



## Modernization of the local seismological network in Provadia

*Lilia Dimitrova, Svetlana Nikolova, Dimcho Solakov*

Geophysical Institute of Bulgarian Academy of Sciences, Sofia; E-mail: lidim@geophys.bas.bg; sbnik@geophys.bas.bg; dimos@geophys.bas.bg

**Key words:** seismological network, local seismicity, monitoring

### Introduction

The Provadia Region is located in seismically quite part of the region — since the beginning of the last century no strong or moderate seismicity is reported, there also no historical evidences of strong earthquakes. The exploitation of the Mirovo Salt Dome started in 1956 using leaching method that is extracting of saline brine to the surface. Since 1980 several moderate earthquakes with magnitude greater than 4.0 were generated in this region and caused damages to the neighboring villages. To monitor the seismicity in the region a local seismological network was deployed in 1993. This network considerably increases possibilities for localization of the earthquakes in the region, however due to the complex tectonic setting — neotectonic faults are located in the vicinity of the salt dome, cannot solve the problem. The equipment installed in the seismic stations of LSN Provadia was one component short period sensor with analogue radio transmission to the collecting station Provadia and than send via leased telephone line to the NOTSSI.

The accuracy of the hypocentral location achieved by this network was not enough high to draw conclusions about the nature of the seismicity or about the seismogenic activity of mapped faults. Therefore a definitive need for increasing the registration and location possibilities and performing modern seismological analyses of the acquired data exists. To answer this necessity Geophysical Institute in frame of 3 projects started modernization of the local network with digital acquisition systems, 3 component geophones and modern radio connections.

### Status of seismological monitoring in Provadia

The main task of LSN in Provadia is to provide reliable detection and precise location of earthquakes in this particular region. The improvement of the location accuracy of the earthquakes is the key-factor for determining the type of the observed seismic-

ity in Provadia Region. The increased seismic activity during last 25 years shows that there are active tectonic processes in the region. The seismic activity in this region is prevails the activity of Plovdiv Zone that is known by three earthquakes of magnitude 7.0 occurred in the last century. The earthquakes generated in Provadia Zone are almost of same magnitude that is a characteristic feature of induced seismic events (fig. 1).

To increase the accuracy of the earthquake hypocenter location (geographic coordinates and depth) and to increase the capacity of the network to detect lower magnitude earthquakes and to record stronger earthquakes the on-site digital recording is essential. This improves signal to noise ratio, enables application of different procedures for detecting of signal and further processing. Three component seismic stations are necessary for recording of wave forms, and particularly shear waves and application of different methods for their analysis, i.e. 3D modelling of shear waves that are more sensitive to the changes in the state of the stress.

### Technical parameters of the upgraded stations

The modernization is started with two seismological stations Roiak and Avren, located in the close vicinity to the Mirovo Salt Dome. The DAS Reftek 130-01 on that is in use in the national seismological network proved to be the datalogger that meets the requirement for robust data transmission and management from the Centre for data collection and analyses in Sofia. It has true 24 bit ADC, with GPS unit for coordinates and time, with included amplifier board in it. The deployed sensors are 3 component system Geospace (GS) geophones with frequency band 4.5-50Hz. This is cost effective solution for monitoring local seismicity that is widely applied in many countries in temporary networks and is proved to be very effective. The high frequency range 5-50 Hz where the microseismic events related to the solution mining should be is reliable covered. The cen-

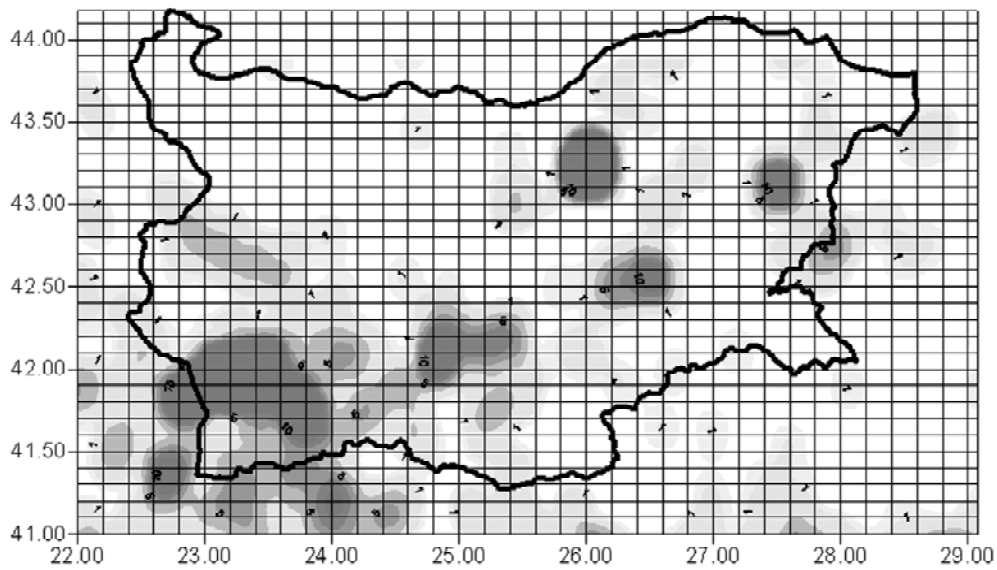


Fig. 1. Map of density function of the number of earthquakes with  $M \geq 3.0$  occurred on the territory of Bulgaria within the period 1980-2005  $N/900 \text{ km}^2$



Fig. 2. Seismic stations Provardia, Avren and Roiak (ROA) — mast, antenna, radio-modem, lightning protection and the installed seismological equipment on ss Roiak and Avren — geophone as seismometer, DAS Reftek 130-01 lightning protection; height of the masts are correspondingly 25, 13 and 14 m

tral station Provardia is equipped with BB seismometer KS2000 and Reftek 130-01 and enables recording of very broad frequency range — 120 sec — 50 Hz; the current network solution of the national seismological network permits easy adding of new devices to the data stream to the Centre. Therefore the incorporation of the data streams from seismic station Roiak and Avren was smooth.

The radio transfer of data in the non-licensed frequency band of 2.4 GHz was chosen. The applied topology for the network is point-to-multipoint. Radio-modems and antennas were mounted on the masts in the station Provardia (25 m) — hub, Roiak (14m) and Avren (13 m) — remotes. The mount of the radios is shown on stations is shown in fig. 2.

The radios operate in time division duplex mode and automatically synchronize the burst transmissions of all co-located radios. In a point to multipoint network the hub radios allocate the available bandwidth dynamically among the remote radios that are currently active. The maximum and committed information rates may be configured separately for each remote radio and presently are set to 1.3 Mbps. An important advantage of this solution is that each radio has its own IP address can be logged-in through VPN network of the National Seismological Network and current status of the radio frequency spectra, all parameters for transmitting and receiving can be changed remotely.

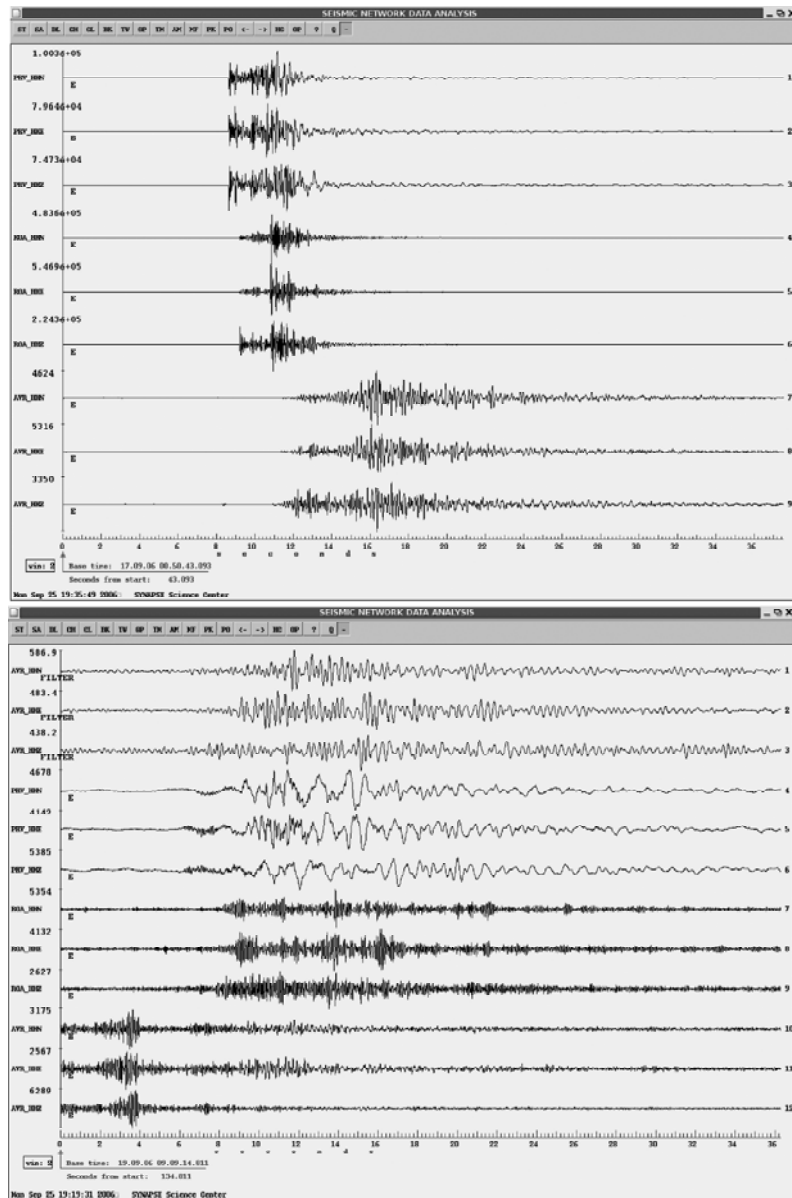


Fig. 3. Records of a local earthquake (17.09.2006, GMT 00:50) and blast in Devnia region (19.09.2006 GMT 09:09). Note different pattern of the waveforms, typical energy release in surface wave for near-surface multiple explosion.

All stations were prepared for the digital data acquisition and data transfer in one week time in September 2006. All necessary technical preparation for grounding, lightning protection, cables laying was done by the technical experts of Geophysical Institute. Since 10.09.2006 the CDCA started receiving continuous data streams from stations Roiak and Avren.

### Some results from the monitoring

The data acquisition and transfer from the stations Roiak and Avren proved to be reliable. The analyses of the several earthquakes and blasts in the region

show good signal/noise level of recording events. Three-component records give possibilities for additional restriction of the location of the events and prove the necessity to develop a local velocity model for the events in the region. Records of the earthquake and blast recorded by the stations of the local network are shown in fig.3. Present digital recordings permit performing of advanced procedures for data analysis of the seismic waveforms.

### Conclusions

After modernization, LSN in Provadia meets the requirements for digital network providing reliable,

high quality real-time seismic monitoring of the local seismicity and may serve as for a basis for information and rapid earthquake information to both scientific communities and authorities in Bulgaria for seismic hazard mitigation.

**Acknowledgement.** This study was supported by Contract N ИКИ-11/01.09.2005 with Bulgarian National Science Fund, Ministry of Education and Science: “Environmental Monitoring Implement for Risk Assessment of natural and man-made hazard (EMIRA)”, Contract N Д 01-416/20.12.2005 with

National Science Fund, Ministry of Education and Science “Stand-Alone Portable Digital Seismic Stations for Long-Term Field Deployment”, Contract IO-2 with Bulgarian National Science Fund, Ministry of Education and Science “PROvadia Monitoring network — way for Improving Risk Assessment from natural and man-made hazards (PROMIRA)” and by Permanent Commission for Prevention of the Population from Natural Disasters, Technological Accidents and Catastrophes (PCPNDTAC), Bulgaria, Decision СБ-3/04.05.2005.

## Модернизация на локалната сеизмична мрежа в Провадия

*Лилия Димитрова, Светлана Николова, Димчо Солаков*

**Резюме.** През септември 2006 в рамките на 3 проекта финансирани от Министерството на Образованието и Науката е направена модернизация на 2 станции на локалната сеизмична мрежа (ЛСМ) в Провадия. По настоящем базовата станция Провадия, която е част от националната сеизмологична мрежа е оборудвана с широколентов сеизмометър KS2000 с честотна лента 120 sec — 50 Hz, 3 канална цифрова сеизмична станция Reftek 130—01 и е свързана към VPN и чрез нея с Националния Център за Сеиз-

мологична Информация в ГФИ. Сеизмичните станции Рояк и Аврен, които са част от ЛСМ са оборудвани сега с 3 компонентна система геофони GS с честотна лента 4.5—50 Hz и Reftek 130—01. Преносът на цифровите данни е осъществен с радио-модеми работещи в нелицензионния обхват 2,4 GHz. Използуваната топология на мрежата е точка до много точки. Показани са възможностите на модеризираната мрежа за мониторинг на локалната сеизмичност.