

## ABSTRACT

of the Dissertation for the degree of Doctor of Philosophy (PhD)

6D071100 (8D07301) – Geodesy

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Digital geodetic monitoring after displacement of the Earth surface in the development of deposits

**Relevance of the research topic.** Throughout the entire period of development of mineral deposits, the issue of shifting and deformation of the earth's surface remains one of the paramount issues. At present, on the territory of the Republic of Kazakhstan and CIS countries the volume of mining works carried out is very large, which in turn leads to a shift of the Earth surface, in connection with which there is a need for geodetic monitoring in the undermining areas. The process of shifting of the the Earth surface and rock massif on ore deposits differs significantly from coal deposits, this is due to the fact that the ore bodies are characterized by a wide variety of shapes and sizes; on the territory of the same deposit, the geometric elements of the occurrence of ore deposits are often very different. One of such deposits is the Zhezkazgan copper ore deposit, where both steeply dipping and flat-dipping ore deposits are found. Over the long period of mining at the Zhezkazgan deposit, a significant number of voids have formed, which has a significant impact on the condition of the ground surface in the undermining areas, and the engineering facilities located in the immediate vicinity. Despite the fact that previously a considerable number of different pillars were left to ensure safe mining operations, recently there have been cases of self-detonation of overburden rocks.

The traditional methodology of instrumental observations of deformations and displacements of the earth's surface, along with being highly accurate, is a rather time-consuming process, which takes a significant amount of time to carry out. This issue can be solved through the development of digital geodetic monitoring, based on modern geodetic equipment. The application of innovative technologies allows to reduce the time of geodetic measurements by several orders of magnitude, to increase the speed of processing, as well as to create visual models of the earth's surface. Based on the above, it should be noted that the digital geodetic monitoring of deformations and displacement of the earth's surface during the development of mineral deposits will make it possible to predict the appearance of critical deformations in a timely manner.

The dissertation work was carried out on the basis of research on the project: on the topic 27-07-10 "Instrumental observations of the earth's surface displacement along the profile lines located in the village of Zhezkazgan and in the village GRP-Lermontovo" in 2018-2020.

**The purpose of the research** is to develop a comprehensive system of observations of geomechanical processes of earth surface displacement in the territory of the re-development of the field on the basis of digital geodetic measurements.

**The idea of the research** is a methodology for constructing a geodynamic polygon based on a geomechanical survey of the Earth's surface on the territory of

the field re-development using a comprehensive approach, using digital geodetic technologies.

**The main objectives of the research:**

- to analyze the existing methods of geodetic monitoring in the study of shifting zones of the earth's surface during the development of mineral deposits;
- to create a three-dimensional model of the earth's surface, taking into account the conditions of the formation of shifts on the earth's surface;
- to develop a methodology for creating a geodynamic polygon for observations of shifts of the earth's surface;
- to implement the developed methodology and recommendations for forecasting areas of possible technogenic disturbances and measures for their timely prevention during mining operations.

**The object of the research:** Zhezkazgan copper ore deposit of Kazakhmys Corporation LLC.

**The subject of the research** is the deformation processes of the Earth's surface and the rock massif of the deposit in order to use them for forecasting.

**Research methods:** Literature review, analytical research methods, practical experience in the study of geomechanical processes, methodology of geomechanical monitoring based on the use of modern geodetic instruments, mathematical analysis of measurement results processing and the use of geoinformation technology.

**The scientific novelty of the research** consists in:

- development of a methodology for surveying the geodynamic ground displacement polygon during redevelopment based on the integrated use of aerial photography, high-precision geometric levelling, space radar interferometry, GPS technology and seismic observation data;
- obtaining grapho-analytical comparative characteristics of observations for the period 2015-2020 based on the results of deformation process measurements in the form of wireframe, contour and vector maps, DTM using Surfer Golden Software, allowing the most reliable determination of the earth surface shift parameters, identifying dangerous areas, making long-term forecasts and taking timely measures for safe mining operations.

**The scientific significance of the research** lies in the creation of a new promising approach to managing mining operations on the territory of the re-development of the deposit based on the use of innovative technologies for collecting and processing geospatial data.

**Theoretical and practical significance of the research:** The main results of research and practical work have been implemented at the mines of Kazakhmys Corporation LLC, and are used by surveying and geotechnical services as a regulatory document. The implementation of the obtained results allows to ensure safe mining operations, and to preserve engineering structures and objects located on the earth's surface.

The use of integrated monitoring data, including: the use of satellite radar interferometry, high-precision geometric leveling, visualization of the results of geodetic observations using GIS technology, the creation of a geodynamic polygon using satellite geodesy and UAV techniques make it possible to identify in a timely

manner weakened zones, confirming the movement of the earth's surface evicted settlements Zhezkazgan and GRP-Lermontovo and conduct comprehensive digital geodetic monitoring.

The improvement of methodology of high-precision leveling, taking into account the use of electronic digital devices for monitoring the processes of displacement of the earth's surface make it possible to produce timely and reliable prediction of the state of the earth's surface from the harmful effects of mining operations.

Recommendations on the design and creation of geodynamic polygons in the study area in the future will provide information on the state of the earth's surface and rock massif, and thus ensure safe mining operations at the proper level.

**Scientific statements made for the defense:**

- during the re-development of the Zhezkazgan deposit, the change in values and rates of subsidence of the reference points of the profile lines are constant and stable, this is ensured by laying the mined-out space;

- the methodology of creating a geodynamic polygon for monitoring on the territory of re-development of the deposit, taking into account the results of comprehensive observation methods, provides reliable information about the process of displacement of the earth's surface and rock massif.

- the comparative grapho-analytical characterization of observations based on the analysis and visualization of the results of subsidence measurements using the Surfer Golden Software geoinformation system (GIS) to determine the most reliable parameters of earth's surface shifts allows to identify the most dangerous zones of the rock mass, which will be directly reflected on the state of the earth's surface.

**The reliability and validity of the research results** is justified by a significant amount of theoretical research and practical work directly in the field for the period since 1996, which are based on the main achievements in the field of geodesy, geomechanics and surveying by substantiating the basic technological parameters of the Zhezkazgan deposit being developed to study the processes of shifting the earth's surface in the territory of re-development, comparing the results of space radar interferometry, high-precision leveling, seismic monitoring and compliance of the data of the obtained results with the current regulatory documents.

**Implementation of the results of the work.** The main provisions of the dissertation work are recommended for use in the planning of mining operations at Zhezkazgan deposit, geomonitoring of the possible processes of displacement of the earth's surface in the weakened areas for timely prediction and prevention of dangerous situations with the exit to the surface during the re- development of the deposit.

**The author's personal contribution** consists in reviewing and generalizing existing domestic and foreign methods of observing the movement of the earth's surface in the development of mineral deposits, conducting instrumental observations in the study area, developing a project to create a geodynamic polygon, data visualization to create digital contour, wireframe maps, three-dimensional models.

**Publications and approbation of the work.** Two articles have been published on the topic of the dissertation in the rating journals included in Scopus database and Web of Science «Analysis of Ground Surface Displacements under the Influence of Repeated Mining Activities in the Zhezkazgan Area», Journal of Mining Science, Published by Springer, Q3, USA; "Automated control system for the condition of bulk dams of tailings dumps of screening plants", Mining Journal, Q3, Russia); five articles in journals recommended by Committee for Quality Assurance in the Sphere of Education of the Ministry of Education and Science of the Republic of Kazakhstan; one article in the collection of the International Conference (International Conference "Process Management and Scientific Developments" Birmingham, United Kingdom).

There are Patents on entering information into the State Register of utility models protected by copyright (in co-authorship):

- No. 6179 Utility model Patent "Monitoring pylon", registration number No. 2020/1152.2 dated December 22, 2020.;

- No. 7283 Utility model patent "Method for monitoring the movement of the Earth's surface", registration number No. 2022/0388.2 dated May 5, 2022.

There are certificates of entry of information into the State Register of Rights to objects protected by copyright (in co-authorship):

- No. 7673 "Remote sensing of the Earth", registration date January 22, 2020;

- No. 8025 "Surveying in underground mining", registration date February 7, 2020;

- №8584 «Geomechanical monitoring of the Earth's surface during the development of mineral deposits», registration date March 4, 2020;

- No. 33685 "Features of the creation of a geodynamic polygon for geodetic monitoring of shifts of the Earth's surface", registration date March 17, 2023.

The main provisions of the dissertation work and the results of the research were reported, discussed and approved at 3 international scientific and practical conferences:

Proceedings of the International Scientific and Practical Conference "Rational use of mineral and technogenic raw materials in Industry 4.0" (Almaty, 2019), Proceedings of the International Forum of Mine Surveyors "Digital technologies in geodesy, mine surveying and geotechnical engineering" (Karaganda, 2020), Proceedings of the International Scientific and Practical Online Conference "Integration of science, education and production – the basis of implementation of the national Plan" (Saginov readings №3), dedicated to the 30<sup>th</sup> anniversary of independence of the Republic of Kazakhstan (Karaganda, 2021).

**Structure and scope of the dissertation.** The dissertation work consists of an introduction, four chapters, a conclusion and a list of references. The work is presented on 160 pages of typewritten text, contains 31 tables, 78 figures, a list of references of 120 titles.