

ARCHAEOSEISMOLOGICAL STUDIES – BULGARIA-RUSSIA COOPERATION

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Keywords: *Archaeoseismology, Bulgaria-Russian cooperation, Black Sea*

Abstract: *Several expeditions to the Bulgarian and Russian coastal areas have been performed during the last two years in the frame of the bilateral scientific cooperation. The main purpose of these expeditions was to reveal the relationships between the seismic effects and the archaeological objects, (discovered and excavated) and the influence of the strong earthquakes occurred in ancient and historical times. This approach is newly performed and is targeted to the increased completeness to the earthquakes catalogues, data about secondary effects (such like tsunamis, landslides, turbidities, etc.) and the collection of new data to serve about new seismic zoning of the Black Sea areas. The massive measurements in situ, visual documentation, comparative studies, can help drastically to fulfill the gap of data into the earthquakes catalogues. The combination between archeological findings, surface and deep and blind active faults and geophysical characteristics of the local and regional seismic sources are these fundamentals which helps the discoveries done in this bilateral cooperation.*

АРХЕОСЕИЗМОЛОГИЧНИ ИЗСЛЕДВАНИЯ – БАЛГАРСКО- РУСКО СЪТРУДНИЧЕСТВО

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Ключови думи: *Археосейсмология, Българо-Руско сътрудничество, Черно море*

Резюме: *В рамките на съвместни проекти са проведени няколко експедиции с основна цел установяване на земетръсни ефекти върху археологически обекти (на повърхността или разкопани.) Използван е нов подход, специално разработена методика и богат опит на специалистите – участници в разработките. Измервания на място, установяващи систематични ефекти върху различни структури са в основата на определянето на параметрите и характеристиките на минали земетресения. Това ще спомогне за допълване на каталожната информация и нови резултати в сейсмичното райониране на северното причерноморие.*

Introduction

Despite the relatively well documented catalogue about the local seismicity in Northern Black Sea area, a lot of unknown and not proved facts exist, especially related to the ancient seismic events. This area is famous with the development of multihazard natural disasters such like earthquakes, landslides, tsunamis, floods, storm surges etc. [1, 2], frequently generating each other and thus creating so called domino effects which are dangerous for the population and the infrastructure [3, 4]. Because of its location on the Black Sea shore the areas were inhabited since very ancient times. Due to this a lot of historical descriptions exist about different hazardous events observed since a long time ago. Such situation combined with the earthquake sources located in the aquatory of the

sea creates still a lot of interest especially among the specialists in seismology, geodynamics, geomorphology, seismostratigraphy and archaeology. Such situations are creating huge interest among these specialists. The Bulgarian-Russian cooperation is targeted to the study of seismic effects over the archaeological sites – excavated or on the surface. The objects of the study are the North Bulgarian Black sea coast from the Balkans to the Romania-Bulgaria boundary and in Russia to Kerch and especially Taman peninsula.

Methods, Data and Information Collection

To combine the seismological investigations with the archaeology, the previously developed methodology was used [5, 6]

The methodology in this study was limited due to the specifics of:

- Earthquake source location in the sea
- The multihazards chains of disastrous events (earthquakes, landslides, water level changes, tsunamis, surge storms, etc.) frequently affected the ancient inhabited areas [7, 8].
- Archaeological excavations and disclosures of the preserved sediments, destructions and disturbances limited in space and time, and frequently a lack of finances for extended archaeoseismology research when necessary.
- Removal of the deposits during the excavations, which almost always eliminated all signs of disaster affection to the historical and archaeological sites.

According to the developed archaeoseismological studies before, the following methodology was applied in depths to support both studies – in Russia and in Bulgaria:

- Data collection by field observations, measurements, documentation, interpretation and seismic intensity assessment
- Seismic sources formalization, based on known past earthquakes and seismic zoning.
- New interpretation and the seismic sources formalization.
- Use of the referent seismic event (M7.2 31st March, 1901) relatively well documented with an extended macroseismic map, good description of the effects of this strong event (secondary effects generated by it – subsidence, rockfalls, landslides, tsunami, etc.- and their influence to the environment) to create the calibration curve – intensity vs. distance [4].
- Creation of the calibration curve itself, considering the sea location of the epicenter, the azimuth distribution of the intensities, intensity attenuation, destructions and disturbances, etc.
- Selection of the most affected part of the coastal area with the investigated objects.

Research and Discussion

The following archaeological sites have been visited, observations made and interpretations done according to the described methodology:

Russia

Several national and international expeditions in the frame of Russia-Bulgaria bilateral project cooperation focused on:

- Gorgippia – ancient city (Greek colony) located in the centre of Anapa city. Many seismic effects have been observed.
- Raevskoe – ancient fort, mostly under the recent sediments.
- Utrish – natural reserve area with a lot of expressions of the paleoseisimogenic dislocations, landslides and silt volcanoes.
- Fanagoria – huge ancient city located to the bay of Taman peninsula. Many archaeological layers are discovered which preserve a lot of seismic deformations.

The study of ancient objects has revealed a number of seismically induced deformations and destructions: systematic tilts and shifts of upper parts of the walls, as well as their arch-like warping in plan; shear ruptures; rotations of different components of walls and other building elements around vertical axis; squashing of water wells' mouths and stems. Some of mentioned deformations can be formed during strong historical earthquakes in 3rd and 1st centuries BC, as well as in 1st and 3rd century AD. There seismic events were accompanied by local destructions and fires. Summarizing the data on historical earthquakes of the Taman's Peninsula it can be concluded that regional seismic potential is determined by a possibility of $M \geq 7.0$ crust earthquake occurrence with average

recurrence interval – one seismic event if few hundred years. Seismic oscillations in the source zone from such natural events are about $I_0 = IX$ or even more [9, 10].

Bulgaria

Several national and international expeditions in the frame of Bulgaria-Russia bilateral project cooperation to the sites:

- Durankulak - very ancient site developed in long time interval from Neolithic structures to the medieval buildings with observed seismic effects.
- Balchik – famous with its Cybela temple destroyed by a complex disaster (earthquake, tsunami, landslide).
- Kavarna – ancient Greek colony Bisone, flooded by tsunami generated by huge landslide, generated by an earthquake.
- Kaliakra – ancient city, castle and fort, source of many paleoseismodislocations.
- Varna – old city Odessos, with observed seismic affects on its preserved ancient structures.
- Pobiti kamani. – natural reserve preserved a long lasted geological history of seismic effects in situ to the stones.

Almost all seismic effects to the investigated archaeological sites, structures (excavated or surface), or rocks are expressed as fallen stones or bricks or cracks to the direction of the possible epicenter. The calibration curve derived from the macroseismic map of the M7.2 seismic event of 31st March, 1901 is essential for the investigated objects, observed seismic effects and assessed intensities. The variations in distances (respective intensities) cover the observed effects and give the possibility of eventual reconstruction of the acting forces, their directions and correct interpretation of the observations. There are a lot of effects observed on the archeological sites, paleoseismological and recently active faults and their activated segments, which could be considered as sources of the seismic effects to the investigated sites and objects. Sometimes integrated effects of several seismic effects are impossible to separate.

The most difficult to asses parameter is the time of the seismic event, affected the respective site and structures. To solve this problem an intensive cooperation between seismologists, geomorphologists and archaeologists is essential [11].

Conclusion

The extended cooperation between Bulgarian and Russian specialists reveal many new and unknown facts about the seismic influence to the archaeological objects on Bulgarian and Russian Black Sea coastal areas. Many objects have been discovered, documented and investigated and new data and information collected.

This important information is available to the both teams working on the topic and detailed interpretation will follow by the Russian and Bulgarian specialists.

The promising results are expected due to the systematic deformations observed to all archaeological objects located in the areas of high seismicity. There are a lot of indications that this information will drastically change the image of the local seismicity and its influence to the ancient habitats and the cooperation between seismologists and archaeologists seems to be very fruitful.

Acknowledgements:

Several projects supported this study:

"Research of the Consequences of Strong Earthquakes in the Coastal Areas of Bulgaria and the Taman Peninsula. Program for bilateral cooperation Bulgaria-Russia. Funded by the FNI (Contract №DNTS / Russia 02/20 of 25.06.2018).

RFFI grants - №№ 19-55-53017 ГФЕН_а; 18-55-18014 Болг_а; 18-05-01004 А

The National Science Program "Environmental Protection and Reduction of Risks of Adverse Events and Natural Disasters", supported by the Ministry of Education and Science (MES) of Bulgaria (Agreement № D01-230/06.12.2018).

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