kaláb et al., 1991).

We began using modified program for routine elaboration of seismic data and our results complied in general with geomechanical ideas (Kaláb, 1991), but in some cases we had different results for the same event after the repeated calculation with changed input conditions. That is we decided to check again the conduct of the program. We used a set of seismic records of explosive works of large extent (weight of charge more than 1000kg), its seismic energy was determined to be more than 1×10^{3}J and mining tremors with seismic energy more than 10^{4} J, recorded by the stations of Seismic Polygon Ostrava - Karviná Coal field and of local seismic network Lazy Colliery (Fig. 2).

The focus coordinates of all seismic events was calculated in

tpo773

24.2.91 15:31:27 E= H:455150. 1101340. 630.

model.2 sit.1 utlum: n 65 th=0 dH: . . .

DSRV(1:2):(12.5 80.6) (39.2 177.7) (130.8 81.7) .708E-01 Fmin .769E+Q0

stan	ch	Ax	Ay	Az	At	ch	Arod	Gl	δ	ßxf	δzf	xyof	dt	El	rl	tiss	cns	n.utl	?887
KVE	1.	+0.2	-2.2	+1.63		xx	.422E-01	0	42	181.9	95.2	5425.	5447.	5448.	0.	.13E+01	-.08976	.559E+01	.125E-01
MAJ	1.	-9.42	-9.04	+2.39		xx	.148E+00	0	86	219.7	92.2	3970.	3973.	3973.	0.	.94E+00	-.03775	.404E+01	.112E-03
Z0	1.	+11.1	+2.93	+3.67		xx	.131E+00	0	45	247.9	92.5	3685.	3689.	3689.	0.	.88E+00	-.04337	.375E+01	.234E-02
Z1	1.	+3.8	+2.67	+5.53		xx	.875E-01	0	83	231.2	94.8	4328.	4343.	4343.	0.	.10E+01	-.08336	.443E+01	.591E-02
Z2	1.	+8.73	+2.23	+4.53		xx	.148E+00	0	42	252.1	92.8	5219.	5225.	5225.	0.	.12E+01	-.04823	.536E+01	.586E-02
Z3	1.	+7.0	+3.27	+4.4		xx	.107E+00	0	58	244.1	93.6	4324.	4333.	4332.	0.	.10E+01	-.06233	.442E+01	.452E-03
ZAP	0.	-1.72	-1.73	-6.12		zz	.180E+00	0		253.2	99.0	5409.	5477.	5477.	0.	.13E+01	-.15720	.563E+01	.407E-03
MAV	0.	-0.4	-0.3	-1.33		zz	.344E-01	1		193.4	53.9	9806.	9850.	10606.	5947.	.23E+01	-.56033	.104E+02	.188E-02
CHO	0.	+0.15	-0.6	-1.14		zz	.303E-01	1		158.1	53.9	10052.	10095.	10832.	6193.	.23E+01	-.56033	.107E+02	.599E-01
LUT	0.	-1.95	+1.63	-8.82		zz	.414E+00	0		307.8	96.9	7030.	7081.	7080.	0.	.17E+01	-.11963	.734E+01	.123E+00
PRS	0.	+1.9	+1.9	-7.53		zz	.163E+00	1		33.7	53.9	8294.	8336.	9063.	4577.	.20E+01	-.56033	.871E+01	.799E-01
RAJ	0.	+4.35	+0.6	+21.2		zz	-.747E+00	0		92.3	78.4	6107.	6173.	6173.	0.	.15E+01	-.14611	.637E+01	.380E+00
BNZ	0.	-0.2	-4.2	+0.68		zz	-.449E-01	2		271.2	50.4	25642.	25637.	27006.	16708.	.52E+01	-.63787	.297E+02	.836E-01
Z6	0.			-10.		zz	.261E+00	0		340.0	100.4	4957.	5040.	5040.	0.	.12E+01	-.18016	.516E+01	.155E-02
Z9	0.			-8.1		zz	.156E+00	0		237.1	102.6	4058.	4159.	4159.	0.	.99E+00	-.21882	.424E+01	.107E-01

prima vlna (fok. nad stanici) — prima vlna (fok. pod stanici) — lomena vlna

□ direct wave (focus above station)

△ direct wave (focus below station)

○ head wave

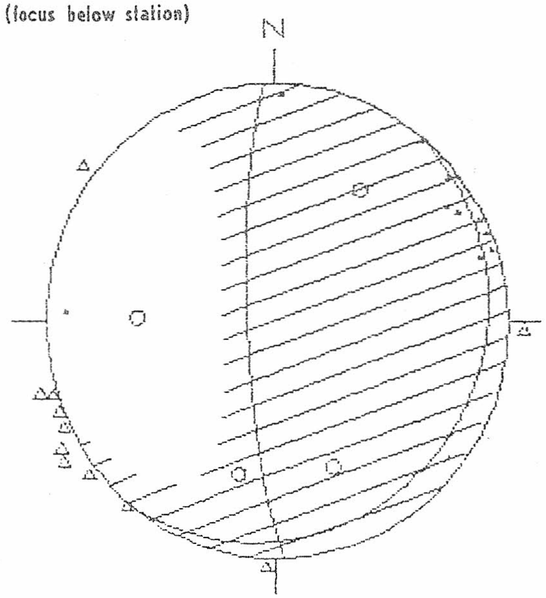
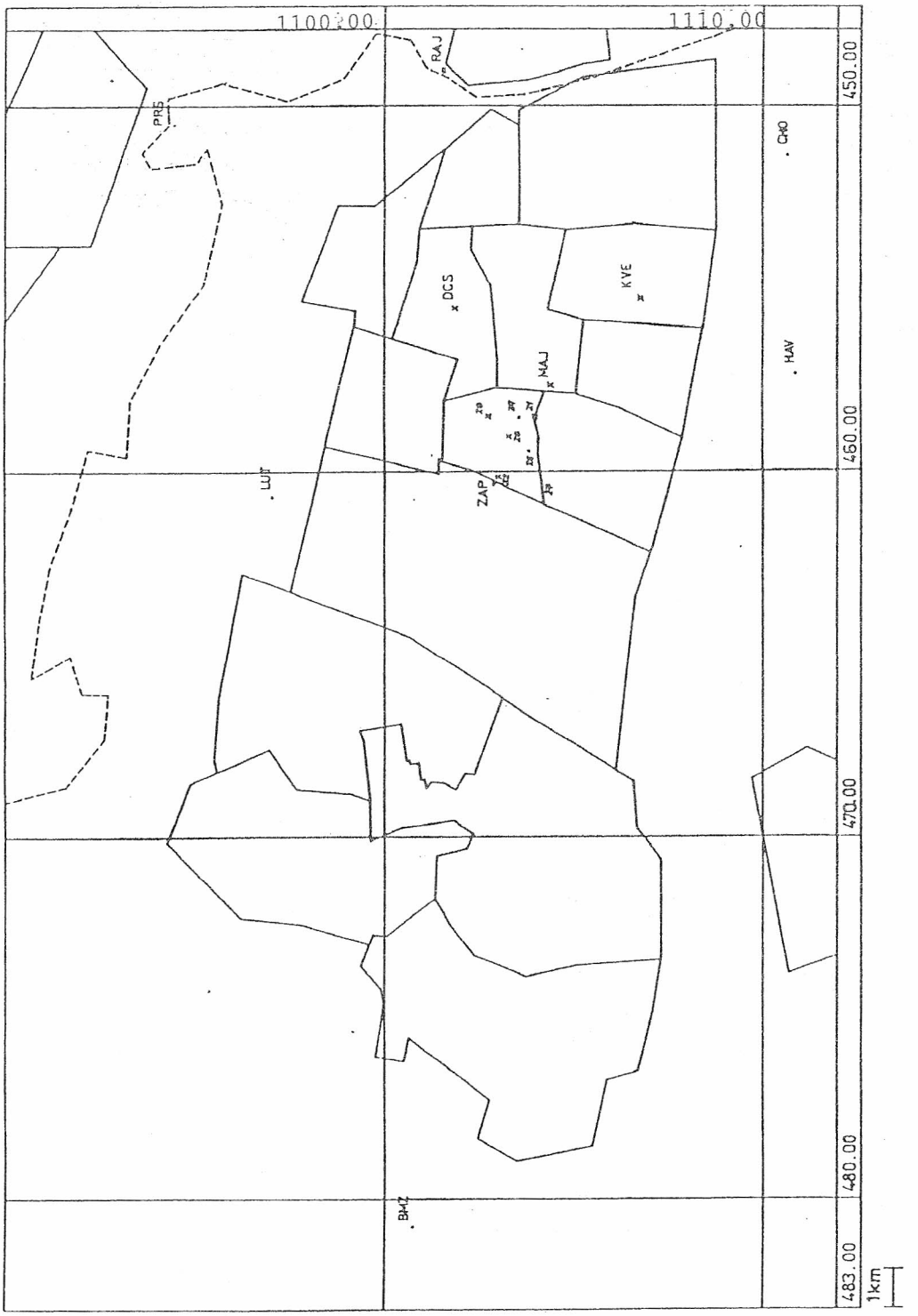


Fig. 1
Output of program

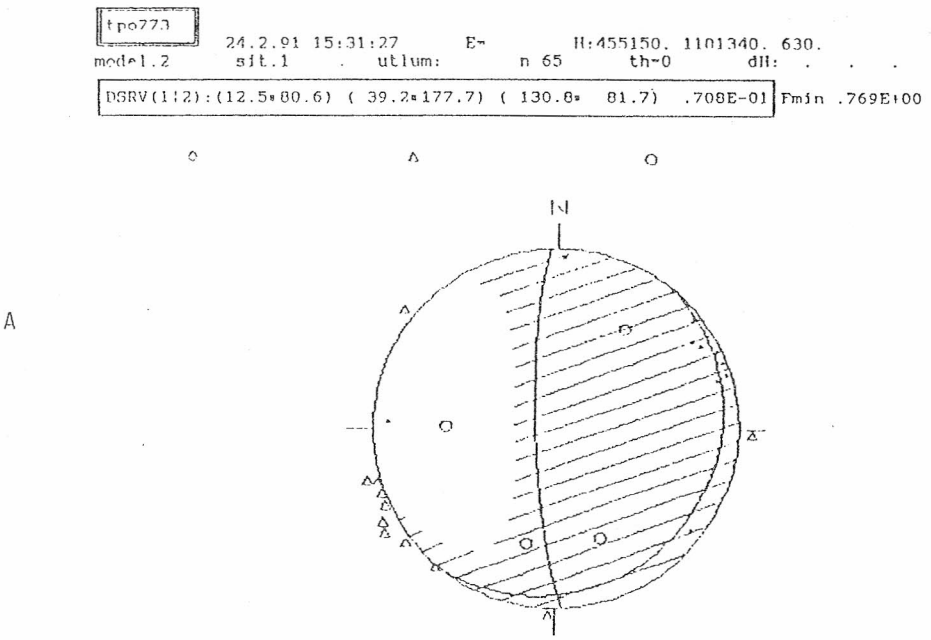


x = underground station • = surface station

Fig. 2 Map of seismic networks

XXX - Seismic Polygon Ostrava-Karviná Coal Field
zx - Local seismic network Lazy Colliery

A



B

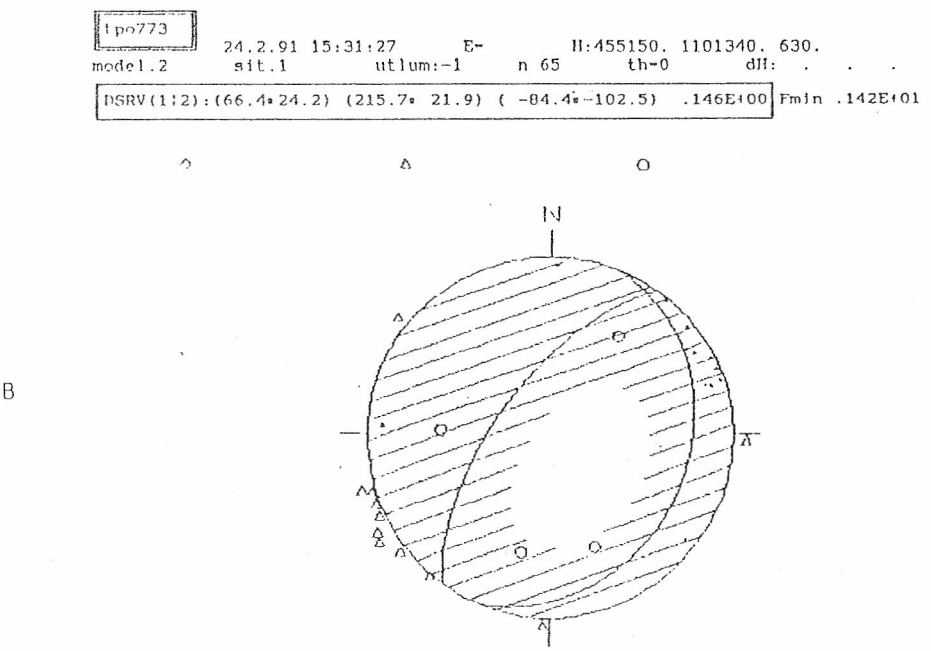


Fig. 3. Optimization criterion effect.

A - standard amplitudes motion

B - registered amplitudes motion

□ - direct wave (focus above station)

△ - direct wave (focus below station)

○ - head wave

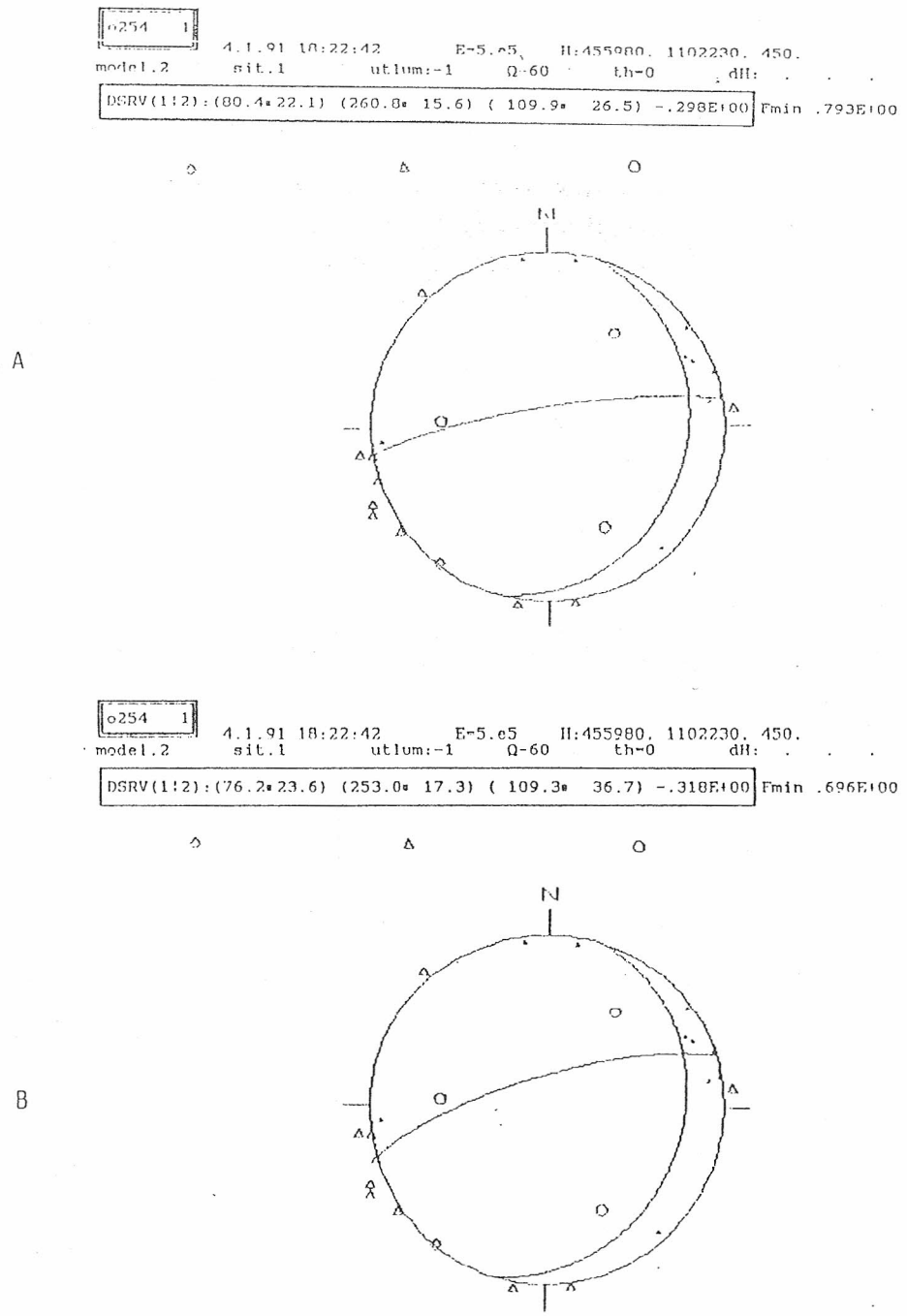


Fig. 4. Influence of input amplitude changes on a calculating focal mechanism generation with registered amplitude motion for an optimization criterion.

A - amplitude motion value in PRS station -3.8×10^{-8} ms^{-1}

B - amplitude motion value in PRS station 49.3×10^{-8} ms^{-1}

□ - direct wave (focus above station)

△ - direct wave (focus below station)

○ - head wave

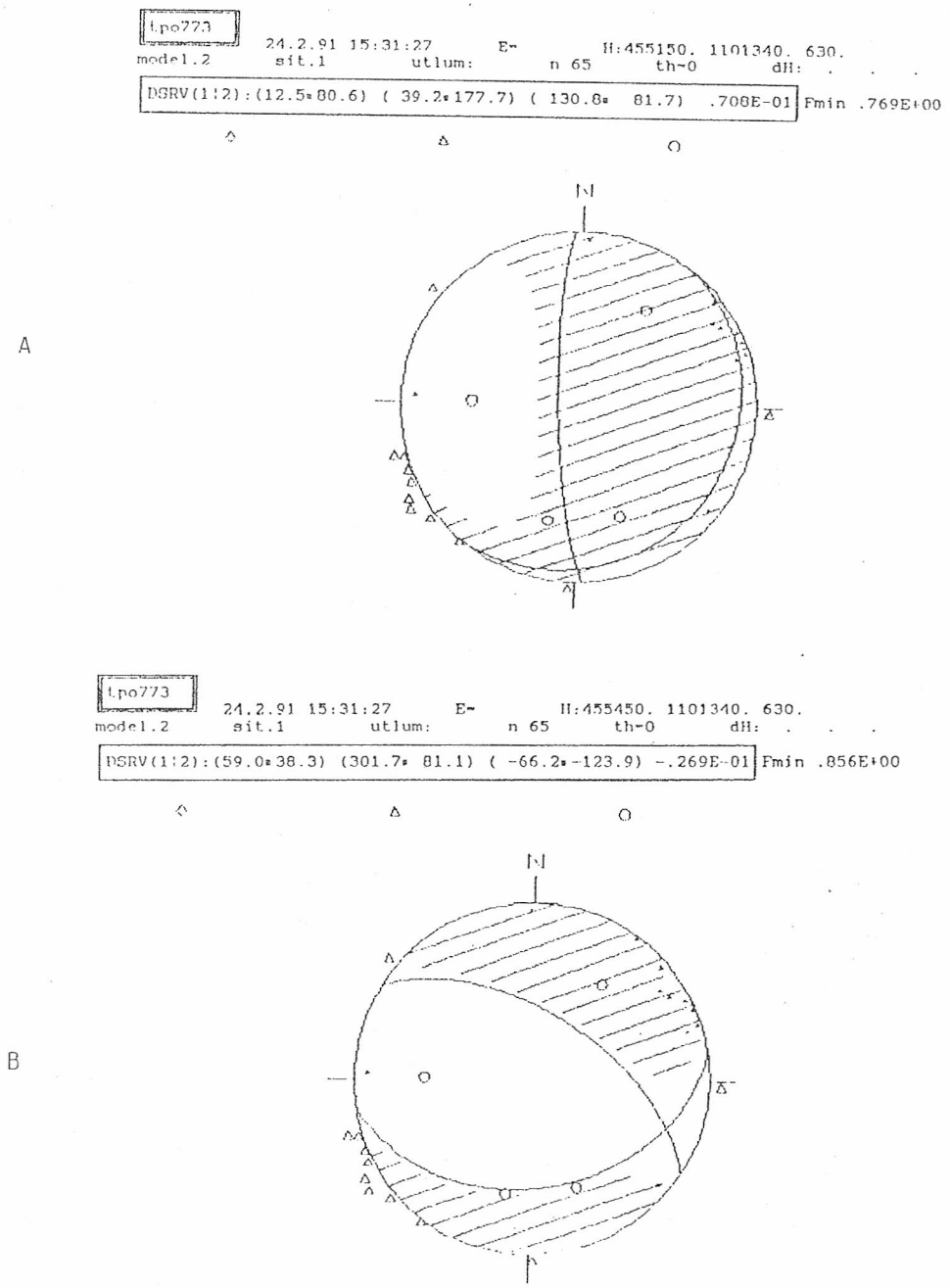


Fig. 5. Influence of x coordinate value changes on a calculating focal mechanism generation.

□- direct wave (focus above station)

△- direct wave (focus below station

○- head wave

Seismic Polygon Ostrava - Karviná Coal Field centre.

2. SELECTION OF CRITERION OF OPTIMISATION

Minimum sum of squares of differences of theoretical and standardised measured value of amplitudes motion was considered to be a criterion of optimisation in the original version of the program. Small values of amplitudes near nodal surfaces cause non-uniform weighting of information from the stations. Therefore our updated version enables us to use a criterion optimisation, the sum of squares of relative deviations of measured and theoretical amplitudes motion (Kaláb et al., 1991).

The calculated value of the volumetric component of the focal mechanism is much greater in case of the criterion of optimisation selected, which correspond with the theoretical presumptions for example for explosive works. The sensitivity of the result on the change of input values of amplitudes was supposed to be higher, however this presumption was not confirmed (Fig. 4).

The results are different while using various optimisation criteria. For routine calculations we provisionally used the original criterion, but for test set of seismic registration of explosive works we are going to use a new method (Fig. 3).

3. INFLUENCE OF ACCURACY OF FOCUS COORDINATES

For an explosive work and a mining tremor we performed calculation of focal mechanism generation at change of every coordinate ± 300 m with step 50 m. We theoretically presumed that the result won't be changed at changing horizontal coordinates, or only insubstantially whilst depth coordinate can have influence on the ray passing through another layer of surrounding and can influence the result a great deal.

The test showed that the result could be effected also by the form of minimising function. If more shallow minimum occurred, we can get another result even having inaccurate horizontal coordinate.(Fig. 5).

In case of depth coordinate the theoretical presumption was confirmed. There are the depth values in table II, which set qualitative changes of results.

Tab. I. Types of medium models
(d - depth, v_p - speed of p-waves)

model.2		model.k05		model.sv		model.v	
d [m]	v_p [m/s]	d [m]	v_p [m/s]	d [m]	v_p [m/s]	d [m]	v_p [m/s]
1470	4215	500	3700	-150	800	-150	800
2627	5089	1500	3981	500	3200	100	3200
7258	5473	2500	4753	1300	4200	1300	4200
>7258	6478	6840	5780	>1300	5500	>1300	5500
		30000	6150				
		>30000	8000				

Tab. II: Deep values which set qualitative changes of rockbursts focal mechanism generation results influence medium model (see fig. 6)

d_- depth value less then original one

d_+ depth value greater then original one

model	d_-[m]	d_+[m]
2	540	860
k05	495	760
sv	460	910
v	560	no change

4. INFLUENCE OF ACCURACY OF INPUT VALUES OF AMPLITUDE

The experiments with input data of amplitudes were performed on test sets. Changed values on some stations were used for calculations, eventually an opposite mark in the amplitudes with the highest absolute value was used. There are examples in table III.

When omitted the input value from one of the stations from the complex of amplitude, the result was different the seismic medium model depend on. The position of the station also influences the trajectory of the seismic ray and the resulting model of formation mechanism of focus as well.

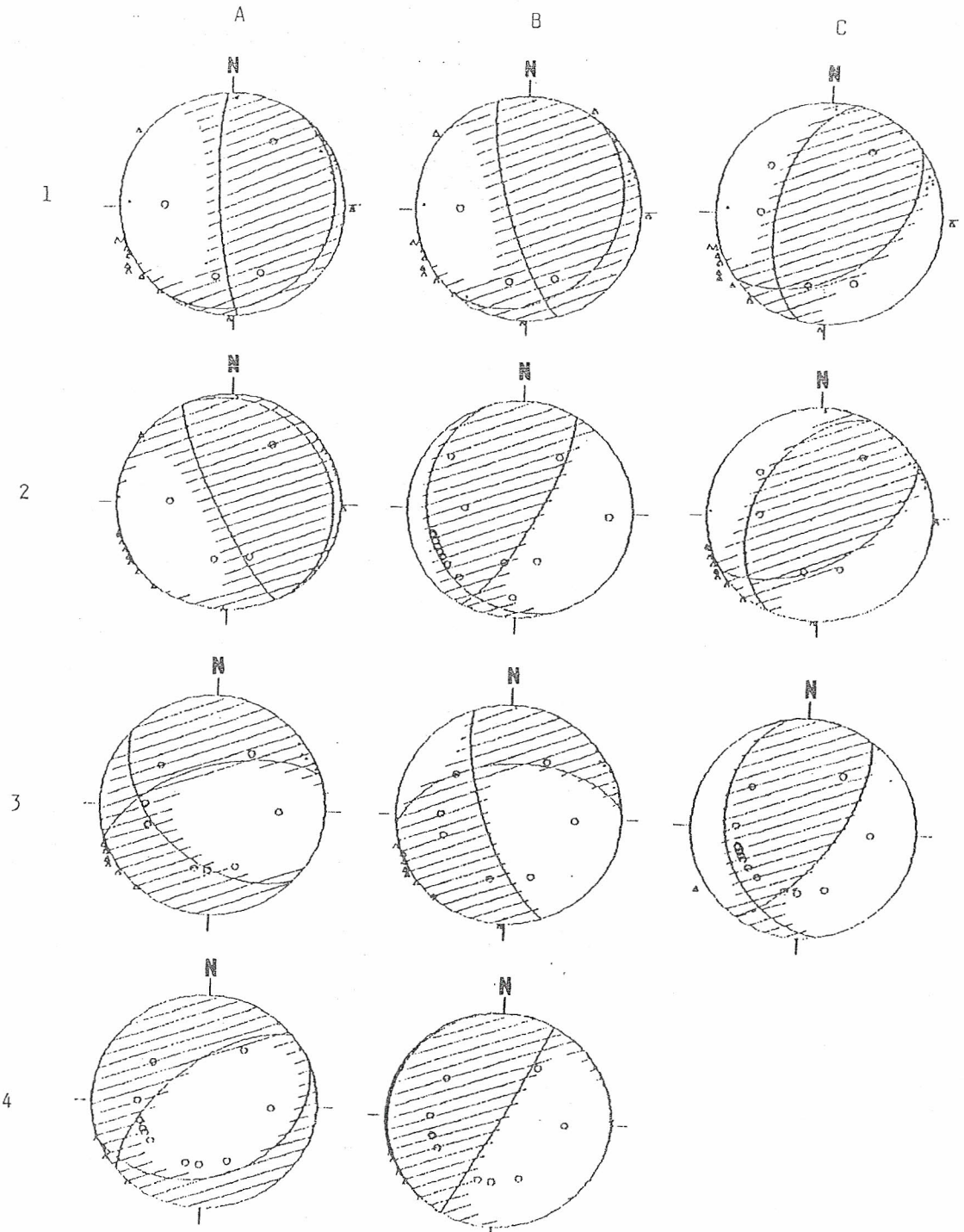


Fig. 6. Models of focal mechanism for four seismic medium models and changed vertical coordinate of focus see tab. 2.

1 - model 2
2 - model k05
3 - model sv
4 - model v

A - result with original depth focus
B - result with depth focus less then original one
C - result with depth focus greater then original one

Tab. III. Examples of input amplitude motion influence on result of determination mechanism foci generation. (The original values see fig.1)

changed channel	changed values of input ampl.	D[°]	S[°]	R[°]	V[%]
kve_y, maj_y	+2.2, +9.04	84.9 5.1	177.7 349.7	90.7 82.	3.9
kve_z	-1.65	12.5 80.6	39.2 177.7	130.8 81.7	7.
$kve_{x,y,z}$	+2, -22, +16.5	56.5 39.2	286.7 71.	-68.4 -119.2	6.5
$kve_x, z6_z$	+0.02, 10.	77.9 12.1	174.5 353.6	90.2 89.2	6.6
$maj_{x,y,z}$	+9.42, +9.04, -2.89	83.2 7.	173.7 340.7	91.6 77.1	5.3
$kve_x, lut_z, z6_z, z9_z$	+0.02, +8.82, +10., +8.1	76.2 88.6	345.7 76.0	-1.5 -166.2	-8.3
$kve_{x,y}, maj_y$	+0.02, +2.2, +9.04	85.3 4.8	178.3 349.4	90.7 81.1	3.8
kve_x, raj_z	+0.02, -21.2	46.1 47.7	14.7 223.4	-110.3 -69.8	5.9
$kve_{x,z}$	+0.02, +16.5	78.8 13.2	167.8 19.9	83.0 121.5	8.9
$kve_{x,y,z}$	+0.2, -22., +16.5	56.5 39.2	286.7 71.0	-68.4 -119.1	0.7
$kve_{x,y,z,}$	-0.2, +2.2, -1.65	45.2 62.	131.1 252.9	-41.4 -127.1	4.6
$kve_{x,y,z,}$ $maj_{x,y,z}$	-0.2, +2.2, -1.65 +9.42, +9.04, -2.89	66.5 24.1	183.8 350.6	-84.7 -102.0	1.4

5. INFLUENCE OF SEISMIC MEDIUM MODEL

The seismic medium models influence the result a great deal. (Fig. 7) Accuracy of all other input values is determined by the accuracy of measuring and deducting and it can be influenced by the interpreter that works accurate or makes mistakes that can be excluded. From this point of view the result should be unambiguous. The seismic medium model is only very inaccurate approximation of the fact and can cause a considerable mistake in the calculation.

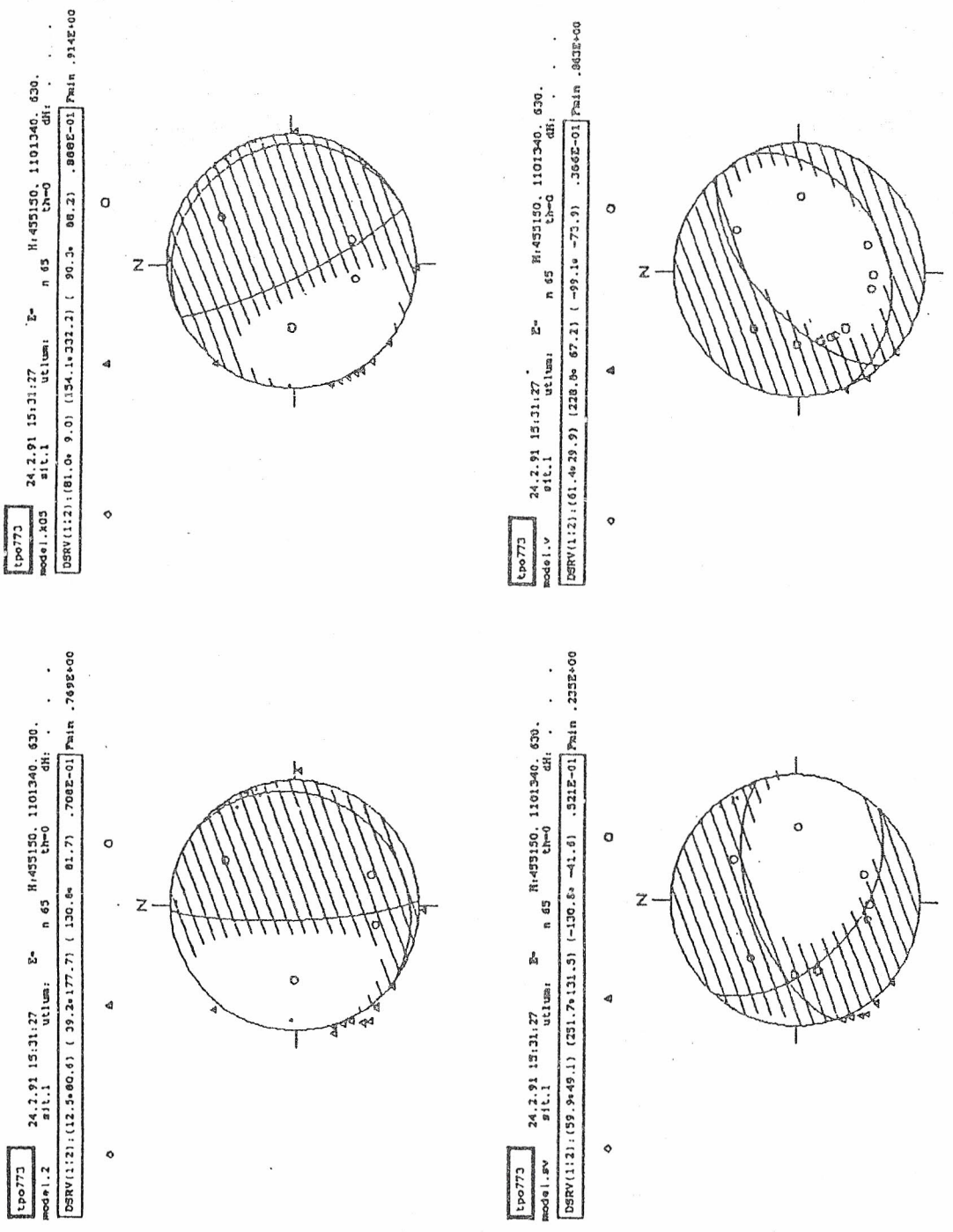


Fig. 7. Focal mechanisms with four seismic medium models:

□ - direct wave (focus above station)

Δ - direct wave (focus below station

○ - head wave

We apply the six-layer medium model (model. K05) (see tab.I), for routine elaboration of seismic data, which is applied also in the Seismic Polygon Ostrava-Karviná Coal Field actually. Both model.k05 and model.2 was calculated in Seismic Polygon Ostrava-Karviná Coal Field from the hodochrons. Both model.sv and model.v was judged from the arrival time difference between underground and surface seismic stations. Gradient of velocity has been supposed.

6. CONCLUSION

While calculating the rockbursts focal mechanisms by inversion method of amplitudes it is necessary to take into consideration the possibility of random formation of different results at the same seismic event with changed input data.

It is necessary to know horizontal coordinates with accuracy ±200 m; accuracy of determination focus depth depends on selected medium model (tab. II).

The influence of input amplitudes motion values on resulting focal mechanism generation is not too meaningful. Allowed mistake of input value of amplitude motion is one order (tab.III).

It is necessary to pay special attention to making of the seismic medium model because it principally influences the results.

Implementation of other optimising criteria that use relative deviation of measured and theoretical amplitudes' motion is not quite evident.

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