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GEODYNAMIC STUDY OF THE MOVEMENT FOR LITHOSPHERE PLATES IN ALMATY

АЛМАТЫ ҚАЛАСЫНЫҢ ЛИТОСФЕРАЛЫҚ ТАҚТАЛАР ҚОЗҒАЛЫСЫН ГЕОДИНАМИКАЛЫҚ ЗЕРТТЕУ

ГЕОДИНАМИЧЕСКОЕ ИССЛЕДОВАНИЕ ДВИЖЕНИЯ ЛИТОСФЕРНЫХ ПЛИТ Г. АЛМАТЫ

Annotation. The article examines the distribution of current surface movements and changes due to the movement of lithospheric plates. Due to the proximity of the city of Almaty to the earthquake center, the occurrence of earthquakes, tectonic belts, geodynamic polygon zones, features of underground movement are described.
Keywords*: earthquake, geodynamics, crust, oscillations, globality, polygon, location, point.*

Аңдатпа. *Мақалада қазіргі уақытта болып жатқан жер беті қозғалыстарының таралауы менлитосфералық тақталардың қозғалуына байланысты өзгерістер зерттеген. Алматы қаласының дүмпу орталығына жақын орналасуына байланысты жер асты дүмпулермен қозғалыстардың орын алуы, тектоникалық белдеулер, геодинамикалық полигон аймақтары, жер асты қозғалысының ерекшеліктері жайында сипатталады.*
Түйін сөздер: *дүмпу орталығы, геодинамика,жер қыртысы, тербеліс, ғаламдық, полигон, орналасу, нүкте.*

Аннотация. *В статье рассматривается распределение современных движений поверхности и изменений, связанных с движением литосферных плит. В связи с близостью города Алматы к очагу землетрясений описывается возникновение землетрясений, тектонические пояса, зоны геодинамического полигона, особенности подземного движения.*
Ключевые слова: *очаги землетрясении, геодинамика, кора, колебания, глобальность, полигон, местоположение, точка.*

Introduction. Modern movements on the surface of the earth are an integral part of the surrounding world, and there is no point on earth completely free from them. Today, active tectonic zones are characteristic, such as active continental platforms, rift zones, mid-ocean

ridges, plate collision boundaries, etc. Tectonic modern terrain movements are the largest manifestation of earthquakes in these areas. It has been found that the earth's crust and the entire surface of the earth experience complex, various vibrations.

Materials and methods of research. In seismic zones, where the deformation of the earth's crust - the rise of some of its blocks and the subsidence of others - is maximum, the modern terrain movements is of particular importance.

In places weakened by tectonic faults, deformations can, in a short period of time, reach the limiting values for the integrity of the rock mass that makes up the earth's crust. Therefore, it is necessary to monitor accumulated deformations through repeated observations and study the characteristic features of their development over time [1-3].

In the course of the study, based on these data, it is possible to estimate the degree of proximity of the deformation process to the critical state, which is an instantaneous release of accumulated stresses.

Motion detection is a very difficult task nowadays. The intensity of tectonic movements of the earth's crust is usually measured in millimeters per year, and it is possible to distinguish them from other processes occurring both on the surface and in the interior only by various instrumental methods and high-precision measurements, but these studies include long-term and urgent measurements.

The study of modern movements and deformations occurring in the upper part of the earth's surface requires high-precision geodetic measurements in the mode of monitoring the movement of points at specially equipped monitoring stations - geodynamic polygons [4].

Various methods for studying modern movements. Vertical movements are studied mainly by the multiple smoothing method. On this basis, maps of modern tectonic movements are compiled.

Such geodetic inspections are important along railroads, oil and gas pipelines, and at large dam, hydroelectric, and nuclear power plant construction sites.

Global geodynamic research is supported by the International GPS Service (IGS). In Northeast Asia, regional studies are carried out in Kamchatka, Primorye and Japan; There are about a thousand permanent stations in the GPS network.

An extensive modern terrain movements research program is planned in the United States. In the latitudinal and meridian directions, the country is crossed by high-precision levels with a total length of more than 30,000 km, which provide a detailed map of the vertical movements of the earth's surface. For several years, the US Geodetic Survey conducted regular triangulations at 14 sites in California, Nevada and Utah, resulting in characteristics of the horizontal movement of the Earth's surface.

In the western part of North America, in California, there is a seismic fault called the San An Dreas, which can be traced over a distance of more than 1000 km and a width of up to 20 km.

The San Andreas Fault is a complex tectonic zone consisting of many rock faults along which displacements of 30-80 mm or more are established annually (Fig. 1).

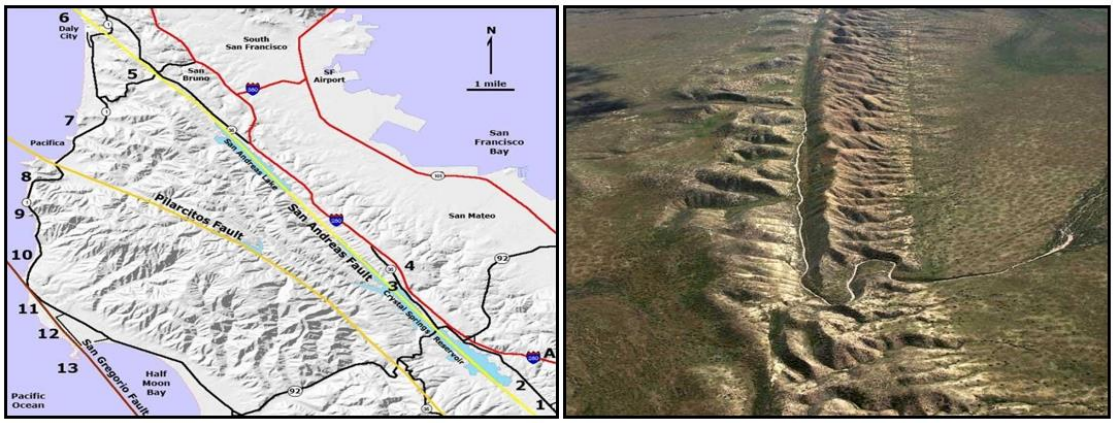

Figure 1. Eruption of San Andreas, California (USA)

Currently, GPS satellite navigation systems are widely used and can replace classical measurement methods in geodesy. Accuracy that satisfies the accuracy of classical methods in geodesy, but at the same time it is desirable to effectively use this method in modern terrain movements studies, since it requires less investment in both time and financial costs (Fig. 2).

The study of modern movements and deformations occurring in the upper part of the earth's surface requires high-precision geodetic measurements of displacements of geodynamic polygon points at specially equipped monitoring stations in monitoring mode.

The term "Geodynamic site" refers to an area selected for geodetic, astronomical, gravimetric and oblique observations, data used to determine the movement of points on the earth's surface. Geodynamic polygons are sometimes called “model areas” and geodetic work in them is part of a complex of scientific geodetic and geophysical studies aimed at obtaining quantitative characteristics of the stability of the relative positions of points on the earth’s surface over time (Fig. 2).

Figure 2. Space geodesy

When studying geodynamic processes using GNSS technologies, two spatiotemporal modes are predominantly used - a one-time redefinition of the initial coordinates of GGS points and reference geodetic networks and measurement of displacements and deformations in the monitoring mode.

When performing long-term studies, a mixed mode is often used, when the initial coordinates of the reference stations of the monitoring station are redefined during the zero

cycle of operation, and displacements and deformations are determined over a certain period of time during the following measurement cycles.

As a result of a study of the use of global navigation satellite systems, Earth remote sensing data, as well as ground-based methods, differing in measurement and data processing parameters and conditions for assessing horizontal and vertical displacements of the earth's surface, the following conclusions were made: Chapter two:

- the use and application of satellite technologies in the study of modern movements of the earth’s surface makes it possible to effectively solve the problems of geodynamic monitoring, which can replace classical methods in terms of accuracy and productivity;
- despite the advantages of satellite technologies over classical geodesy methods, there are also certain disadvantages. The main ones are sources of errors in satellite orbital ephemeris and atmospheric errors in signal propagation through the troposphere and ionosphere, as well as satellite and receiver clock errors. Multiband propagation typically occurs in urban areas with extensive urbanization;
- in addition, methods for using remote sensing data and the principles of satellite radar are considered. Advantages and disadvantages of radar interferometry [5].

Compared to satellite technology and ground-based methods used in geodesy to study modern movements of the earth's surface, radar interferometry occupies a leading position. Because it is the most effective, but the data obtained from processing radar images show only the vertical component of terrain deformation, their size is relative.

Ground survey methods together with satellite technologies make it possible to identify both horizontal and vertical components of deformations, the magnitudes of which are absolute.

In my opinion, integration with ground-based methods, satellite technologies and radar interferometry methods is necessary.

The city of Almaty is located in the center of the Eurasian continent, in the southeast of the Republic of Kazakhstan, at the foot of the Trans-Ili Alatau mountains - the northernmost ridge of the Tien Shan, at an altitude of 600 to 1650 meters above sea level. Geographic coordinates: 77 degrees east longitude and 43 degrees north latitude (Figure 3).

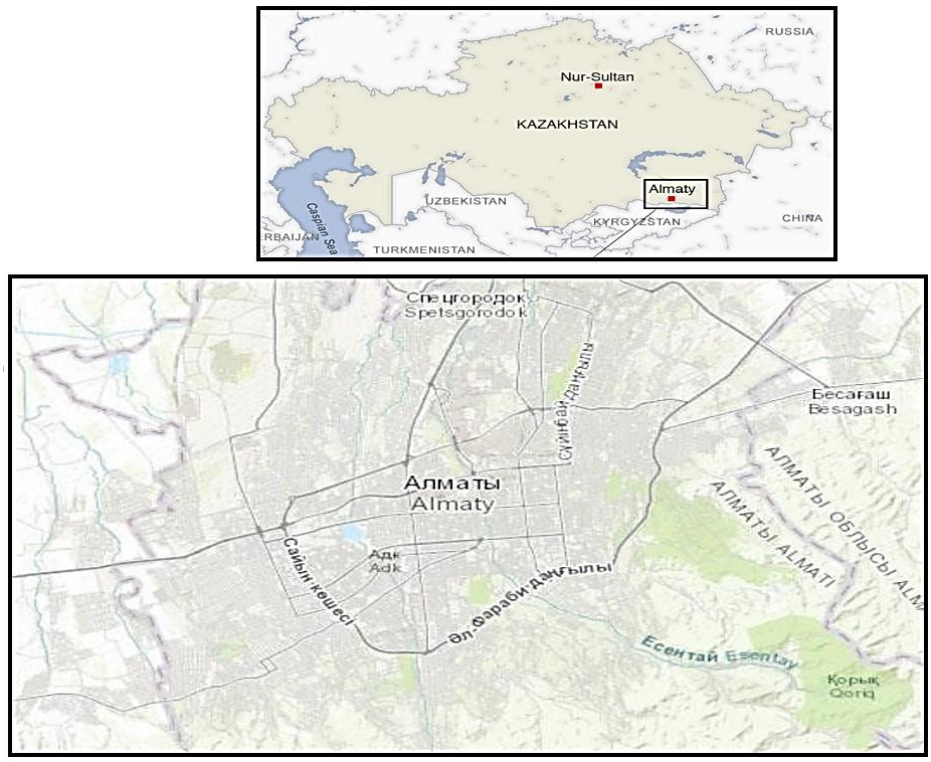

Figure 3. Location of Almaty

In the epicentral area of the destructive Verny and Kemin earthquakes on the territory of Almaty, the prognostic Almaty Geodynamic Test Site (AGP) was created to monitor and study the earthquake modern terrain movements (Fig. 4). This test site was created for the purpose of microseismography and a more detailed study modern terrain movements of the highly seismic zone of the Northern Tien Shan, which occupies an area of about 400 square kilometers.

In 2019, satellite observations were carried out using GPS equipment for the purpose of research work and further study of geodynamic processes characterizing horizontal movements in the studied area of the Almaty geodynamic test site.

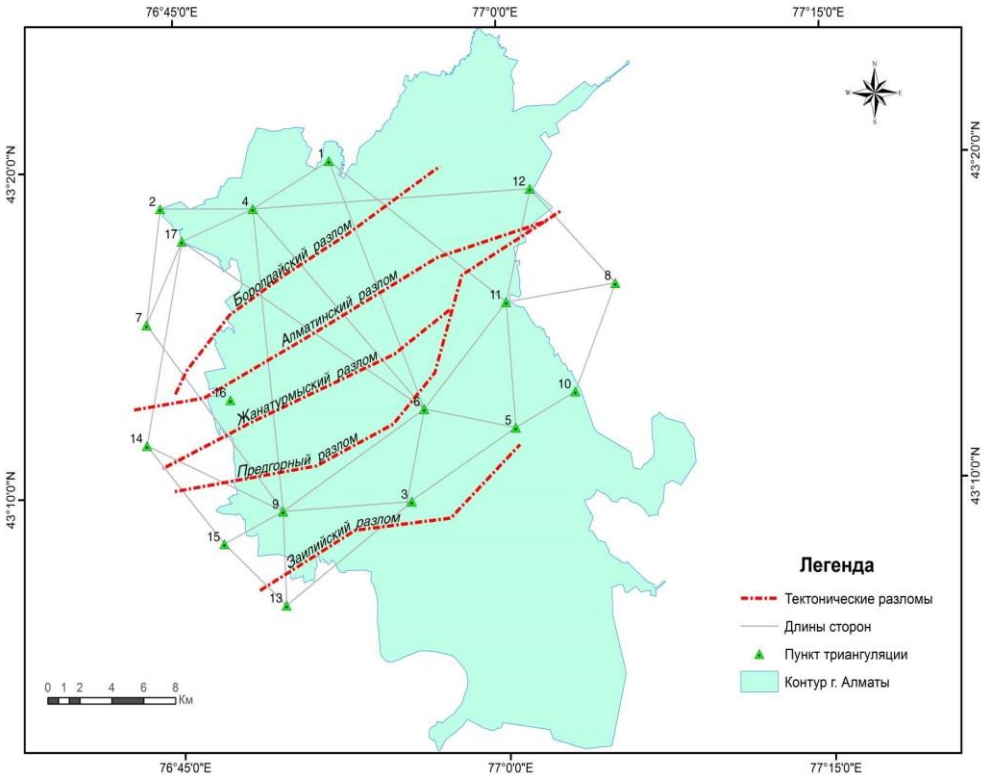

Figure 4. Almaty GDP Chart

Previously, in all cycles, geodetic measurements were carried out using traditional methods, that is, angles and side lengths were measured. The last measurement cycle was carried out in 1992. There is currently no visibility between points in some directions, and outliers over point centers are lost, making angular measurements impossible.

As a result of a comprehensive analysis of several geodetic measurements of the Almaty geodynamic range, carried out using ground survey methods and satellite technologies, it became possible to study in detail the modern movements of the surface of the object under study:

- to obtain reliable data on the territorial distribution of the horizontal component of the displacement, it is necessary to jointly use in processing the data obtained by linear measurement with an LED meter and GNSS measurement data;

- to determine and assess the degree of modern activity of faults, as well as to determine the parameters of modern vertical movements of the earth's surface, use the method of high-precision geometric leveling used for geodynamic polygons;

- comprehensive analysis and interpretation of the obtained qualitative and quantitative indicators of the dynamics of modern geodynamic processes of the object under study is directly related to high-quality post-processing and choice of software;

- repeated leveling lines of classes I and II in comparison with several levelings of previous years mainly showed a discrepancy between new and old overhangs;

- based on the results of leveling in 2016, it can be concluded that vertical movements are mostly insignificant, since the amplitude of changes in emissions according to benchmarks ranges from -0.1 to +14.1 mm per year and does not exceed the possible accumulation of measurement errors ±3L;

- the values of the differences in the inclined ranges measured between points show that the number of negative differences over 42 years is 2.1 times greater than the number of positive ones, and their sum is 3.8 times greater than the sum of positive ones, which corresponds to the process of horizontal compression of the area at an average speed - 1.0 mm/year [6].

According to geological data, the tectonic structure of the Ili region and the Ili depression is very complex. Predominantly explosive faults are oriented to the northeast and northwest.

A more pronounced step structure of the fall zone is presented in the Almaty region, where systems of tectonic belts in the form of linear blocks rise from north to south. There are about 11 tectonic blocks separated by a distance of about 25 km.

The boundaries of Almaty's GDP include all of the above neighborhoods, as well as the city itself and its surrounding suburbs. The total number of places on the territory of the regional landfill is in the thousands. Meridional faults intersect with latitudes and form tectonic nodes that increase the seismic activity of the entire region.

Conclusion. After all, it is in these places that the maximum velocity gradients of large deep faults and vertical tectonic movements appear. A brief description of these GDP control points (points) is as follows: 4-sided metal pyramids were used as external signs. The legs of the pyramids are concreted on concrete pillars 1.5 m high, 0.3 m in diameter, 0.5 m high above the ground.

A study of the geological conditions for the occurrence of strong earthquakes in the central part of the Tien Shan has shown that they occur in zones of junction with the ridges of subalpine and interalpine valleys, in places where the foundation bends.

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