NON-REVIEWED CONTRIBUTION

SEISMIC ACTIVITY IN THE CZECH REPUBLIC IN 2008

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1. INTRODUCTION

The Czech Regional Seismological Network (CRSN), consisting of fourteen permanent digital broadband stations and two data centres, recorded and detected 9073 seismic events from all epicentral distances in 2008. Most of these events were located by the Czech Seismological Service, and many of them were analyzed in detail. This paper provides basic information on the configuration of the CRSN, routine data processing, seismicity in the Czech Republic in 2008 as well as macroseismic observations collected in 2008.

The seismic activity on the territory of the Czech Republic and surrounding regions has been traditionally reported in annual bulletins published on the web sites of the Institute of Geophysics of the Academy of Sciences of the Czech Republic, Prague (*http://www.ig.cas.cz*), and in reports issued by the Institute of Physics of the Earth of Masaryk University, Brno (*http://www.ipe.muni.cz*). The bulletins however include events from local to teleseismic distances which makes the search for regional information complicated. The aim of this paper is to provide a quick overview of earthquakes and mining-induced seismic events which originated in the Czech Republic in 2008. The overview follows the contribution to the seismic activity in 2007 (*Zedník and Pazdírková, 2009*). Earthquakes and mining-induced events in the Bohemian Massif in 1995–1999 were discussed by *Zedník et al. (2001)*. A similar paper covering the seismicity in the period 2000–2006 is in preparation.

2. SEISMIC STATIONS OPERATING IN 2008 AND DATA PROCESSING

The Czech Regional Seismological Network (CRSN) consists of fourteen permanent seismic observatories: Průhonice (PRU), Kašperské Hory (KHC), Dobruška/Polom (DPC), Nový Kostel (NKC), Panská Ves (PVCC), Úpice (UPC), Třešť (TREC), Králíky (KRLC), Praha (PRA), Vranov (VRAC), Moravský Beroun (MORC), Moravský Krumlov (KRUC), Velká Javorina (JAVC), and Ostrava/Krásné Pole (OKC). Stations PRU, KHC, DPC, NKC, PVCC, TREC, KRLC, and UPC are operated by the Institute of Geophysics Prague (IG), station PRA by Charles University Prague (CU), VRAC, MORC, KRUC, and JAVC by the Institute of Physics of the Earth Brno (IPE), and OKC jointly by Technical University (TU) and the Institute of Geonics (IGN), Ostrava. A new broadband seismic station Králíky (KRLC) operated by the IG Prague was put into test operation in November 2008. The position of the CRSN stations as well as the data centers of the IG in

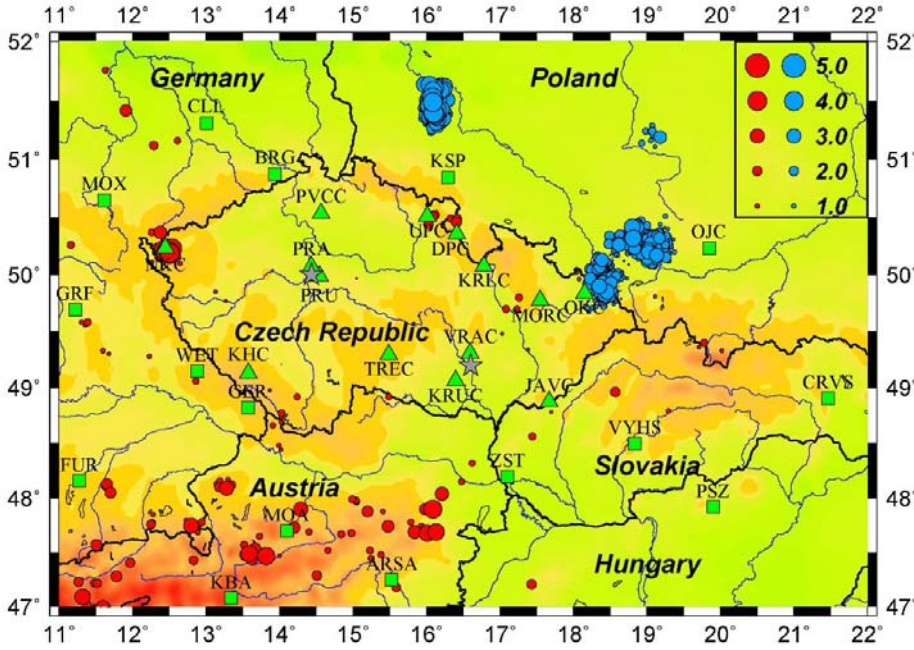

Fig. 1. Seismological stations operating in the Czech Republic and surrounding countries and epicentres of seismic events in 2008 (green triangles - seismological stations of the CRSN; green squares - neighbouring stations; grey stars - IG and IPE data centres; red circles - epicentres of regional tectonic events; blue circles - epicentres of mining-induced events). Diameters of the circles are proportional to local magnitude.

Prague and IPE in Brno are shown in Fig. 1. All stations except UPC are equipped with broadband digital recording systems, stations PRU, KHC, NKC, OKC, and UPC have also short-period seismometers. Basic information about the CRSN stations and their instrumentation is summarized on the web page *http://www.ig.cas.cz/en/structure /observatories/czech-regional-seismological-network*.

Digital data from all CRSN stations are transferred continuously to the data centres at IG Prague and IPE Brno either by VHF radio telemetry or by the Internet. For regional locations and detailed studies of selected earthquakes, digital data from seismic networks of Slovakia, Germany, Poland, Austria, Hungary, Romania, Slovenia, Italy and Switzerland were used. Software packages Antelope (Boulder Real Time Technologies) and SeisComP (*Hanka et al., 2000*) are used for data acquisition and exchange at both IG and IPE.

Routine analysis of the digital recordings at the IG has been performed by the Unix package Seismic Handler (*Stammler, 1993*) which allows interactive location of seismic events by program LocSat. For the estimation of local magnitudes from recordings of the IG stations of the CRSN, *Kárník's (1968)* calibrating curve has been employed. To ensure historical continuity, only short-period (bandpass ~ 0.6–3.3 Hz) vertical channels were used for measuring amplitudes of Sg/Lg waves.

At the IPE the collected digital observational material has been analyzed by means of the graphical program Geotool (*Henson and Coyne, 1993*). This software contains also the LocSat program which performs routine epicentre location with IASP91 travel-time curves. Local magnitudes were determined from maximum vertical trace amplitudes of Sg waves, using *Scherbaum and Stoll's (1983)* formula for local events at distances up to 1°.

3. SEISMIC ACTIVITY IN 2008

In the year 2008, about 9100 local, regional and teleseismic events were recorded and most of them located by the CRSN. A large number of seismic events identified as quarry blasts was excluded from further processing and is not included in the event statistics. Results of data processing at both the IG Prague and IPE Brno were jointly evaluated to eliminate mislocations and industrial events (quarry blasts). All events recorded by the CRSN and analysed at both data centers were published on the IG web site in the section Bulletins of seismic events (*http://www.ig.cas.cz/en/seismic-service/seismic-bulletins*). Regional events were published in Catalogs of regional seismic events (*http://www.ig.cas.cz/en/seismic-service/catalogs-of-regional-seismic-events*). Altogether 2375 seismic events originated in the territory of the Czech Republic in 2008, 1051 of them reached magnitude 1.0 or more on the Richter scale. Seismic events with local magnitude $M_L \geq 2.0$ are listed in Table 1.

In 2008 vast majority of seismic events from the Czech territory is represented by tectonic events from the West Bohemia earthquake swarm. The swarm started on October 6th and lasted about two months. About 20000 events from the Nový Kostel focal zone (circa 50.21°N, 12.45°E) were detected in the local network WEBNET (IG) recordings with maximum M_L 3.8 and focal depths 6.5–11 km. Nine earthquakes reached local magnitude 3.0 or more, about 110 earthquakes reached local magnitude 2.0–2.9. Basic information about the 2008 swarm activity was presented in *Horálek et al. (2009)*, a detailed study made by the WEBNET group is under preparation. Preliminary results of data evaluation are presented on the WEBNET web pages, final catalogue of local events will be available after completion. Stations of the CRSN detected and located 1005 swarm earthquakes. Nevertheless, the CRSN locations are not so precise as the locations made by the local seismic network and partly differ, mainly in focal depths. Local magnitudes M_L determined by the CRSN are about 0.3 greater than WEBNET magnitudes due to different methodology used for the M_L computing. Local magnitudes of two strongest events computed by the CRSN are 4.1 and the number of $M_L \geq 2.0$ events is more than 230 in the CRSN catalogue. Higher estimates of M_L by the CRSN are effected by broadband station NKC situated on top of the Nový Kostel focal region. Magnitudes estimated by other seismological agencies are slightly greater than the WEBNET magnitudes, too (Table 2).

A numerous sequence of earthquakes was recorded by the CRSN from the epicentral area of the Hronov-Poříčí Fault Zone. Almost 70 events were detected during January 22–26, four of them reached local magnitude M_L 2.1. Three other stronger events from this area were recorded on June 4 within an hour (M_L 1.8, 1.3 and 1.7). Other very weak events were detected during the year. Three earthquakes were originated in the Hronov

Table 1. Seismic events in the Czech Republic in 2008 with local magnitude ML ≥ 2.0. Individual earthquakes from the West Bohemia seismic swarm 2008 are not included. M - mining induced event, T - tectonic event.

Date	Origin Time (UTC)	Lat. [°N]	Lon. [°E]	Depth [km]	M_L	I_0	Type	Region
2008-01-08	20:36:49.5	49.84	18.39	0	2.2		M	Ostrava
2008-01-21	19:39:37.9	49.80	18.42	0	2.5		M	Ostrava
2008-01-24	00:48:06.4	50.51	16.09	0	2.1		T	Hronov
2008-01-24	05:39:34.5	50.51	16.09	0	2.1		T	Hronov
2008-01-24	06:39:16.1	50.52	16.11	0	2.1		T	Hronov
2008-01-25	09:19:46.9	50.44	16.03	0	2.1		T	Hronov
2008-01-27	11:10:50.2	50.23	12.45	9	2.2		T	West Bohemia
2008-02-06	01:55:54.3	49.82	18.46	0	3.1	3	M	Ostrava
2008-02-18	15:27:00.0	49.87	18.34	0	2.0	2	M	Ostrava
2008-02-20	05:43:45.9	49.85	18.40	0	2.0		M	Ostrava
2008-04-05	13:11:18.5	49.80	18.50	0	2.0		M	Ostrava
2008-04-12	16:11:31.1	49.88	18.44	0	2.1		M	Ostrava
2008-04-13	16:15:28.9	49.85	18.43	0	2.1		M	Ostrava
2008-04-17	17:27:47.7	49.84	18.42	0	2.2		M	Ostrava
2008-04-29	22:07:28.7	49.83	18.47	0	2.0		M	Ostrava
2008-06-05	23:39:39.6	49.85	18.50	0	2.7		M	Ostrava
2008-06-09	22:06:54.1	49.85	18.43	0	2.1		M	Ostrava
2008-08-26	17:10:57.7	49.86	18.41	0	2.5	2	M	Ostrava
2008-09-30	15:48:55.4	49.86	18.45	0	2.5	2	M	Ostrava
2008-10-06	---	*~50.21*	*12.45*	*9*	*max 3.8*	*5*	*T*	*West Bohemia swarm*
2008-12-10	*~120 events*				*≥ 2.0*			
2008-11-20	05:31:01.4	49.87	18.42	0	2.4		M	Ostrava
2008-11-22	22:27:56.1	49.88	18.40	0	3.3	2	M	Ostrava
2008-12-04	06:54:32.3	49.85	18.46	0	3.2	2	M	Ostrava
2008-12-04	06:54:32.3	49.85	18.46	0	3.2	2	M	Ostrava
2008-12-18	03:03:05.6	49.84	18.35	0	2.2		M	Ostrava
2008-12-29	00:24:25.3	49.84	18.47	0	2.0		M	Ostrava

wider epicentral area also near Czech-Poland boundary on the Polish territory - on February 29 (M_L 2.2) and April 13 (M_L 1.1 and 1.6).

About 200 microearthquakes occurred in North Moravia, most of them with epicentre in the Upper Morava basin (epicentral areas Šumperk, Šternberk, Litovel, Chropyně, Prostějov). Only three events exceeded local magnitude M_L 1.0 - an earthquake near Litovel on October 12 with M_L 1.7 and two events from Šternberk-Lašťany on October 26 (M_L 1.6) and on December 25 (M_L 1.3).

Several earthquakes occurred in the south and southwest Bohemia. Four events were recorded on November 11 and 12 in Horní Planá by the Lipno reservoir with maximum magnitude M_L 1.6. One weak earthquake with M_L 1.0 was detected on July 19 in Chvalšiny near Český Krumlov. Four microearthquakes did not reach local magnitude 1.0 - two events west of Plzeň and events near Boubín in the Šumava Mts. and near Tachov.

Table 2. The strongest earthquakes of the West Bohemia seismic swarm 2008 - magnitudes estimated by various seismological agencies: WEBNET - West Bohemia network, IG Prague; NKC - NKC station, IG Prague; IG-Ant - Antelope system, IG Prague; IPE - IPE Brno; GRF - Graefenberg Array, Germany; LDG - Laboratoire de Détection et de Géophysique, France; ZAMG - Zentralanstalt für Meteorologie und Geodynamik, Austria; GSR - Geophysical Survey of the Russian Academy of Sciences. M_L - local magnitude, m_b - body-wave magnitude.

Date	Time (UTC)	WEBNET M_L	NKC M_L	IG-Ant M_L	IPE M_L	GRF M_L	LDG M_L	ZAMG M_L	GSR m_b
2008-10-10	03:22	3.6	3.9	3.9	3.7	3.6		3.9	
2008-10-10	08:08	3.7	4.0	4.3	4.1	4.1	4.4	4.3	4.4
2008-10-12	07:44	3.8	4.0	4.3	3.9	3.9	4.2		
2008-10-14	19:00	3.7	4.1	4.1	3.9	3.8	4.0	3.9	
2008-10-28	08:30	3.6	4.1		4.1	3.8	4.2	4.2	4.0

Most of seismic events from the Czech territory are represented by induced seismic events from the Ostrava-Karviná Coal Basin. The strongest induced event from Ostrava region was recorded on November 22 at 22:27 UTC and reached local magnitude 3.3. The rockburst caused two fatalities and three injuries in the mine. It was felt within 15 km around the epicentre.

4. MACROSEISMIC OBSERVATIONS

65 seismic events were felt on the territory of the Czech Republic during 2008. 30 observed events are individually confirmed observations of rockbursts in the copper mine region of Lubin (Poland) of intensity 2° reported by a sensitive observer in Harrachov in NE Bohemia. 11 felt events are rockbursts from Ostrava-Karviná Coal Basin region with intensities 2° or 3°.

The only macroseismically observed earthquakes in 2008 are 24 events from the West Bohemia seismic swarm. People reported trembling or swinging of buildings, some of the stronger shocks caused non-structural damages like cracks in plaster. Windows, doors and dishes rattled, some objects or furniture moved or fell down. Acoustic effects like vibrations, explosions, rumbling and thundering were reported (*Horálek et al., 2009*). The evaluation of obtained macroseismic questionnaires has not been finished yet but maximum intensities greater than 5° are not expected.

List of all macroseismically observed events since 1991 is published on the web page of the IG (*http://www.ig.cas.cz/cz/seismicka-sluzba/pocitene-seismicke-jevy*). Intensities were estimated by the European Macroseismic Scale 1998 (EMS-98) introduced by *Grünthal (1998)*.

5. CONCLUDING REMARKS

The Czech Regional Seismological Network is jointly operated by the Institute of Geophysics AS CR Prague, Institute of Physics of the Earth MU Brno, Charles University Prague, Institute of Geonics AS CR Ostrava, and Technical University Ostrava. Data from

all stations are transferred in real-time to the data centres at the Institute of Geophysics in Prague and the Institute of Physics of the Earth in Brno. Data processing and routine analysis are performed digitally by interactive seismological software packages SeismicHandler and Geotool. Digital data are publicly accessible both on-line and off-line in standard data formats. Bulletins of seismic events recorded by the CRSN and regional catalogues are published on the web pages of the Institute of Geophysics (*http://www.ig.cas.cz/en/seismic-service*).

Epicentres and local magnitudes were determined for 5492 earthquakes and mining induced events in the Czech Republic and surrounding regions in 2008.

The most significant seismic activity in 2008 was the earthquake swarm in the Nový Kostel focal zone in western Bohemia. About twenty thousand earthquakes were detected by local seismic network WEBNET from October to December 2008. Nine of the strongest events reached local magnitude 3.0 or more. The strongest event reached magnitude 3.8. 24 earthquakes of the October 2008 swarm were felt by people in west Bohemia. Maximum epicentral intensity probably did not exceed 5° EMS-98.

Weak seismic activity was also recorded from the Hronov-Poříčí Fault Zone, from the northeastern Bohemian Massif and from the southwestern part of the Czech Republic.

41 mining induced shocks from Lubin (Poland) and Ostrava-Karviná were felt on the territory of the Czech Republic in 2008.

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