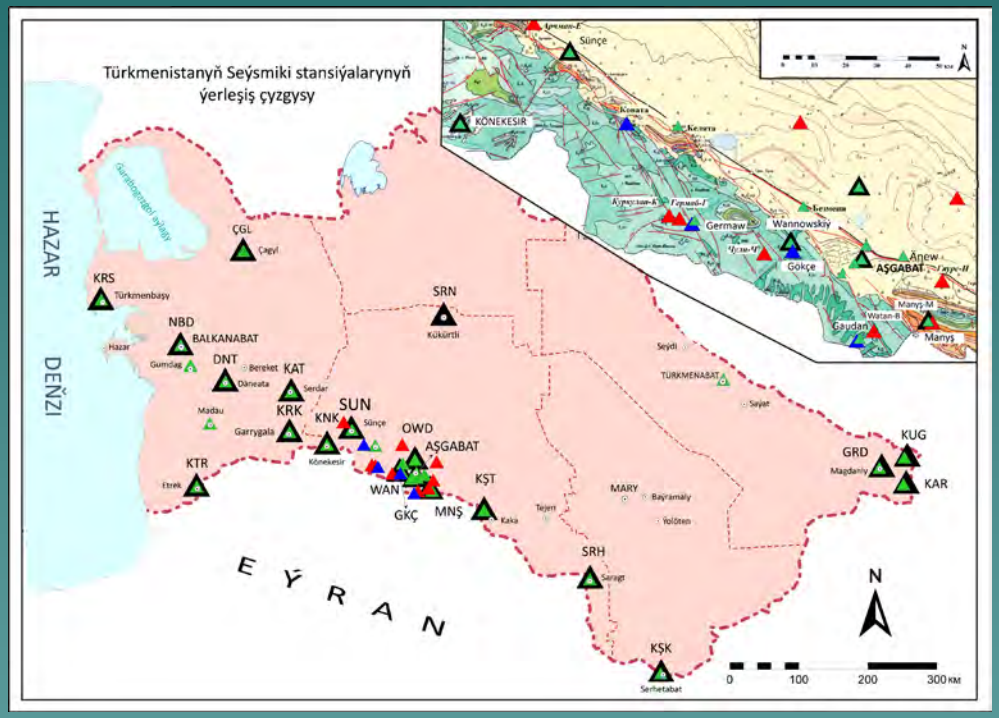
"Focus zones of strong earthquakes occurring in Turkmenistan. Disaster and recovery after Ashgabat earthquakes of 1948"



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An earthquake is one of the most dangerous natural disasters, claiming tens to hundreds of thousands of humans lives and causing devastating destruction over vast areas. One of the regions with frequently occurring strong earthquakes is the Alpine-Himalayan mountain-fold belt, about 10 thousand km long and up to 300 km wide, stretching from Gibraltar through the Alps, the Caucasus, Iran, the Himalayas to Burma. The territory of Turkmenistan stands in the lineup of highly seismic regions of the aforesaid seismic belt.

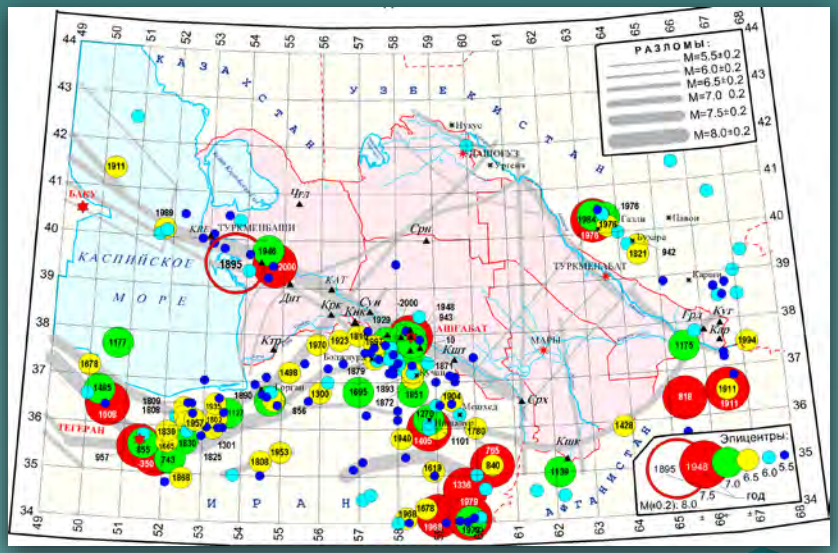


Fig.1 Map of the epicenters of Turkmenistan and neighboring countries with M ≥5.5

Of all historically recorded strong earthquakes in Turkmenistan the oldest one dates back to as early as 2 thousand years BC. The next earliest of this type are Nyssa earthquakes occurred nearly at the same place and dated 10 and 943 AC, respectively. Also well-known is the Kerkinsky earthquake occurred on 1175 AC in the eastern part of this country. On July 8, 1895, nearby the city of Turkmenbashi, there occurred the Krasnovodsk earthquake - the strongest seismic event ever known to take place within the territory of Turkmenistan. A significant feature of this earthquake is a huge area where it was felt, occupying the territory of about 3,000 thousand square kilometers. On May 1, 1929, the Germab earthquake occurred on the border with Iran, where the magnitude of the shaking was estimated at 9 points. The earthquake was followed by a long-term aftershocks activity in Iran and Turkmenistan , which persisted throughout the next few decades until about 1933. The intensity strength during one of the later events, namely, the Kazanjik earthquake of 1946, was estimated at 8 points MSK-64, where about 70% of the existing buildings were damaged. The 1997 Bojnurd Iranian earthquake was preceded by a fairly strong foreshock that occurred 43 minutes prior to the main shock. In the villages of Turkmenistan, located in the border area, the earthquake was felt at the intensity strength level of 6 to 7 points by MSK-64. On December 6, 2000, in Western Turkmenistan, there occurred a strong Balkhan earthquake with a magnitude of Ms=7.3. This earthquake is the most powerful in Turkmenistan over the past few years.

2000 BC Ak-Tepinskoye. M=7.1, h=18 km, I_O=9-10 b.
10g. Nyssa. M=7.1, h=18 km, I_O=9-10 b.
943 Nyssa. M=7.1, h=18 km, I_O=9-10 b.
1139 Kushkinskoe. M=7.0, h=20 km, I_O=9 b.
1175 Kerkinskoe. M=7.1, h=15 km, I_O=9-10 b.
1208 Amudarya. M=6.1, h=10 km, I_O=8-9 b.
07/08/1895 Krasnovodskoe. M=8.2, h=60 km, I_O=9-10 b.
01/05/1929 Germabskoe. M=7.2, h=21 km, I_O=9 b.
11/04/1946 Kazandzhik. M=7.0, h=26 km, I_O=9 b.
10/05/1948 Ashgabat. M =7.3, h=18 km, I_O=9-10 b.
14/03/1983 Kumdag. M=5.7, h=12 km, I_O=8 b.
22/02/ 1984 Burunskoye. M=5.9, h=15 km, I_O=8 b.
06/12/2000 Balkhan. M=7.3, h=45 km, I_O=8-9 b.

Strong earthquakes

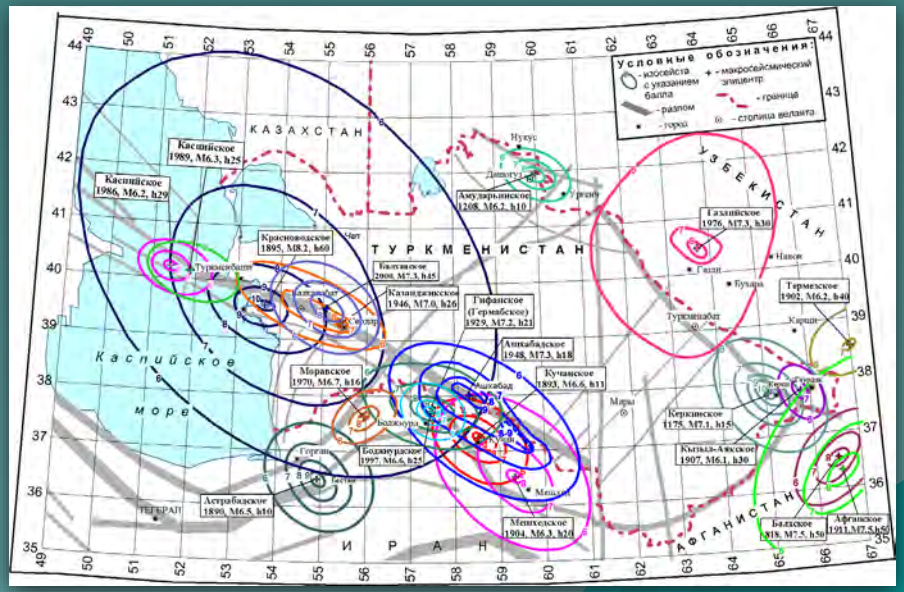
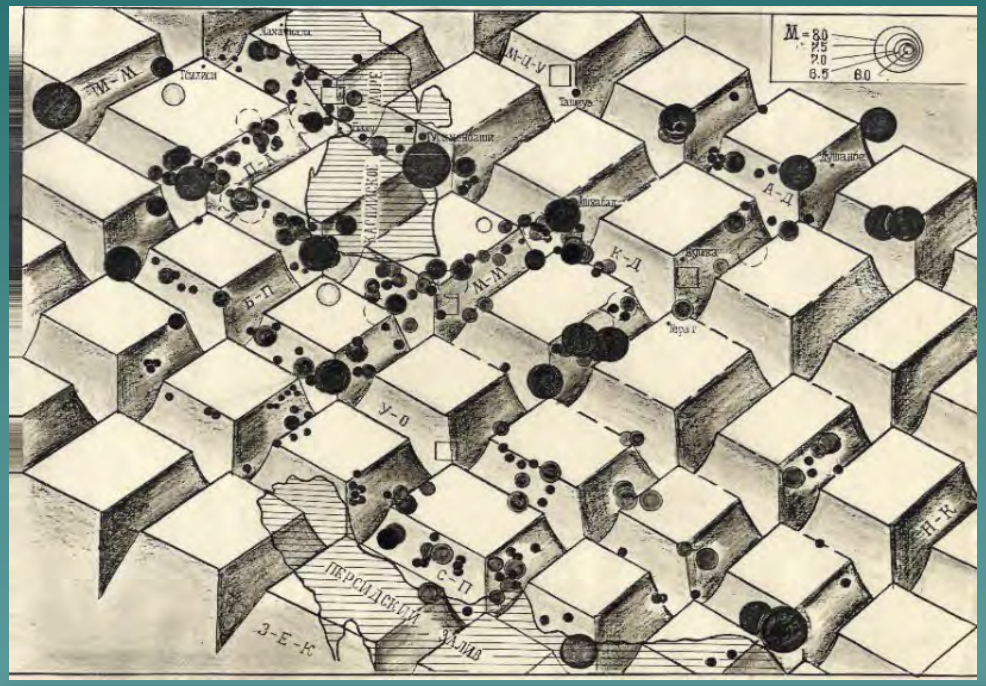
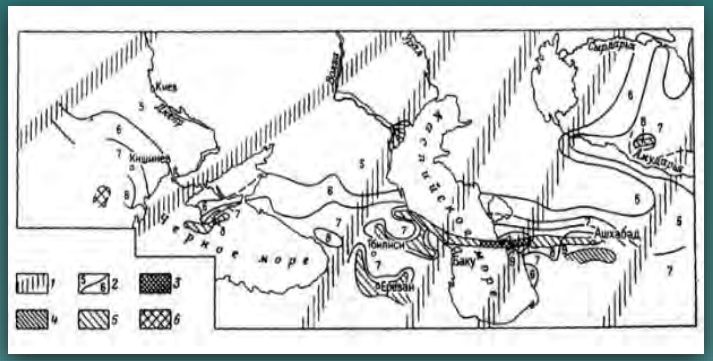


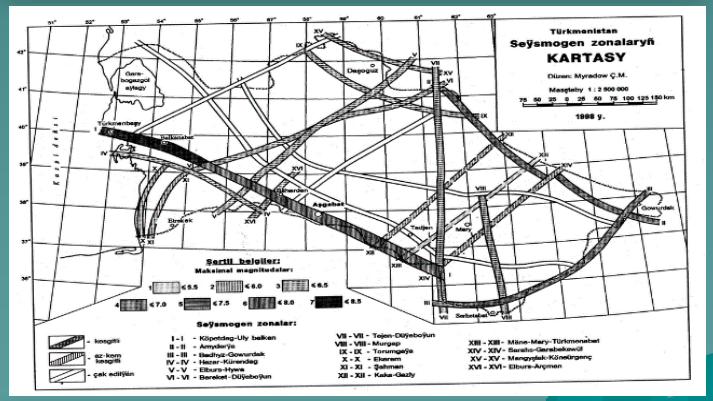
Fig.2 Isoseist map of the strongest earthquakes

The Institute of Seismology and Physics of Atmosphere of the Academy of Sciences of Turkmenistan is studying the strongest earthquakes, the nature of their occurrence, identifying spatial-temporal patterns in the distribution of seismicity in the region. A catalog of all earthquakes has been created for the entire Turan-Iranian region (Fig.3). When building a map of epicenters, it has been found that a magnitude M = 7.5 and stronger earthquakes are arranged in an orderly manner as a function of magnitude at predominant inter-epicentral distances of about 450 km.



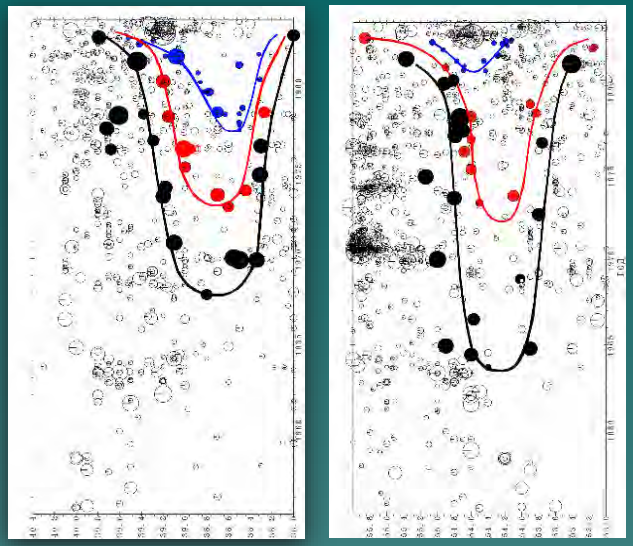
Rice. 3 Scheme of seismotectonic lithospheric blocks with a potential of M max=7.5. The most seismogenic are the northwest trending lineaments:1) North Persian (S-P); 2) Urmia-Ormuz (U-O); 3) Bolshebalkhan-Kopetdag (B-K); 4) Mangyshlak - Central Ustyursky (M-Ts-U) and northeast strike: 1) Iskander-Makhachkala (I-M); 2) Palmyro-Absheron (P-A); 3) Bagdat - Pekhlevansky (B-P); 4) Mend-Mullaly (M-M); 5) Nal-Kashgar (N-K), as well as their extensions, delimiting blocks of the earth's crust



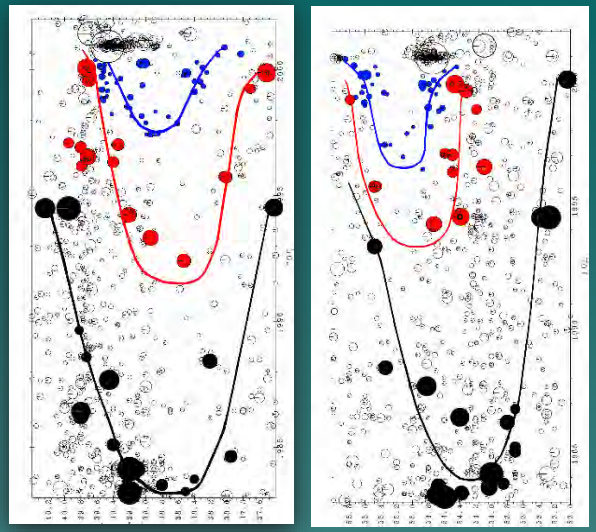


Fragment of the map of lineaments in the territory Turkmenistan and northern Iran.
Map of seismogenic zones of Turkmenistan.

None of more or less felt seismic events escaped the attention of the institute. Several stages of earthquake preparation were identified: from a stationary seismic regime to the eemergence of a system of self-organized areal elements, when significant earthquakes all of a sudden cease to occur in one or another local region, followed by the occurrence of a strong earthquake within the “deepest part” of the spatial-temporal "bay» on the relevant scatter graph.



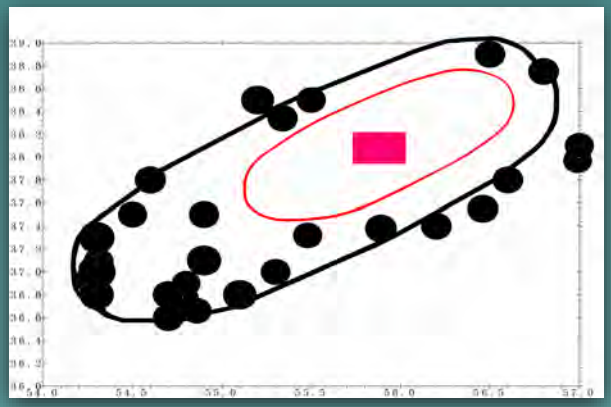
Kumdag earthquake in 1983



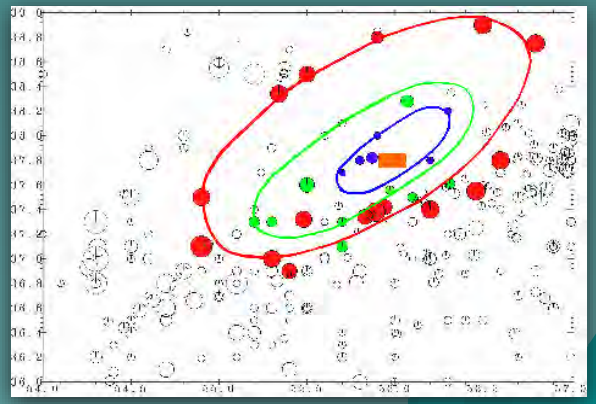
Balkhan earthquake in 2000

Fig.4 Spatial-temporal distribution of seismicity with K≥ 9 along and across the seismogenic zone

Areas of deficiency in seismic energy release, which often occur before large crustal earthquakes, can serve as precursors. Among a number of studied phenomena that are of value in modern practice as precursors are seismic “gaps of the second kind” of the Mogi “doughnuts” type of ring seismicity. The temporal sequence of earthquakes manifested itself in space in the form of nested orbital trajectories of the distribution of earthquakes K ≥ 11, K ≥ 10, K ≥ 9. The trajectory of earthquakes K ≥ 11 coincides with the volume limits of the calm region, including deformations and the future source of destruction.



Map of epicenters of earthquakes with K≥12 for 1955-1970.



Map of epicenters of earthquakes with K≥9 for 1955-1970.

Fig.5 Moravian earthquake in 1970.

The city of Ashgabat is located directly in the zone of the Kopetdag-Big Balkhan fault, which, according to tectonic data, has the highest seismic potential among the faults in Turkmenistan, namely, Mmax = 8.0. On October 6, 1948, a strong earthquake occurred in the Ashgabat region. In less than a very short period of 10 to 15 seconds, the city and nearby villages were destroyed. The earthquake was recorded by a large number of seismic stations, including those located in Russia, Georgia, Armenia, Uzbekistan, Kazakhstan, Azerbaijan and others. The focal depth of the earthquake is estimated at 18 km; magnitude (MLH) - 7.3. This earthquake is considered one of the most destructive earthquakes in human history; the intensity of shaking in the epicentral region reached the intensity level of 9 to 10 according the MSK-64 macro-seismic scale. The main earthquake consisted of two shocks, with an interval of 5-8 seconds. Almost 100% of residential one-story adobe constructions collapsed and were destroyed. After the disaster, only a few buildings were considered to be suitable for use after a major reconstruction.

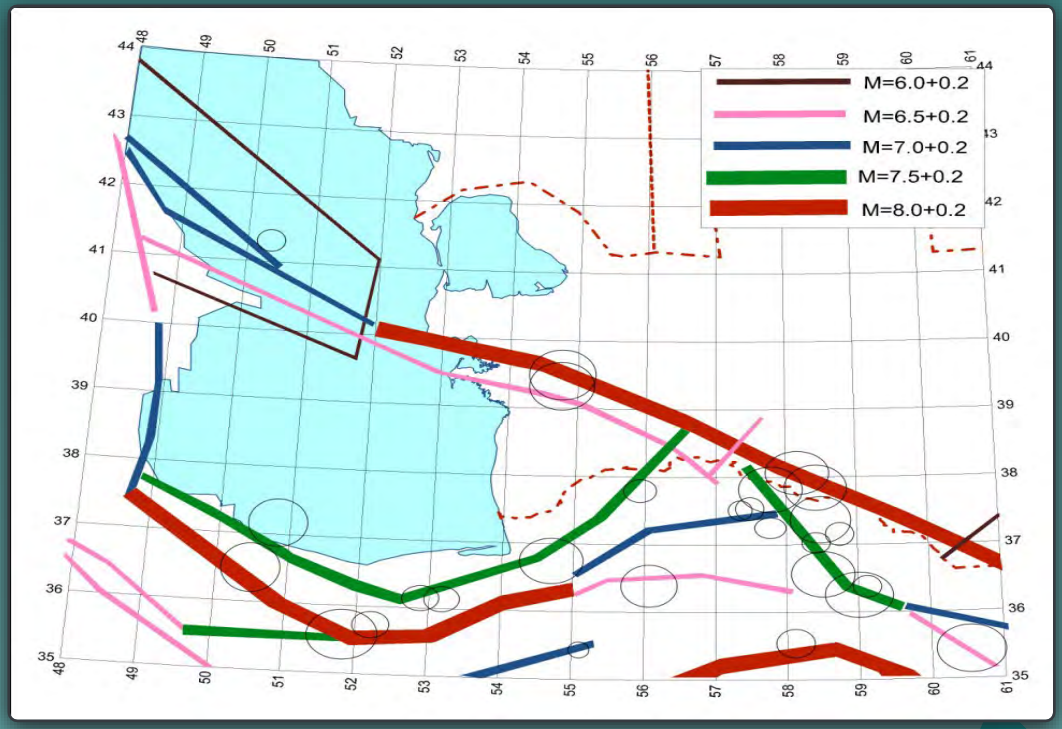
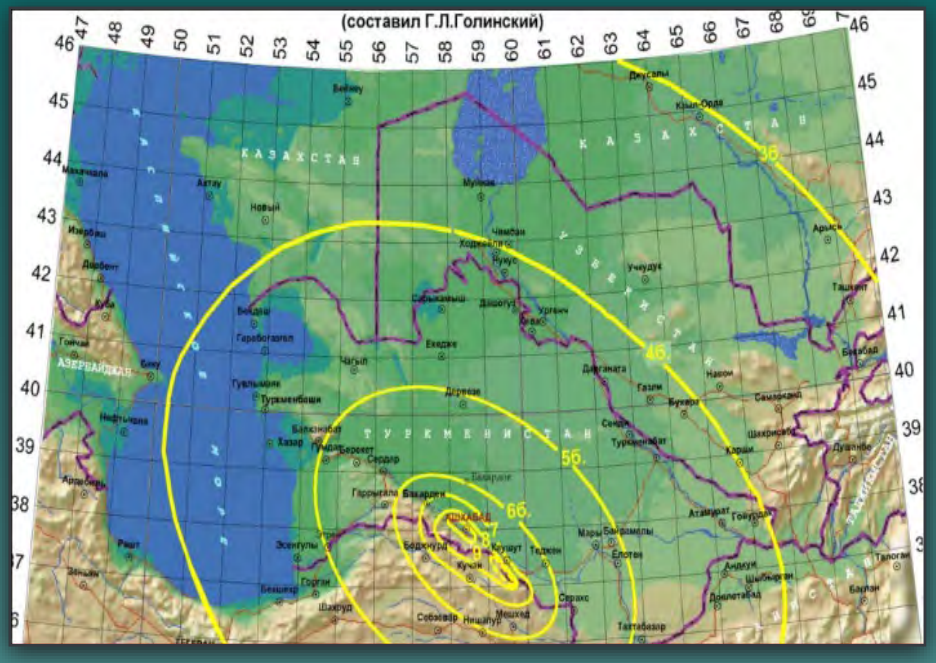


Fig.6 Seismic potential of faults (INTAS)



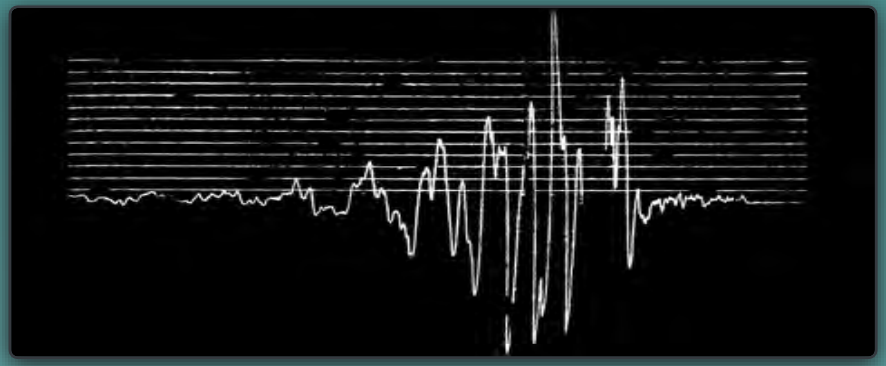


Fig.7 Isoseist and seismogram of Ashgabat earthquake in 1948

What is the reason for such large losses? First, the source of the earthquake resided at a relatively shallow depth within a densely populated area. Secondly, seismology in this country took its first steps - the first seismic station "Ash-Khabad" was opened in 1947, which did not allow an objective assessment of the seismic hazard. Seismic resistance standards were underestimated by two or three intensity points. During the construction of the city territory, the engineering characteristics/properties of soils, the hydrological conditions of the area and the location of the main tectonic seismogenic structures were not taken into account in full or even were not taken into consideration at all. And, thirdly, the due attention was not paid to the quality of construction. As a consequence, adobe buildings and the buildings mostly made of raw bricks prevailed. The situation was aggravated by the fact that the earthquake occurred late at night, when most of the inhabitants of the city were asleep. The consequences of the devastating Ashgabat earthquake on October 6, 1948 turned out to be catastrophic for Turkmenistan. The capital and many surrounding villages were completely destroyed. Thousands of residential buildings, plants and factories, shops, hospitals and kindergartens, schools and higher education institutions, historical and architectural monuments turned into a pile of ruins, under which tens of thousands of people died.

This day became the national tragedy of the Turkmen people. Since 1995, the October 6, 1948 event has been commemorated as a Memorial Day in Turkmenistan.

Fig.8 Consequences of the Ashgabat earthquake.

A crack in human growth (photo from the archive)

The Ashgabat earthquake of 1948, in fact, (i) gave rise to a heightened interest in Seismology-related scientific and technical activities , (ii) presented new requirements for the assessment of real seismic hazard, for methods for calculating buildings and structures for seismic loads, for the quality of design, building materials and the construction in seismically active zones .

To date, every effort is made in this country to minimize the risk of earthquake-related tragedies. The country has a state program "Seismic Risk Reduction in Seismic Zones of Turkmenistan". An expert council for seismic hazard assessment and earthquake prediction was established under the Academy of Sciences of Turkmenistan with the participation of a working group of the Institute of Seismology and Physics of Atmosphere of the Academy of Sciences of Turkmenistan. The program includes doing the works aimed at clarifying the seismic hazard for the territory of Turkmenistan, compiling maps for the quantitative assessment of seismic hazard of various degrees of detail, and determining zones of possible earthquake sources.

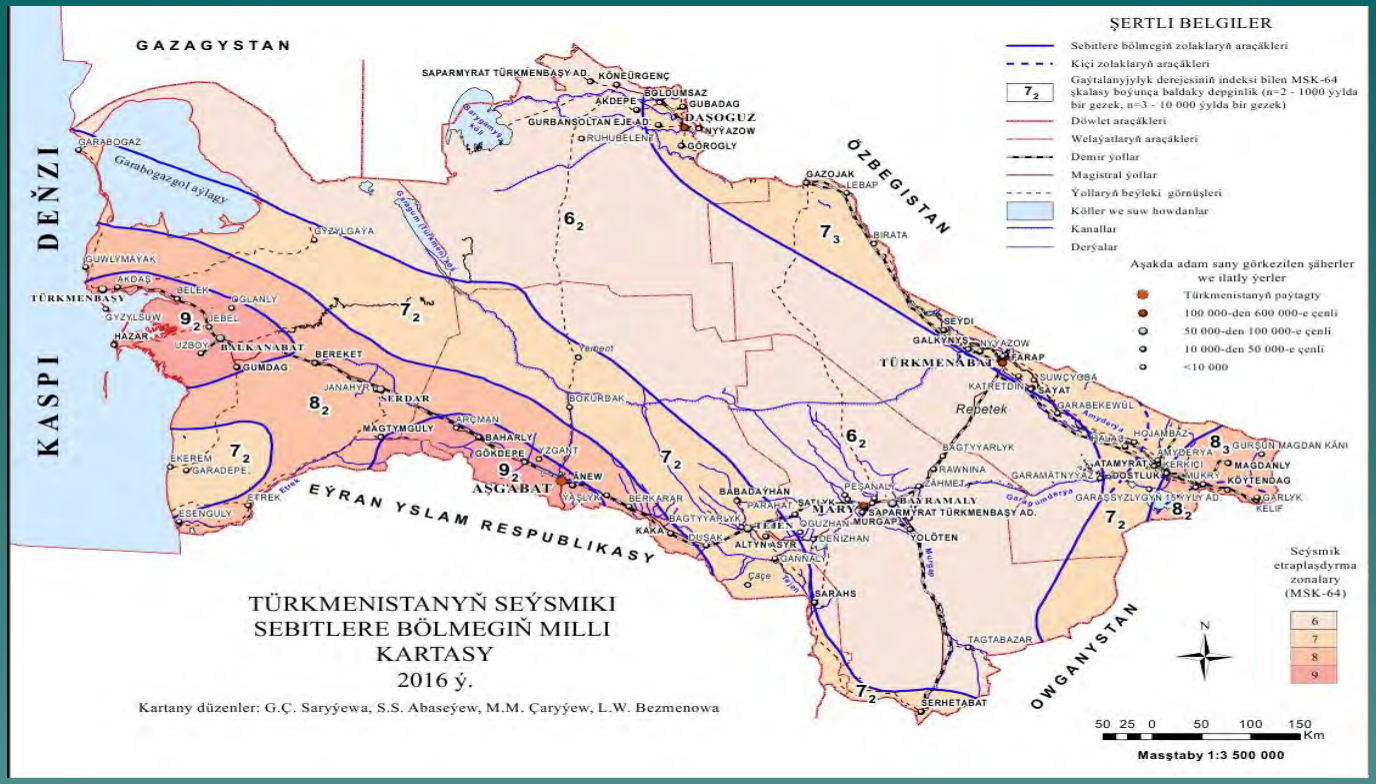


Fig.9 National map of seismic zoning of Turkmenistan (2017)

The Institute of Seismology and Physics of Atmosphere of the Academy of Sciences of Turkmenistan developed the National Map of Seismic Zoning of Turkmenistan in 2017 and a new seismic microzoning map of Ashgabat in 2023. Now the Institute is developing maps of Arkadag and Balkanabat cities. All new maps being developed will be approved as regulatory documents for construction. On the basis of normative maps of seismic zoning, earthquake-resistant construction, rational land use and long-term socio-economic planning are carried out, seismic vulnerability and possible damage from the destructive consequences of strong earthquakes are assessed.

In this country, ensuring the seismic resistance of buildings and structures is given the first priority attention. Much attention is also paid to assessing the seismic vulnerability of industrial and social facilities; creating an engineering seismometric monitoring network, especially as regards the buildings of critical importance and structures in seismically active zones; training specialists in seismic risk management. The success of Turkmen scientists in the field of earthquake-resistant construction has been achieved owing to improvement of the methods for calculating structures, obtaining new materials and, on their basis, the development of earthquake-resistant structures. Considerable foundations are being laid for industrial construction employing, as a raw material, (i) the dune sands, (ii) production wastes and other local materials in earthquake-resistant construction.

A new line in seismological science is seismic risk, that is, predicting what will happen to buildings and structures as a result of one or another strong earthquake. Since 2018 , the Institute, in cooperation with the United Nations Development Program, participates in the Project “Strengthening the National Capacity of Turkmenistan in Seismic Risk Assessment, Prevention and Response to Potential Earthquakes”. The motivation for these studies is the ability to quickly assess all the risks of an earthquake that is being prepared or has just occurred and quickly make management decisions to reduce these risks and reduce catastrophic consequences. Much attention at the Institute is paid to cooperation with international seismological organizations. The project “Improving the system of seismological observations in the city of Ashgabat and around it” is being implemented under the “Technical Cooperation Agreement”, notes verbale between the Government of Japan and the Government of Turkmenistan. The project is aimed at modernizing the system of seismological observations, at the same time creating an appropriate information network, as well as engineering and geological study and seismic assessment of the territory of the city of Ashgabat. One of the outcomes of the project will be the commissioning of a real-time digital seismological observation system.

Over the past 75 years, the city of Ashgabat has been reborn anew and has become one of the most beautiful modern cities on the planet (Fig.8). The experience of mankind, drawn from many tragedies associated with seismic catastrophes, shows that it is possible to reduce the degree of destructive effect of earthquakes by increasing the seismic resistance of buildings and structures. But this can only be achieved with the support of scientific and technological research to develop measures to protect against natural disasters. It is this purposeful policy pursued in our country by the President of Turkmenistan, who pointed out seismology and earthquake-resistant construction among other priorities of science.

Rice.10 The modern city of Ashgabat

Thank you for your attention