РЕЗЮМЕТА НА НАУЧНИТЕ ПУБЛИКАЦИИ

представени в конкурс за академична длъжност „доцент” в професионално направление 4.4. Науки за Земята по научна специалност “Земен магнетизъм и гравиметрия” от **гл. ас. д-р Методи Иванов Методиев**

B4-1 Petya Trifonova, Stela Simeonova, Dimcho Solakov, Metodi Metodiev (2012) Exploring Seismicity in Bulgaria Using Geomagnetic and Gravity Data, Compt. Rend. Bulg. Acad. Sci., v.65, N5, 653-661

The present study aims at demonstrating the capability of gravity and magnetic anomalous data for revealing deep structures in the Earth crust of Bulgaria. Interpretation of gravity and magnetic data is well known and often applied to delineate various geological structures such as faults, flexures, thrusts, borders of dislocated blocks, etc., which create a significant rock density contrast in horizontal planes. Delineated gravity and magnetic anomalies with their characteristics (amplitude, width, length and coordinates) are compared with the spatial distribution of seismicity and map of the active faults on the territory of Bulgaria. As a result, integrated geophysical data and geological information is incorporated to prove the reliability of potential filed data application for the purposes of seismic hazard assessment.

B4-2 D. Solakov, M. Metodiev, S. Simeonova and P. Trifonova, Population exposure index – an element of seismic risk assessment DOI: 10.3997/2214-4609.201902659, 10th Congress of the Balkan Geophysical Society, Sofia, 2019

This paper presents assessment of one of the main elements of the seismic risk – human exposure at the territory of Bulgaria. Seismic hazard in terms of Peak Ground Acceleration map is modelled using GIS and overlaid with a model of population distribution in order to extract a population exposure index (PEI). We use as indicator the population density to allow comparison between less populated and more populated regions. Analysis is performed on a gridded network with a single element of 1x1 kilometer. Information about the population cover the period 2011-2018 using data from the last census performed in 2011 and the updated information for the towns provided by the National Statistical Institute for 2018. As a result, a classification of region is provided based on the results obtained for PEI.

B4-3 P. Stavrev, S. Dimovski, A. Kisyov, P. Trifonova and M. Metodiev, Regional mapping of geophysical and geological data in the process of their integrated analysis and interpretation, DOI: 10.3997/2214-4609.201902632, 10th Congress of the Balkan Geophysical Society, Sofia, 2019

A joint mapping of two type of data - geophysical gravity data in terms of Total Horizontal Gradient (THG) and geological data for the distribution of known metal ore deposits, occurrences and mineralization in Bulgaria, is presented in a regional scale. For the purpose the whole territory of Bulgaria is divided in 1270 areal elements

E of size 10x10 km. The number V_1 of metal ore objects, and the length V_2 (km) of gravity lineaments (THG, mGal/km), that appear in every single element E, are used as input data. Thus, a space index of coincidence, $Qi = [(V_1+V_2)/\sqrt{(V_1^2+V_2^2+C)}]i$, can be calculated in the areal elements Ei , i=1,2, ..., N. The space distribution of this index gives us the integrated geological-geophysical information which can be used for revealing of different characteristics such as common origin, similar tectonic environment, etc

B4-4 Solakov, D., Trifonova, P., Metodiev, M., Simeonova, S.. GIS based analysis for evaluation of human risk due to earthquakes in Bulgaria. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, 20, 1.2, 2020, ISBN:978-619-7603-05-7, ISSN:1314-2704, DOI:10.5593/sgem2020/1.2/s05.072, 567-574.

In this research, the term risk follows the definition by the United Nations (UNDRO [1]) and refers to the expected losses from a particular hazard to a specified element at risk in a particular future time period. In our case, population exposure refers to the human occupancy of hazard zones in Bulgaria, or the population present within the hazard area that would be potentially directly affected by an event.

Placed at the central part of the most seismically active region in Europe, the territory of Bulgaria is surrounded by major seismic zones. The epicentral zones of Aegean Arch, the westward continuation of Anatolian fault system, the Struma-Rhodope region, the Adriatic seismogenic strip and the Vrancea area are clearly expressed on the seismic maps. Territory of Bulgaria includes important industrial and urban areas that face considerable earthquake risk.

Population exposure is modelled by crossing the seismic hazard and population living in the potentially affected area. We use two input indicators: population and population density, first to give equal “weight” of human being and second to allow comparison between less populated and more populated regions. Before calculation, both variables (seismic hazard and population/population density) are classified using separate classification schemes. The number of classes was chosen according to several criteria such as the optimum number for visual representation or the number and level of errors between classes. According to these tests, with the aim to minimize internal class distances and maximize distances between classes, the number of five classes from low (1) to high (5) was chosen.

Seismic hazard is presented in terms of Peak Ground Acceleration (PGA) in agreement with Euro Code 8 (EC8) for generic rock conditions (VS30=800m/s), for a 475 years return period. In addition, the impact of soil conditions through the global VS30 model is also taken into account.

Information about the population is obtained from published by the National Statistical Institute of Bulgaria data after the census performed in 2011. Distribution of population by municipality and distribution of population in 1x1 km grid are used for calculation of two indices: Population Exposure Index (PEI) and Population Exposure

Index in Municipality (PEIM). The obtained results provide information about human exposure as an element of the seismic risk in Bulgaria. They are presented in two maps using categories from 1 to 5: minor, low, moderate, high and major. Based on that, different types of analysis can be performed concerning prevention and planning measures in case of a major earthquake, necessary resources for rescue activities, first aid supplies, etc.

B4-5 Dimitrova, L., Georgieva, G., Trifonova, P. Oinakov E., Protopopova V. and Metodiev M. (2020) Seismic sources and Earth structure in the transition zone between Fore-Balkan unit and Moesian platform, NE Bulgaria, Acta Geodaetica et Geophysica, pp. 1-20 https://doi.org/10.1007/s40328-020-00288-3

Provadia region is one of the most specific seismic regions in Bulgaria. It is situated in the South Moesian depression, between Fore-Balkan unit in the South and Moesian platform in the North. The seismic characteristics of the area, the industrial activity connected with salt deposit exploitation and extraction of aggregates and limestone, and the near location of big cities like Varna, put this zone at high seismic risk level.

Present research aims to reveal the seismic potential of the Provadia region. We present the regional tectonic structures according to geological and geophysical information, analysis of the observed seismicity in the last 12 years and results from application of two seismic techniques for revealing of geological bodies in the near vicinity of the salt exploitation site. Results show that several faults are delineated from geological information and confirmed by interpretation of geophysical data. The complex geological structure of the region is unambiguously the cause for the major part of the observed seismicity, which does not disprove however the possibility that there might be induced seismicity also.

B4-6 Trifonova, P., Solakov, D., Simeonova, S., Metodiev, M., & Balan, S. F. (2021). Seismic scenario and people exposure for Blagoevgrad region, Bulgaria, Studies in Systems, Decision and Control, Volume 361, Pages 293 – 305, doi:10.1007/978-3-030-70190-1_20

Present research analyses the human exposure at one of the most dangerous earthquake zones in Bulgaria-Blagoevgrad region and propose a detailed seismic scenario for the main city. Seismic hazard is modelled using GIS and overlaid with one square kilometer grid of population distribution in order to determine the population exposure in the region. We define a parameter called "population exposure index" (PEI) which has five classes: Minor, Low, Moderate, High and Major. As was expected, the seismic hazard levels of Blagoevgrad region are in the upper part of the classification scale.

The total population in the Blagoevgrad region (NUTS II) is around 323 000 people. Results show that more than 130 000 people are exposed to the highest level of seismic hazard.

City of Blagoevgrad gathers nearly 22 % of the population in the region. A specially developed seismic scenario for the city accounting the soil conditions as well is used for detailed assessment of the people exposed to seismic hazard. The obtained values of Peak Ground Acceleration (PGA) varying between 0.29g-0.45g are crossed with the population living in each building to determine the lev-els of population exposure.

Our results show that people living in 398 buildings are majorly exposed to the seismic hazard in Blagoevgrad city. Another 1465 buildings are determined as highly exposed to this threat. Delineation of these buildings might be very important for the regional authority and focusing on the prevention of possible earthquake effects.

B4-7 Petya Trifonova, Metodi Metodiev Geomagnetic Events Recorded in PAG Observatory During the First Year of Solar Cycle 25. Conference Proceedings, 11th Congress of the Balkan Geophysical Society, Oct 2021, Volume 2021, p.1 - 5, 2021, DOI: https://doi.org/10.3997/2214-4609.202149BGS20

Geomagnetic observatories placed all over the globe determine some parameters which show the geomagnetic activity as a signature of the response of the Earth magnetosphere and ionosphere to solar forcing. Indices might be local, which are calculated from data of a single geomagnetic observatory, or planetary, which characterize the planetary disturbances of the geomagnetic field as a whole. We use the (local) K-index which is a 3-hour quasi logarithmic scale developed to measure magnetic activity ranging from 0 to 9, with 0 indicating completely quiet conditions and 9, representing extreme magnetic activity. The Solar Cycle24 finished in December 2019 and started the Solar Cycle 25. There are prediction that SC25 will be similar in size to SC24 with a maximum expected to be in 2025. A different hypothesis is also published suggesting that SC25 could be among the strongest sunspot cycles ever observed. We examine the geomagnetic activity events during the first year of the new cycle. Our data show that 2020 had calm geomagnetic conditions. Only 12 days have reached the levels of a minor storm in the records of PAG observatory. Two autumn periods are chosen to display the local geomagnetic response of the observed solar impacts

B4-8 Petya Trifonova, Christan Tzankov, Metodi Metodiev. Importance of Using a Reference Base Station in Geomagnetic Surveys - Case Studies from Bulgaria. Conference Proceedings, 11th Congress of the Balkan Geophysical Society, Oct 2021, Volume 2021, p.1 - 5, 2021, DOI:https://doi.org/10.3997/2214-4609.202149BGS21

During ground magnetic surveys are recorded signals from a wide variety of sources – from terrain, natural and man-made surface features, as well as instrumental, geological, and planetary sources. Such signals directly disturb the subsurface effects over the Earth's surface causing errors in the measurements. External variations which are due to the Solar-Earth interaction are one of the "noise" signals which are always removed as a pre processing procedure. This could be done by using a locally installed base station or using the data from the nearest geomagnetic observatory. We analyze records from six ground surveys accomplished on the territory of Bulgaria using a reference base station to see what would be the errors if such station was not available and Panagjurishte observatory data were used instead. Our results show that the differences in the recorded daily variations are limited to ± 5 nT and the frequency interval is large enough to prevent the misinterpretation of signals from the real sources.

B4-9 Solakov, D.,Simeonova, S., Raykova P., Metodiev, M., Earthquake scenarios for the city of Plovdiv International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, 21, 1.1, 2021, DOI:10.5593/sgem2021/1.1/s05.085, 459-466

Global seismic risk and vulnerability to earthquakes are increasing steadily as urbanization and development occupy more areas that a prone to effects of strong earthquakes. The assessment of seismic hazard and generation of earthquake scenarios is the first link in the prevention chain and the first step in the evaluation of the seismic risk. The territory of Bulgaria represents a typical example of high seismic risk area in the eastern part of the Balkan Peninsula. Over the centuries, Bulgaria has experienced strong earthquakes. Some of the Europe`s strongest earthquakes in 20th century occurred on the territory of Bulgaria. Impressive seismic activity developed along the Maritsa valley (central part of Southern Bulgaria) in 1928 - the Chirpan earthquake of April 14 with Mw6.5 (foreshock) and the Parvomay Mw7.1 quake of April 18 – the main event. The present study is a comprehensive earthquake scenario study. A set of 10 deterministic earthquake scenarios (expressed in peak ground and spectral acceleration, peak ground velocity, and in macroseismic intensity MSK) is generated for the city of Plovdiv. The study is guided by the perception that usable and realistic, based on both local seismic history and tectonic setting, ground motion maps have to be produced for urban area. The local ground shaking levels are computed using six ground motion prediction equations (GMPE's). The scenario maps account soil amplification effects using the geotechnical zonation of the considered urban area. Two scenario earthquakes with different location and magnitudes are considered. The results for scenario Mw7.1 earthquake generated in the northern fault are mapped. The macroseismic intensity for Mw7.1 quake varies between 7 and 9 MSK, the peak ground acceleration and velocity varies between 0.15 and 0.40 g, and 11.4 and 54.2 cm/s, respectively.

B4-10 Petya Trifonova, Liliya Dimitrova, Metodi Metodiev, Maria Chamati, Plamena Raykova. EARTHQUAKE EFFECTS RECORDED ON MAGNETOGRAM - WHERE, WHEN AND WHY. cnternational Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, 21, 1.1, 2021, , DOI:10.5593/sgem2021/1.1/s05.084, 451-458

Records of the magnetometers responding to the effects of big earthquakes were noticed more than a hundred years ago. Even then began to dispute what caused these effects: mechanical vibrations of instruments or electric or magnetic oscillations generated by the earthquakes. In Panagjurishte (PAG) observatory we have great opportunity to shed light on this issue because we have four important instruments installed on the site - three different types of magnetometers and one seismometer. Three large earthquakes with magnitude Mw >6 happened recently in the Balkan Peninsula. These are the events of: 30 October 2020 with moment magnitude Mw 6.9

located in the offshore region north of Samos Island, Greece; 29 December 2020 Mw 6.2 earthquake occurred in Petrinja (Croatia) and 3 March 2021 Mw 6.3 earthquake which hit the northeastern part of the Thessaly basin (Greece). The energy released was enough to give us data for investigation. In our research we compare the recorded signals of all instruments. It is shown that a magnetic torque is introduced by the pendulum swing of the FGE suspended sensors. This instrument may in fact be used in some places as a seismometer of ultra-low sensitivity. But even though we expected to find some small amplitude signals from real electromagnetic waves generated by the earthquakes. It doesn't happen however either because these effects were too small to be observed against the background of geomagnetic noise or they are really missing due to the great distance from the epicenters or the electrical properties of the earth section under the site.

Г7-1 M. Metodiev, P. Trifonova (2016) Geophysical analysis of the Eastern Rhodope region, Compt. Rend. Acad.Sci, v. 69, № 5, 615-621

Geological studies [1] suggest crustal interactions and interplay between various processes involved in the late Alpine history of the Eastern Rhodope Massif, namely the extensional tectonics, volcanic activity and ore formation. In this active geodynamic context complicated geological structures were formed including metamorphic domes, as well as magmatic intrusive bodies and vol canic products. Previous geophysical studies [2–4] have shown well expressed heterogeneity in the gravity anomalous field and clear contrast of the observed anomalies. This outlines the presence of magmatic and metamorphic bodies as well as structural discontinuities in depth. In the present paper, tectonic deformations in the Earth's crust upper layer of the Eastern Rhodope region are mapped using direct inverse techniques for gravity and magnetic data interpretation. More than 25 gravity transitions are outlined revealing projections of possible faults, flexures and other dislocation structures. 3-D Euler deconvolution detected several magnetic bodies placed between 2 and 15 km in depth

Г7-2 Metodiev, M. and Trifonova, P., (2017) Bulgarian Geomagnetic Reference Field (BulGRF) for 2015.0 and secular variation prediction model up to 2020, Annales Geophysicae, 35, 5, pp 1085--1092, https://www.ann-geophys.net/35/1085/2017/, DOI 10.5194/angeo-35-1085-2017

The Bulgarian Geomagnetic Reference Field (Bul GRF) for 2015.0 epoch and its secular variation model pre diction up to 2020.0 is produced and presented in this paper. The main field model is based on the well-known polynomial approximation in latitude and longitude of the geomagnetic field elements. The challenge in our modelling strategy was to update the absolute field geomagnetic data from 1980.0 up to 2015.0 using secular measurements unevenly distributed in time and space. As a result, our model gives a set of six coefficients for the horizontal H, vertical Z, total field F, and declination D elements of the geomagnetic field. The ex trapolation of BulGRF to 2020 is based on an autoregressive forecasting of the Panagyurishte observatory annual means. Comparison of the field values predicted by the model with Panagyurishte (PAG) observatory annual mean data and two vector field measurements performed in 2015 shows a close match with IGRF-12 values and some difference with the real (measured) values, which is probably due to the influence of crustal sources. BulGRF proves to be a reliable alternative to the global geomagnetic field models which together with its simplicity makes it a useful tool for reducing magnetic surveys to a common epoch carried out over the Bulgarian territory up to 2020.

Г7-3 Metodiev, M., Trifonova, P.. GEOMAGNETIC FIELD ELEMENTS OF THE BULGARIAN TERRITORY FOR 2020.0 EPOCH. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, 20, 1.2, 2020, ISSN:1314-2704, DOI:10.5593/sgem2020/1.2/s05.069, 543-550.

It is well known that geomagnetic field varies in time, as well as in space. Besides, the world magnetic models which are the main sources of information concerning the values of geomagnetic field elements in a particular place, we present more precise and accurate model of these elements covering the territory of Bulgaria. Our study uses information from the last absolute geomagnetic survey involving measurements in 473 points, secular data from Panagyurishte (PAG) and several other Intermagnet observatories near Bulgaria, as well as secular magnetic measurements of the Bulgarian network. Above and beyond the scientific investigation which are performed using geomagnetic field values, this information has also practical application. The most significant element is the geomagnetic declination, which is widely used in geodesy, cartography and their associated navigational systems. The geomagnetic declination is very important for navy and aviation (civil or military), radio connections, etc. As the geomagnetic field changes with time, the topography maps has to be updated regularly. Each edition must have a reliable value of the geomagnetic declination to allow orientation with the help of a compass. Present paper gives most up-to-date models of the total geomagnetic field (F), horizontal component (H) and declination (D) over the whole territory of Bulgaria determined for the 2020.0 epoch. The observatory measurements, existing records and calculations of geomagnetic field elements are also described

Г7-4 Metodi Metodiev. Local geomagnetic activity recorded on the Bulgarian territory for the Solar cycle 24. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM 2021, DOI10.5593/sgem2021/1.1/s05.093, 509-518

Records of the magnetic variations are different at every observatory. They depend mainly on the latitude of the observatory and the local time. To give a quantitative measure of the amount of magnetic disturbance at any time, we need to rely on magnetic indices. Usually, local K-index is preferred as indicator of the geomagnetic activity in a specific area. Each observatory assigns a digit ranging from 0 to 9 to both H and D, for every three-hour interval starting at midnight, universal time (UT).

Recently, in December 2019 finished the last Solar Cycle - one of the main periodic variations of the solar activity. This inspired the topic of the present research to investigate the dependence of the local magnetic activity recorded at Panagjurishte (PAG) observatory and the records of the sunspot numbers during the 11 years long cycle. PAG observatory is situated at middle latitude and does not experience the polar electrojet which causes intense 'negative bays' or polar magnetic substorms in the high latitudes and the terrestrial ring current centered at the equatorial plane and responsible also for global decreases in the Earth's surface magnetic field.

The Solar Cycle 24 was announced as one of the weakest in the last century of observations. Similar is the statistics of the recorded geomagnetic event at the PAG observatory. Plot of the days with registered geomagnetic storms for the whole 11-year period clearly shows two maxima of the annual numbers - one in 2012 and another (larger) in 2015 when 67 days have had K-index ≥5. In June that year happened also the largest event with K-index=8. Examining the monthly distribution of magnetic storms, it was found that the periods in which there are largest recorded events are also two: February - March and September- October with more than 30 stormy days in total. As a conclusion it was found the for Solar Cycle 24, 75% of the time has had calm geomagnetic condition, 16 % has been disturbed and only in 9% of the time (less than a year), the Sun has caused geomagnetic storms.

Г8-1 P. Trifonova, Cholakov I., Redzhov S., Metodiev M., Radev I. (2011) Sofia Airport Geomagnetic Survey, Bulg. Geophysical Journ., 37, 105-112

Although the modern electronic devices are used as a primary direction indicators for aircrafts, magnetic compasses remain important back-up systems on airplanes. Airports infrastructure must include special sites which allow an aircraft check to be performed, and to calibrate onboard compasses. There are certain requirements towards those sites and the most important one is the geomagnetic declination homogeneity. The present paper describes methodology and results of the geomagnetic survey performed at the Sofia airport investigating the suitability of the north deicing pad to be used as a calibration site for aircraft compass systems. The total intensity of the geomagnetic field and geomagnetic declination were measured and analyzed. As a result, major magnetic disturbers were delineated and the suitable for compass calibration area was determined.

Г8-2 P. Trifonova, M. Metodiev , I. Cholakov, S. Redzhov & I. Radev (2011) Geomagnetic Study for Determination of the Compass Calibration Site Suitability at the Sofia Airport, Proceedings of the 6th Congress of the Balkan Geophysical Society - Budapest ISBN 978-90-73834-16-3, EAGE 2011.

Despite the presence of modern electronic devices aeronautics still needs of magnetic compasses as a primary direction indicators on small aircrafts and as very important back-up devices on larger airplanes. Airports infrastructure must include elements which allowed an aircraft check to be performed, and to calibrate or compensate onboard compasses (Rasson, 2006). Main task of the present research is to determine the suitability of the north deicing pad of the Sofia airport to be used as a calibration site for backup compass systems of Airbus 320 and Boeing 737 airplanes. For this purpose two types of investigations have been performed: 1) magnetic total field intensity measurements and 2) magnetic declination measurements. Analysis of the obtained results showed the influence of located magnetic disturbers and outlined the homogeneous enough zone for performing aircraft compass calibration procedures.

Г8-3 Solakov, Dimcho, Stela Simeonova, Irena Alexandrova, Petya Trifonova, Metodi Metodiev (2011) Verification of seismic Scenario Using Historical Data-Case Study For The City Of Plovdiv, in Grutzner C., Perez-Lopes R., Steeger T. F., Papanikolaou, Reicherter K., Silva P. G., Vott (Edt.) Proceedings, Vol.2, 2nd INQUA-IGCP 567 International Workshop on Active Tectonics, Earthquake Geology, ISBN: 978-960-466-093-3, p. 239-242

The territory of Bulgaria represents a typical example of high seismic risk area. Over the centuries, Bulgaria has experienced strong earthquakes. The main purpose of this work is to compare the calculated and observed intensity values and to judge if they are meaningful and can be used to "validate" forecasting scenario. To make this, a test scenario for the city of Plovdiv is generated and the obtained intensity values are compared to the observed data from real earthquakes. Plovdiv is the second-largest city in Bulgaria with a population of about 400 000. It is situated in the southern part of the country along the Maritsa River valley. History of the city of Plovdiv spans some 6000 years, with traces of a Neolithic settlement dating to roughly 4000 BC. The earthquakes that mainly influence the hazard for Plovdiv originate near the city. The intensity assessments used for verification are from the 1928 earthquakes (on April 14th, M=6.8 and the earthquake on April 18th , 1928, M =7.0).

Г8-4 Solakov, Dimcho, Stela Simeonova, Irena Alexandrova, Petya Trifonova, Metodi Metodiev (2011) Utilizing historical data for urban area (the city of Ruse) seismic scenario validation, Proceedings of the 6th Congress of the Balkan Geophysical Society - Budapest ISBN 978-90-73834-16-3, EAGE 2011.

Approaches used for scenario developing could be two types: deterministic and probabilistic. The procedure of scenario generation includes the following stages: 1)Compilation of regional seismotectonic data base; 2) Analysis of regional seismotectonics; 3) Seismo-tectonic zonation; 4)Geotechnical characterization of the studied area; 5) Seismic hazard assessment; 6) Cross validation. Deterministic scenario is representation of the severity of ground shaking, using one or more hazard descriptors either from the assumption of a "reference earthquake" specified by a magnitude or an epicentral intensity, associated to a particular earthquake source or, directly, showing values of local macroseimic intensity generated by a damaging, real earthquakes of the past.

Г8-5 P. Trifonova, D.Solakov, S. Simeonova, M. Metodiev (2012) Black sea earthquake safety net(work) – ESNET, Bulgarian Geophys. Journal, vol.38, p. 44-50.

ESNET project is working in the frame of the Joint Operational Programme "Black Sea Basin 2007-2013" financed by EU and national co-financing. The project objective is to contribute to the prevention of natural disasters generated by earthquakes in Black Sea basin by developing a joint monitoring and intervention concept between the partner countries (Romania, Bulgaria, Moldova and Turkey, see Fig. 1). Its duration is 24 months starting in March 2012 and has five major groups of activities. In the end of project implementation the disaster potential, with accent on the seismic risk degree and the earthquakes effects in the intervention area will be assessed, an integrated seismic monitoring and intervention concept will be developed and the capacity of local emergency intervention units for joint response activities in case of disasters will be increased. The present paper describes the expected cross border impact of the action, its methodology and final results and outputs for the project's beneficiaries.

Г8-6 P. Trifonova, M. Metodiev (2012) Annual report of the observed geomagnetic activity in Panagyurishte observatory, Bulgarian Geophys. Journal, vol. 38, p. 51-78.

Presently, in the era of Internet communication the preliminary time series (INTERMAGNET's reported data) acquired in geomagnetic observatories are available in near-real time, while the final absolute time series (definitive data) are disseminated with many months delay, being subject to many checks. This paper reports the quasi-definitive geomagnetic data obtained in Panagyurishte observatory in 2012, prepared in the form of local geomagnetic indices and absolute time-series of hourly mean values plots. Verification of data quality is performed according to "IAGA guide for magnetic measurements and observatory practice"

Г8-7 M. Metodiev, P. Trifonova (2013) Characteristics of the 2012 geomagnetic activity recorded in Panagyurishte observatory, Proceedings of the Second National Congress of Physical Sciences, Sofia, 2013

The 2012 annual daily mean values of the geomagnetic components are shown on Figure 2. For the total field (F), vertical component (Z) and declination (D) there is a visible upward trend of the secular variations, which is also observed for the past five years. The horizontal component (H) also follows the trend from the previous years remaining in a plateau form. In the daily mean record of the horizontal component (H) are visible the periods with the highest magnetic activity during the year. In most of the cases detected geomagnetic storms in Panagyurishe observatory began suddenly, continued less than 24-houres and are marked by an abrupt decrease of the H amplitude

Г8-8 P. Trifonova, D. Solakov, S. Simeonova, M. Metodiev, and P. Stavrev, 2013, Regional pattern of the earth's crust dislocations on the territory of Bulgaria inferred from gravity data and its recognition in the spatial distribution of seismicity, Pattern Recogn. Phys., 1, p. 25-36, doi:10.5194/prp-1-25-2013

Deformations in the earth's upper layer can be mapped using a variety of methods and techniques. This paper examines the regional pattern of linear structures on the territory of Bulgaria using Bouguer gravity anomalies. The gravity data were analyzed using integrated gradient interpretation techniques, such as the Total Horizontal Gradient (THG) and Vertical Gravity Gradient (VGG). Derived gravity maps reveal persistent lateral changes in density caused by faults, thrusts or dislocated block borders. We thoroughly examine and describe the observed lineation pattern and relate it to the existing tectonostratigraphic information. Several decades after the earliest attempts of potential field data application for revealing first order faults and crustal blocks in the Bulgarian territory, we take advantage of improved techniques and high quality gravity and seismological data for more reliable estimation of the seismogenic potential of faults and thrust structures in the earth's crust. The interpreted structural elements are compared with the epicentral map and epicentral density function of the examined area, to evidence relations between the revealed structures and seismicity. The study indicates possible seismological significance of these lineations and motivates the interest of further quantitative investigations for the purposes of seismic hazard assessment.

Г8-9 M. Metodiev (2014) Modelling of declination's secular variation for the purposes of regional topographic mapping, Bulgarian Geophys. Journal, vol.40, p. 76-84

The most significant of the Earth's magnetic field elements is the geomagnetic declination, which is widely used in geodesy, cartography and their associated navigational systems. The geomagnetic declination is incorporated in the naval navigation maps and is used in the navigation process. It is also a very important factor for aviation where declination data have major importance for every airport (civil or military). As the geomagnetic field changes with time but maps of the geomagnetic declination are not published annually and are reduced to an epoch in the past (Buchvarov and Cholakov, 1985), it is necessary to define two additional parameters in the maps, needed to determine the value of the geomagnetic declination for a particular moment in the future: 1) estimated value of the annual declination variation and 2) a table with the average diurnal variation of the declination for a given month and hour.

Г8-10 M. Metodiev, P. Trifonova (2015) Geomagnetic activity for the last solar cycle recorded in PAG observatory, Proceedings of the 7th National Geophysical Conference, Sofia, 2015

From the beginning of Solar cycle 24 (4 Jan 2008) there are more than 25 days with K-indices reaching or exceeding 6. Regardless of the fact that the current Solar cycle have low sunspot numbers there have been several days with local K-index of 7 and planetary index Kp with magnitude 8. Geomagnetic storms of such magnitude could affect high-latitude power systems which may experience voltage alarms, long-duration storms may cause transformer damage. In the field of spacecraft operations corrective actions to orientation may be required by ground control as well as there might be changes in drag affect orbit predictions. Also HF radio propagation can fade at higher latitudes. (NOAA Space Weather Center)

Г8-11 Petya Trifonova, Metodi Metodiev, Petar Stavrev, Stela Simeonova, Dimcho Solakov, 2018, Methodology for numerical integration of different data types for the purposes of seismic hazard assessment, Proceedings of the IX National Geophysical Conference, 30th November 2018, Sofia

Analysis of input data is a fundamental component of the seismic hazard assessment. The territory of Bulgaria, located in the seismically active region of the Balkans, gives us the opportunity to test new methods of integrating different types of data in order to refine our seismotectonic model. In recent years, a number of high-quality geological, geophysical and seismological data have been collected that are used for the purpose of seismic hazard assessment. The present paper presents an algorithm for the so-called spatial matching index, which indicates the absence or presence of potential seismic sources in the input data. The Spatial Match Index (Q) is used to assess the hazard in Bulgaria by quantifying the seismic potential of 416 square blocks of 20x20 km covering the entire territory of Bulgaria and extended by 20 km outside of the country borders. All operations are performed in GIS using their capabilities to handle different types of georeferenced spatial data. The results show that the highest seismic potential (the highest Q) was observed in 56 network elements (13% of the territory), in which all three types of data were matched. Expected are the areas near Varna, Rousse, Veliko Tarnovo, Sofia, Plovdiv, Krupnik and several other places. Partial matching, i.e. one of the features is missing, is recorded in 98 block elements. There are no signs of a seismogenic structure according to our calculations in 117 network elements, covering 28% of the studied area.

Г8-12 Metodiev, M., & Trifonova, P. (2019). Annual report of the observed geomagnetic activity in Panagjurishte observatory for 2013. Bulgarian Geophysical Journal, Vol. 41, p. 65-82. https://doi.org/10.34975/BGJ-2018.41.7

Continuous registration of the geomagnetic field components gives the sum of all field contributions from the internal and external to the Earth sources. A straightforward separation of the individual contributions is impossible and many scientific studies deal with different aspects of this problem (Mandea nad Korte, 2010). Approximate description of the strength of different external variations however, are provided by geomagnetic indices. A quantitative measure of the 2013 local geomagnetic activity in the form of 3 hour K-index is published here, based upon the range of fluctuations in the PAG observatory records over 3 h. intervals. Tables show that 2013 has relatively quiet geomagnetic field with only 15 disturbed days having K-index = 5. Annual variations of the geomagnetic field components are plotted by means of daily mean values. Data are checked and verified according to IAGA requirements (Jankowski and Sucksdorff, 1996).

Г8-13 Trifonova, P., Metodiev, M. , Stavrev, P. , Simeonova, S. and Solakov, D. (2019) Integration of Geological, Geophysical and Seismological Data for Seismic Hazard Assessment Using Spatial Matching Index. Journal of Geographic Information System, 11, 185-195. doi: 10.4236/jgis.2019.112013.

Probabilistic seismic hazard assessment (PSHA) takes into account as much data as possible for defining the initial seismic source zone model. In re sponse to this, an algorithm has been developed for integration of geological, geophysical and seismological data through a spatial index showing the pres ence or absence of a potential seismic source feature in the input data. The spatial matching index (SMI) is calculated to define the coincidence of inde pendent data showing any indications for existence of a fault structure. It is applied for hazard assessment of Bulgaria through quantification of the seismic potential of 416 square blocks, 20 × 20 km in size covering the entire ter ritory of Bulgaria and extended by 20 km outside of the country borders. All operations are carried out in GIS environment using its capabilities to work with different types of georeferenced spatial data. Results show that the high est seismic potential (largest SMI) is observed in 56 block elements (13% of the territory) clearly delineating cores of the source zones. Partial match is registered in 98 block elements when one of the features is missing. Not any evidence for earthquake occurrence is predicted by our calculation in 117 elements, comprising 28% of the examined area. The quantitative parameter for spatial data integration which is obtained in the present research may be used to analyze information regardless of its type and purpose.

Г8-14 Trifonova, P., Metodiev, M., & Buchvarov, I. (2019). Digital data records in PAG geomagnetic observatory available for a 60 years period. Bulgarian Geophysical Journal, Vol. 42, p. 46-61. https://doi.org/10.34975/BGJ-2019.42.5

. Geomagnetic observatory data are used for investigation of internal Earth structure and processes occurring in the deep interior. In addition, long series of data allow extracting signals related to the Sun, Moon, Earth's motion, etc. To obtain a 60-years long record of the hourly mean values of the geomagnetic field component a lot of efforts have been performed including scan of the old magnetic yearbooks, digitalization of the images and verification of data. As a result, geomagnetic database is created and made available through the institutional web-page and WDC Edinburgh providing basis for scientific research and analysis.

Г8-15 Metodiev, M., & Trifonova, P. (2019). Annual report of the observed geomagnetic activity in Panagyurishte observatory for 2014. Bulgarian Geophysical Journal, Vol. 42, p. 62-76. https://doi.org/10.34975/BGJ-2019.42.6

Continuous registration of the geomagnetic field components gives the sum of all field contributions from the internal and external to the Earth sources. A straightforward separation of the individual contributions is impossible and many scientific studies deal with different aspects of this problem (Mandea nad Korte, 2010). Approximate descrip tion of the strength of different external variations however, are provided by geomagnetic indices. A quantitative measure of 2014 local geomagnetic activity in the form of 3 hour K-index is published here, based upon the range of fluctuations in the PAG observatory records. Table 1 shows that 2014 has relatively quiet geomagnetic field with only 18 disturbed days. The most active period is recorded in December 2014 with 6 days having K-index ≥ 5 and 1 with K=6. Annual variations of the geomagnetic field components are plotted in form of daily mean values. Due to technical reasons records are missing for February. Data are checked and verified according to IAGA requirements (Jankowski and Sucksdorff, 1996).

Г8-16 Metodiev, M., & Trifonova, P. (2020). Annual report of the observed geomagnetic activity in Panagjurishte observatory for 2015. Bulgarian Geophysical Journal, Vol. 43, p. 43-58. https://doi.org/10.34975/BGJ-2020.43.4

Continuous registration of the geomagnetic field components gives the sum of all field contributions from the internal and external to the Earth sources. A straightforward separation of the individual contributions is impossible and many scientific studies deal with different aspects of this problem (Mandea nad Korte, 2010). Approximate descrip tion of the strength of different external variations however, are provided by geomagnetic indices. A quantitative measure of 2015 local geomagnetic activity in the form of 3 hour K-index is published here, based upon the range of fluctuations in the PAG observatory records. Table 1 shows that 2015 has disturbed geomagnetic field with 67 disturbed days. The most active period are recorded in September, October, November and December each of them having at least 7 days with recorded geomagnetic storm. The most strong events during 2015 are two – between 17-23 March with largest K=7 and 22-23 June when K=8 was reached. The observed activity is quite reasonable because 2015 is in the middle of the 24th Solar cycle. with 6 days having K-index ≥ 5 and 1 with K=6.

Г8-17 Petya Trifonova, Dimcho Solakov, Stela Simeonova, Metodi Metodiev, Stefan Florin Balan. Parameters of the Seismic Risk for Blagoevgrad Region, Bulgaria. Az-buki National Publishing House, 2020, ISBN:978-619-7065-38-1; e-ISBN 978-619-7065-39-8, DOI:https://doi.org/10.48365/envr-2020.1.32, 353-360

Exposure means people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses. Present research analyses the human exposure at one of the most dangerous earthquake zones in Bulgaria-Blagoevgrad region as one of the main parameters of the seismic risk. Seismic hazard is modelled using GIS and overlaid with one square kilometre grid of population distribution in order to determine the population exposure. We define a parameter called “population exposure index” (PEI) which has five classes: Minor, Low, Moderate, High and Major. As was expected, the seismic hazard levels of Blagoevgrad region are in the upper part of the classification scale. The Krupnik-Kresna area is fully covered with the highest 5th level and the remaining part falls within the interval limits of level 4. The total population in the Blagoevgrad region (NUTS II) is around 138 000 people. Results show that more than 45 000 people are exposed to the highest level of seismic hazard. More than 50 settlements (towns and villages) are classified with Major (5) PEI.

Г8-18 Metodiev, M., Trifonova, P.. Annual report of the observed geomagnetic activity in Panagyurishte observatory for 2016. Bulgarian Geophysical Journal, 44, 2021, ISSN:2683-1317

Magnetic variations shows different records at each observatory. They depend mainly on the latitude of the observatory and the local time. This paper reports the definitive geomagnetic data obtained at Panagjurishte Observatory in 2016, prepared in the form of local geomagnetic indices and absolute time-series of daily mean values plots. The Solar cycle 24 was a slowly rising one having moderate amplitude (https://www.swpc.noaa.gov/products/solar-cycle-progression). It had a "double-peaked" solar maximum, with the first peak reaching sunspot number of 99 in 2011 and the second peak in April 2014 with 101. Calculated indices show that 2016 had 62 days with “storm” level conditions of the geomagnetic field but only moderate levels have been reached. Only one day, 25.10.2016 picked at K-index 7. This is reasonable due to the fact that the sunspot numbers that year continue to decline. Verification of data quality is performed according to “IAGA guide for magnetic measurements and observatory practice”.

Г8-19 Metodiev, M., Trifonova, P.. Annual report of the observed geomagnetic activity in Panagyurishte observatory 2017. Bulgarian Geophysical Journal, 44, 2021, ISSN:2683-1317

Continuous registration of the geomagnetic field components gives the sum of all field contributions from the internal and external to the Earth sources. A straightforward separation of the individual contributions is impossible and many scientific studies deal with different aspects of this problem (Mandea nad Korte, 2010). Furthermore, there are also effects of additional sources which could influence the magnetic records as for example thunderstorms (Chamati and Andonov, 2021).

Approximate description of the strength of different external variations however, are provided by geomagnetic indices. A quantitative measure of 2017 local geomagnetic activity in the form of 3 hour K-index is published here, based upon the range of fluctuations at the PAG observatory records. Table 2 shows that the number of data having disturbed geomagnetic field in 2017 is decreasing down to 50 (for comparison - in 2016 there were 62). The most active period began on August 31 and led to 10 stormy days in September. The strongest events during 2017 were on 22 February and 08 September with largest K-index 7. The observed activity is quite reasonable because 2017 is already in the declining part of the 24th Solar cycle.

Г9-1 Симеонов, С., Солаков, Д., Георгиев, И., Вацева, Р., Димитров, Д., Стефанов, Д., Симеонова, С., Трифонова, П., Васева, Е., Черкезова, Е., Александрова, И., Канева, А., Върбанов, **М., Методиев**, М., Райкова, П., Динков, Д.. Методика за анализ, оценка и картографиране на сеизмичния риск на Република България. МРРБ, Итус'98, 2018, 132

Използването на геофизични методи при оценката на сеизмичната опасност се прилага в страната и чужбина от последните десетилетия. След направен преглед на нормативната уредба в страната (Закон за опазване на околната среда, обн., ДВ, бр. 91 от 25.09.2002 г.; BDSEN 1998-1/NA (2012):EUROCODE 8: Design of Structures for Earthquake Resistance - PART 1: General Rules, SeismicActionsandRulesforBuildings, и съответното национално приложение, Български институт по стандартизация 2012), както и на ръководствата, касаещи сеизмично осигуряване на язовири (Selecting seismic parameters for large dams guidelines, Bulletin 72, 2010 Revision) и за безопасност на ААЯР (IAEA SSG-9 - Seismic Hazards in Site Evaluation for Nuclear Installations. IAEA, Vienna, 2010), описващи обхвата на геофизичните изследвания за оценката на сеизмичната опасност става ясно, че видът, обемът и мащабът на геофизичните изследвания за оценка на сеизмичната опасност не се определят експлицитно в нормативни документи като закони, наредби и правилници. Обикновено се дават предписания за обхвата на геофизичните работи, като се акцентира на резултата, който трябва да се постигне. Ето защо в изпълнените досега проекти за оценката на сеизмичната опасност се наблюдава разнообразие в приложените методи и техники на интерпретация. Основната цел на проведените по настоящия договор изследвания на гравиметричното и геомагнитното поле е извличането на информация за строежа на земната кора на територията на България и близките околности с оглед установяване местоположението на дълбочинни разломи, граници на тектонски блокове, картиране на отделни структури по геофизични данни и маркиране на основни плътностни и магнитни нееднородности в земната кора. При комплексния анализ на гравитационното и геомагнитното поле въз основа на публикувани и фондови материали на проведените количествени определения са компилирани бази данни на аномалните полета за територията на България и околностите. Направено е детайлно описание на наблюдаваните аномалии, изчислени са набор от трансформации на базата на пространствените производни, които са силно чувствителни към по-резките изменения в стойностите на гравитационното и магнитното поле. Картирането на тези изменения дава възможност да се очертаят местата, линиите и зоните на аномалните прояви от типа гравитационни преходи, свързани най-често с разкъсвания в дълбочина и наличие на денивелирани блокове с различаваща се плътност и или намагнитеност в хоризонтален план. Тези източници на аномални ефекти са отбелязани общо като контактни геоструктури. Те могат да послужат за компилирането на сеизмотектонския модел, необходим за оценка на сеизмичната опасност.

Г9-2 Димчо Солаков, Стела Симеонова, Петя Трифонова, Иван Георгиев, Пламена Райкова, **Методи Методиев**, Ирена Александрова, Димитър Стефанов, Светослав Симеонов, Румяна Вацева, Елена Васева, Дейвис Динков, Георги Георгиев. Управление на сеизмичния риск за сгради. Проф. Марин Дринов - София, 2019, ISBN:978-954-322-988-8, 248 - 4 глави

Представеното в настоящия труд е обобщение на резултатите получени от изълнението на проект ДСД-04 „Управлрние на сеизмичния риск за сгради“ целево финансиран от правителството на Република България чрез Българска Академия на Науките.

Под сеизмичен риск се разбират повредите или загубите, които е вероятно да възникнат от излагането на опасност (хазарт) от земетресение. Обикновено загубите се измерват по отношение на очакваните жертви (смъртни случаи и ранени), директните икономически загуби, директните физически и материални загуби (разрушени и повредени сгради) и косвени икономически и физически загуби. По-специфични загуби като обем на отломките, брой на домакинства, които се нуждаят от подслон, и други се използват директно за планиране на действията в случай на бедствие (Seismic hazards, https: //www.fema.gov/earthquake/your-earthquake-risk).

Сеизмичният хазарт (seismic hazard) може да се дефинира като процес или физическо явление, свързано с реализацията на земетресение, което може да доведе до загуба на живот, нараняване или други въздействия върху здравето на човека, имуществени щети, социални и икономически сътресения и увреждане на околната среда (UNISDR). Сеизмичният хазарт е природна даденост, която не може да бъде контролирана от човека.

Най-общо, анализът на сеизмичният хазарт е свързан с оценката на земните движения на дадена площадка вследствие на множество от сеизмични сценарии (Bommer, Abrahamson, 2006). Всеки сценарий се дефинира чрез силата на земетресението (магнитуда, M), разстояние до площадката (D) (което може да бъде епицентрално/ хипоцентрално/ най-близко до разкъсването/ JB – най-близко до проекцията на разкъсването на земната повърхност), други параметри на земетресението като тип разломяване, геометрия на разломяването, почвени условия на площадката и други (означават се с X). Стойността на избрания за анализ параметър на земното движение (интензивност, ускорение, скорост, преместване) се изчислява (прогнозира) чрез закони за затихване,

Съществуват два основни подхода за оценка на сеизмичния хазарт – детерминистичен (DSHA) и вероятностен (PSHA). Съществената разлика между детерминистичния и вероятностния анализ на сеизмичния хазарт е, че при DSHA се разглежда само един или няколко M-D-X сценария, а при PSHA се разглеждат ефектите от всички възможни комбинации на M, D и X.

Детерминистичният подход постулира появата на земетресение с определена сила и конкретно местоположение и оценява въздействията от това земетресение за конкретна площадка. Детерминистичната оценка е нивото на сеизмичните земни движения, предизвикани от най-силните земетресения, реализирани в най-близките до дадена площадка сеизмични източници. Този подход не прогнозира вероятността за случване на даденото събитие през определен период от време.

Вероятностният подход оценява вероятността земното движение да превиши определено ниво вследствие на земетресение за даден период от време. Вероятностният подход дава количествена оценка на сеизмичния хазарт за дадена площадка от всички възможни земетресения на различни разстояния като брой надвишавания или вероятност за надвишаване, на дадено ниво на земното движение за интересуващи ни периоди от време (Thenhaus, Campbell, 2003).

Изложеността описва всичко, което е потенциално изложено на сеизмична опасност. Това включва хора, имущество, съоръжения, инфраструктури и др., разположени в сеизмично опасна област и по тази причина са обект на потенциални загуби (UNISDR).

Уязвимосттта, най-общо, е връзката между степента на увреждане на сгради и съоръжения и сеизмичните въздействия. Съществуват много аспекти на уязвимостта, произтичащи от различни физически, социални, икономически и екологични фактори. Уязвимостта варира значително в рамките на дадена общност и с течение на времето. В общата употреба на термина “уязвимост” често се влага по-широк смисъл като се включва и “изложеността” (UNISDR).

Оценката на уязвимостта е извършена на базата на Европейската макросеизмична скала (EMS-98) с използването на индекс на уязвимост. В EMS-98 са дефинирани 6 класа на уязвимост, означени от А до F и подредени в намаляващ уязвимостта ред. Всеки тип сграда се характеризира с преобладаващ, най-вероятен клас на уязвимост, за който съществува зависимост между сеизмичната интензивност и претърпяната повреда. В класовете на уязвимост са групирани различни типове сгради, които се характеризират с подобно сеизмично поведение. Чрез анализа на уязвимостта се разработват зависимости между параметрите на земното движение и възможните повреди в конструкциите за всеки един прототип (представител на всяка група конструкции). Тези зависимости се използват за определяне на очаквания размер на конструктивните повреди на сградата за дадено ниво на сеизмичното въздействие.

Сеизмичния риск зависи от редица фактори – социално икономическо развитие, сьотношение на опасността между различните, очаквани природни явления – земетресения, наводнения, тайфуни и др.

Основните фактори, които определят сеизмичния риск, са: ниво на сеизмичния хазарт, брой на хората и обектите (частна и публична собственост, паметници на културата, инфраструктура, управление, функции на града и т.н.), изложени на сеизмичния хазарт (фактор изложеност), и степен, до която хората и собствеността в този район са уязвими при земетръсната опасност (фактор уязвимост) (Seismic hazards..., https: //www.fema.gov/ earthquake/your-earthquake-risk).

Сеизмичният риск се оценява чрез комбиниране резултатите от анализа на сеизмичния хазарт с изложеността и функциите на уязвимост (оценка на вероятността за поява на различни нива на увреждане на съоръженията в зависимост от земните движения). Най-общо оценката на сеизмичния риск включва определяне на неблагоприятните последици, които хората и обществото могат да претърпят в резултат на бъдещи земетресения. В този смисъл оценката на сеизмичния риск е част от превантивните дейности за намаляване на загубите при бедствия.

18. 07. 2022 г.

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д-р инж. Методи Методиев,
гл. асистент в деп. Геофизика на НИГГГ-БАН