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SEISMOLOGICAL MEASUREMENT IN THE MORAVO-SILESIAN REGION IN 2003

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ABSTRACT
A detailed research of the mobility of tectonic zones in the Moravo-Silesian region was begun in 1997 due to the support of the Grant Agency of the Czech Republic. A major part of the grant was for a geodynamical measurement using GPS signals on geodetic points. The seismological monitoring results are described in the paper, and the geological and structural mappings of these points are necessary components of the analysis.
The registered information of these seismic stations confirms not only higher number of seismic events in this area due to technical and industrial reasons but also current occurrences of weak natural earthquakes. Experimental seismological measurement in 2003 documents the occurrence of weak natural earthquakes with local magnitude that usually do not exceed the value of zero. It is evident that only shocks in the surrounding of the stations were recorded. The main source areas are the wider surroundings of Opava town, the eastern margin of Hrubý Jeseník Mts. (e.g. Rýžoviště), parts of Hrubý Jeseník and the surroundings of Staré Město town.

KEYWORDS: weak local seismic activity, Moravo-Silesian Region, seismic station Zlaté Hory

INTRODUCTION

The seismological monitoring of the investigated area was a major significant work of the project "Fundamental mobility trends in the northern part of the Moravo-Silesian zone (the Bohemian Massif) – A complex geodynamic analysis", supported by the Grant Agency of the Czech Republic during the period (2001-2003). The seismological results obtained during the whole monitoring period from 1997 to 2003 are briefly summarized in this contribution.

The area under study (49.5^{o}N – 50.5^{o}N, 17^{o}E – 19^{o}E approximately, see also Fig. 1) was characterized by the complex geological and tectonic settings of the Cadomian, Variscan and Alpine ages (e.g., Kumpera and Suk, 1985). The present seismic activity of the northern part of the Moravo-Silesian zone is weak but should be pointed out that in the region stronger earthquakes took place in the past (firstly 1785-1786, 1931-1935, 1986; e.g. Kárník et al., 1981). Last earthquake swarm occurred in the period 1992 – 1993 with the macroseismic intensity up to I_0 = V^{o} MSK-64. Gravimetric, magnetic and radiometric geophysical fields of investigated area are of a complicated character because of complex geological and tectonic structure. The visual analysis of isoseismic lines of the most intensive earthquakes in confrontation with geophysical anomalies, which represent also significant fault lines, has shown a considerable directional similarity (Kaláb et al., 1996).

Detailed seismological study supported by the Grant Agency of the Czech Republic started in 1997 (205/97/0679). Obtained results of this grant were published (e.g. Schenk et. al., 2000). During the project duration (1997-1999), three local earthquakes with local magnitude up to 0.8 were recorded in the area of Opava in February 1999. Seismic events recorded at the solitaire stations Zlaté Hory, Žáry, Hradec above Moravice and Poruba during this period (Kaláb and Knejzlík, 2000) were divided into three groups:

- Local seismic events – local earthquakes, quarry blasts in the surrounding of the stations, so far unidentified local seismic events that could belong to local earthquakes,
- Mining induced seismic events occurred in the Karviná part and the Polish part of the Upper Silesian Coal Basin and in the cooper mine in the Lubin area,
- Unidentified parts of teleseismic events.

Seismic observations by the IGN have been taken continually at the Moravo-Silesian region since 1997 up to now. Monitoring places were often moved to document very weak seismic activity because one of the aims of the project was to prove the current existence of seismic activity in investigated region (more than 20 positions were tested). New positions have been found in the northern part of the above mentioned area, in which seismic station did not exist. Detailed description of the operation of seismic stations was presented in Kaláb and Knejzlík (2003).

There are three solitaire seismic stations operating now – Raduň near Opava (X=1093100, Y=494300 JTSK), Slezská Harta (X=1091100, Y=520100) and new location in Zlaté Hory (X=1052900, Y=529200; all coordinates are estimated using a map). However, removed seismic stations Jánský Vrch in Javorník and Janov were operated practically during the whole time of the observation period. The positions of the stations operated in the past and current ones are shown in Fig. 1.

INSTRUMENTATION OF SOLITAIRE SEISMIC STATIONS

All above-mentioned seismic stations were equipped with PCM3-EPC digital seismographs, which were developed in IGN. The PCM-EPC records 3-component seismic signals in a triggered regime on the disc embedded in a single board PC computer. Frequency range of seismic signal amplifiers is between 0.05 – 30 Hz, sampling frequency of A/D conversion is usually 100 Hz and the dynamic range 90 dB (MSB/LSB). The recording is triggered when a given number of the signal amplitude trespasses over the triggering level in a defined time interval. It is possible to record up to 15 s of signal time history before triggering. The time base of the records is synchronised by DCF 77.5 kHz signals.

Three SM-3 seismometers in a geographical configuration, adjusted to a natural period of 2 s were generally installed on the stations (S5S seismometers, adjusted to a natural period of 5 s, were installed only in the Raduň station).

All stations were remote controlled via a GSM network. This enabled to check functions of the apparatus, to set of the trigger parameters, to start continuous data recordings for a given time interval and mostly to transmit recorded data.

More detailed description of the PCM3-EPC apparatus and software was given by Knejzlík and Kaláb (2002).

NEW SEISMIC STATION IN ZLATÉ HORY

At first the Zlaté Hory seismic station was placed in the territory of the ore mine „Zlaté Hory - East Colliery“. The seismometers were placed underground in the area of an abandoned main shaft (the 3-rd level) at the depth of about 300-m deep. Signals were transmitted from seismometers to the PCM3-A seismograph (older model of PCM3 apparatus with external PC) in an analog form using current loops (Knejzlík, 1998). The operation of this station was interrupted in July 1998 because of the sudden closure of all mining operations. The new instrumentation developed for this station, especially the new instrumentation for digital data transmission from remote seismometers via telephone line, was described by Kaláb and Knejzlík (1999).

At present, another part of Zlaté Hory mine called Blue Gallery is used as a children sanatorium for speleoterapeutic purposes by „Edel Ltd.“. The seismometers of new seismic station are placed in a closed area of this sanatorium. The recording apparatus (PCM3-EPC and a GSM modem) were installed in a service house near the entrance of the gallery (see Fig. 2). A pair of telephone lines (about 800 m long) was used to connect both places. The forenamed instrumentation, developed for the first position, was optimal for the new place too. The block diagram of the instrumentation is presented on Fig.3.

Seismometers together with PCM3-Tx digital telemetric transmitter were installed on a concrete foundation in a closed area of a mine gallery about 40-m below the surface. To obtain the lowest noise, modified seismometers SM3M with built-up preamplifiers and voltage-to-current converters were used. This modification of seismometers was developed for long distance analog seismic signal transmission using current loop. Preamplifier is wired as a voltage/current converter in a known circuit called the “Howland´s current pump” – see schema on Fig.4.

To obtain the maximum signal from a seismometer, working (Lw) and dumping (Ld) coils of SM3 seismometer are connected to the input circuit of operational amplifier series (double generator constant G = 35 $V.m^{-1}.s$). Proper dumping of electrodynamic system is achieved by the selection of input resistance of an electronic circuit, which is given as the sum (R1A+R1B). If proper values of resistors are used (R2=R3+R4), this circuit converts the velocity of the oscillation v to an output signal current i_s by the equation:

$$i_s = v.G.\frac{2.R2}{Rw + Rd + R1A + R1B} = v.K$$

where Rw and Rp are internal resistance of Lw and Ld respectively. In this schema, the optimal current matching is obtained because of the total signal (including dumping) current from the electrodynamic system of seismometers flows through an input of an operational amplifier designated U1. Current loop of signal closes through power supplies +Ub and –Ub, respectively.

Natural frequency of seismometer was tuned to 0.5 Hz and damping to 0.707. Resulting sensitivity of modified seismometer was set to $K = 2\ A.m^{-1}.s$ determined by the values of the resistors. Output voltage of seismic signal u_s is given according to formula $u_s = i_s.R_Z$, where Rz is the loading resistance (the input resistance of the next amplifier stage).

The great advantages of the above described circuit are:

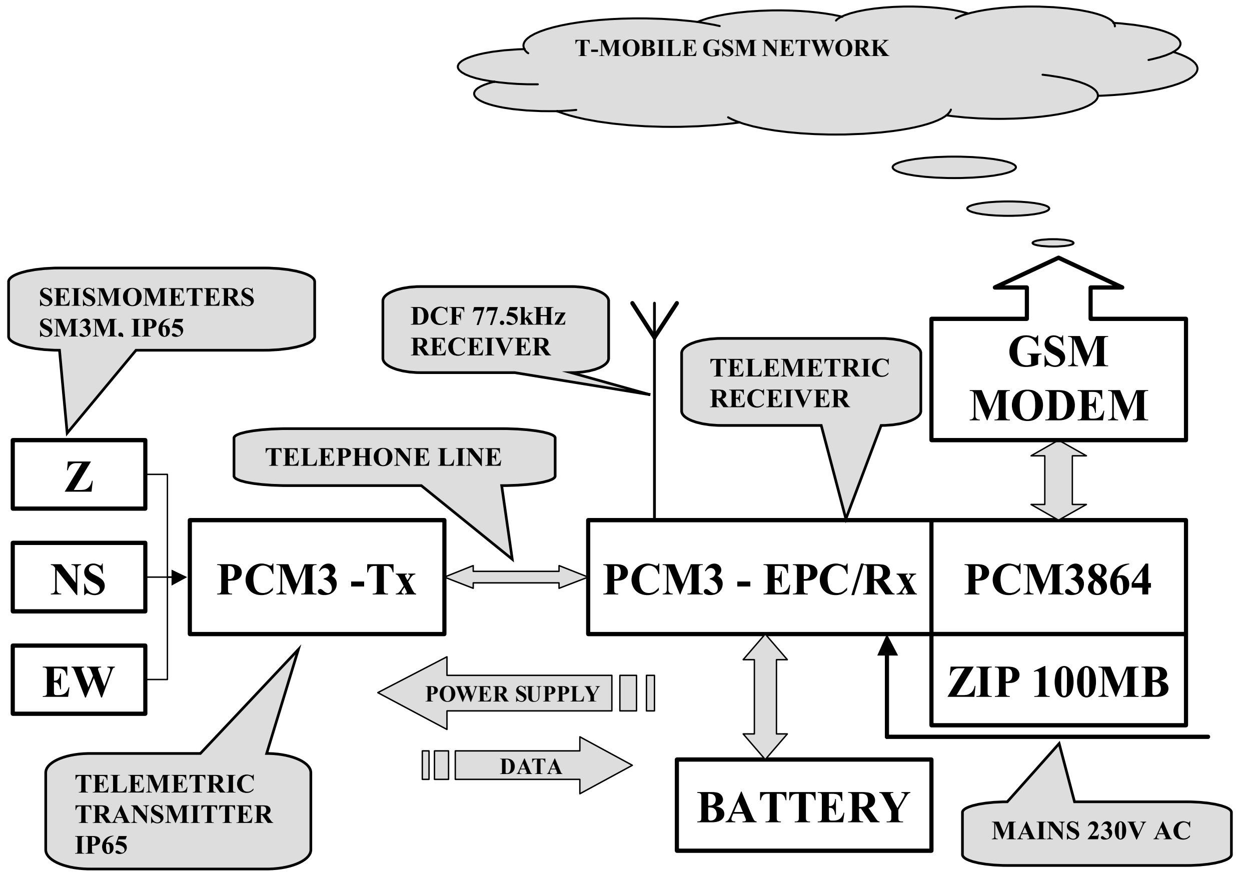

Fig. 3 Block diagram of instrumentation of Zlaté Hory seismic station

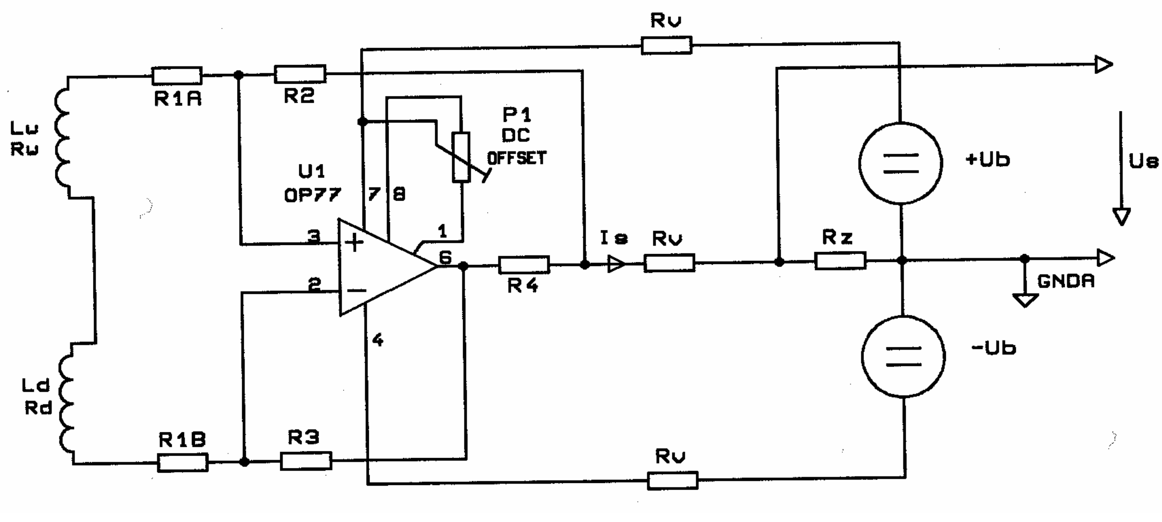

Fig. 4 Simplified schema of modified seismometer SM3M

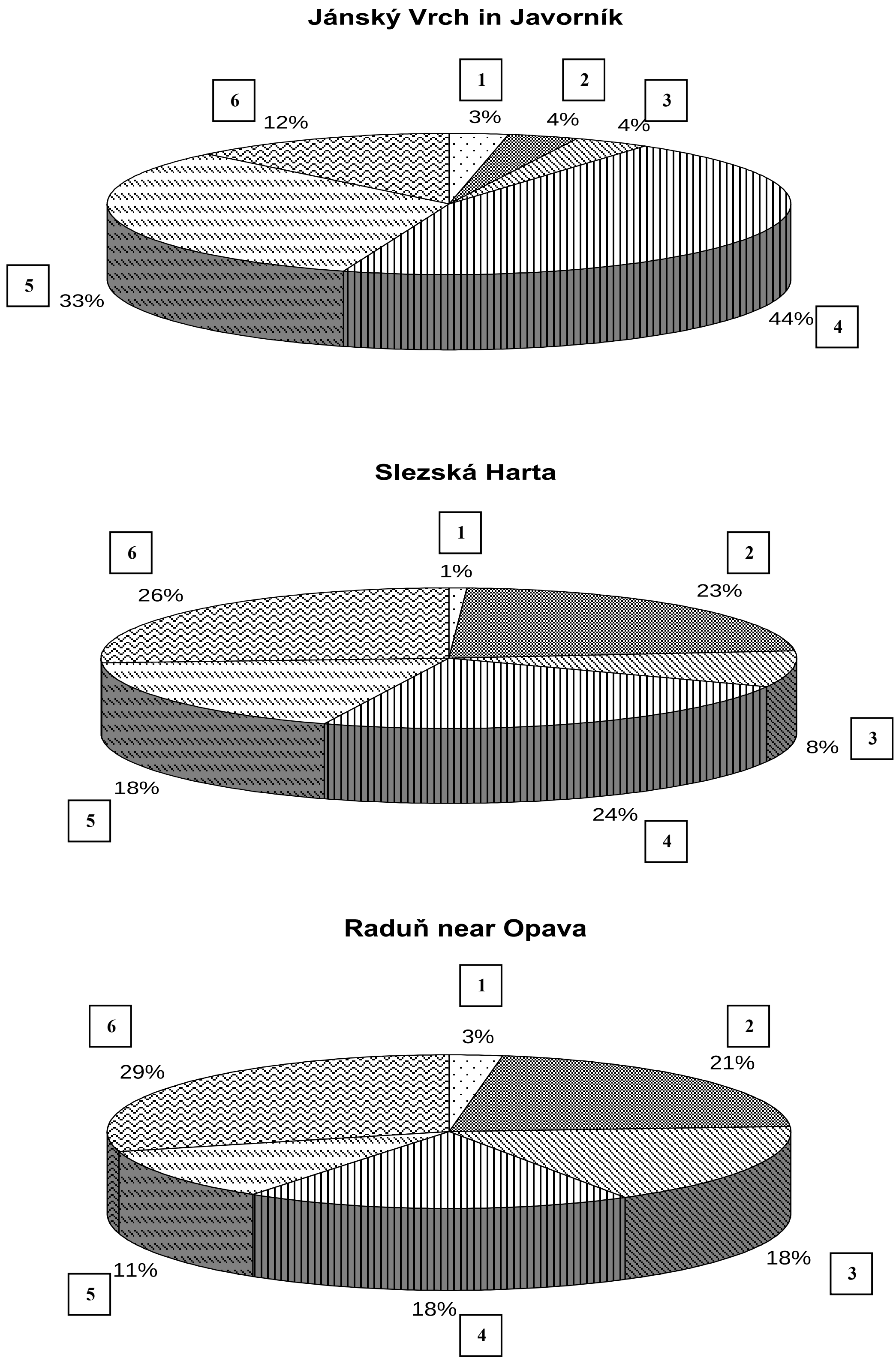

Fig. 5 Percentage distribution of seismic events in 2003 (1 – local earthquakes, 2 – quarry blasts, 3 – mining induced seismic events from Karviná region, 4 – mining induced seismic events from Poland part of the Upper Silesian Basin, 5 - mining induced seismic events from Lubin region, 6 – unidentified parts of teleseismic events)

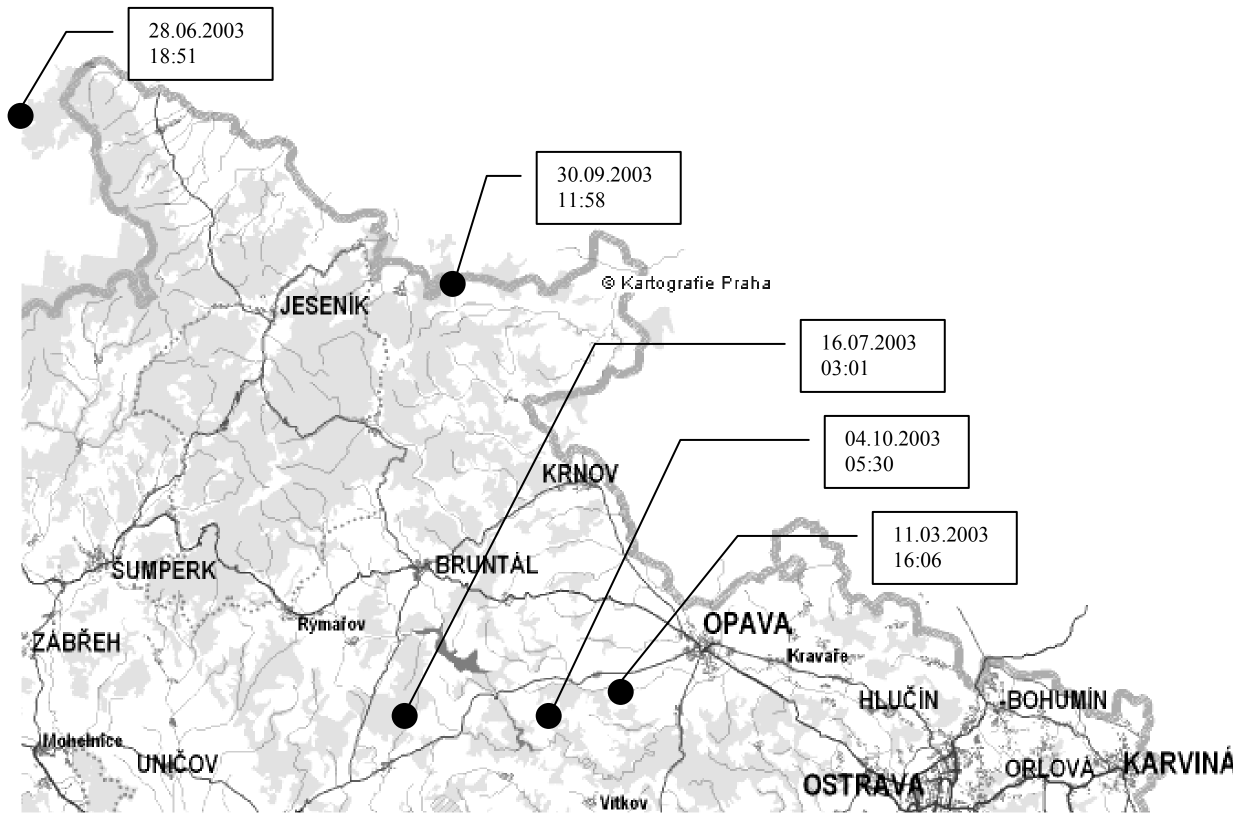

Fig. 6 Epicentres of local earthquakes recorded by solitaire seismic stations of IGN in 2003 (local time)

- Three-core cable is necessary for the signal transmission and the power supply,
- No influence of the resistance Rv of the connecting lines on the signal transmission,
- High resistance of analog signal transmission to disturbances induced in the signal line,
- Simple change of output voltage of seismic signal by change of Rz value only.

Very low level of seismic noise that does not usually exceed $5*10^{-9}$ m.s^{-1} was noticed using the modified seismometers SM3 in Zlaté Hory. The maximum-recorded seismic signal amplitude was set to 0.125 mm.s^{-1}.

For data transfer from telemetric transmitter PCM3-Tx to the receiver PCM3-EPC/Rx we used the Miller code. Digital data were modulated by the current consumption of PCM3-Tx powered by DC current from PCM3-EPC/Rx. The data rate was 5600 bps.

The telemetric receiver was equipped by single-board computer PCM3864, ZIP 100MB drive and GSM modem. Basic operational function was similar as previous versions PCM3; only in place of AD converter a decoder of Miller code was placed. Software package pcAnywhere is used for remote control and data transmission. For more detailed description see Knejzlík and Kaláb (2002).

The new station Zlaté Hory has been operating since September 2003.

RECORDED DATA

The sensitivity and the triggering parameters of the used equipment determined the amount of recorded events. The lowest practically considered magnitudes of earthquakes are about 1.0 for the region under investigation. Many false events of technical seismic events and other vibrations are recorded also. To decrease the amount of these false events, the trigger mode and the parameters were adjusted according to the seismic characteristics of the individual positions. The recorded seismic events are available for sharing and further analysis upon the request of other seismological institutions.

The set of wave patterns, which were recorded at solitaire seismic stations of IGN in 2003, includes almost 600 records of seismic events. These events can be divided into three groups as well as in the previous period. The percentage distribution of these individual groups is very similar to the previous years (Fig. 5). This distribution is not presented for Zlaté Hory seismic station due to the short period of operation. There is a cooperation between the Institute of the Physics of the Earth (Brno) that is operating two seismic stations in the southern part of the investigated area and the local network of Dlouhé

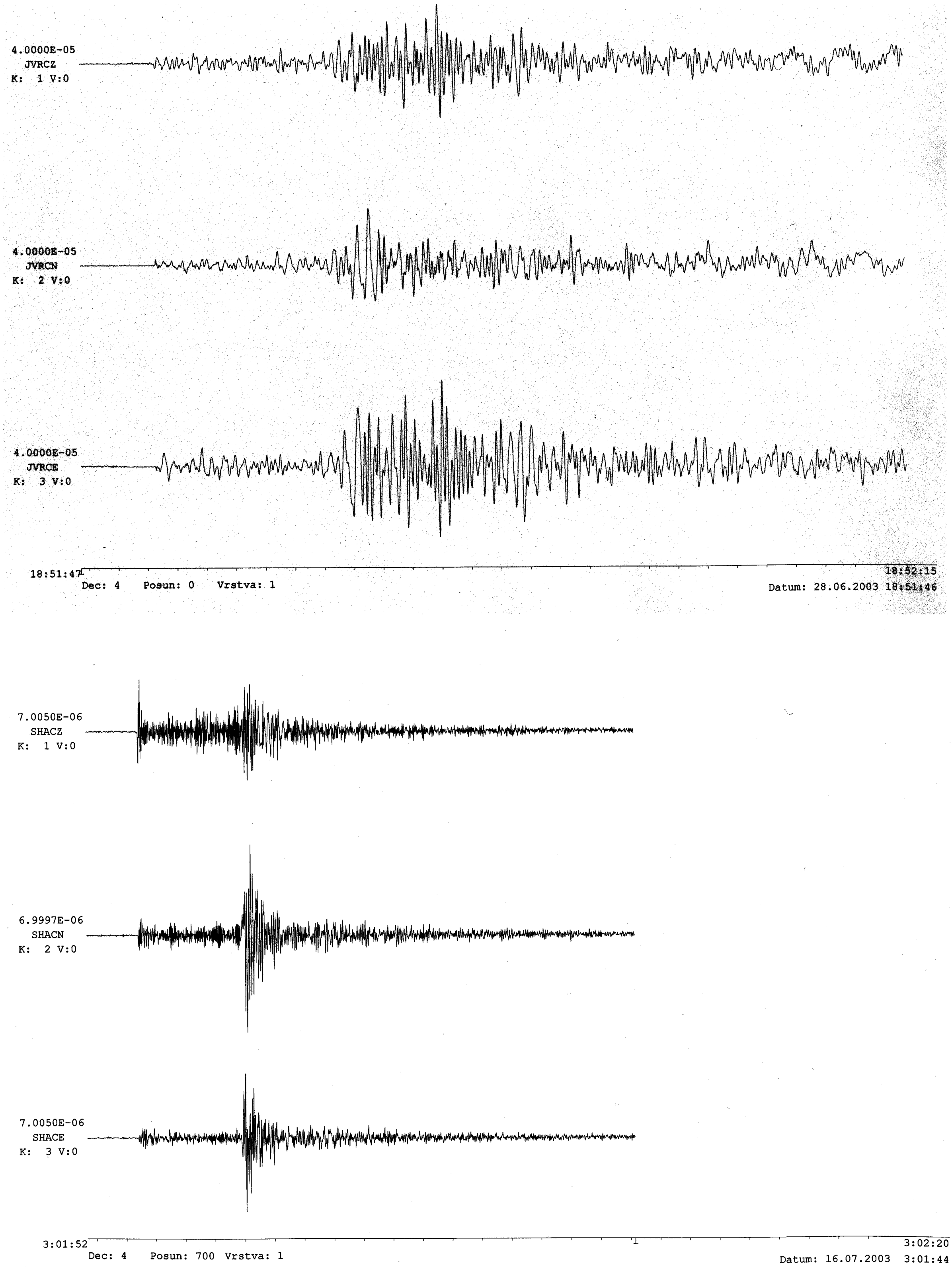

Fig. 7 Two wave patterns of local earthquakes recorded at seismic station Jánský Vrch (JVRC, components Z, N-S, E-W top-down, maximum value of channels normalized to $4*10^{-5}$ m.s^{-1}) and Slezská Harta (SHAC, maximum value of channels normalized to $7*10^{-6}$ m.s^{-1})

Stráně transfer power-plant in the Hrubý Jeseník Mts. (e.g. Sýkorová et al., 2004). This data was used not only for identification of recorded events but also for specification of physical parameters of earthquakes. The identification of the recorded events was based also on the comparison with bulletins of the Czech national network (Geophysical Institute of the ASCR in Prague), the Swiss Seismological Service (RedPuma), the database of mining induced seismic events from Ostrava – Karviná Coal Basin and the database of mining induced seismic events from Poland. Information about local blasts (e.g., quarry technology, reconstruction of roads...) was given by the Regional Mining Bureau, local authorities and the authorities of the quarries.

Five seismic events recorded in 2003 can be included in a group of local earthquakes (Fig. 6, 7). However, several seismic events are not identified up to now; these events are either local earthquakes or the seismic effect of unknown anthropogenic activities. Due to the low intensity of these events, often only one seismic station recorded these ones. Therefore, it is not possible to make serious seismological study of the detected natural seismic activity. The locations of these seismic events are usually estimated from the differential S-P time and polarization analysis of the input of an initial wave group.

CONCLUSION

Main results carried out of the seismological investigation in frame of both discussed projects are:

- The continuous monitoring of seismic activity of the northern part of the Moravo-Silesian region since 1997, southern part of investigated area is monitored by the Institute of the Physics of the Earth, Brno (e.g. Kaláb and Knejzlík, 2000, Kaláb et al., 2003),
- The identification of recorded seismic events using all available information,
- A detailed interpretation of the local seismic events (e.g. Kaláb and Skácelová, 1999),
- Comparison of seismological data with geomorphologic, geological, tectonic and geophysical pattern of the region (Kaláb et al., 1996),
- Specification of a methodological knowledge for the location, the magnitude and the classification of local seismic events (e.g. Kaláb and Knejzlík, 2003),
- Modernization of instrumentation (e.g. Knejzlík and Kaláb, 2002).

Weak local earthquakes are proved during seismic monitoring in the Moravo-Silesian region (see also Kaláb and Knejzlík, 2003, Skácelová, 2001). The analysis of the current and archival databases of local earthquakes in documented time series in a long period, therefore, new more detailed seismological studies need longer observation. Three solitaire seismic stations of IGN do not interrupt the monitoring after the finalization of the grants in 2003. At this time, we suppose that the microearthquakes occur near the E-W and NW-SE trending faults. These trends are the most significant structural geological units in the investigated area and these ones very often represent the main directions of isoseismic lines and detailed seismological studies from IGN and Institute of the Physics of the Earth, Brno.

Significant points for subsequent research are as follows:

- To continue seismic monitoring in the investigated region,
- To specify seismic active areas of a given region and the determination of their seismic load using new seismological, geological and geodetic measurement and knowledge (e.g. Schenk et al., 2003).

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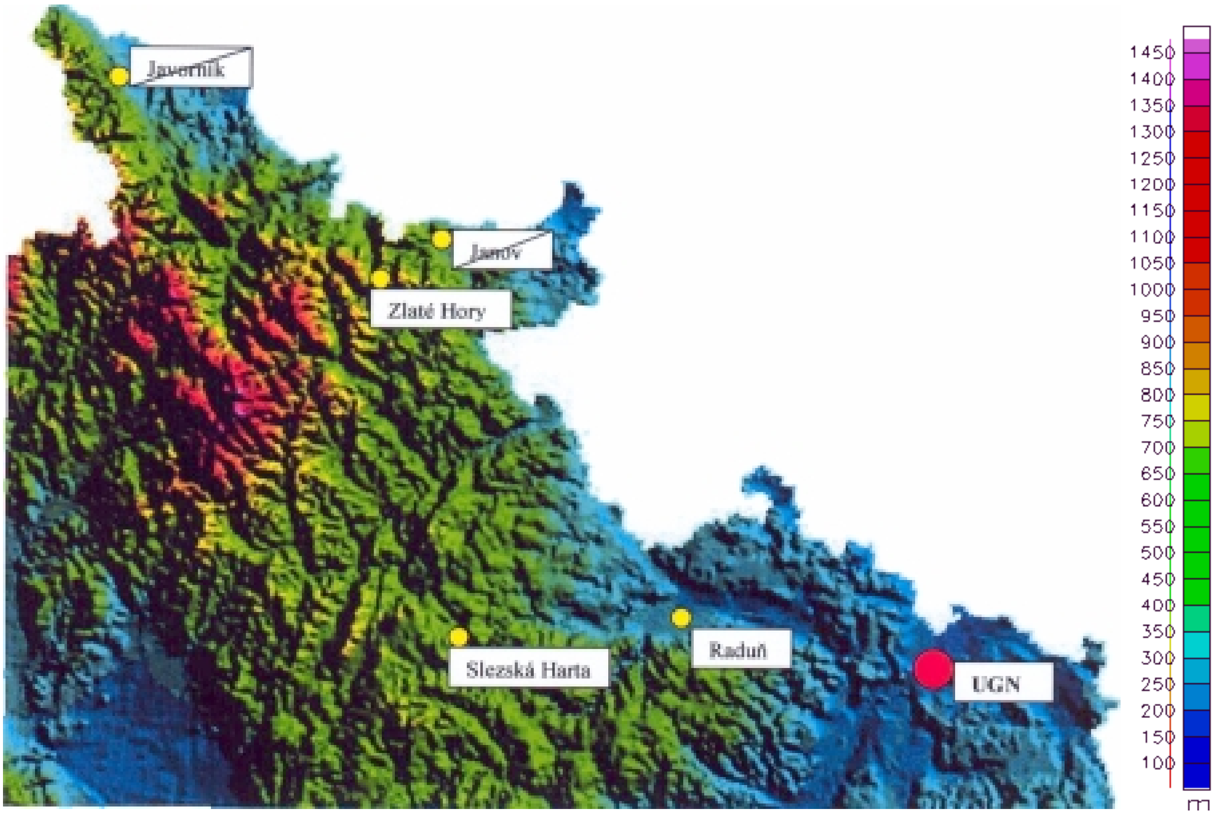

Fig. 1 Position of the solitaire stations operated by IGN in the past (scratched) and at present on a relief map (Map Atlas, 1998)

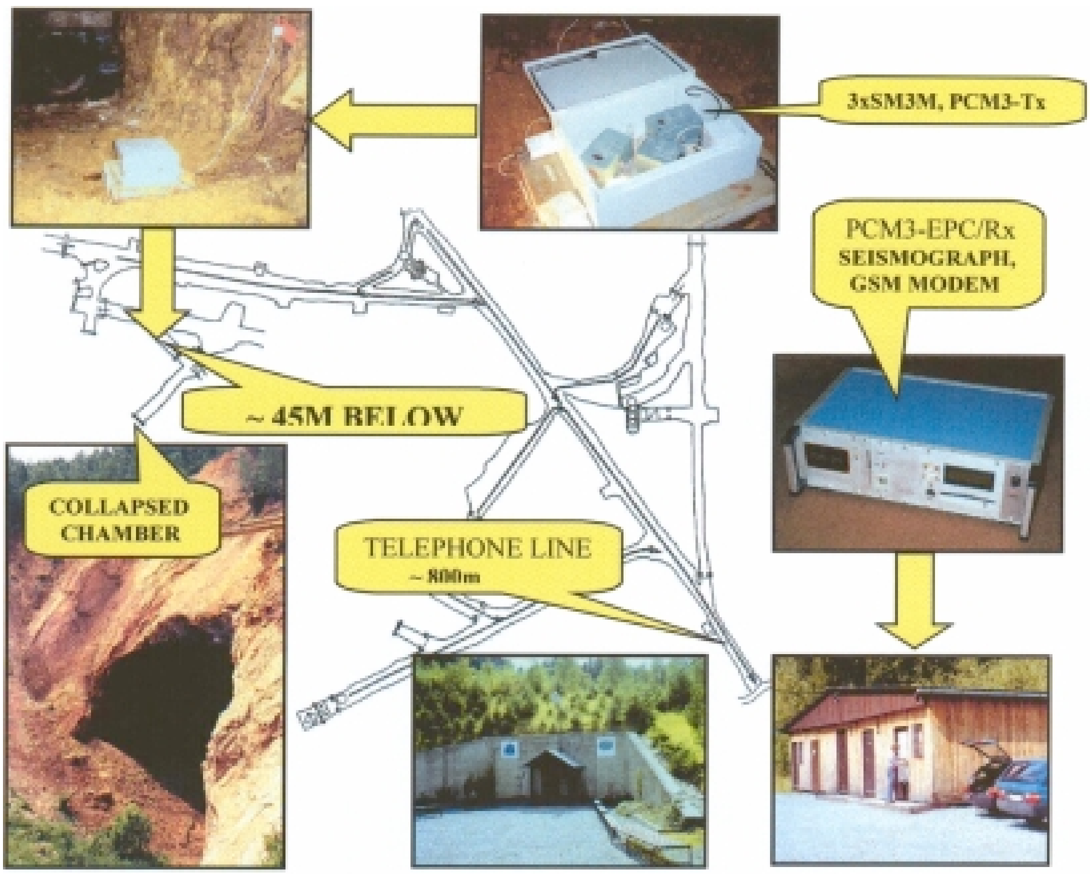

Fig. 2 Disposition and figures of the main parts of the new localisation for Zlaté Hory seismic station