Bulgarian Geophysical Journal, Vol. 31, 2005, 1-4
Geophysical Institute, Bulgarian Academy of Sciences

WEAK SEISMICITY OF RHODOPES FROM NATiONAL SEISMOLOGICAL NETWORK OBSERVATIONS (1980 - 2006)

S. Dimitrova, E. Botev

Geophysical Institute, ul. Acad. G. Bonchev, bl3, Sofia1113, Bulgaria

Abstract. Maps of the epicentres of earthquakes after the national seismological network (NOTSSI) construction in the Rhodopes region (outlined by longitude λ=23.9°-26.3°E and latitude φ =41.2°- 42.0°N) is presented. Analysis of the space and time distributions of various parameters of the earthquakes in the investigated region is made. A more detailed analysis of epicentres and depth distributions of the stronger events (M>2.5) is performed. Some general conclusions about the weak seismicity in the Rhodopes are proposed

Key words: seismicity, epicentres

Introduction

This paper presents an unpublished work reported at the Fourth National Geophysical Conference (Dimitrova &Botev., 2004). The work gives some generalized information about the seismic events in the Rhodopes region (λ= 23.9° -26.3° E and φ = 41.2° - 42.0° N) recorded by the seismological network of Bulgaria (NOTSSI) during the period 1980-2003.

The Rhodopes is situated between the Mesta and Maritza river valleys and comprises the area of the Rhodope mountains. It is characterised by a heterogeneous crust with strongly decreasing thickness from the west (45- 50 km for the West Rhodopes) to the east (30-35 km for the eastern periphery of the zone) (Tectonic struct.,1977, Yosifov et all.1980, Dachev 1988, Velev 1996). The gravity field is positive in the Eastern Rhodopes and becomes strongly negative to the west; the gradient belt has a N-S direction and is associated with the boundary between the Central and Eastern Rhodopes. The magnetic field has a complex mosaic structure, and again, the central and eastern sectors of this zone are strongly differentiated.

The seismic activity in the Rhodopes is moderate and is mainly associated with the Chepino, Dospat, Devin, Ardino and Momchilgrad (Tzarichina) depression fault systems (

Gochev & Matova 1977,1989, Dachev 1988, Simeonova et all.1993, Botev et all.1996b, Alexiev 1999). Further small seismic faults represent the boundaries between uplifted local dome structures within the Rhodope mountain (Tectonic struct., 1977, Alexiev 1999). The maximum observed earthquake in the 20th century is the event of 1905 with magnitude M=5.4. There is no information for larger events before 1900 in the Bulgarian territory of this zone, but the strong historical earthquakes of 1829 (magnitudes 7.2 and 6.9) in the Greek territory can be assigned to this zone (Christoskov et all. 1979). These quakes occurred at the southern margin of the Rhodope mountains and are associated with the activity of the Middle Mesta fault. Since the beginning of 20th century the seismic activity, instrumentally recorded is rather moderate and scarce in the Rhodopes. Because of very small number of instrumentally recorded moderate earthquakes the investigation of the weak seismicity is required to overcome the existing laps. The registration of smaller shocks enabled to complete the describing of seismological information about the seismicity of the region, to recognise and detail the localisation of seismogenic structures and peculiarities of the source of earthquake zones, and also to confirm the historic seismological data.

Seismicity patterns from NOTSSI observations and analysis

Detailed investigations of the weak seismicity in the Rhodopes begin after 1980 with the starting of NOTSSI operation. In such a way for a twenty four year period (1980 - 2003) more then 1800 earthquakes have been registered in the area with coordinates λ=23.9°-26.3°E and φ=41.2°- 42.0°N. The basic kinematic parameters of the earthquake sources are calculated by a computer program, an adaptation of HYPO'71 and a regional velocity model (Solakov & Dobrev,1987). The magnitude is estimated by the record duration applying the formula of Christoskov and Samardjieva (1983). Geographical distribution of the events is presented in the Fig.1.- it is seen that the eppicenters of all microearthquakes are not clearly grouped around the well known active geotectonic structures.

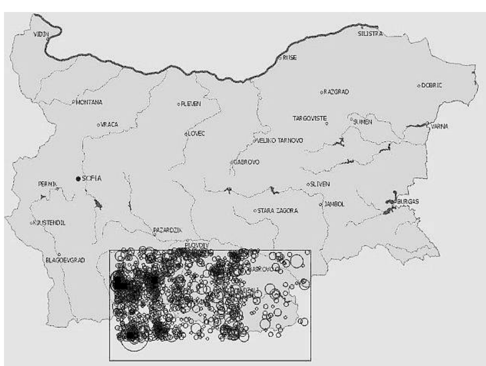


Fig1.Geographical distribution of the events

The magnitude-frequency distribution of all 1800 events in intervals of 0.5 units is presented in Fig. 2. The lowest event is with magnitude M=0.4 and the strongest - with M=4.6. Most number of events (746) occur within the magnitude interval 1.5 - 1.9.

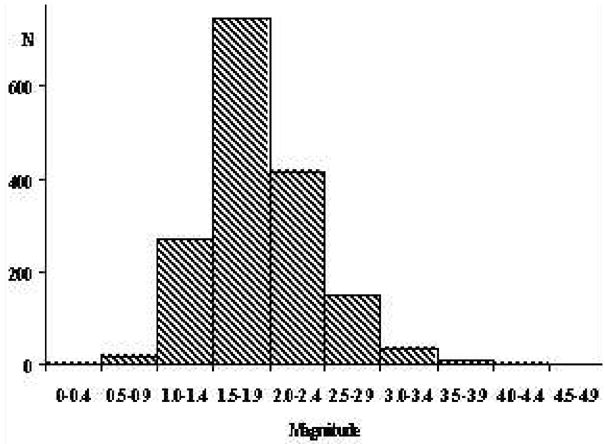
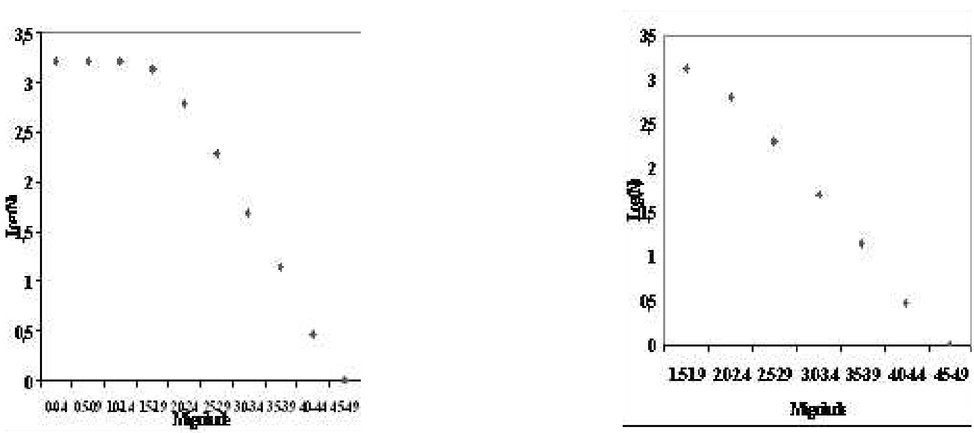


Fig. 2 Magnitude-frequency distribution of the earthquakes

The abrupt diminishing of the number of earthquakes in the lower intervals also determines the registration power of the seismic stations network. In this way it can be assumed that the magnitude sample for levels with M > 1.5 is comparatively closer to reality for the bigger part of the investigated territory.



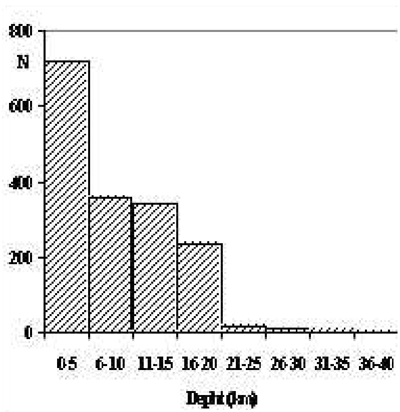
a b

Fig. 3 Cumulative magnitude-frequency dependence (Gutenberg-Richter relation)

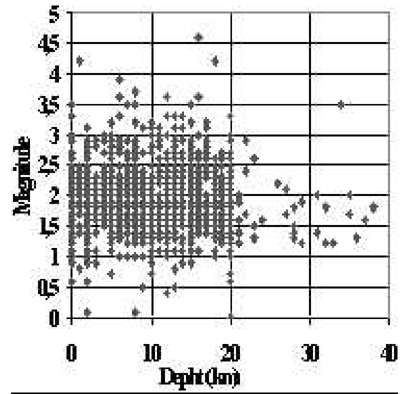
The cumulative magnitude-frequency dependence:

$$\log(N) = a \pm b\,M \qquad (1)$$

The so called Guttenberg - Richter relation (1965) is presented on the diagram on Fig. 3a. A linear distribution of the events with magnitude M> 1.5 is observed (Fig.3b). The distribution line has coefficients *a* = 4.73 and *b* = 1.01. The value b is approximately in the range of the corresponding values from the standard dependence for longer periods and stronger events which means that some equilibrium between weak and strong events is not available.



a



b

Fig. 4. Depth-frequency distribution of the earthquakes

Fig.4 represents the depth-frequency distribution of the earthquakes. The inaccuracy of the solutions concerning the events in the region of investigation in some cases reaches up to 4-5 km, but the average varies around 1 - 2 km. The ordinary depth distribution of the weak earthquakes from the Fig.4a as well as the one from the stronger earthquakes at the beginning of the century are located within a depth of 20 km, confirming the small thickness of the seismogenic layer. Almost all events are realized up to a depth of 20 km. It is possible that the established abrupt maximum for the interval 0-5 km depths is also due to the presence of identified industrial explosions. The magnitude - depth distribution diagram from Fig.4b shows a seismic level situated between 5 and 20 km, the major part of the events with M>3.0 are observed

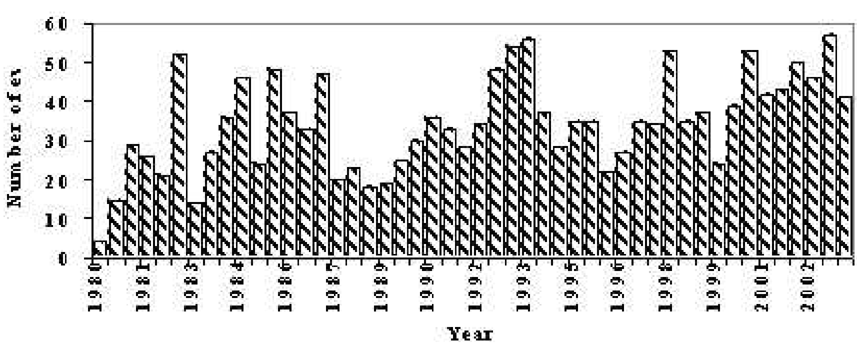


Fig. 5 Time distribution of the earthquakes

The diagram on Fig. 5 represents the 6-monthly distribution of the events during the investigated period. The largeest number of earthquakes (>50) is observed in the second half of 1982, 1992, 1993 and 2003; lowest - in 1988, 1989 , 1996 and 1999.

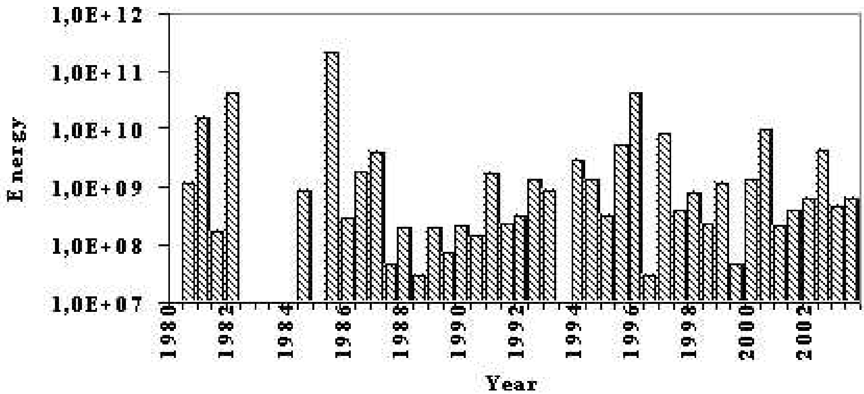


Fig. 6 Energy distribution of the events

The distribution of the global energy emitted by the earthquakes for a six-month period is presented in Fig. 6. The diagram shows the energy distribution estimated by the formula:

$$\log(E) = 2.23 + 2.23M - 0.055\ M2 \qquad (2)$$

The energy distribution of the earthquakes from Fig.6 does not allow the establishment of a quasi-periodic peculiarity of the seismicity.

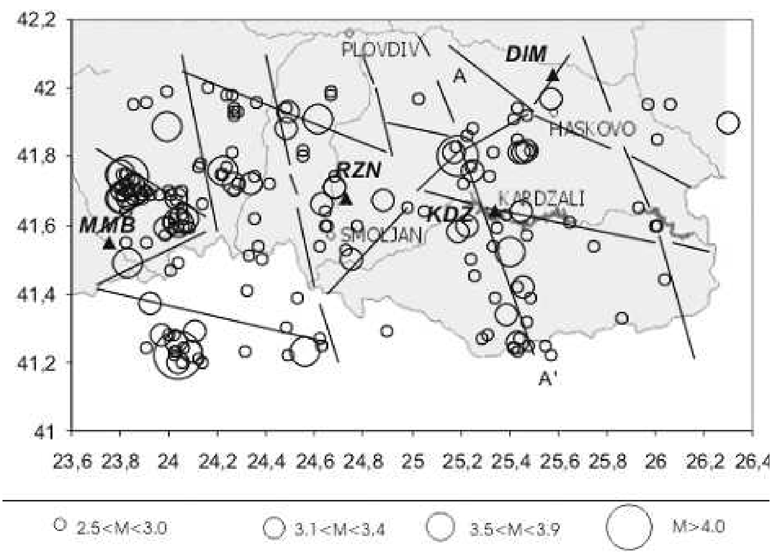


Fig.7. Epicentral distribution for the events M>2.5

The epicentre distribution of the events with M>2.5 for the period 1980-2003 (Archives of the Geoph.Inst.,1980-1999, Bulgaria catalog..,1993, Botev et all.1993-2004) is presented on the figure Fig.7 together with the morphostructural lineaments according to Gochev & Matova (1977,1989). Three relatively outlined zones of grouping of the epicentres could be marked at the background everywhere within a space distribution of the weak seismicity during the last twenty years. Generally, the detail analysis of the obtained territorial distribution of the earthquakes shows an agreement with the known tectonic structure, confirming the decisive role of the fault systems in the western border regions (Kovachevitza, Chepino and Midle-Mesta depressions) and around the boundary between central and eastern Rhodopes (western board of the Momchilgrad depression).

The last linear zone of concentration of seismic events has approximately north-south elongated direction in the central -eastern part of the region (Fig.7). This zone is relatively the most active and could be associated with the manifestations of the Varbitza river fault line, which marks the morphological contact between the eastern and central parts of the Rhodopes. Of course, the earthquakes are not uniformly distributed along the whole contact belt - a higher density of the epicentres is observed around the known source regions. The depth distribution of the events of the most active zone along the profile A-A' from Fig.7 shows a dipping of the active layers to the North (Fig.8a). More clear dipping is observed in the perpendicular direction - to the West across the profile A-A' (Fig.8b). But this profile marks approximately the border line between the central and eastern part of the Rhodopes. In short, we could generalize that, the depth activity beneath this border line confirms the hypothesis about the sinking of the Eastern Rhodopes to the West beneath the central parts (Velev et al., 1996).

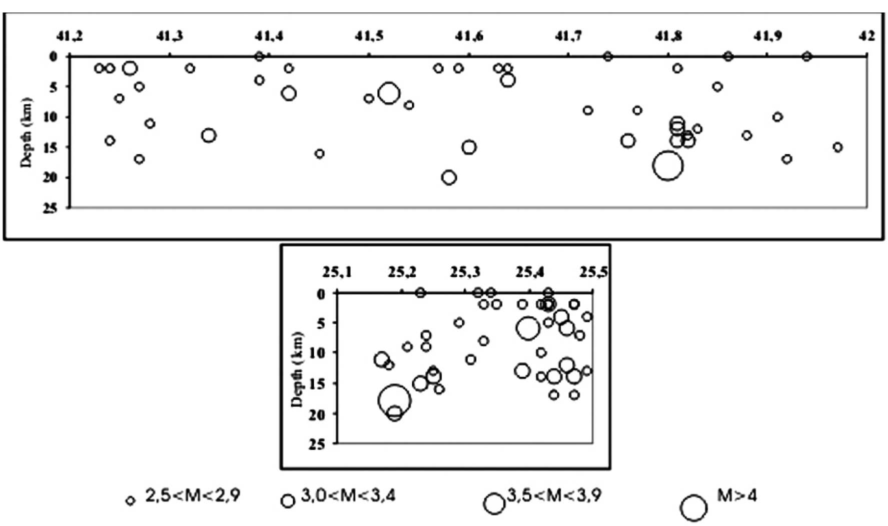


Fig.8. Depth distribution for the events M>2.5 for a) along the profile A-A' and b) across the profile A-A'

Conclusions

The analysis of the instrumentally observed seismicity after the starting of NOTSSI operation makes evident:

- the energetic level of the observed seismicity for the period 1980-2003 is relatively weak - 98% Thus, about all the 1800 seismic events are microearthquakes (M<3.0)); the maximum magnitude event (M=4.6) is located on the territory of Greece.

- the magnitude-frequency distribution of earthquakes shows that the earthquake catalogue is almost complete for events of M > 1.5; the slope of the averaging straight line of the recurrence relationship of events shows some convenience between the weak and relatively stronger events.

- the epicentre distribution of the all events is relatively diffuse -the eppicenters of all microearthquakes are not clearly grouped around the well known active geotectonic structures.

- probably due to the high accuracy of determinations of epicenters for the stronger earthquakes (M>2.5), some clear expressed grouping of epicenters around the Kovachevitza, Chepino, Midle-Mesta and Momchilgrad depressions is established.

- the linear zone which marks the contact between the eastern and central parts of Rhodopes is relatively the most active seismically, and could be associated with the manifestations of the Varbitza river fault line.

- the depth distribution of the events along this zone confirms the hypothesis about dipping of the eastern parts beneath the central parts of the Rhodopes.

References

Alexiev G., 1999. The role of intense destructive taphrogenesis in shaping the morphostructural patterns of Bulgaria territory. Problems of Geography, BAS, Sofia , 4, 46-57.

Botev E., Babachkova B., Dimitrov B., Velichkova S., Tzoncheva I., Donkova K., S.Dimitrova, 1993-2004. Preliminary data on the seismic events recorded by NOTSSI in 1992. Bulg.Geophys.J., 19-30, N1-4.

Bulgaria catalogue of earthquakes 1981-1990, 1993. Bulgarian Academy of Sciences, Geophysical Institute, Seismological department, Sofia, 37p.

Christoskov L, Sokerova D. and Rizhikova Sn., 1979. New catalogue of the earthquakes in the territory of Bulgaria and adjacent region for the period V century BC to XIX century, Archives of the Geophysical Institute of BAS, Sofia

Christoskov L. and Samardzhieva E. 1983. Investigations on seismic waves duration as energy characteristic of earthquakes. Bulg. Geoph.J., v.IX, 1, 79-91(in bulgarian).

Dachev Hr., 1988. Structure of the earth crust in Bulgaria. Technika, Sofia, 334p, (in bulgarien).

Dimitrova S. & E.Botev , 2004. Weak seismicity of Rhodopes from national seismological network observations (1980 - 2003).*Fourth National Conference with International Participation "Geophysics in economic activity, environment and cultural heritage investigations"*, 4-5 Oct. 2004, Sofia. Book of Abstracts, publ. by Bulg. Geophys. Society, 63-64.

Gochev P. and Matova M. (1977). The Present Fault Mosaic in Bulgaria and the Seismic Activity. Geotect., tectonophys. and geodyn.,6, 32-47.

Gochev P. and Matova M., 1989. Midle Mesta Fault bundle and recent tectonic activity of part of the Rila-Rhodope region, Geologica Rhodopica, v.1, 139-144.
Simeonova St., Glavcheva R., Solakov D.,Dineva S., Botev E., Hristova Tz., Babachkova Bl.,Donkova K. And Aleksandrova I., 1993. Seismicity in Bulgaria for the period 1981 - 1990. Bulg.Geophys.J., 19, N4, 108-118, (in bulgaran).
Solakov D. and Dobrev Ch., 1987. Program for determination of main parameters of the earthquakes. Bulg.Geophys.J., 13, N4. Tectonic structure of Bulgaria, 1971. Technica, Sofia, 558p. (in bulgarian).
Velev A., 1996. Deep seismic profiling of the Earth's crust along a regional profile Ivailovgrad-Ardino. Bulg.Geophys.J., 22, N2, 91-109. (in bulgarian).
Yosifov D., Tzvetkov A., Grigiriva E., Stavrev P. and Nedev V. , 1980. Main features in the structure of the crust in Rhodope massife. Geotect., tectonophys. and geodyn.,12, 27-45.

(Received 04.04.2006; accepted 2006)

Слаба сеизмичност в Родопския регион по данни от регистрацията на Националната сеизмологична мрежа (1980 - 2003)

С.Димитрова, Е.Ботев

Резюме. В работата се представят епицентрални карти на земетресенията в Родопския регион (λ=23.9°-26.3°E и φ=41.2°- 42.0°N) след въвеждането в действие на Националната Сеизмологична Мрежа (НОТССИ). Направен е анализ на пространственото и времево разпределение на параметрите на земетресенията в изследвания регион. По-детайлен анализ на епицентралното и дълбочинно разпределение е проведен за по-силните земетресения (M>2.5). Предлагат се някои обобщени заключения относно характера на слабата сеизмичност в Родопския регион.

(λ=23.9°-26.3°E è φ=41.2°- 42.0°N)