Tectonic fault monitoring at open pit mine at Zarnitsa Kimberlite Pipe

To cite this article: VI Vostrikov et al 2018 IOP Conf. Ser.: Earth Environ. Sci. 134 012069

View the article online for updates and enhancements.

You may also like
- Research of Optimal Transition Depth in opencast-underground combined mining
  Jian Gong, Hailing Sun and Yingran Liu
- The Key Factors Analysis of Palisades Temperature in Deep Open-pit Mine
  Yuan Wang, Cuifeng Du, Wenbo Jin et al.
- Application of 3D Laser Scanning Technology in Inspection and Dynamic Reserves Detection of Open-Pit Mine
  Zhumin Hu, Shiyu Wei and Jun Jiang
Tectonic fault monitoring at open pit mine at Zarnitsa Kimberlite Pipe

VI Vostrikov1*, NS Polotnyanko1, AS Trofimov2, AA Potaka2

1Chinakal Institute of Mining, Siberian Branch, Russian Academy of Sciences, Novosibirsk, Russia
2Management Department, Udachny Mining and Processing Works, Udachny, Republic of Sakha (Yakutia), Russia

E-mail: *viv@misd.ru

Abstract. The article describes application of Karier instrumentation designed at the Institute of Mining to study fracture formation in rocks. The instrumentation composed of three sensors was used to control widening of a tectonic fault intersecting an open pit mine at Zarnitsa Kimberlite Pipe in Yakutia. The monitoring between 28 November and 28 December in 2016 recorded convergence of the fault walls from one side of the open pit mine and widening from the other side. After production blasts, the fault first grows in width and then recovers.

1. Introduction

Hard rock masses hosting mineral deposit, in particular, diamond-bearing kimberlite pipes, are structured as hierarchies of blocks. The blocks are separated by fractures and crevices the width of which ranges from tens fractions of centimeter to several tens centimeters. Furthermore, diamond-bearing pipes occur in the zones of faulting as, for instance, Nyurbin Pipe [1]. The cluster zone of submeridional and sublatitudinal faulting accommodates Komsomol [2] and Zarnitsa diamond-bearing pipes. The zone of faulting tens and more meters in size.

Aiming to assess geomechanical behavior in a complex-structure rock mass from the viewpoint of movement of edge blocks in faulting zones, and to estimate pitwall stability, deformation monitoring is performed in open pit mines using different measurement equipment [1, 3–5]. The Institute of Mining is currently engaged in development and manufacture of the prototype multichannel measurement equipment named Karier (open pit mine in Russian) [6].

Karier equipment system composed of three geodynamic monitoring set has been deployed in Zarnitsa open pit mine to control a north-eastward fault.

2. Description of the north-eastward fault at Zarnitsa OPM

Figure 1 shows the plan view of Zarnitsa OPM. It develops Zarnitsa kimberlite pipe and is located at the intersection of quasi-perpendicular north-eastward (line 1-1) and north-westward (line 2-2) faults.

Faults affect the open pit mine at Zarnitsa pipe; they are characterized by wide zones of crevices and sets of fractures, the width of such zones can reach tens meters and more.

On the bench terrace at level +380 m, a few series of crevices are observable across the whole width. Total width of the fault at this place is of the order of 11 m. On both sides of the fault, fractures 5–15 cm wide are observed at the distance of 20–30 cm.
Figure 1. General view of Zarnitsa OPM.

Figure 2. Schematic Karier equipment deployment in Zarnitsa OPM: S1 … S3—sensors; R—retransmitter; DAP—data acquisition and processing point; DCC—data collection center.

Figure 3. (a), (b) Sensor stations S1 and S2. (c), (d) Fault width by the data from S1 and S2, respectively in the time period from Nov 29 to Dec 28, 2016.
3. Karier equipment set

Deployed to monitor the north-eastern Fault at Zarnitsa OPM, Karier equipment set is composed of three sensors stations (Figure 2). On the north-east pitwall, on the bench at level +380 m, at the widest point of the fault, two sensor stations S1 and S2 are installed across the fault. On the opposite pitwall, at the bench of level +380 m, S3 sensor station is arranged.

The sensor stations S1–S3 send data to the data acquisition and processing point DAP in operators’ office at Zarnitsa OPM using a retransmitter R situated at the edge of the pitwall since there is no line of sight between the sensors and DAP. Then, the data are forwarded to the Data Collection Center of the Uchaly Mining and Processing Plant in Uchaly town via a data transmission channel.

Figure 3 shows the pictures of the deployed sensor stations D1 and D2 (Figs. 3a and 3b, respectively). The gage length of S1 station is 10 m. An extension element is constructed from a few segments of rod made of precision alloy feature extremely coefficient of expansion. The gage length of S2 station is 8.73 m. This station uses an extension element made of a cable. A small load is used to ensure tension and eliminate sagging of the cable. The temperature calibration tests of the cable were carried out in laboratory conditions. The length–temperature relation of the cable is linear. Deflection of the rod and cable under dead weight is eliminated by support legs. Sensor station S2 is installed at the same place as S1 but closer to the edge of the bench terrace.

4. Geodynamic monitoring of edge blocks of the north-eastern fault in Zarnitsa OPM

Figure 3c and 3d illustrate variation in the fault width between Nov 28 and Dec 28, 2016 by the data from S1 and S2, respectively. The plot shows the change in the distance rather than its absolute value the maximum change in the fault width at the mentioned time by the data from S1 was 0.8 mm. The curve trend has a negative incline, i.e. the fault undergoes contraction. The air temperature in that period ranges as −15° to −4°C.

The maximum change in the width of the fault according to S2 was 3.3 mm. The curve trend is again negative. The edge blocks of the fault ‘approach’ more appreciably.

Sensor station S3 on the opposite pitwall at the same level has the gage length of 1.76 m. this stations uses the cable instead of the extension rod.

(a)  
(b)

Figure 4. (a) Sensor station S3; (b) curve of change in the fault width.

Figure 4 shows the picture of S3 (Figure 4a) and the change in the fault width between Nov 28 and Dec 28, 2016 (Figure 4b). The maximum change in the fault width at this place was 1.6 mm. The curve shows a positive trend, which means that the edges of the fault move apart here.

The wavy behavior of the curves plotted based on the data from all sensor stations is explained by the effect of blasting in the open pit mine.

5. Conclusion

Karier system allows recording displacement of blocks in a complex-structure rock mass with the extended gage lengths and under low temperatures. The extension elements can be a rod or a cable to connect the reference points.
Karier system composed of three sensor stations has been used in the geodynamic monitoring of edge blocks of the north-eastern fault cutting Zarnitsa open pit mine. Two stations were installed on the north-east pitwall, and one station—on the opposite pitwall.

Measurement data transmission from the open pit mine to the data processing center in Udachny town uses GSM channel and internet communication tools.

The measurement taken in 28 Nov–28 Dec in 2016 show that the both stations on the north-east pitwall record ‘contraction’ in the fault width: by 0.8 mm by S1 and 3.3 mm by S2 arranged closer to the bench terrace edge. The difference in the values can be explained by higher freedom of motion of the edge blocks of the fault. At the same time, sensor station S3 at the opposite pitwall shows expansions of the fault by 1.6 mm.

The fault exhibits clear response to blasting operations in the open pit mine.

From the analysis of the geodynamic condition of the fault between Nov 28 and Dec 28, 2016, the fault has undergone insignificant change. The measurements were not carried out in spring and autumn due to intensive thawing–freezing cycles. It is supposed that the change in the geodynamic behavior of the fault is stronger in these seasons.

References
[1] Bornyakov SS and Salko DV 2016 Instrumental deformation monitoring system and its trial in open-pit diamond mine J. Min. Sci. Vol 52 No 2 pp 388–393
[2] Potekhina IA, Makovchuk IV and Gladkov AS 2008 Tectonic fracturing in rock mass around Komsomolskaya Pipe Vestn. Irkutsk. Gos. Univer. No 4(38) pp 25–31
[3] Dimaki AV and Psakhe SG 2009 Spaced monitoring system for displacement in block media, designed based on SDVIG-4MR system J. Min. Sci. Vol 45 No 2 pp 194–200
[4] Vostrikov VI, Ruzhich VV and Federyaev OV 2009 Monitoring rock fall-hazardous sites in open pit walls J. Min. Sci. Vol 45 No 6 pp 620–627
[5] Vostrikov VI and Oparin VN 2009 Multichannel instrumentation system for strain and displacement measurements Proc. 2009 Int. Symp. on Mechatronic and Biomedical Engineering and Applications Taiwan pp 13–17
[6] Vostrikov VI and Polotnyanko NS 2014 Karier multichannel measurement system for deep open pit walls monitoring J. Min. Sci. Vol 50 No 6 pp 1094–1098