RESEARCH OF HORIZONTAL MOVEMENTS OF THE EARTH'S CRUST IN THE ARCHIPELAGO ARGENTINE ISLANDS (ANTARCTIDA) DURING PERIOD 2003-2018

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Abstract - A network of triangles with vertices of GNSS observation points is created. The deformation parameters of each triangle were calculated using the software "GPS TriangleStrainCalculator" developed by UNAVCO. The obtained values are used to construct maps of distribution of velocities of dilation and displacement of points for the period of 2003-2018 years, that shows movements of tectonic plates in the area Penola Strait.

Key words: geodynamics, deformation parameters, area strain, GNSS, Antarctica.

Introduction

The Antarctic continent plays important role in the context of plate tectonics. Investigation of the lithosphere and the detection of the grid of faults in the continent and adjoining territories is essential for understanding the geodynamic evolution of the region. In the last time, for such investigations, GNSS measurements have been used more often. This is mainly due to the rapid increase in the number of GNSS stations, and the accuracy of determining their coordinates reaches 2 mm in X,Y and 3 mm in Z. According to [1], satellite observations confirm their high efficiency for solving geotectonic problems, enable not only discrete measurements, but also regular monitoring of deformations and stresses occurring in the earth's crust. For example in [2] on the basis of analysis of GNSS data (20 years) in network the Victoria Land Network for Deformation control transformation of the Tasman and Balleny rupture zone has been established and extended to land in Antarctica. Also created new geodetic and gravimetric maps of Earth Victoria (Antarctica), the interpretation of which allows to highlight geodynamic motions. In [3], GNSS observations over the lake Vostok (Antarctica) were used to research the vertical movements of the glacial surface. It is established that the height of the glacial surface above Lake Vostok is stable during the last decade. [4] as a result of a comparison of the current movements of GNSS stations with tectonic processes of the past years, the geodynamic model of the Antarctic lithospheric plate with an anchorage to the pole of Euler rotation has been constructed. In [5], according to the results of daily solutions of 28 permanent GNSS stations in Antarctica (1996-2014), the position of the middle pole of the Euler and the angular velocity of the plate and their annual changes are determined. Annual parameters of the tensor of inertia and momentum of Antarctic tectonic plate are determined. In [6], according to the results of repeated GNSS observations in the territory of Antarctica, the assessment and differentiation the earth's surface movements on the global (Antarctic Plate), the regional (Antarctic Peninsula) and the local (Argentine Islands archipelago) have been assessed. In [7], the geodynamic model of the Penola fault is detailed. As a result of a detailed analysis the results of the GNSS measurements, planar displacements in the area of the islands of Roka, Galindez, Fanfare, and Petermann, as well as elevation in the Barkhan Islands are found. Regular surveys of local objects in Antarctica are conducted. The analysis confirms the presence of local movements in the Antarctic continent, as well as raises questions of their research and interpretation.

Results

Within the framework of the seasonal 8th Ukrainian Antarctic expedition (February-March

2003) in the Antarctic Station "Academician Vernadsky" joint efforts employees of the National University "Lviv Polytechnic" (K. Tretiak, V. Glotov) and CJSC "ECOMM" (Yu. Ladanovsky, P. Bahmach) and with the support of the National Antarctic Scientific Center a geodynamic polygon for the archipelago of Argentine Islands was created. The purpose of the field was to discover the tectonic fault of Penol Strait. Developed program at each of the points of the geodynamic polygon in the archipelago of the Argentine Islands is to hold independent sessions of static GNSS measurements. However, due to very difficult weather conditions, as well as the lack of time in some cycles, it is not possible to measure some points. Static method is considered a classic method of GNSS measurements. The principle of which is that simultaneous measurements are made between two and more fixed GNSS receivers.

To date 4 cycles of static GNSS measurements (February-March 2003, April 2005, April 2014, March-April 2018) have been performed and the coordinates in each of them have been determined. Starting from the second cycle (2005), the mean square error (MSE) of the determination leading coordinates decreased and varies within 2 mm. This makes it possible to assert that the geodynamic polygon network is stable and fully suitable for high-precision geodynamic researches. In Figure 1. is given a map of the vectors horizontal movements points of the geodynamic polygon in the archipelago Argentine Islands during 2003-2018.

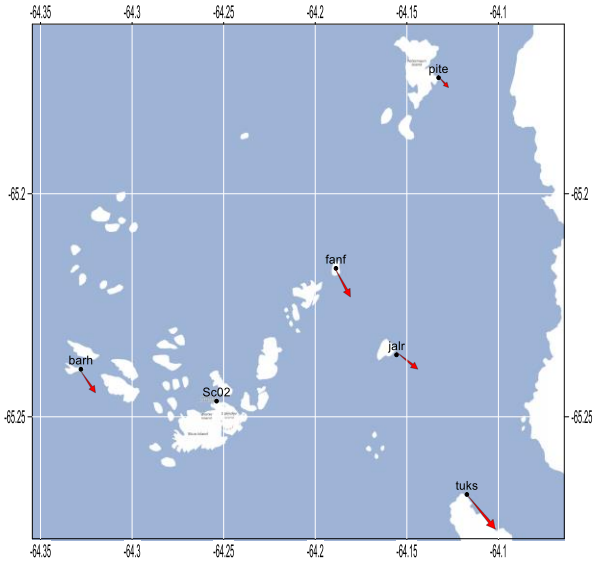

Figure 1. Map of the vectors horizontal movements points of the geodynamic polygon in the archipelago Argentine Islands during 2003-2018.

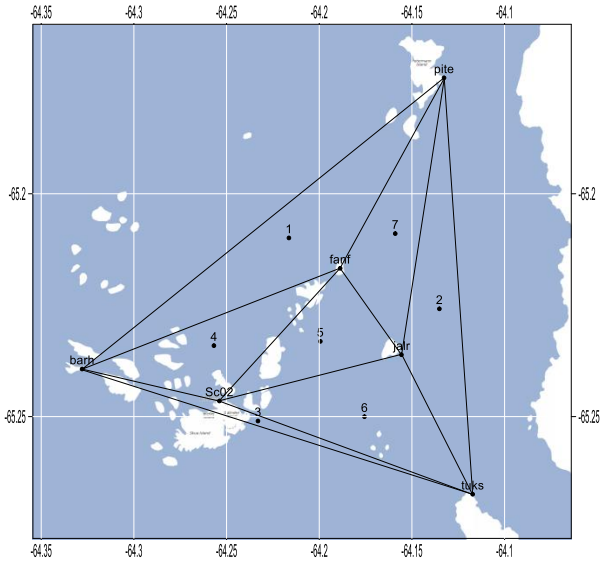

Figure 2. Configuration of triangles

Horizontal displacement vectors of the geodynamic field archipelago of the Argentine Islands (see Figure 1.) mainly have a south-eastern direction of movement. The most intense horizontal displacement is recorded at tuks and is 18.3 mm during the observation period (2003-2018). Due to the high tectonic activity of the region, it was decided to analyze the geodynamic processes in the region of the archipelago Argentine Islands. The Earth Deformation Research was performed using the GPS Triangle Strain Calculator software, developed by the Plate Boundary Observatory in conjunction with UNAVCO. Thus, on the basis of the points geodynamic polygon of the archipelago Argentinian islands, seven triangles were formed, the scheme of the created triangles is shown in Figure 2.

Using the "GPS Triangle Strain Calculator" for each triangle obtained, calculations of the individual parameters of the earth's deformation were performed, namely:

- Translation Vector – calculates the displacement of the vertices triangle along the X and Y axes, the azimuth and the velocity triangle displacement.
- Rotational Velocity – calculates the shear rate relative to the center of the triangle in a circle. Depicted by the angle of displacement..
- Max and Min Horizontal extension - calculation of tensile and compression parameters relative to the deformation ellipse, center of which is the center of the triangle.
- Max shear strain - is calculated by averaging deformation relative to the ellipse axes.
- Area strain – displays the distortion area change.

The results of the calculations performed for each triangle are given in Table 1.

Table 1

Parameters deformation of the earth's surface for each triangle

№ of triangle	Translation Vector, mm/yr		Rotational Velocity, 10^{-8}	Horizontal extension, 10^{-8}		Max shear strain, 10^{-8}	Area strain, 10^{-8}
	X	Y		Max	min		
1	0,3	-0,4	1,53, anti clock.	1,06	-8,48	9,54	-7,43
2	0,3	-0,4	-14,51, clock.	10,0	-8,63	18,63	1,36
3	0,5	-0,5	-14,48, clock.	4,81	-26,04	30,86	-21,23
4	0,4	-0,5	2,18, anti clock.	0,73	-5,66	6,39	-4,93
5	0,2	-0,4	2,00, anti clock.	1,48	-3,17	4,66	-1,69
6	0,3	-0,4	3,29, anti clock.	19,23	-9,74	2,90	9,49
7	0,4	-0,4	4,25, anti clock.	-3,87	-17,61	13,74	-21,48

By analyzing the table, one can notice that triangles 1, 4, 5, 6 and 7 have a positive rotation (1,53 - 4,25 nano-strain), and 2, 3 are negative (-14,48 - -14,51 nano strain). The values in the table, called Area strain, are used to construct a mapping scheme for the distribution of this parameter.

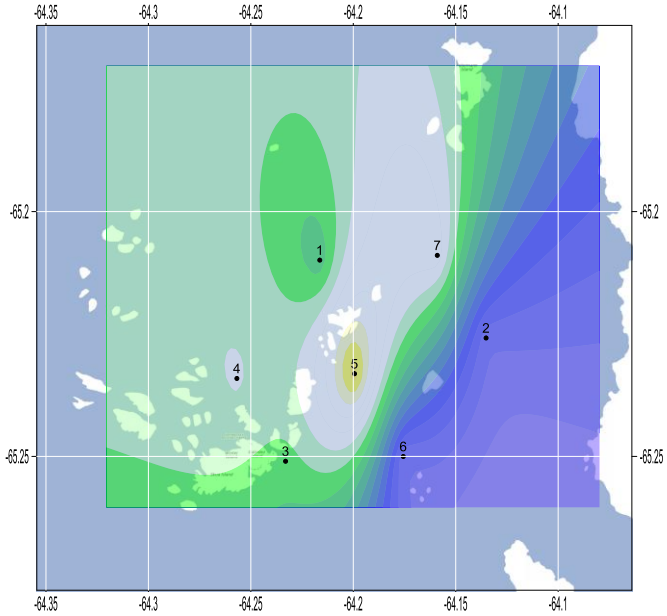

Figure 3. Map of the distortion area change.

Analyzing the presented map (Figure 3.), is able to see that in the territory archipelago of the Argentine islands are located places to detect the dilatation of the earth's crust, which

predetermines the deformation of the territory. Apparently, they are associated with the existing tectonic fault in the area through the Penola Strait.

Conclusion

As a result of the research, were calculated the parameters of horizontal deformations: Translation Vector, Rotational Velocity, Max and Min Horizontal extension, Max shear strain, Area strain. The obtained values are used for constructing maps of the distribution velocities dilatation territory of the archipelago Argentina island for period 2003-2018 of research. This allows to observe other deformation facts, in particular Area strain. Such results confirm the relevance of the research carried out and prove the attractiveness of Antarctica for geodynamic research.

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