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SEISMIC EFFECTS OF THE QUARRY BLASTS ON THE TERRITORY OF BOHEMIA

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ABSTRACT
Quarry blasts can be exploited as a source of seismic waves for structural studies of upper crust. For these studies, accurate origin times are necessary. During years 2002 and 2003 the origin times of 48 blasts at 39 quarries were measured and the results are presented. Typical features of seismograms are demonstrated on a broadband seismic record. Parameters of all active quarries on the territory of Bohemia (western part of the Czech Republic), in which blasts are performed, are listed.

KEYWORDS: quarry blasts, broadband seismograms, list of quarries

INTRODUCTION

Seismic waves generated by quarry blasts are registered frequently at most stations on the territory of Bohemia. In seismological practice they are regarded as technological noise and in most cases they are not interpreted. Their magnitudes only rarely exceed 2. Quarry blasts started to attract more attention in seismology when sensitive local networks for detecting very small earthquakes were put into operation. The discrimination between seismograms of weak earthquakes and quarry blasts is not a trivial problem and many authors tried to find criteria which could be used for their reliable distinguishing (Bucha, 1992). Quarry blasts were also used for testing and calibrating of location methods (Janský and Novotný, 1997). Finally, quarry blasts were recognized as advantageous seismic source for tomography of shallow geological structure down to several kilometers (Málek et al, 2004). Quarry blasts were also used for mapping of Moho discontinuity (Mayerová et al., 1994) and for refraction experiments (Málek et al., 2001).

In this paper, we intend to give an overview of active quarries on the territory of Bohemia (western part of the Czech Republic). For structural studies, the exact information about their source parameters, especially geographical coordinates and origin times, is necessary. During 2002 and 2003 the source parameters of 48 blasts covering the territory of Bohemia were measured. Geographical coordinates were determined using GPS, origin times were measured with a special strong-motion seismograph with high sampling frequency BUMPRECORDER (Brož, 2000). Some of these blasts were performed during international refraction experiments ALP 2002 (Bruckl et al., 2003) and SUDETES 2003 (Grad et al., 2003). In that case, they were recorded on hundreds of short-period stations operated within these experiments. Records from local seismic networks (WEBNET, KRASNET, Příbram, Tušimice) are also available. During 2002 and 2003, quarry blasts were registered at 45 stations within international project BOHEMA (Plomerová et al., 2003).

MAP OF THE ACTIVE QUARRIES

The map of active quarries covers approximately the territory of Bohemia (the border of this territory is shown in Fig. 1) and it was compiled on the basis of information from the Czech Mining Office. The map in Fig. 1 covers all mines, where blasts of more then 100 kg of explosive are regularly performed.

The list of active quarries is given in Tab.1. The coordinates were measured either at the site by the GPS, or from a geographical map (as indicated in Tab. 1). In case of a GPS measurement, the coordinates of the blast was determined. In case of a map reading, the coordinates represent the center of a quarry.

LIST OF THE MEASURED BLASTS

During years 2002 and 2003, 48 quarry blasts were measured at the site. Geographical coordinates WGS-84 were determined using GPS. Altitudes were verified from geographical maps. Origin time was measured with help of the seismograph BUMPRECORDER, which was specially developed for this purpose. It is a strong-motion velocigraph with precise time synchronization and high sampling frequency (500 Hz) designed for measurements in close epicenter distances (tens of meters). The first P-wave onset is picked with precision of 2 ms. A cor-

rection for epicentral distance is considered. In some measurements, two or more stations were used simultaneously. In that case the correction was made by extrapolating a travel time curve to zero epicentral distance. If only one measurement is available, the correction is made with reduction velocity 3.7 km/s. The average total error of origin time is estimated to be 5 ms. A typical seismogram, measured close to the blast at the Rožmitál quarry, is shown in Fig.2.

EXAMPLE OF THE QUARRY BLAST SEISMOGRAM

Blasts in open-pit coal mine Tušimice are performed for disintegration of roof stone. Blasts take place very frequently, in some time intervals they are performed almost daily. One of these blasts was used also during the ALP2002 refraction experiment on July 4, 2002. The blasts are registered at two stations in nearby villages (several kilometers), Černovice (CER) and Spořice (SPO). These stations are designed mainly for monitoring of amplitudes of seismic waves from strong blasts, which can eventually cause damage to buildings in the villages. The seismic station Přísečnice (PRI) was installed in Krušné hory Mts. It was also included to international experiment BOHEMA. After the experiment, PRI continued its operation mainly for monitoring of quarry blasts from coal mines in northwest Bohemia. Station PRI is equipped with broadband seismic sensor GURALP 40 CMG with the frequency range from 0.03 to 30 Hz. It is operated in continuous regime with sampling frequency of 100 Hz. The epicentral distance from Tušimice is 15.8 km.

The seismogram from Tušimice at station PRI is an example of a broadband record of the blast (Fig.3). We can demonstrate some typical features, which were observed also at many other seismograms from other blasts. The P-wave onset is quite clear and sharp in spite of the fact that the blast itself is stacked (it consists of many partial blasts). A delay between subsequent explosions is several milliseconds, the whole process takes approximately half a second. Clear P-wave onsets enable to use stacked quarry blasts for structural studies. S-waves have large amplitudes, much larger than P-waves. This is a little surprising, because explosive source is expected to produce mainly P-waves. (This effect is observed only at some seismograms, while the other records have small S-waves.) However, even if the amplitude is large, the S-wave onset is unclear and can be determined only very approximately. It is caused by the long P-wave coda, which is another typical feature for quarry blasts seismograms. The S-wave onset seems to be shifted on different components, which is probably caused by splitting of S-waves due to large anisotropy in near surface layers. Dominating amplitudes on the seismogram belong to surface waves. Clear dispersion of a surface wave group is obvious. Another group of surface waves is visible just after the P-wave onset. This group belongs probably to leaking modes of surface waves. Unknown phases are visible between P-wave and S-wave onsets. They represent probably reflected and converted waves corresponding to shallow structure. The seismogram is quite long, seismic waves exceed significantly seismic noise even 20 s after the first onset. Some unknown late phases are also detectable on the seismogram. They probably comprise information of deeper structure of the Earth crust.

The complete interpretation of seismograms from quarry blasts is not the topic of this paper. Here, we only want to demonstrate the complexity of such seismograms by using a typical example.

CONCLUSIONS

The territory of Bohemia is covered with a relatively dense network of quarries in which blasting is performed routinely. The coordinates and other parameters of these quarries are summarized (see Fig.1 and Tab.1). In the past three years 48 blasts were measured to obtain their precise origin time and coordinates. These blasts were recorded at many seismic stations. The parameters of these blasts are given in Tab.2. Some typical features of quarry blast seismograms are demonstrated on the example of the Tušimice blast recorded at broadband seismic station Přísečnice.

Blasts in quarries are repeated more or less regularly. Intervals between individual blasts in the same locality vary from several days to several months. This circumstance enables to use quarry blasts also for studies of time changes in a rock massif.

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REFERENCES:

Brož, M.: 2000, Detection of the origin time and seismic ground motion of quarry blasts. *Acta Montan*, ser. A, No. 16 (118), 17-24.

Bruckl, E., Bodoky, T., Hegedus, E., Hrubcová, P., Gosar, A., Grad, M., Guterch, A., Hajnal, Z., Keller, G.R., Špičák, A., Sumanovac, F., Thybo, H., Weber, F. and ALP 2002 working group: 2003, ALP 2002 Seismic Experiment. *Studia geophysica et geodaetica* 3, Vol 47, 671-680.

Bucha,V.: 1992, Differences between earthquakes and explosion sources in North Western Bohemia. *Acta Montana*, ser. A, No.3 (89), 165-188.

Grad, M., Špičák, A., Keller G.R., Guterch, A., Brož, M., Hegedus, E. and Working group: 2003, SUDETES 2003 Seismic Experiment. *Studia geophysica et geodaetica* 3, Vol 47, 681-690.

Janský, J. and Novotný, O.: 1997, Reinterpretation of the travel times of *P*-waves generated by quarry blasts in western Bohemia. *Acta Montana*, ser. A, No. 11 (103), 1-14.

Málek, J., Brož, M., Fischer, T., Horálek, J., Hrubcová, P., Janský, J., Novotný, O., Růžek, B. and the CELEBRATION working group: 2001, Seismic measurements along short profiles in western Bohemia during the CELEBRATION 2000 experiment. *Acta Montana*, 21, Series A No. 18 (121), 15-28.

Málek, J., Horálek, J. and Janský, J.: 2004, One-dimensional qP-wave velocity model of the upper crust for the West Bohemia/Vogtland earthquake swarm region. *Studia geoph. et geod.,* (submitted).

Mayerová, M., Novotný, M. and Fejfar, M.: 1994, Deep seismic soundings in Czechoslovakia. In: *Crustal Structure of the Bohemian Massif and the West Carpathians* (Eds. V. Bucha and M. Blížkovský), Academia, Praha, 13-20.

Plomerová ‚J., Achauer, U., Babuška, V., Granet, M. and BOHEMA working group: 2003, BOHEMA 2001-2003. Passive Seismic Experiment to Study Lithosphere-Astenosphere System in the Western Part of Bohemian Massif. *Studia geophysica et geodaetica* 3, Vol 47, 691-701.

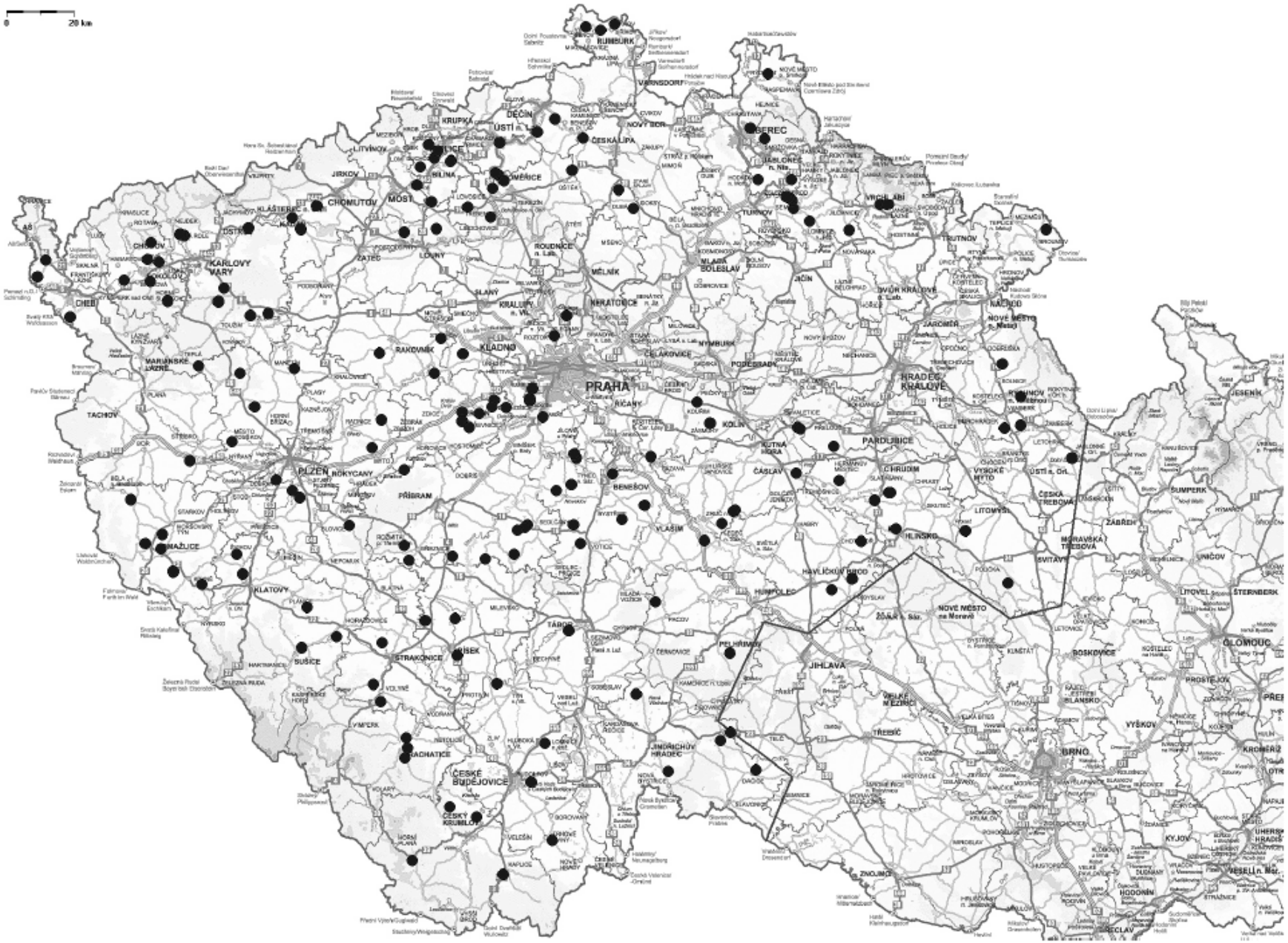

Fig. 1 Active quarries on the territory of Bohemia, where blasts of more then 100 kg of explosive are regularly performed.

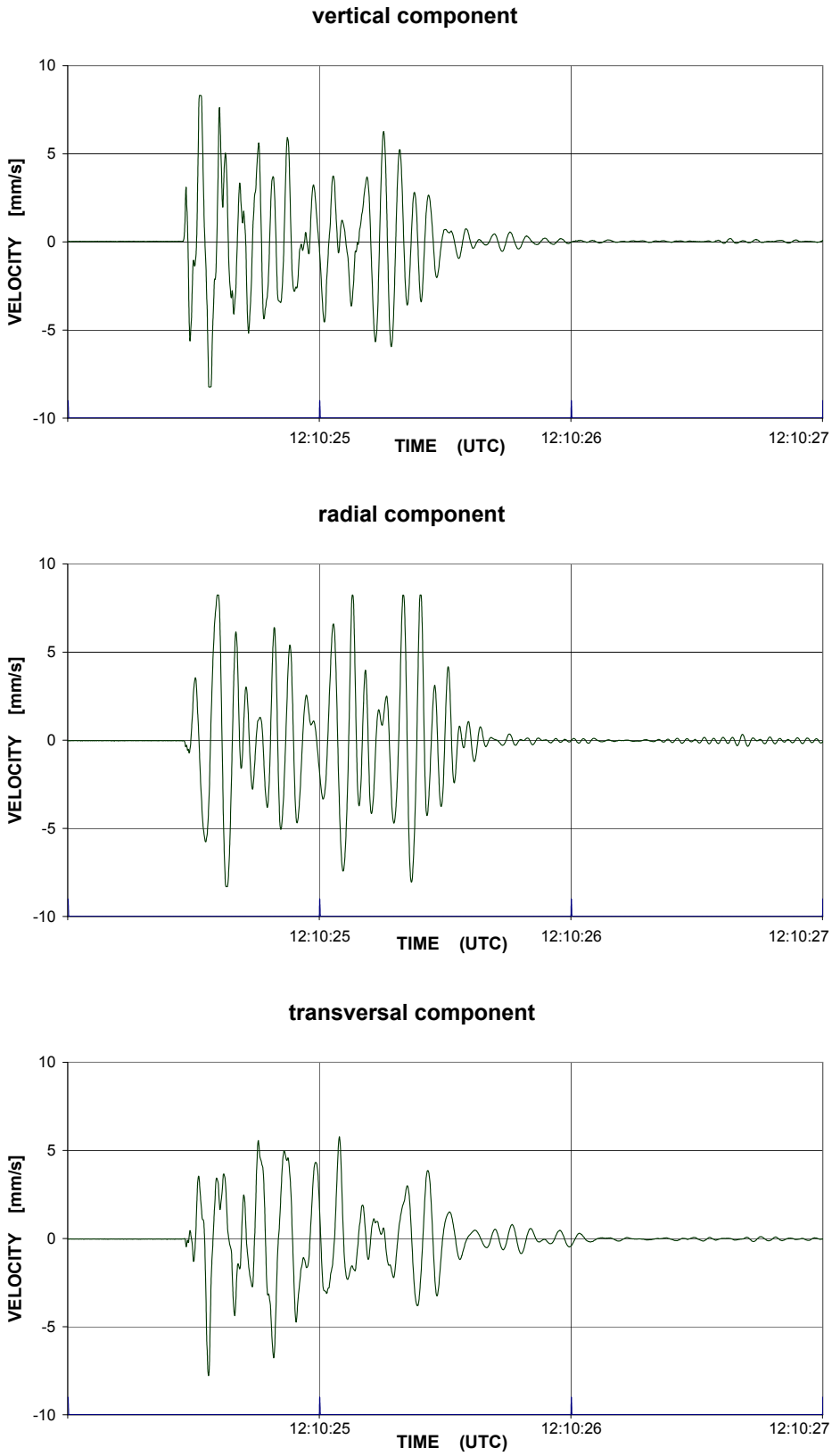

Fig. 2 Velocigram registered at Rožmitál quarry during the blast 29.8.2003 12:10 UTC. Seismograph BR-3 and geophone DGA101 were used. Epicentral distance is 150 m.

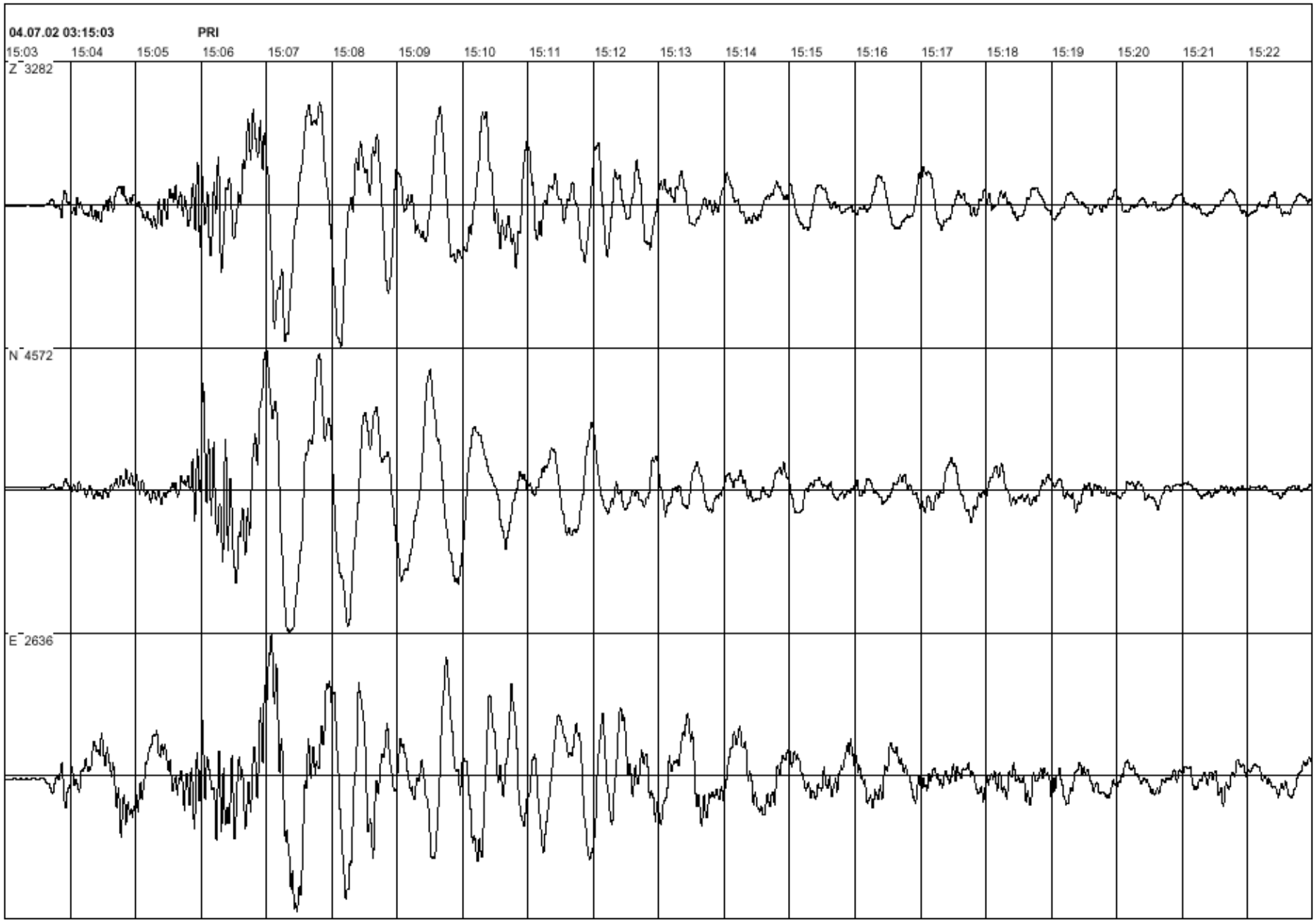

Fig. 3 Blast at Tušimice registered at station PRI

Table 1 Active quarries (see Fig.1) listed according districts and in alphabetical order. The coordinates (WGS 84) were measured either at the site by the GPS or from a geographical map. 'L' in the last column means, that blasts of large extent (more then 200 kg) are allowed. 'S' means that only small blasts are performed.

Quarry/Mining area	Latitude ° N	Longitude ° E	Method	Raw material	Blasts
District Benešov					
Bělice	49.764	14.485	map	gravel	L
Borovsko	49.684	15.118	map	gravel	L
Chrášťany	49.787	14.542	map	gravel	S
Krhanice	49.859	14.546	map	gravel	L
Krhanice (Požáry)	49.869	14.535	map	dimension stone	L
Martinice (Bažantnice)	49.634	14.612	map	gravel	L
Mladovice	49.712	14.768	map	gravel	L
Mrač	49.830	14.705	map	gravel	L
Takonín	49.759	14.853	map	gravel	L
Vrchotovy Janovice	49.680	14.573	map	dimension stone	S
District Beroun					
Čertovy schody/Koněprusy	49.915	14.058	map	limestone	L
Čeřinka/Kozolupy	49.964	14.173	map	limestone	L
Kosov/Jarov	49.939	14.054	map	limestone	L
Loděnice	49.983	14.178	map	limestone	L
Suchomasty, I	49.902	14.089	map	limestone	L
Tetín - Hostim	49.941	14.124	map	limestone	L
Trněný Újezd	49.967	14.231	map	limestone	L
Zaječov	49.764	13.850	GPS	gravel	L
District Česká Lípa					
Chlum I	50.583	14.573	map	gravel	L
Tachov, I, II	50.539	14.645	map	gravel	L
Žandov	50.707	14.396	GPS	gravel	L
District České Budějovice					
Rejta/Trhové Sviny I, II	48.835	14.662	map	gravel	L
Rudolfov	48.982	14.544	map	gravel	S
Ševětín I	49.091	14.578	map	gravel	L
District Český Krumlov					
Černá v Pošumaví	48.729	14.109	map	gravel	S
Kaplice	48.726	14.481	GPS	gravel	L
Plešovice	48.869	14.342	map	gravel	L
Zrcadlová huť/Chvalšiny	48.887	14.231	map	gravel	L
District Děčín					
Císařský	51.000	14.406	map	gravel	L
Lipová u Šluknova	51.005	14.341	map	dimension stone	S
Rožany I.	51.021	14.462	map	dimension stone	S
Soutěsky	50.748	14.267	map	gravel	L
Těchlovice/Přední Lhota, I	50.707	14.200	map	gravel	L

District Domažlice					
Luženičky	49.457	12.908	map	gravel	S
Mračnice	49.496	12.906	map	feldspar	S
Smržovice	49.380	13.097	map	gravel	L
Svržno	49.574	12.756	map	gravel	L
Tisová/Klíčov	49.401	12.973	GPS	gravel	L
Ždánov	49.464	12.842	map	feldspar	S
District Havlíčkův Brod					
Pohled	49.597	15.662	map	gravel	L
Sloupno/Slavíkov	49.734	15.760	GPS	gravel	L
Železné Horky	49.632	15.740	map	gravel	L
District Cheb					
Libá, I, II	50.119	12.223	GPS	gravel	L
Lipná	50.166	12.245	map	dimension stone	S
Slapany/Háje I.	50.032	12.385	map	gravel	L
District Chomutov					
Mikulovice	50.383	13.235	map	gravel	S
Tušimice	50.426	13.329	GPS	brown coal	L
Úhošťany	50.356	13.278	GPS	gravel	L
District Chrudim					
Hlinsko, I	49.777	15.890	map	dimension stone	S
Nasavrky	49.847	15.795	map	gravel	L
Prachovice	49.890	15.639	map	limestone	L
Žumberk/Vížky	49.872	15.851	map	gravel	L
District Jablonec nad Nisou					
Bezděčín, I	50.660	15.146	map	gravel	S
Hraničná, I	50.770	15.155	map	dimension stone	S
Radčice	50.669	15.288	map	gravel	S
District Jindřichův Hradec					
Číměř/Dobrá Voda	49.060	15.090	map	gravel	S
Dačice	49.091	15.444	map	gravel	L
Deštná	49.252	14.920	GPS	gravel	L
Horní Němčice	49.158	15.285	map	gravel	L
Sumrakov	49.184	15.332	map	dimension stone	S
District Karlovy Vary					
Číhaná	50.133	12.984	GPS	gravel	L
Děpoltovice	50.292	12.801	GPS	gravel	L
Heřmanov	49.956	12.943	map	dimension stone	S
Horní Tašovice	50.170	12.998	map	gravel	L
Hutnický vrch	50.293	12.784	GPS	gravel	L
Mokrá I	50.124	13.197	GPS	gravel	L
Ratiboř	50.112	13.124	map	gravel	S
Stráž nad Ohří	50.339	13.060	map	gravel	S
District Kladno					
Družec	50.095	14.022	map	gravel	S

District Klatovy					
Hamr u Sušice	49.251	13.540	GPS	gravel	L
Hejná/Velké Hydčice	49.295	13.674	GPS	limestone	L
Klatovy-Svrčovec	49.423	13.258	map	gravel	L
Trnčí	49.473	13.220	map	gravel	L
Velenovy	49.361	13.538	map	dimension stone	S
District Kolín					
Libodřice	49.998	15.079	GPS	gravel	L
Plaňany	50.051	15.015	GPS	gravel	L
Stříbrná Skalice	49.890	14.852	map	gravel	L
District Kutná Hora					
Bohdaneč	49.777	15.228	map	gravel	S
Bohdaneč I	49.772	15.220	map	limestone	S
Vlastějovice	49.736	15.179	map	gravel	L
Žleby	49.894	15.458	map	gravel	L
District Liberec					
Krásný Les	50.942	15.133	GPS	gravel	L
Ruprechtice	50.794	15.087	map	dimension stone	S
District Litoměřice					
Dubičná	50.618	14.367	map	gravel	L
Kamýk	50.564	14.089	map	gravel	S
Libochovany I, III	50.582	14.051	map	gravel	L
Malé Žernoseky	50.541	14.048	map	gravel	S
Obřice	50.481	13.956	map	gravel	L
Úpohlavy, I	50.464	14.056	map	limestone	L
District Louny					
Břvany	50.391	13.706	map	gravel	S
Chraberce	50.412	13.839	GPS	gravel	L
District Most					
Želenice	50.521	13.731	map	gravel	L
District Náchod					
Rožmitál	50.617	16.369	GPS	gravel	L
District Pardubice					
Chrtníky	49.979	15.599	map	gravel	L
Chvaletice I	50.017	15.441	map	gravel	L
Zdechovice	50.015	15.451	map	gravel	L
District Pelhřimov					
Nemojov/Radňov	49.393	15.280	map	gravel	S
Těchobuz	49.504	14.949	GPS	gravel	L
District Písek					
Jistec II	49.389	14.144	map	gravel	S
Kožlí u Čížové	49.372	14.023	map	gravel	L
Lašovice/Záhořany	49.558	14.233	GPS	gravel	L
Písek - Kamenné Doly	49.292	14.176	map	gravel	L
Slavětice	49.230	14.351	map	gravel	S

District Plzeň					
Litice	49.687	13.334	GPS	gravel	L
District Plzeň jih					
Mítov	49.594	13.661	GPS	gravel	L
Nebílovský Borek	49.649	13.439	map	dimension stone	S
Štěnovice	49.665	13.406	map	dimension stone	S
District Plzeň sever					
Březín	49.953	13.121	map	gravel	S
Mladotice	49.988	13.339	GPS	gravel	L
Pňovany/Úlice, I	49.769	13.128	map	gravel	L
Zahrádka	49.871	13.198	GPS	gravel	L
District Praha					
Hvížďalka/Zadní Kopanina I	49.993	14.324	GPS	limestone	L
Řeporyje	50.027	14.328	map	gravel	L
Špička/Radotín	49.999	14.323	GPS	limestone	L
Zbraslav/Záběhlice	49.956	14.387	map	gravel	L
District Praha východ					
Čenkov	50.234	14.428	GPS	gravel	L
Klecany/Husinec, I, II	50.176	14.388	map	gravel	L
District Prachatice					
Kobylí hora	49.027	14.026	map	gravel	L
Prachatice	49.000	14.021	map	gravel	S
Těšovice	49.054	14.014	map	gravel	L
District Příbram					
Bezděkov/Vševily	49.564	13.894	map	dimension stone	L
Hudčice I	49.524	13.923	map	dimension stone	S
Kozárovice II	49.553	14.097	map	dimension stone	S
Skoupý	49.580	14.348	map	limestone	L
Solopysky	49.656	14.377	map	dimension stone	S
Solopysky I, II - (Deštno)	49.663	14.387	map	dimension stone	S
Štíleček/Hrabří	49.645	14.348	map	gravel	L
District Rakovník					
Brand/Senec	50.065	13.678	GPS	gravel	L
Rynholec	50.126	13.922	map	claystone	S
Sýkořice (Zbečno)	50.031	13.915	map	gravel	L
District Rokycany					
Těškov	49.810	13.705	map	gravel	L
Třebnuška	49.888	13.729	GPS	gravel	L
District Rychnov nad Kněžnou					
Černá Skála/Potštejn	50.079	16.288	GPS	gravel	L
Javornice	50.168	16.343	map	gravel	L
Masty	50.250	16.251	map	gravel	L

District Semily					
Chuchelna (Slap)	50.615	15.300	map	gravel	L
Chuchelna I	50.595	15.310	map	gravel	L
Košťálov I, II	50.565	15.385	map	gravel	L
Smrčí	50.624	15.275	map	gravel	L
Studenec	50.554	15.557	GPS	gravel	L
Záhoří - Proseč	50.621	15.289	map	gravel	S
District Sokolov					
Dasnice/Hlavno II	50.150	12.582	GPS	gravel	L
Družba/Nové Sedlo	50.211	12.715	map	brown coal	L
Horní Rozmyšl	50.261	12.668	GPS	gravel	L
Jiří/Alberov	50.213	12.665	GPS	brown coal	L
Krásno I	50.113	12.776	GPS	feldspar	L
Vítkov I	50.157	12.691	map	gravel	S
District Strakonice					
Černětice	49.139	13.891	map	gravel	S
Krty - I	49.296	13.863	map	gravel	L
Nihošovice	49.182	13.852	map	gravel	L
District Svitavy					
Budislav	49.794	16.177	GPS	gravel	L
Stašov II	49.669	16.373	map	gravel	L
District Tábor					
Hnojná Lhotka	49.399	14.613	map	gravel	S
District Tachov					
Kladruby u Stříbra	49.702	12.968	GPS	gravel	L
District Teplice					
Bílina	50.570	13.735	map	brown coal	L
Dolánky	50.597	13.857	map	gravel	L
Jeníkov - Lahošť	50.631	13.757	map	quartzite	S
Lysec	50.598	13.859	map	gravel	S
Měrunice, I.	50.482	13.802	map	gravel	L
Všechlapy	50.618	13.798	map	gravel	L
Želénky	50.600	13.787	map	brown coal	S
District Trutnov					
Černý Důl	50.636	15.699	map	limestone	L
Horní Lánov	50.634	15.670	map	limestone	L
District Ústí nad Labem					
Stříbrníky/Mariánská Skála	50.664	14.051	map	gravel	L
District Ústí nad Orlicí					
Litice nad Orlicí	50.091	16.356	map	gravel	L
Mistrovice	50.020	16.581	map	gravel	L

Table 2 Precise origin times and coordinates of the quarry blasts measured during 2002-2003.

Quarry	Latitude	Longitude	Altitude	Date	Time (UTC)		Charge
	° WGS84	° WGS84	m	d:m:y	h:m:s	ms	kg
Brand/Senec	50.0653	13.6787	493	5.12.2002	11:19:48	266	4 000
Budislav	49.7945	16.1776	460	6.6.2003	3:40:00	613	469
Čenkov	50.2340	14.4282	260	5.6.2003	3:50:00	029	260
Černá Skála/Potštejn	50.0790	16.2888	390	5.6.2003	3:40:01	274	400
Číhaná	50.1332	12.9853	730	3.7.2002	18:20:05	526	792
Číhaná	50.1330	12.9833	720	4.6.2003	17:40:06	311	400
Dasnice/Hlavno II	50.1502	12.5827	460	7.10.2003	10:00:00	234	387
Děpoltovice	50.2921	12.8011	550	18.10.2002	11:23:13	664	8 820
Deštná	49.2523	14.9207	580	5.6.2003	3:30:01	235	532
Hamr u Sušice	49.2516	13.5409	510	3.7.2002	18:00:00	146	2 000
Hejná/Velké Hydčice	49.2954	13.6745	500	29.11.2002	10:01:24	510	1 900
Horní Rozmyšl	50.2610	12.6684	560	5.6.2003	17:49:59	546	400
Hutnický vrch	50.2935	12.7840	610	25.10.2002	10:56:53	404	2 602
Hvížďalka	49.9938	14.3245	270	17.7.2002	11:30:49	090	1 765
Jiří/Alberov	50.2130	12.6657	406	9.12.2002	12:00:03	734	3 424
Jiří/Alberov	50.2140	12.6659	407	9.12.2002	12:05:00	772	3 424
Kaplice	48.7265	14.4817	580	4.6.2003	17:30:10	298	400
Kladruby u Stříbra	49.7028	12.9685	380	3.7.2002	19:00:13	312	485
Tisová/Klíčov	49.4015	12.9737	480	11.10.2002	9:54:00	518	4 904
Královec/Příštpo	49.0808	15.9136	420	6.6.2003	17:29:59	960	400
Krásno I	50.1131	12.7767	750	21.6.2002	9:28:11	236	1 524
Krásno I	50.1133	12.7758	750	17.9.2002	10:40:36	306	1 900
Krásno I	50.1137	12.7762	740	4.6.2003	17:20:00	476	270
Krásno I	50.1135	12.7768	750	11.12.2003	10:03:27	386	1 800
Krásný Les	50.9428	15.1337	400	5.6.2003	17:40:01	328	410
Lašovice/Záhořany	49.5580	14.2330	530	4.12.2002	12:36:24	950	5 800
Libá	50.1198	12.2245	610	18.12.2002	11:31:37	747	800
Libá	50.1198	12.2229	590	4.6.2003	17:09:59	525	400
Libodřice	49.9989	15.0796	310	5.6.2003	18:09:59	724	583
Libochovany I	50.5793	14.0652	400	4.6.2003	18:19:52	329	395
Libouš/Tušimice	50.4265	13.3292	260	4.7.2002	3:15:00	828	6 775
Litice	49.6870	13.3340	380	3.12.2002	12:29:34	086	5 238
Mirošov	49.4635	16.1655	460	6.6.2003	3:11:15	778	400
Mítov	49.5946	13.6616	500	3.7.2002	18:30:02	974	3 280
Mladotice	49.9884	13.3390	480	16.12.2002	13:06:39	312	5 900
Mokrá	50.1244	13.1970	560	26.11.2003	11:28:03	895	6 800
Rožmitál	50.6172	16.3698	547	29.8.2003	12:10:24	413	9 704
Rožmitál	50.6182	16.3698	550	18.11.2003	13:23:14	298	10 701
Sloupno/Slavíkov	49.7343	15.7602	510	4.6.2003	17:50:01	843	400
Studenec/Královec	50.5547	15.5570	550	5.6.2003	17:30:00	635	400
Těchobuz	49.5049	14.9498	540	27.6.2002	5:00:04	428	500
Těchobuz	49.5048	14.9498	540	5.6.2003	3:20:00	603	502
Třebnuška	49.8882	13.7290	360	4.7.2002	3:55:01	528	2 400
Úhošťany	50.3578	13.2759	380	13.12.2002	10:41:07	450	5 386
Úhošťany	50.3562	13.2787	370	4.6.2003	18:40:00	575	423
Zahrádka	49.8715	13.1984	530	14.10.2002	13:31:07	618	5 874
Zaječov	49.7648	13.8500	530	4.7.2002	18:30:01	320	200
Žandov	50.7074	14.3964	180	6.6.2003	17:40:25	789	200