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SEISMICITY IN THE EASTERN PART OF UPPER THRACIA LOWLAND AS AN ELEMENT OF THE GEOECOLOGIC HAZARD IN THE AREA OF THERMAL POWER PLANTS "MARITSA-EAST" 1-3

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ABSTRACT. The local seismicity in the eastern part of Upper Thracia Lowland which covers the area of Thermal Power Plants "Maritsa-East" 1-3 is studied for the period of high-sensitive instrumental registration of earthquakes after establishment of modern National Operative Telemetric System for Seismological Information (NOTSSI). Historical seismicity which created damaging impacts to this area is also presented. The influence of neighboring high-activity seismogenetic zones is assessed.

СЕИЗМИЧНАТА ОБСТАНОВКА В ИЗТОЧНАТА ЧАСТ НА ГОРНОТРАКИЙСКАТА НИЗИНА КАТО ЕЛЕМЕНТ НА ГЕОЕКОЛОГИЧНАТА ОПАСНОСТ ЗА РАЙОНА НА ТЕЦ-ОВЕ "МАРИЦА-ИЗТОК" 1-3

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РЕЗЮМЕ. Изучена е локалната сеизмичност в източната част на Горно-Тракийската низина, обхващаща района на ТЕЦ-ове "Марица-изток" 1-3, за периода на високоточна инструментална регистрация на земетресенията след създаване на Националната Оперативна Телеметрична Система за Сеизмологична Информация (НОТССИ). Представена е и историческата сеизмичност, повлияла днешната територия на района. Оценено е въздействието от съседни високоактивни сеизмогенни области.

Introduction

The importance of power producing plants and safety of energy supplying equipment belonging to them is indisputable because of the social living conditions. The goal of this study is to make known the seismic conditions in the eastern part of the Upper Thracia where the Thermal Power Plants (TPP) "Maritsa-East" 1-3 are operating.

Present investigation is developed in two aspects: (i) a long-term influence in a sense of appropriate ground motions in the sites of TPP "Maritsa-East" 1-3, caused by near and regional moderate and strong earthquakes; (ii) a short-term high sensitive seismic monitoring in the local zone establishing the influence of weak and micro-earthquakes on the sites. The seismological review of the long-term seismic history shows an absence of a very strong seismicity in the local zone around the TPP-sites (Report of BAS, 1982). The absence of high sensitive seismological data in the local zone before 1980 determines the importance of nowadays weak- and micro-earthquake investigations as a beneficial way in which to integrate the limited availability of seismological information in the local zone. Recording of microearthquakes permits drawing inferences on the seismicity in and around the sites of TPPs, location of active structures near-by, properties of the eventually established source zones, confirmation or questioning of some irrelevant historical data. In such a way, the investigation of weak or microearthquake seismicity in the local zone can provide further assurance of the actual seismic situation in the TPP-sites region. Therefore, the microseismic investigations could be an important instrument for accurate locations of potentially active structures and further treatment of earthquakes which have not been associated with known structures. This way the entire seismicity pattern can be outlined and seismic danger within the area would be revealed by seismological tools.

Long-term seismic influence

The knowledge of long-term seismic history is directly connected with every decision concerning the seismic safety of a given area. The successive steps to study of the long-term seismic influence on the considered area are arranged depending on the state-of-the art of the available material.

The 20th century's earthquakes including the effects they have caused are the best documented ones. All the witnesses reports within Bulgarian archives (Tremblements de terre en Bulgarie, 1902-1966) have been reassessed according to the MSK scale. Once having got intensity distribution the necessary macroseismic features have been clarified.

Going back in time the reports amount in Bulgaria is too scarce. To fill in gaps, two kinds of materials are used. As first-hand materials, a great number of descriptions coeval to the seismic events are applied as initial source of information and they are assessed in terms of intensity. Especially for strong earthquakes originated in Turkey, intensity assessment is undertaken on the background of original reports found out by Guidoboni (1994) and Ambraseys and Finkel (1991; 1995). In such a way catalogue entries are compiled for more than 40 Turkish earthquakes occurring prior to 1800 which should have affected the study area. The strength of excitation in Bulgaria has been calculated combining the new catalogue's parameters with the intensity attenuation based on the rich macroseismic picture at 20th century's earthquakes.

Some main catalogues, like the ones compiled by Grigorova et al. (1978) for Bulgaria, Papazachos et al. (2000) for Greece, Cornea and Radu (1979) and Kondorskaya and Shebalin (1977) for Romania, Shebalin et al. (1974) for the Balkans, as well as atlases of isoseismal maps (Shebalin, 1974; Isoseismal maps (published set) for Turkey; Glavcheva, 1993 for Bulgaria) are used as second-hand sources.

Some results from the undertaken inventory are presented in Fig. 1.

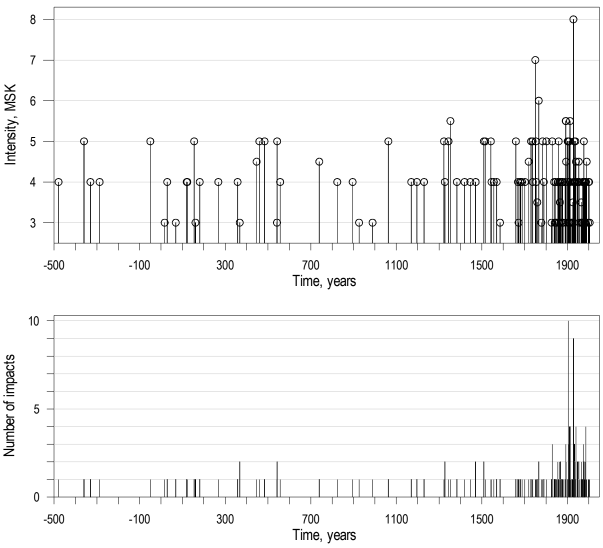

Fig. 1. Time distribution of seismic impacts on the study area: annual maximum intensity of excitation (top plot); annual number of impacts (bottom)

The time distribution of seismic impacts coming from everywhere is not steady either by quantity or by strength. In principle, this is to be expected. However, some peculiarities point to data incompleteness. For instance, intensity values as 6 to 8 MSK can be met only since 18th century now (Fig. 1, top plot); bursts of excitations are documented only in the 20th century (Fig. 1, bottom). It might be concluded that the impacts distribution is most representative for the latest three centuries. Besides, the time dependence of information sources availability is also evident in the figure.

It is important to identify the source regions having power of causing damaging seismic impacts on the study area. The comprehensive work through the available materials shows that the experienced seismic excitations are produced by activation in certain regions roughly outlined in Fig. 2.

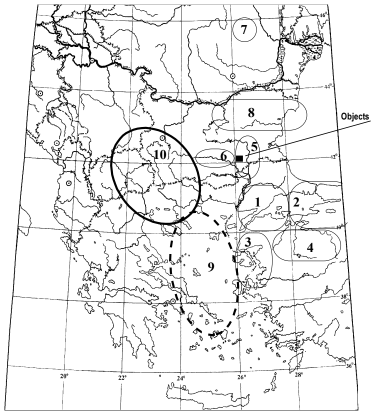

Fig. 2. Regions producing seismic impacts to the Eastern Upper Thracia

Table 1.
Impacts distinguished by seismogenic regions as outlined in Fig. 2

Identity N	Seismic Region	Number of impacts	Strongest impacts Intensity, MSK [occurrence time]
1	Marmara - West	25	6 [1766]; 5-6 [1353, 09.08.1912]
2	Marmara - East	31	5 [155, 1063, 1323, 1542]
3	Aegean Sea – Asia Minor contact area	3	4
4	Asia Minor (inside)	4	4
5	Upper Thracia - East	16	8 [25.04.1928]
6	Upper Thracia - West	20	7 [1750, 14.04.1928, 18.04.1928]
7	Vrancea	29	5 [1516, 1802, 1977]
8	Moesian platform & boundaries	9	5-6 [1892]
9	Aegean Sea basin	9	5-6 [1893]
10	Westernmost sources	32	5 [1904-1905 series]

In Table 1 main information about the experienced seismic impacts can be found. Obviously, damages were caused by local earthquakes (25 April 1928) and in cases of catastrophic events in the Upper Thracia as a whole (1750, 1928 and probably in 1810-1811). Minor damages to buildings and equipments are potential in case of earthquakes in regions 1, 8 and 9 (identification in Table 1).

Short-term high sensitive seismic monitoring in the local zone of the TPP- sites

The Bulgarian National Operative Telemetric System for Seismological Information (NOTSSI) started operating in 1980. At present the recording and space localization of the seismic events in NOTSSI is realized by means of one-type seismographs S-13 "Teledyne Geotech" situated in 21 stations on the territory of the country (Christoskov et al., 1987). The routine processing and acquisition of initial data is performed in a real time duty regime realizing the main goal of NOTSSI - a monitoring of seismicity with view to a quick response in case of felt earthquakes on the territory of the country. The computing procedure for determining the parameters of the seismic events is an adaptation of the widespread product HYPO'71 (Solakov & Dobrev, 1987). The energy parameters of these events are presented mainly by the magnitude M calculated according to the record duration by the formula in (Christoskov & Samardjieva, 1983).

The high sensitivity of the seismographs allows recording and processing of a great number of earthquakes with magnitude around M=1.0 and less. As a result of this and first of all of the records of the near-by situated seismic stations in Dimitrovgrad, Jambol and Plovdiv and of the achieved experience in the interpretation of the records of smallest events as well, more then 150 microearthquakes are successfully localized in the local area around the TPP “Maritsa-East“ 1–3. For instance, only 1 microearthquake to have been realized before 1980 is known for approximately the same area in the last published investigation (Report of BAS, 1982). In this local area (with coordinates 42.00N – 42.40N and 25.60E – 26.40E, presented in Fig. 3), the precision of determining the epicentral location is different and it depends mainly on the specific position of the epicenter in respect to the geometry of the recording sites.

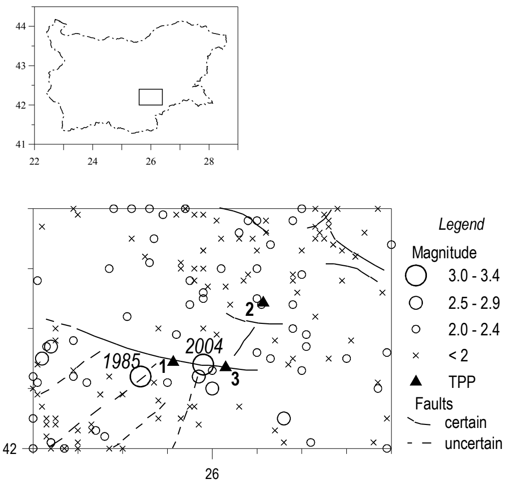

Fig. 3. Epicentral distribution of local earthquakes (1980 – 2004)

For the 25-years period of high sensitive observations, presented in this communication, exactly 157 events in magnitude interval M = 0.7 – 3.2 are localized in NOTSSI (Botev et all., 1991 – 2004; Working bulletins of NOTSSI, 1980 – 2004). The earthquake epicenters differentiated by magnitude levels are presented in Fig. 3. Almost all of the events are microearthquakes – approximately about 99% are with a magnitude M<3.0, only 2 are with M>3.0. The strongest event recorded in NOTSSI is the 1985 magnitude M3.2 earthquake – near the “Maritsa-East” 1 site. As a whole, the seismic situation in the local zone is characterized by a spatially smoothed seismicity with the floating microearthquakes. There is no correlation between the space distribution of the epicenters and the main structural disturbances, marked as faults in Fig. 3. There is no any tendency to outline some new linear seismogenetic structures. The concentration of epicenters of strongest events (with M>2.5) is marked in the southwestern part of the territory presented in Fig. 3. This is a part of the Maritsa fault lineament whose northern board is marked by continuous line in the figure and is confirmed by the distribution of epicenters of strongest events in E-SE direction, in close vicinity of the TPP “Maritsa-East“ 1 and TPP “Maritsa-East“ 3 - sites.

A detailed analysis of seismicity in the separate parts of the Local zone of TPP-sites is hard to be realized because of the insufficient quantity of events and the low magnitude range of the earthquakes. The joint statistical analysis of all the events in Fig. 3 gives the generalized parameters of seismicity in all active parts of the territory under investigation.

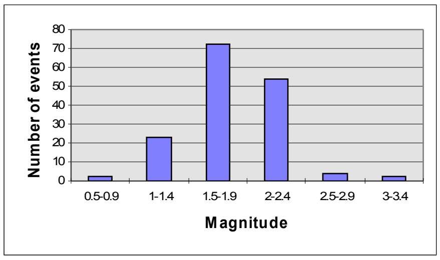

Fig. 4. Magnitude-frequency distribution (1980 – 2004)

The magnitude-frequency distribution for all the events is presented in Fig. 4. The number of localized sources increases with the decrease of magnitude: for M > 3 the number of events is 2, for M > 2.5 it is 4, for M=2.0-2.4 - 54, for M=1.5-1.9 - 72, for M=1.0-1.4 - 23 and so on. The abrupt diminishing of the number of earthquakes in the last two intervals determines also the registration power of the seismic stations network. This way, it can be supposed that the magnitude sample for levels with M > 1.5 is comparatively closer to the reality for the predominant part of the territory of Bulgaria.

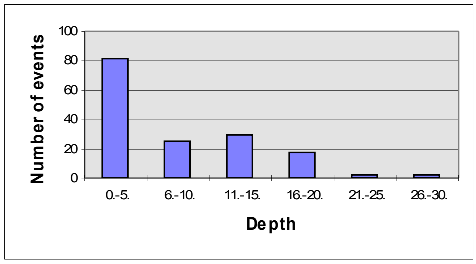

Fig. 5. Depth distribution in Local zone (1980 – 2004)

The picture of the depth distribution in Fig. 5 shows that the majority of events occur down to 20 km depth. It is possible the established predominating depth (from 0 to 5 km where more then ½ part of all events occur) for most events to have been also due to the presence of unidentified industrial explosions; nevertheless, these events time distribution does not permit to find out any local daily maximum.

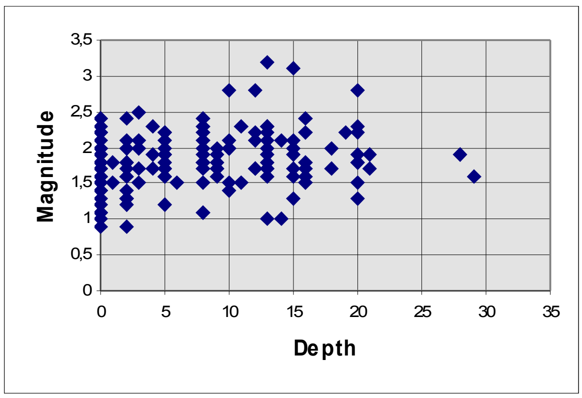

Fig. 6. Local seismicity magnitude-depth distribution (1980 – 2004)

The magnitude distribution of the events in depth (Fig. 6) does not permit any categorical differentiation of depth layers with the increase of magnitude. Some tendency can be traced out that a local maximum exists between 10 and 20 km depth where the strongest earthquakes have occurred.

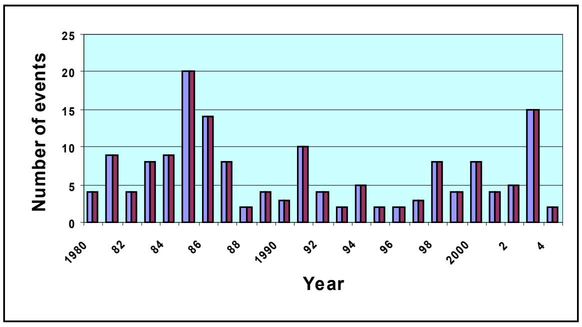

Fig. 7. Frequency of local earthquakes (1980 – 2004)

Fig. 7 illustrates the distribution of the annual number of events in time. The highest seismic activity is in the 1980-ies, when a local maximum of 34 realized events could be noticed (1985 and 1986). This is remarkably higher in comparison with the 1990-ies with about 5 events per year. An exception is observed concerning the year 2003 which covers 15 local events.

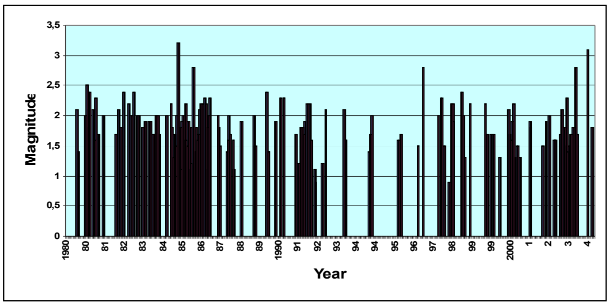

Fig. 8. Magnitude-time distribution of local seismicity (1980 – 2004)

The magnitude – time distribution of seismic events (Fig. 8) shows some correlation between the annual number of events and their magnitude. For instance, one of the strongest events occurred in 1985 when the biggest amount of events was realized (Fig. 7). In Fig. 8 it can be seen that the high energy distribution not always coincides with the high frequency distribution – some events with relatively big magnitude occurred in 1996 and 2004 when the annual number of events was only 2.

Conclusions

The conclusions we can draw from the analysis of seismicity for the period 1980 – 2004 in the Local zone of TPP "Maritsa-East" 1-3 are the following:

-The energetic level of the observed seismicity is very low - 99% of the seismic events are micro-earthquakes with magnitude M < 3.0;

-The only two stronger earthquakes are at a very low magnitude level, too - M = 3.2 and M=3.1, which is nearly the same "microearthquake" range. The location of the epicenters of these events is much closed to the TPP "Maritsa-East" 1 and 3 – sites;

-Almost all strongest earthquakes have occurred along the northern board of Maritza fault lineament, which passes by the sites of TPP "Maritsa-East" 1 and 3;

-There is no tendency the microearthquake activity to confirm some other known or to outline some new seismogenetic structures;

- As a whole, the seismic situation in the local zone is characterized by a spatially smoothed seismicity with floating microearthquakes.

The seismic history, most representative for the latest three centuries, reveals that the local zone is under dangerous influence of catastrophic earthquakes everywhere in the Upper Thracia. Greatest threat is likely to arise at severe activation along the Maritsa fault system.

References

Ambraseys, N. N. and C. F. Finkel. 1991. Long-term seismicity of Istanbul and of the Marmara Sea region. - *Terra Nova,* 3, 527-539.

Ambraseys, N. N. and C. F. Finkel. 1995. *The Seismicity of Turkey and Adjacent Areas, A Historical Review, 1500-180*0, Istanbul, EREN, 240 p.

Botev, E., B. Babachkova, B. Dimitrov, S. Velichkova, I. Tzoncheva, K. Donkova, S. Dimitrova. (1991, 1991, 1992, 1992, . . . , 2003, 2003; 2004, 2004). Preliminary data on the seismic events recorded by NOTSSI in January - June 1991 (July – December 1991), . . , (July – December 2002). - *Bulg. Geophys. J*., 18, 18, . . . 30, 30 (1, 2).

Christoskov L. and E. Samardjieva. 1983. Investigation on the duration of the seismic signals like an energetic characteristic of the earthquakes. - *Bulg. Geophys. J*., vol. IX, N1 (in Bulgarian).

Christoskov L. et al. 1987. Real time and background data processing in the Bulgarian seismological network. *Proc. XX Gen. Assembly 1986,* Kiel, Zurich.

Cornea, I., C. Radu (Eds.). 1979. *Cercetari seismologice asupra cutremurului din 4 martie 1977*. Comitetul de stat pentru energia nucleara, Institutul central de fizica, Centrul de Fizica pamintului si seismologie, Bucuresti, 751 p.

Glavcheva, R. 1993. *Atlas of Isoseismal Maps Bulgaria, 1981-1990*. Geophys. Inst., Bulg. Acad. Sci., Sofia, 67 p.

Grigorova, E., L. Christoskov, D. Sokerova, S. Rijikova, A.Roglinov. 1978. *Catalogue of earthquakes in Bulgaria from the ancient times until 1977.* Geophys. Inst. - BAS, Sofia, 335 p.

Guidoboni, E. (Ed.). 1994. *Catalogue of Ancient Earthquakes in the Mediterranean Area up to the 10th Century.* Ist. Naz. Geofis., Rome, 504 p.

Isoseismal maps of 20th century earthquakes in Turkey. (published set, privately provided by Dr D. Kalafat).

Kondorskaya, N. V. and N. V. Shebalin (Eds..). 1977. *New catalogue of strong earthquakes within the territory of USSR from the ancient times until 1975*. Nauka, M., 535 p.

Papazachos, B. C., P. E. Comninakis, G. F. Karakaisis, B. G. Karakostas, Ch. A. Papaioannou, C.B. Papazachos, and E. M. Scordilis. 2000. *A catalogue of earthquakes in Greece and surrounding area for the period 550BC - 1999*. http://geohazards.cr.usgs.gov/iaspei/europe/greece/the/catalog.htm.

Report of BAS: *Seismogeological conditions of the sites of "Maritsa-East" 2 and 3*. 1982. Sofia, 528 p.

Shebalin, N. V. (Ed.). 1974. *Atlas of Isoseismal Maps - Balkan Region.* UNDP/UNESCO Surv. Seism. Balk. Reg., Skopje.
Shebalin, N. V., V. Karnik and D. Hadzievski (Eds.). 1974. *Catalogue of Earthquakes, Part I, 1901-1970; Part II, prior to 1901.* UNDP/UNESCO Surv. Seism. Balk. Reg., Skopje, 595 p.
Solakov, D. and Tch. Dobrev. 1987. Program for determination of main parameters of the earthquakes. - *Bulg. Geophys. J.,* vol. XIII, N4 (in Bulgarian).
Tremblements de terre en Bulgarie au XIXe siecle; pendant les annees 1901 - 1964. 1902-1966. Inst. centr. meteor. Bulg. and Geophysical Inst., Sofia.

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