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Дискусии

SHORT-TERM FORECASTING OF EARTHQUAKES AND TSUNAMIS AND EXPLOITATION OF METHANE THROUGH GAS DETECTION DEVICES AT SEA AND ON LAND

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The article is a brief description of the devices developed in Bulgaria in the last decades for the short-term prediction of earthquakes and tsunamis at sea and on land. It presents ways of using the methane from gas vents as an ecological resource and as a means for preventing it from entering the atmosphere. In addition, an overview is provided of the current state of affairs in Bulgaria and internationally regarding the shortcomings of seismologists' efforts to implement short-term earthquake prediction as the main objective of modern seismology.

Keywords**:** earthquake, tsunami, gas vents, short-term earthquake prediction, methane exploitation.

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КРАТКОСРОЧНА ПРОГНОЗА НА ЗЕМЕТРЕСЕНИЯ И ЦУНАМИ И ЕКСПЛОАТАЦИЯ НА МЕТАНА ЧРЕЗ УСТРОЙСТВА ЗА КАПТИРАНЕ НА ГАЗОВИ ИЗВОРИ В МОРЕТО И НА СУШАТА

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Статията представлява кратко описание на устройствата, създадени през последните десетилетия в България, с цел краткосрочното прогнозиране на земетресения и цунами в морето и на сушата и експлоатацията на метана от газовите извори като екологичен ресурс и за да не попада в атмосферата. Същевременно е дадена обща представа за ситуацията у нас и в чужбина относно досегашните неуспехи на усилията на сеизмолозите за осъществяване на краткосрочното прогнозиране на земетресенията като основна цел на съвременната сеизмология.

***Ключови думи**:* земетресение, цунами, газови извори, краткосрочно прогнозиране на земетресения, експлоатация на метан.

In Bulgaria and, according to the literature data, in the world, the first invention of a device for gas springs was patented by Trayan K. Trayanov (BG 62499 B1/01.08.1990). It was intended for the utilization of natural gas as an ecological resource and for the protection of the environment from pollution, but

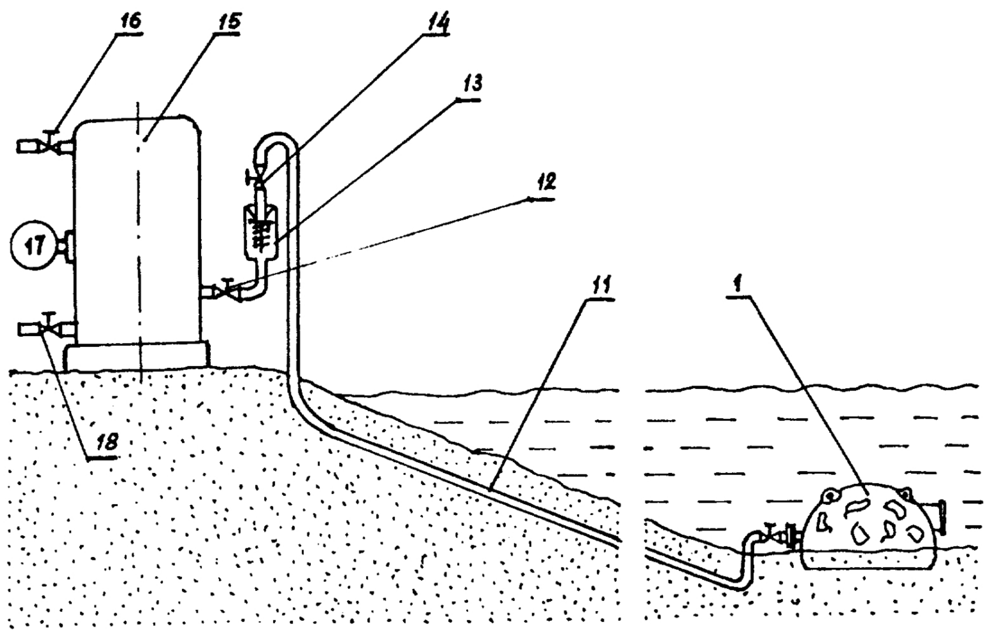

Fig. 1. Device for capturing underwater gas vents. Designations: 1 – dome (reinforced concrete hemisphere); 11 – outlet pipeline; 12 – valve; 13 – gate valve; 14 – valve; 15 – tank; 16 – valve; 17 – control manometer; 18 – dehumidification valve (BG 62499 B1/01.08.1990).

not for the short-term (most important) earthquake prediction. The T. Trayanov device (Fig. 1) is a dome from reinforced concrete connected to a reservoir on the shore by a pipe, dug into the seabed. Its parts are complicated by a number of details performing different functions. It is suitable for gas vents very close to the shore, but not for those on the extensive shelf area. It can only be used in front of a sandy shore and a flat seabed, but not in front of a rocky shore with an uneven bottom. However, it is in front of a sandy shore and bottom that any disturbance will cause the greatest changes in the bottom topography and sediment composition, where the connecting pipe, complicated by the difference in height of its beginning and end, will be stripped, displaced or broken. This entire device is designed to capture only a single gas source. The invention will only serve to use CH_4 as an ecological resource and for environmental protection. These drawbacks complicate and significantly increase the cost of the device. This may be the reason why the invention has not yet been implemented in Bulgaria or abroad. It uses the changes in the characteristics of gas emissions observed around seismically active faults in the Earth's crust as a predictive indicator for an impending earthquake.

The second device for capturing of gas vents, patented by Dimitar G. Parlichev et al. (BG 61997 B1/06.01.1994), (Fig. 2) is actually the first device

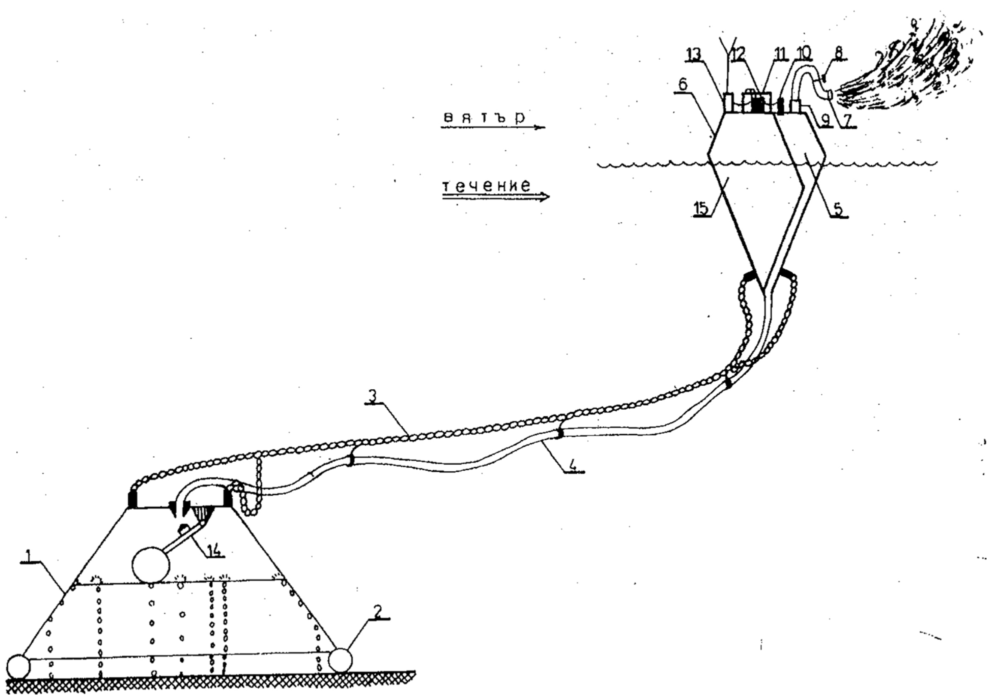

Fig. 2. Device for capturing underwater gas vents. Designations: 1 – pyramid; 2 – weights; 3 – chain; 4 – hose; 5 – chamber; 6 – buoy; 7 – pipe; 8 –- valve; 9 – flow meter; 10 – pressure sensor; 11 – battery pack; 12 – processor; 13 – radio transmitter; 14 – valve; 15 – insulated chamber (BG 61997 B1/06.01.1994).

for short-term prediction of earthquakes in the sea (seaquakes). It was created based on information provided by Petko S. Dimitrov that the 1927 Crimean earthquake was preceded by an abundant release of gas from the seabed, which in particularly high concentrations ignited over the water. It was then assumed that the gas was H_2S, which was known to contaminate Black Sea waters below 200 m depth. However, P. S. Dimitrov decided (correctly, in our opinion) that it was CH_4 gas that was released from faults in the Earth's crust, and according to the testimony of divers of that time (1927), the appearance of the gas preceded the earthquake not by hours, but by days. In fact, this second device was the first invention for the short-term prediction of earthquakes.

The third device (Fig. 3 - BG 109377 B1/14.12.2005 "Device for detection and early warning of underwater earthquakes and early warning of underwater

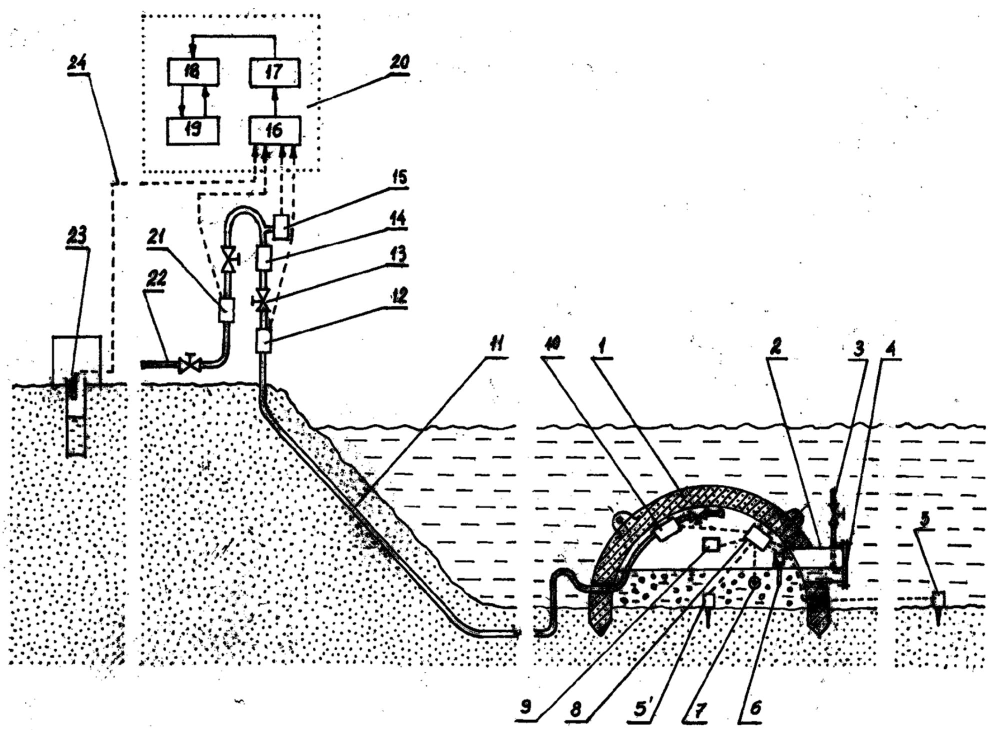

Fig. 3. Underwater earthquake and tsunami detection and early warning device. Designations: 1 – drip tray; 2 – pipe; 3 – equalization pipe; 4 – cover; 5, 5' – seismic and sea level sensor; 6 – seawater temperature sensor; 7 –- seawater salinity sensor; 8 – junction box; 9 – pressure sensor; 10, 12 – socket; 11 – cable-sleeve; 13 – valve; 14 – one-way valve; 15 - pressure sensor; 16 - measuring and commutating unit; 17 - analogue-to-digital converter; 18 – computer; 19 – input/output device; 20 – registration point; 21 – flow meter; 22 – output; 23 – groundwater level sensor; 24 – telemetry cable (BG 109377 B1/14.12.2005).

earthquakes”), (Fig. 3), proposed by Petko S. Dimitrov and Trayan K. Trayanov, is basically a reiteration of the first invention of T. K. Trayanov (as can be seen from the comparison with Fig. 1). It is aimed at “early warning of earthquakes and tsunamis” and not at “short-term prediction of earthquakes” like the second device, i.e. it is aimed at the announcement of weak tremors that may precede a strong earthquake, and these are two very different situations. The main drawback of the third device is its excessive complexity compared to the first, which is why its costs are likely to exceed its revenues.

The advantages of the second device over the first and third are as follows: it is much smaller and therefore much cheaper; it immediately transmits the flow, pressure and velocity of the gas to the receiving device on land; it can be installed over the entire shelf area, unlike the first and third devices, which can only be used in front of beaches; it is not affected by wind, waves and currents; it does not require a special shaft in the seabed; it is not affected by changes in the seabed topography and bottom substrate, including in the surf zone; both the underwater part and the buoy can be easily taken onboard the floating crane for repairs; can be easily moved from one to another, more promising gas source; in the event that the methane from the gas source cannot be utilized, it is ignited in order to prevent its entry into the atmosphere; the device predicts earthquakes of different magnitudes, which will allow the gas vents in an earthquake area, as well as on different faults, to be studied over a long period of time and characterized with the details of their different manifestations, which will probably increase the accuracy and certainty of the predictions.

The fourth device, which was proposed by D. Parlichev and G. Parlichev (patent application № 113713/11.07.2023 “Short-term prediction of earthquakes by means of a gas vents capturing device on land”), (Fig. 4) is used on land and is adapted to atmospheric conditions. The device is a simplified and therefore less expensive version of the second device whose general representation is given in Fig. 4.

Although the second device has not yet been constructed and tested in our country, we would like to emphasize that we have evidence suggesting that if we already had the device on the gas spring near the Zelenka area east of Kavarna in 2009, we would have successfully made the world’s first short-term forecast of a seaquake with a magnitude of 3.4 on the Richter scale (Parlichev, Dobrev, 2019; Parlichev, Vasilev, 2021). Therefore, we offer several considerations and proposals to initiate and accelerate the implementation of such forecasts.

First, the nature of this new technology must be recognized–it is not used for ordinary life purposes and needs, but for the protection and preservation of life itself. It is evident that this technology requires not only immediate experimentation and integration into research activities, but also its maintenance in constant working order, necessitating emergency repairs in the event of malfunction and breakdowns.

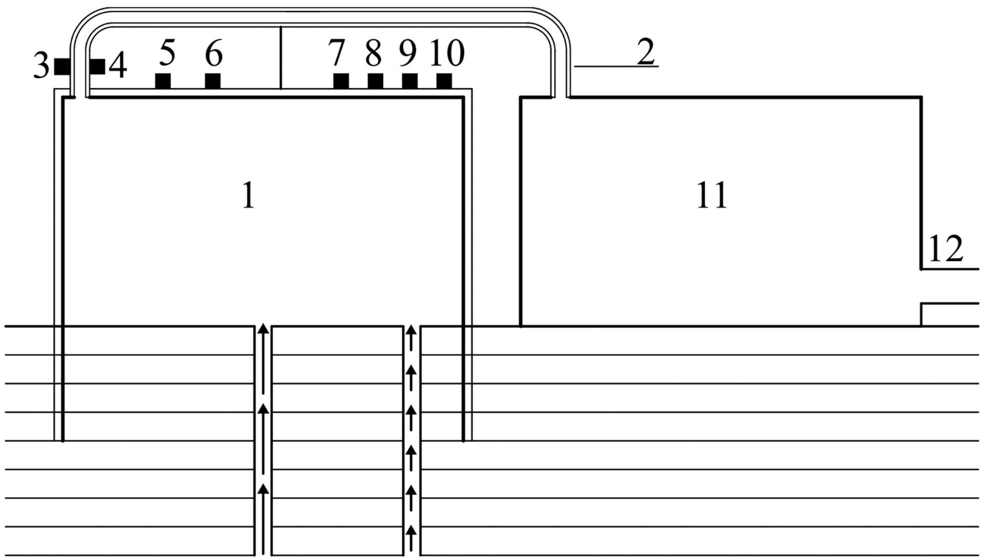

Fig. 4. Short-term prediction of earthquakes by onshore gas capturing device.
Designations: 1 – forecast chamber; 2, 12 – pipe; 3 – flowmeter; 4 – speedmeter; 5 – pressure sensor; 6 – temperature sensor; 7 – power storage; 8 – processor; 9 – radio transmitter; 10 – insulator; 11 – resource chamber (No. 113713/11.07.2023).

It should be emphasized that there are gas seeps of various origins and composition and that only the “informative” ones, i.e. those coming from significant or great depths, can be used for forecasting, and are not difficult to distinguish in well studied areas, particularly in tectonic contexts, whether on land or on the seabed.

It is also necessary to organize the work so that the data and observations obtained from the monitoring complex are quickly interpreted, and the seismic hazard alert is issued, reaching all residents of the area within seconds. Therefore, the communication network must also be kept in good working condition.

The offshore and onshore gas capturing devices, along with the ability to predict and exploit, serve a third, equally important role – that of research equipment. Directly - to continuously monitor the gas vents themselves over which it is placed, and indirectly - to track the behavior of mobile blocks whose impending seismogenic impacts are predicted by the abrupt change in flow rate, velocity and pressure of the gas flow. The information and its accuracy will be enhanced by the number of devices and their proximity in the same seismic zone. This use of the new technology provides confidence that it will shed further light on the overall structure of the seismogenic process, which differs between areas, while continuously enhancing our knowledge of the previously unclear predictive processes and phenomena in seismology that precede such events.

Difficulties also increase due to the fact that short-term prediction of an earthquake implies answering three questions as accurately as possible: location, timing and magnitude. The third question has been answered (by the American seismologist Charles Richter), but the answers to the first and especially the second question are of paramount importance. The difficulties that are perfectly clarified by Christoskov and Solakov (2009) and elucidate why modern seismology is still not able to answer the first two questions with sufficient precision. They will be gradually overcome with the widespread implementation of the new devices in the practice of forecasting this phenomenon.

The situation is further exacerbated by the presence of combustible or rare mineral deposits in the earthquake-prone area. Additionally, caution is needed in drilling activities, particularly deep drilling, as they could hinder efforts to make accurate short-term earthquake predictions.

At present, it is important to acknowledge the indisputable fact that billions of people in earthquake-prone areas around the world live in a state of constant fear, perpetually anticipating a sudden and powerful earthquake that could strike at any moment, leaving them unable even to evacuate their homes. This fear is systematically exacerbated by the increasing frequency and intensity of earthquakes, a phenomenon driven by the acceleration of global warming—a correlation that is no longer disputed in the scientific community (Kim and Lee, 2023; Bohnhoff et al., 2024). In the present era, the correlation between these phenomena makes it imperative to promptly address the most crucial yet challenging issue in seismology – the short-term prediction of earthquakes (Ryzhikova, 1996; Oksanovich, 1979; Christoskov, Solakov, 2009), a problem that remains unresolved to date. The ten predicted earthquakes cannot be considered accurate against the backdrop of thousands of unsuccessful predictions; they can only be mere coincidences. Furthermore, these forecasts are not based on processes, phenomena, and facts related to the seismological process itself. (Oksanovich, 1979). This leads to the most important conclusion: the patents for devices designed for gas capture on land and at sea, are the only ones based on information both preceding and most relevant to the seismological process. They should be immediately made available to seismologists worldwide for construction and installation in the most hazardous seismic zones of each country. In other words, the new seismological equipment needs to be swiftly constructed and installed, thoroughly tested, and then operated and refined by expert teams of seismologists, engineers, and technicians in each seismic area. The urgent necessity for such measures is vividly demonstrated by the situation in Istanbul, a city of 16 million people, where residents are alarmed by Turkish seismologists' long-term forecasts of an imminent, major earthquake (7–9 on the Richter scale) in the Sea of Marmara, likely accompanied by a tsunami, especially given the city's aging infrastructure. Additionally, the unsuccessful six-year ESONET (European Seafloor Observatory Network) expedition in the

Sea of Marmara, which failed to predict future earthquakes despite investigating the gas vents at the seabed, underscores this need. In our opinion, this failure is that the participants did not have access to the patent depicted in Fig. 2, which we had already obtained.

Given the briefly described global state of short-term earthquake forecasting, the response of Bulgarian seismologists appears perplexing. They displayed a marked indifference to the world's only device designed for forecasting earthquakes at sea, applied for on January 6, 1994, neglecting to promptly construct several units and install them at the most critical points along the Kaliakra deep fault. This apparent indifference can be attributed to a clear discrepancy between the methodology and device used for forecasting and the traditional methods and tools employed by seismologists, as detailed in section 4.4 of chapter 4 in the book by Christoskov and Solakov (2009), which corresponds with Semenov's article (Semenov, 2017).

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