ANNOTATION

dissertation for the academic degree of Doctor of Philosophy PhD in the specialty 6D071100 – Geodesy

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Dissertation topic: "Improving the method of geodetic observations of the earth's surface of the Orlovsk mine using GIS technologies"

The purpose of the dissertation: study of dynamic manifestations of deformations of the earth's surface and the rock mass of the Orlovskoye deposit to ensure the safety of mining and the completeness of extraction of minerals from the bowels.

The idea of the work is to comprehensively consider the data of ground and space surveys of the earth's surface and data on the spatial distribution of geomechanical characteristics of the 3D model of the Orlovskoye field in order to predict deformations of its earth's surface.

The object of study is the Orlovsky mine of LLP "Vostoktsvetmet" (JSC "Kazminerals").

The subject of the study is the deformation processes of the earth's surface and the rock mass of the deposit.

Research tasks, their place in the performance of research work in general:

- analysis of the knowledge of the process of displacement of the earth's surface and rocks of the Orlovsky deposit by the method of high-precision leveling;
- establish the dependence of the rate of subsidence of the profile line 0LO on time;
- to substantiate methods for reliable prediction of deformation of the earth's surface.
- improvement of the methodology for a comprehensive assessment of the geomechanical situation of the processes of subsidence of the earth's surface of the Orlovskoye field;
- creation of a unified geomechanical 3D model of the Orlovskoye field.

Research methods:

To solve the tasks set, it is supposed to use analytical methods, instrumental studies, methods of mathematical and computer modeling. The main methods of research and analysis used in the performance of the dissertation work include:

- analysis of technologies used to solve the set goals and formulated tasks;
- analysis of the results of instrumental observations of the deformations of the earth's surface of the Orlovskoye field by high-precision leveling;
- collection and processing of Sentinel radar images obtained during shooting in the C-band;

- measurement and determination of the main orientations of fracture systems based on the stereographic projection method for visualization of 3-dimensional data in the DIPS software;

- determination of geotechnical characteristics and assessment of the stability of the rock mass according to Barton's Q and RMR ratings;

- 3D geomechanical modeling of the Orlovskoye field based on wireframe and block geomechanical models in the Datamine software package.

Relevance of the topic. At present, many mining deposits have switched to the development of deep-seated complex-structured ores, and minerals located in hard-to-reach areas are also involved in the extraction.

However, geomechanical processes can hinder the safe conduct of mining operations and lead to the destruction of elements of mine workings, damage to engineering structures located on the day surface of the deposit. As a result of which huge economic damage is possible, and in some cases there may be irreparable human losses.

One of the striking examples is the territory of the Orlovsky deposit, as a result of intensive mining operations over many decades, subsidence and a reservoir in the center of the shear trough were formed on the surface of the mine, the water level in which in the last 7 years does not allow observations on the earth's surface. The deepening of mining operations and the transition to the development of deep-seated complex structural ores, as well as the involvement in the extraction of minerals located in the trough area and other places of increased danger, require quite frequent, and in some cases continuous measurements, to be carried out on the day surface of the Orlovsky mine.

In modern mining conditions, to monitor the deformations of the earth's surface and mining facilities, various mine surveying and geodetic methods are used, including traditional methods (high-precision leveling), photogrammetric (laser scanning, aerial photography using an unmanned aerial vehicle) and radar observations (GPS, satellite radar interferometry).

In this regard, further studies of deformation processes, their control and forecast of the new approach proposed in the work based on an integrated method using modern information technologies, including geomechanical monitoring of deformations of the earth's surface, using satellite radar interferometry, high-precision leveling and the creation of a unified geomechanical deposit models, will reduce risks and increase efficiency in the process of deposit development, optimize mine design in certain areas.

Provisions submitted for protection. The following provisions are submitted for protection:

- when mining the Novoe-North deposit, the rate of subsidence of the profile line increases in proportion to time and is exponential;

- the complex use of radar interferometry, high-precision leveling and 3d geomechanical models makes it possible to reliably predict deformations of the earth's surface.

The main results of the study.

The dissertation work deals with the development of an integrated method for geomechanical monitoring of deformations of the earth's surface of the Orlovskoye field based on the results of radar interferometry, leveling and creating a unified geomechanical model using modern information technologies.

1. As an effective observation tool and for a better understanding of the behavior of the geomechanical properties of the massif in the deformation zone within the shear trough and reservoir of the Orlovsky mine, a complex method of geomechanical monitoring was used, including high-precision leveling, satellite radar interferometry and the creation of a geomechanical model of the Orlovsky deposit.

2. According to the results of instrumental observations, a zone of intensive subsidence of the earth's surface was revealed - in the region of the profile line 6LSH. The revealed features of modern vertical movements of the earth's surface in the profile line zone are due to the mining of inter-chamber pillars of the upper horizons and the mining of ores of the lower horizons.

3. According to satellite imagery observations for the period from 2017 to 2020, displacements in the western, central and southeastern parts of the earth's surface of the deposit were identified and recorded on the territory of the Orlovsky mine. According to the results of radar interferometry, a thicket of subsidence was revealed on the earth's surface of the Orlovsky mine.

4. The results of instrumental observations are confirmed by the results of radar interferometry and have good convergence.

5. The methodology for a comprehensive assessment of the geomechanical situation of the processes of subsidence of the earth's surface of the Orlovskoye field has been improved, it systematically and qualitatively evaluates mining and geological, mine surveying and geodetic, space, geomechanical and geotechnical data at the regional and detailed levels.

6. A three-dimensional geomechanical model of the Orlovskoye field was created, consisting of a wireframe geological and structural model, a block geomechanical model and a digital database that includes numerical values of all the main geomechanical parameters.

7. Recommendations based on the results of the work:

- updates of the geomechanical characteristics and classifications of the block model of the Orlovskoye field should be carried out systematically. Only in this case, the available block model can be considered reliable enough to provide acceptable reliable geomechanical calculations;
- for further monitoring and detailed assessment of deformations within the trough, reservoir, it is necessary to continue research on radar interferometry and ground monitoring.

8. The results of the dissertation work were accepted into production by the Orlovsky mine of Vostoktsvetmet LLP, which is confirmed by the relevant Act of implementation in the production process.

Scientific novelty and importance of the obtained results.

1. The dynamics of changes in intensive displacements has been established, on the basis of which deformation zones of the earth's surface of the Orlovskoye field have been fixed.

The first subsidence zone. This subsidence thicket was formed in the area above the Novoe-Sever deposit and covers observation benchmarks 35, 34, 33, 32, 31, 30, 29, 28, 27, 26, 25 profile line 0LO. The subsidence zone in this zone is associated with mining operations. Ground observations of the subsidence thicket are not possible, since a reservoir has formed in this zone. For the safety of work, the only method of collecting information about the course of surface deformation processes is radar interferometry.

The second subsidence zone is located in the southeastern part above the deposit Main and covers the observation benchmarks 35, 34, 33, 32, 31, 30, 29, 28, 27, 26, 25 of the profile line 6LSH.

The third subsidence zone was formed in the southeastern part of the mine surface, which covers the profile lines 10ULO and 16ULO. Intensive subsidence in this area is associated with underground mining over the Novoe-South deposit.

2. The methodology for the comprehensive assessment of geomechanical monitoring of earth surface subsidence processes has been improved, including the use of radar interferometry data, high-precision leveling and the creation of a geomechanical model of the Orlovskoye field, reflecting predicted deformation zones and geomechanical indicators that provide a clearer and more detailed visualization of geological conditions at the site of deformations of the earth's surface to make the best technical decision.

3. A three-dimensional geomechanical model of the Orlovskoye field has been created, consisting of a wireframe geological and structural model, a block geomechanical model and a digital database that includes numerical values of all the main geomechanical parameters: RQD - rock quality indicator; FF is the number of cracks per meter; RMR - rating indicators according to Benyavsky, Lobshir, GSI - Geological Strength Index according to Hook; Q is the quality index according to Barton, weathering, the results of modeling the forecast of the natural stress-strain state of the massif, etc. This model evaluates the state of the rock mass of the Orlovskoye deposit and, based on the results of the analysis, stable parameters are recommended for safe and efficient mining of the deposit.

The personal contribution of the author lies in the generalization and analysis of domestic and foreign methods for calculating the displacements and deformations of the undermined earth's surface; mathematical and statistical processing of measurement data; analysis and processing of Sentinel radar images; creation of a three-dimensional geomechanical model, consisting of a wireframe-geological, block geomechanical model and a digital database; collection of geotechnical data such as: RQD; FF; RMR, GSI; Q, etc., improving the methodology for a comprehensive assessment of geomechanical monitoring of the processes of subsidence of the earth's surface of the Orlovskoye field.

The practical significance of the dissertation:

The use of data from the complex method of geomechanical monitoring, including the use of radar interferometry, makes it possible to quickly identify zones

of deformations of the earth's surface of the Orlovskoye field and organize detailed high-precision mine surveying and geodetic observations in these zones.

An improved method for a comprehensive assessment of geomechanical monitoring of subsidence processes makes it possible to give a reliable forecast of deformations of the earth's surface.

The created unified geomechanical model of the deposit reflects a more reliable state of the rock mass, ensures the safety of mining operations and reduces production costs.

The research results have been implemented at the Orlovsky mine of Vostoktsvetmet LLP, confirmed by the relevant Act (APPENDIX A) and in the educational process (APPENDIX B).

Publications and approbation of work. Publications include four articles in publications recommended by the Committee for Control in Education and the Ministry of Education and Science of the Republic of Kazakhstan; one article in a rating journal included in the Scopus database; five articles in collections of international conferences, forums and congresses.

The main provisions of the dissertation work and the results of the research were reported, discussed and approved at 5 international scientific and practical conferences: "Innovative technologies in mine surveying and geodesy" (Almaty, 2015), "50 years of the Russian scientific school of integrated development of the Earth's bowels" (Moscow, 2017), "Innovative solutions to traditional problems: engineering and technology" (Almaty, 2018), including at the international conference "Innovative technologies - the key to successfully solving fundamental and applied problems in the mining and oil and gas sectors of the economy of the Republic of Kazakhstan " in the section “The role of geodesy and mine surveying in digital Kazakhstan”, the author’s report received the nomination “Best Report” (Almaty, 2019) (APPENDIX B).

Compliance with the directions of development of science or government programs. The work is based on the results of fundamental research on the topic "Development of the scientific foundations for the probability of catastrophic man-made collapses at the subsoil use facilities of the Republic of Kazakhstan" (2012-2014, scientific supervisor - Doctor of Technical Sciences. Shamganova L.S.) and "Development of geomechanical models of Artemevsky , Orlovskoye, Irtyshskoye fields" (2016 - 2017, supervisor - Doctor of Technical Sciences. Shamganova L.S.).

10 publications were published on the topic of the dissertation, in which the doctoral student was directly involved as an author and co-author:

1. Altaeva A. A., Shamganova L. S., Jırnov A. A. Sozdanıe tsıfrovoı modelı poverhnostı Orlovskogo mestorojdenıia s prımenenıem geoınformatsıonnyh tehnologıı. Gornyı jýrnal, №4, 2019 g. AO «Izdatelskıı dom «Rýda ı Metally». ISSN 00172278, IF 0,38. (Scopus, 32%), Quartile 3, https://doi.org/10.17580/gzh.2019.04.17.

2. Shamganova L.S., Baltıeva A.A., Lysenko S.B., Altaeva A.A. K voprosý sozdanıia geomehanıcheskoı modelı podzemnogo rýdnıka. Sb. trýdov IGD / Naýchno-tehnıcheskoe obespechenıe gornogo proızvodstva, 2016 g., tom 88, g. Almaty, ISBN 978-601-7093-33-4, s.120-124.

3. Altaeva A.A. Obzor analıtıcheskıh metodov rascheta parametrov sdvıjenıia zemnoı poverhnostı ı gornyh porod, prımenıaemyh na rýdnyh mestorojdenıiah. Vestnık KazNITÝ № 6 (124), 2017 g., g. Almaty, s. 7-10. ISSN 1680-9211.

4. Altaeva A.A., Shamganova L.S., Kashnıkov Iý.A. Tıpy ı harakterıstıkı sovremennyh geoınformatsıonnyh programm dlıa sozdanıia trehmernoı geomehanıcheskoı modelı. Gornyı jýrnal Kazahstana № 11, 2017 g., g. Almaty, ISSN 2227-4766, s.40-46.

5. Altaeva A.A., Sadykov B.B. Osnovnye faktory, vlıiaıýıe na sdvıjenıe zemnoı poverhnostı ı gornyh porod prı podzemnoı razrabotke Orlovskogo mestorojdenıia. Mejdýnarodnaıa naýchno-praktıcheskaıa konferentsıia «50 let Rossıiskoı naýchnoı shkole kompleksnogo osvoenıia nedr Zemlı», 2017 g., g. Moskva, s. 160-165. ISBN: 978-5-9908-5317-1.

6. Altaeva A.A., Sadykov B.B. Obzor analıtıcheskıh metodov polýchenıia tsıfrovyh modelei relefa. Mejdýnarodnaıa naýchnaıa konferentsıia «XVIII Satpaevskıe chtenıia», 2018, Almaty, ISBN 978-601-323-034-4, s. 322-324.

7. Altaeva A.A. Ispolzovanıe spýtnıkovoı radıolokatsıonnoı ınterferometrıı v gornodobyvaıýeı promyshlennostı. Mejdýnarodnaıa naýchno-praktıcheskaıa konferentsıia «Innovatsıonnye tehnologıı - zalog ýspeshnogo reshenıia fýndamentalnyh ı prıkladnyh zadach v rýdnom ı neftegazovom sektorah ekonomıkı Respýblıkı Kazahstan», 2019, Almaty, tom 1, s. 1013-1014. ISBN 978-601-323-145-7, s.120-123.

8. Altaeva A.A., Shamganova L.S. Geodezıcheskıe metody nablıýdenıia za deformatsıiamı zemnoı poverhnostı Orlovskogo mestorojdenıia. Sb. trýdov IGD / Naýchno-tehnıcheskoe obespechenıe gornogo proızvodstva, 2019 g., tom 89, g. Almaty, ISBN 978-601-7093-33-4, s.202-206.

9. Altaeva A.A., Shamganova L.S., Týlganbaeva A. Monıtorıng smeenıı zemnoı poverhnostı Orlovskogo mestorojdenıia metodom radarnoı

ınterferometrıı. Gornyı jýrnal Kazahstana № 11, 2019 g., g. Almaty, ISSN 2227-4766, s.22-25.

10. Altaeva A.A. Vlıianıe razlıchnyh faktorov na polýchenıe kachestvennoı ınterferogrammy v protsesse obrabotkı rezýltatov ızmerenıı. Vestnık KazGASA № 1(75), 2020 g., g. Almaty, ISSN 1680-080H, s.257-260.