UDC 550.34.575 https://doi.org/10.59849/2219-6641.2025.1.38

COMPREHENSIVE FIELD SEISMOLOGICAL RESEARCH AND PROSPECTS FOR EXPANSION OF THE SEISMOLOGICAL NETWORK IN THE REPUBLIC OF KAZAKHSTAN

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ABSTRACT

C A final review of complex field seismological studies and development of a network of seismological stations is conducted. The prospects for the development of complex seismological networks for the implementation of strong earthquake forecasting in the Republic of Kazakhstan on a probabilistic basis are described.

A final review of integrated field seismological research and the seismological research development network was carried out. The prospects for the development of complex seismological networks for the implementation of the forecast of strong earthquakes on the territory of the Republic of Kazakhstan on a probabilistic basis are described.

Key words: seismological research, seismological monitoring, network of seismological stations, tectonic processes, earthquake forecast.

QAZAXSTAN RESPUBLİKASINDA KOMPLEKS SEYSMOLOJİ ÇÖL TƏDQİQATLARI VƏ SEYSMOLOJİ ŞƏBƏKƏNİN GENİŞLƏNDİRİLMƏSİ PERSPEKTİVLƏRİ

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XÜLASƏ

Kompleks çöl seysmoloji tədqiqatlarının və seysmoloji stansiyalar şəbəkəsinin inkişafının yekun icmalı aparılmışdır. Ehtimal əsasında Qazaxıstan Respublikası ərazisində güclü zəlzələlərin proqnozunun məqsədilə kompleks seysmoloji şəbəkələrin inkişaf perspektivləri təsvir edilmişdir.

Açar sözlər: seysmoloji tədqiqatlar, seysmoloji monitorinq, seysmoloji stansiyalar şəbəkəsi, tektonik proseslər, zəlzələ proqnozu.

КОМПЛЕКСНЫЕ ПОЛЕВЫЕ СЕЙСМОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ И ПЕРСПЕКТИВЫ РАСШИРЕНИЯ СЕЙСМОЛОГИЧЕСКОЙ СЕТИ В РЕСПУБЛИКЕ КАЗАХСТАН

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АННОТАЦИЯ

Проведен итоговый обзор комплексных полевых сейсмологических исследований и развития сети сейсмологических станций. Описаны перспективы

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развития комплексных сейсмологических сетей для реализации прогноза сильных землетрясений на территории Республики Казахстан на вероятностной основе.

Ключевые слова: сейсмологические исследования, сейсмологический мониторинг, сеть сейсмологических станций, тектонические процессы, прогноз землетрясений.

Kazakhstan is one of the most seismically active regions of the Asian continent, where large seismic disasters have repeatedly occurred in the recent past (Fig. 1). Since 1976, active research work on the seismic regime, seismic hazard assessment, as well as the creation of networks of seismological stations and earthquake forecasting have begun in Kazakhstan.

Figure 1 – Consequences of earthquakes in different years

In order to reduce the consequences of strong earthquakes occurring here with the development of forecasting methods for possible destructive earthquakes, a comprehensive multi-parameter seismological monitoring has been created in the territory of the Republic of Kazakhstan since 1976, which includes, in addition to various seismological methods, also comprehensive field seismological studies. The most important task of seismological monitoring is the rapid determination of the parameters of the largest earthquakes that pose a potential danger to the population and economy of the country. The results of such monitoring, obtained almost in real time, are used to forecast strong earthquakes. Another very important task is the most complete study of the seismic regime by recording all earthquakes, including the weakest ones. This is necessary for a detailed study of the tectonic activity of the earth's crust in the territory of the Republic of Kazakhstan and the development of probabilistic models of seismic hazard. Based on the results of seismological monitoring,

maps of seismic zoning and zoning of various levels are constructed and special norms and rules for earthquake-resistant construction are developed.

In the most general terms, the most important content of seismological monitoring is determining the location, strength and frequency of earthquakes, where "location" in this case means not only the local epicentral zone, but also the regional seismogenic structure. The problem of predicting the time and place of occurrence of strong earthquakes (SE) is a rather complex task and its solution is possible in two directions. The first is an instrumental study of regional seismicity using complex field studies. However, its capabilities are limited, on the one hand, by the difficulties of creating a sufficiently dense network of recording equipment, and on the other, by the duration of observations for accumulating statistically reliable information on extreme events. The second direction is seismotectonic. It is intended that the shortcomings of the first can be compensated for by historical-tectonic and geological analysis of the studied territory. In the optimal variant, these two directions complement each other. Determining the place of possible occurrence of earthquakes depending on the task and the degree of study of the territory can be considered in a sequential analysis of global, regional and local patterns.

Special attention should be paid to comprehensive field seismological studies in various fields: geophysical, geochemical, hydrogeochemical, hydrogeodynamic, deformation and the influence of external factors, which play a major role in collecting and analyzing comprehensive monitoring seismological data used in making strong earthquake forecasts, constructing seismic zoning maps and developing earthquake-resistant construction standards and rules (Fig. 2).

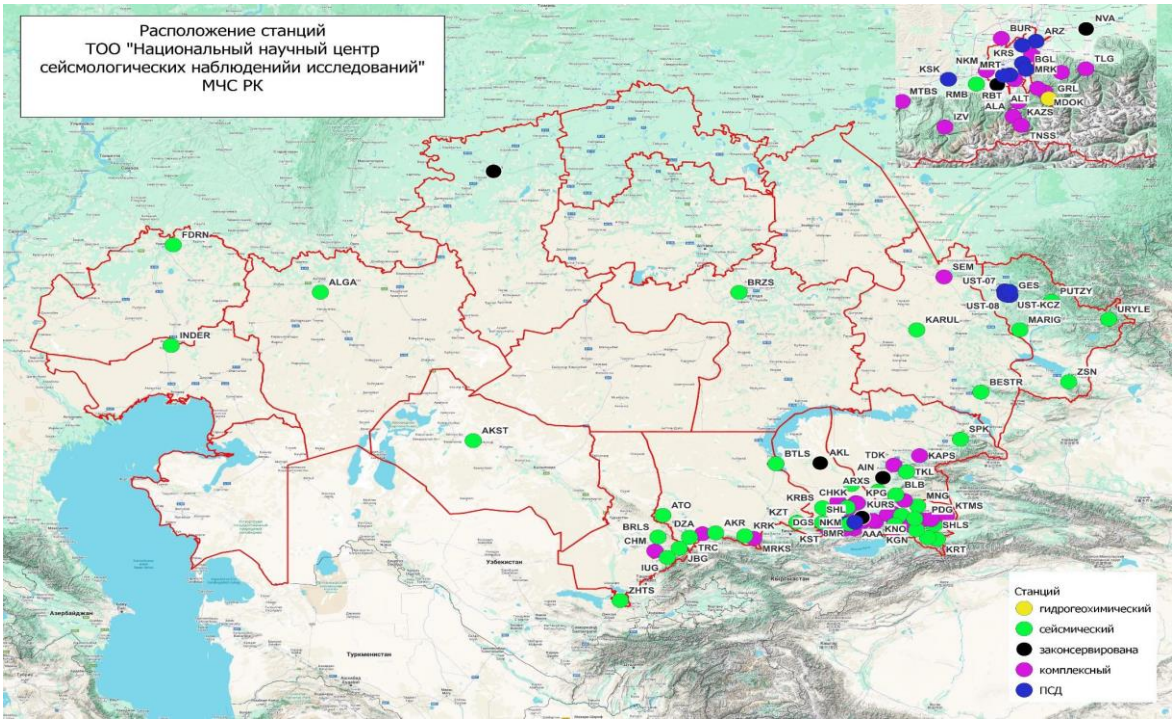


Figure 2 – Layout of seismological stations

Complex field seismological studies are systematic, continuous observations of the parameters of natural fields of the earth's crust, conducted with the purpose of recording its vibrations and searching for precursor effects of strong earthquakes in various fields. These observations include high-precision measurements of seismic data, geophysical fields, geochemical -hydrogeological parameters, as well as monitoring modern movements of the

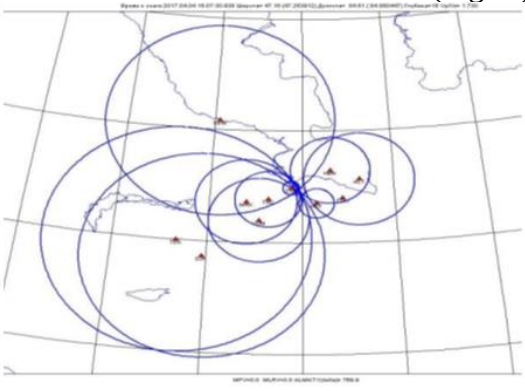
earth's crust and the behavior of some biological species in areas of increased tectonic activity.

Figure 3 – Complex seismological stations "Kurty" and "Saty"

Over a 40-year period, predictive complex field seismic studies are carried out through a network of seismological, geophysical, and hydrogeological stations using continuous measurement of predictor parameters using various methods and observations depending on the geological conditions of the area where the seismological and other stations are located (the presence of tectonic faults, the outcrop of bedrock on the earth's surface, the possibility of laying self-flowing aquifers, the absence of factors that have a negative impact on the quality of seismological data).

At present, in order to implement comprehensive field seismological research at the network of seismological stations of the National Center for Seismic Research (NCSNI) on the territory of the Republic of Kazakhstan, the following methods of comprehensive seismological monitoring are being implemented:

1) Seismic monitoring. It is carried out by digital recording of seismic vibrations and seismic elastic waves generated in rocks by earthquakes with a wide dynamic range, necessary for recording both weak and strong earthquakes of various distances. Short-period equipment (periods from 0.02 to 10 sec.) with high sensitivity records earthquakes in the near zone. Long-period equipment (periods from 10 to 360 sec.) allows recording earthquakes both in the near zone and strong earthquakes at a distance of thousands of kilometers (Fig. 3);



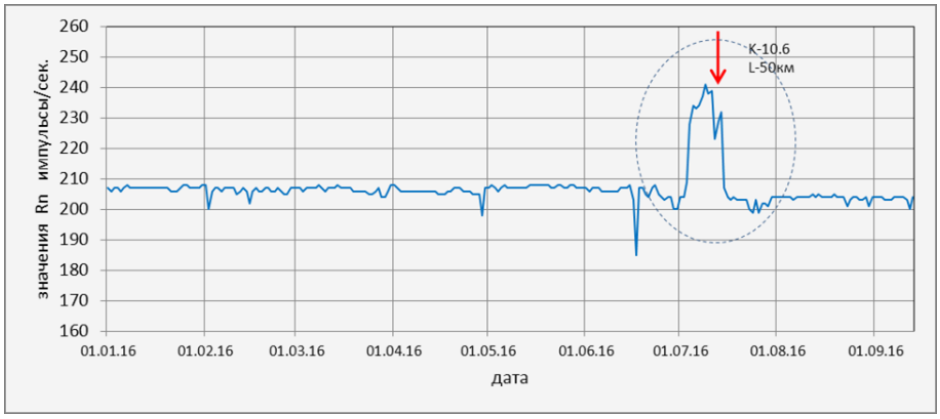
Isoseist map South Saur earthquake 04.04.2017

Definition scheme epicenter

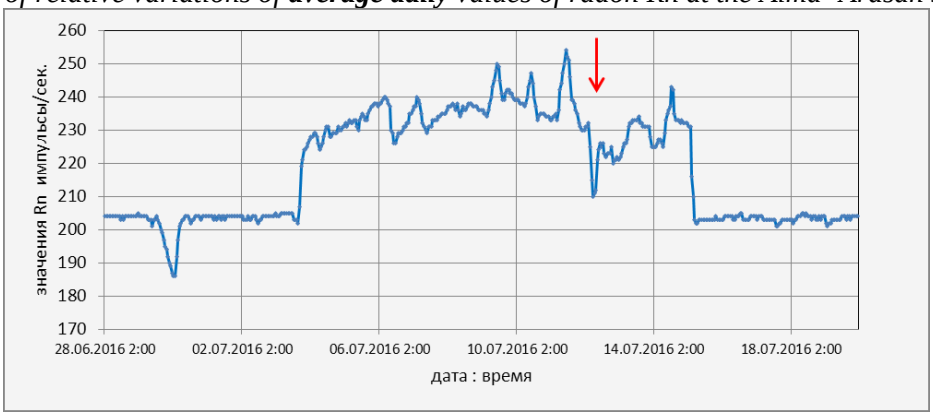
Figure 4 - Map of isoseismals of the South Saur earthquake of 04.04.2017. Earthquake Epicenter Determination Scheme

2) Geophysical monitoring. It is carried out by means of round-the-clock recording of parameters of geomagnetic and geoelectric fields using various geophysical methods (magnetometry, analysis of pulse flow of geoelectric fields). The main task of geophysical monitoring is to obtain long-term series of observations of variations in geophysical fields to provide observation materials for work on searching for precursors of strong earthquakes.

3) Hydrogeochemical and hydrogeodynamic monitoring is carried out by means of hydrogeological observations of variations in hydrogeodynamic, hydro- and gas-chemical parameters of groundwater and the formation of a hydrogeological data bank in order to search for precursor effects of strong earthquakes within the study area. Hydrogeological monitoring includes the analysis of chemical and physical parameters of groundwater, carried out in accordance with the technological scheme for the production of regime hydrogeological observations (Fig. 5);



*Graph of relative variations of **average daily** values of radon Rn at the Alma- Arasan station*



*Graph of relative variations of **hourly** radon Rn values at the Alma- Arasan station*

Figure 5 - Graphs of relative variations in average daily and hourly values radon Rn at the Alma- Arasan station

4) Deformation monitoring. It is based on measurements of the network of the radio channel, local installation (IVT, RAS, CAIAG, NNCSNI, etc.). Studies of deformation using quartz flat strainmeters in adits.

The Medeu, Kurty and Talgar reference stations are equipped with quartz strain gauges. The strain gauges are designed to record horizontal movements of two pedestals relative to each other. The strain gauge rods are 30 m long. Movements are recorded in the range of periods from tens of minutes to several years.

The strain gauge rods at the Medeu and Kurty stations are oriented north-south and west-east. To improve the reliability of operation and to perform internal control of observation results, the strain gauges at these stations have two independent devices in each direction. Information is recorded digitally on the recording unit with subsequent transmission to the PC. At the Talgar station, the strain gauge has one rod (north-south), which is equipped with a digital recording system.

5) Seismobiological monitoring is carried out through regular observations of certain animal species under conditions of limited freedom of movement, which makes it possible to identify and record changes in behavior for use as a predictive indicator used in earthquake forecasting. The following are used: visual observations of animals, automatic recording of animal activity, and instrumental measurements.

Experience shows that good results are achieved by combining field studies and analyzing multiparameter data to identify the precursor effects of strong earthquakes. Many modern seismological publications on predicting expected seismic events are based on the elastic recoil hypothesis. The meaning of this hypothesis is as follows: "It is impossible for a rock to fail without first being subjected to elastic stresses greater than it can withstand. The only conceivable ways of rapidly applying these stresses are by explosion or by rapidly removing or adding a load under some part of the crust. We conclude that the crust in many parts of the Earth moves slowly, and the differences in displacements in adjacent areas create elastic strains greater than the rock can withstand, which eventually leads to a rupture, and the deformed rocks experience a recoil under their own elastic stresses until these strains are almost completely removed...".

Most scientific works on the subject of early forecasting and studying the processes involved in the preparation of earthquakes have been poorly studied to date and represent only hypotheses that require more research, more extensive collection and study of seismological, geophysical, hydrogeological and geochemical data, and training of a larger number of qualified specialists in the field of seismological, geophysical and hydrogeological studies of processes occurring in the depths of the Earth. The development of seismology as an applied science will make it possible to exert a great influence on the formation of a knowledge base in the field of early earthquake forecasting, to obtain a clearer idea of the geological processes occurring during the preparation of expected earthquakes, and will also make it possible to more thoroughly study anomalous and precursor phenomena indicating a direct genetic connection with the preparation of destructive earthquakes.

Today, one of the most important problems of complex field seismological research in the Republic of Kazakhstan is an insufficiently wide network of seismological stations. In the countries of the far and near abroad (USA, South Korea, Japan, China, etc.), the number of points of the seismological activity registration network reaches, according to various sources, from 1,500 to 6,000 units, which significantly exceeds the number of seismological stations in the territory of the Republic of Kazakhstan, which, of course, negatively affects the completeness of seismological data. Undoubtedly, the expansion of the network of complex field seismological stations is a rather complex process and labor-intensive in terms of organizing preparatory and research, construction and installation work and operation of seismological observation facilities. All these works require the involvement of qualified specialists in the field of seismology, which is currently in dire shortage. Not to mention other geophysical, hydrogeological and other field observations, as well as huge financial investments. But at the same time, there is no doubt that the expansion of the network of stations for complex seismological research will have an extremely positive effect on the quality and efficiency of collecting and analyzing seismological data. At the same time, there

is no doubt that a radical reorganization and expansion of the network will in turn affect early earthquake forecasting and the possibility of a more detailed study of geological and geophysical processes indicating the occurrence of earthquakes.

Prospects for the development of a seismological observation network and research in Kazakhstan

As of 29.01.2025, the network consists of 98 seismological stations, 71 stations for monitoring and 27 stations under program-targeted financing (PTF) located in 12 regions of Kazakhstan: Almaty; Zhetysu; East Kazakhstan; Abay; Zhambyl; Karaganda; Kostanay, Kyzylorda, Aktobe, Atyrau, West Kazakhstan and Turkestan, as well as in the megacities of Almaty and Shymkent. The stations conduct comprehensive studies on seismic, geophysical, hydrogeological, deformation, seismobiological and other types of observations - a total of 162 parameters.

In 2025-2026, it is planned to open new seismic stations in the Republic of Kazakhstan: including within the framework of program-targeted financing (PTF) for 2024-2026 (Agreement No. 382 / PTSF24-26 dated October 1, 2024 with the KN MNVO RK) in the spring (April-May) of 2025, installation of 10 strong movement points in the territory of the city of Taraz, and in the summer (August-September) it is planned to install 8 broadband seismometers in the territories of the Turkestan region. In the spring of 2026 (April-May), it is planned to install 7 broadband seismometers in the territories of the Mangistau region.

Pursuant to the instruction of the Government of the Republic of Kazakhstan dated October 1, 2024 No. 16-01/04-656//24-01-12.1, information is provided on paragraph 1.11 "Take measures to study China's experience in the practical application of scientific developments in production and various sectors of the economy." At the initiative of the Institute of Geophysics and the Earthquake Administration of China, the issue of creating a China-Kazakhstan seismic network and a Global Navigation Satellite System is being worked out together with the National Scientific Center for Seismic Research. Financing of this network in the Republic of Kazakhstan is planned by the China Earthquake Administration within the framework of the Belt and Road Initiative (BRI) project.

In pursuance of paragraph 1.11 of the instruction of the Government of the Republic of Kazakhstan, 5 stations will be installed in 2025.

Thus, by the end of 2026, it is planned that the total number of seismic stations will be 198, including both existing and new facilities under construction.

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