International Journal of Mining Science and Technology 23 (2013) 231–236

Contents lists available at SciVerse ScienceDirect

International Journal of Mining Science and Technology

journal homepage: www.elsevier.com/locate/ijmst

3-D modeling of rock burst in pillar No. 19 of Fetr6 chromite mine

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ARTICLE INFO

Article history:
Received 13 July 2012
Received in revised form 16 August 2012
Accepted 10 September 2012
Available online 16 May 2013

Keywords:
Rock burst
Stope and pillar
3-D modeling
3Dec
Domino effect
Faryab mine

ABSTRACT

Fetr6 is an underground mine in which chromite is extracted using stope and pillar mining method. Despite of all improving works such as roof supporting and replacing of ore pillars with concrete pillars, pillar No. 19 failed and other pillars failed progressively as a domino effect and 4000 m^2 of mine collapsed within a few minutes, consequently. For detail investigation, two 3-D numerical models were developed by 3Dec. The first, a base model, was used for estimation of stress on pillars just before failure and the other for investigation of rock burst in pillar No. 19. The results show that discontinuity parameters such as friction angle and shear stiffness is critical parameters in this pillar failure. In addition, it indicates that W/H ratio equal 0.3, the lack of ore extraction strategy and inadequate roof support are the major reasons for this failure. In this paper, the procedure of study was described.

1. Introduction

The Faryab mines are located at 143 km northeast of the town of Bandar-e-Abbas, in the boundary of Kerman and Hormozgan provinces. The Faryab chromite deposit is the main chromite deposit in Iran and one of the known chromite deposits in the entire world.

This deposit includes six surfaces and three underground mines but operation in open pit mines was ceased sometime ago and all activities are concentrated on underground mines. From of all underground mines in the area, Fetr6 is the biggest. Exploration investigations showed that ore reserve in this mine is more than the total reserve of other mines. The ore body of this mine is divided into three zones called phases 1–3. In phase 1, primary mining completed and pillars was being recovered. Also, conceptual design and preliminary exploration were being carried out in phases 2 and 3, respectively. Fig. 1 indicates a 3-D view of the Fetr6 ore body. For primary mining, stope and pillar method was used as the main mining method of phase 1. Fig. 2 shows a general plan of chromite pillars in phase 1 with irregular pillar configurations which can be common where there are major changes in the quality of the mineral bed being mined.

Table 1 summarizes the geometry of pillars determined by field surveying. As can be seen, the rooms and remained pillars have irregular shapes and all pillars have a W/H ratio less than 1 which was because of the lack of an appropriate extraction strategy and the excessive ore extraction. To achieve high ratio of ore extraction, planning for recovery of remained pillars was done. The use of shotcrete and resin rock bolts had been considered for roof support to reduce the risk of damage in secondary mining of phase 1 and provide the desired safety level. For the fact that considered roof support was not done in an appropriate time and pillars were recovered by unconventional methods, the remained pillars have a bad stability conditions.

To prevent the total failure of pillars, several concrete pillars (CP) with the dimension of 12 m × 4 m × 4 m were designed which have never been practiced in other underground mines. The first concrete pillar was made in the mine layout of phase 1. In Figs. 3 and 4, the proposed layout of CP and a closed view of the first constructed pillar are indicated, respectively.

According to technical and executive problems which occurred, it took 60 days to construct the first CP. Unfortunately, it did not help roof stability and the pillar No. 19 failed. Eventually, after the failure of this pillar other pillars failed progressively and 4000 m^2 of mine collapsed within a few minutes. Also, ground subsidence was observed and mining operations ceased in phase 1, consequently.

2. Problem definition

Despite of all afore-mentioned efforts for improving stability conditions of this mine, the pillars have bad conditions. The actual condition of pillar No. 19 is shown in Fig. 5.

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2095-2686/$ - see front matter © 2013 Published by Elsevier B.V. on behalf of China University of Mining & Technology.
http://dx.doi.org/10.1016/j.ijmst.2013.04.014

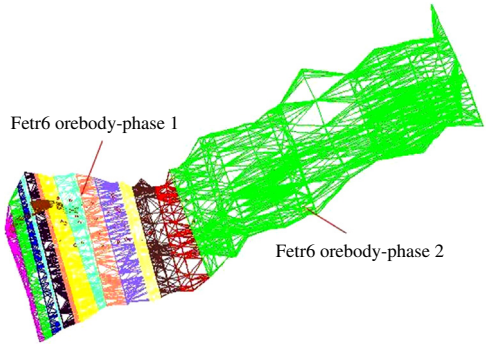

Fig. 1. 3-D view of Fetr6 ore body wire frame.

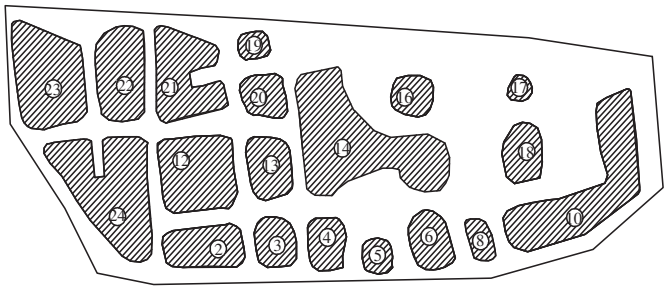

Fig. 2. Plan of phase 1 ore pillars containing the number of pillars.

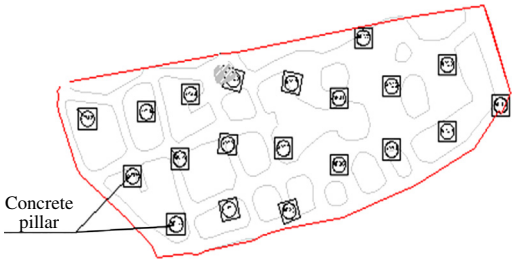

Fig. 3. Layout of concrete pillars between remained pillars in Fetr6 underground mine.

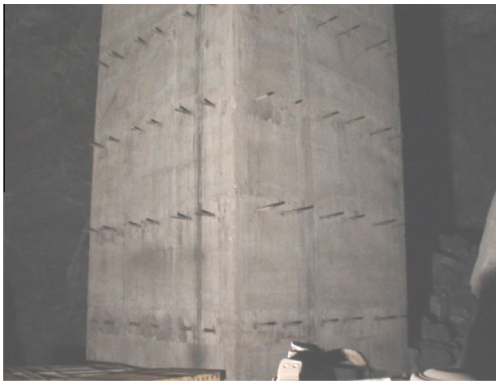

Fig. 4. View of concrete pillar in Fetr6 underground mine.

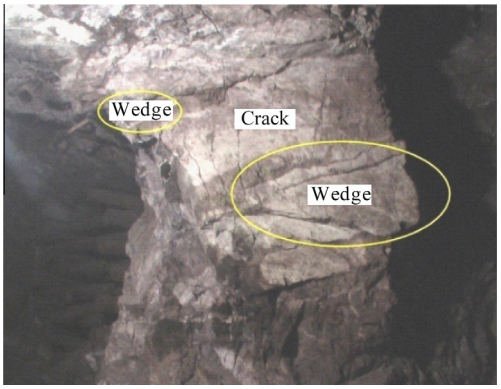

Fig. 5. Actual condition of pillar No. 19 before failure.

Table 1
Geometry of pillars in underground Fetr6 underground mine [1].

Pillar no.	Pillar geometry					Effective width* (m)	W/H
	Area (m^2)	Side length (m)	Height (m)	Circumference (m)	Volume (m^3)		
2	63	12.00	12	32	756.0	7.9	0.7
3	36	6.20	12	22	432.0	6.5	0.5
4	36	5.50	12	23	432.0	6.3	0.5
5	19	4.60	12	17	228.0	4.5	0.4
6	42	6.00	12	24	504.0	7.0	0.6
8	18	3.50	12	17	216.0	4.2	0.4
10	166	12.88	12	72	1992.0	9.2	0.8
12	108	11.00	12	40	1296.0	10.8	0.9
13	50	6.40	12	26	600.0	7.7	0.6
14	213	14.59	12	73	2556.0	11.7	1.0
16	30	6.30	12	20	360.0	6.0	0.5
17	10	3.70	12	12	120.0	3.3	0.3
18	40	6.00	12	24	480.0	6.7	0.6
19	15	4.60	12	15	180.0	4.0	0.3
20	35	6.30	12	22	420.0	6.4	0.5
21	100	10.00	12	50	1200.0	8.0	0.7
22	86	7.20	12	36	1032.0	9.6	0.8
23	130	10.20	12	44	1560.0	11.8	1.0
24	170	10.80	12	65	2040.0	10.5	0.9

* It was determined by Wagner formula [2,3].

Due to vertical stresses, the longitudinal cracks have been created and pillar undergoes the buckling stresses. Also the figure demonstrates that some wedges with different dimensions, are created in this pillar and have the possibility for falling out. In stope and pillar mining method, these conditions occur when asymmetric stresses applied on pillars and it overcomes on pillar strength. Other pillars have had the same conditions.

Consequently, a large scale failure occurred in this mine which is one of the most important Iranian underground mines. Fig. 6 shows caving occurrence in phase 1 of Fetr6 underground mine.

While there was no experience regarding this phenomenon in Iranian mines, it is necessary to study it. The achieved results can lead to prevent the spread of it to other mines.

3. Procedure of study

As above mentioned, due to failure of pillar No. 19, a domino effect occurred in one of the most important Iranian underground mine. To understand the reasons of this phenomenon, extensive studies were done including field and laboratory investigations and numerical modeling. To investigate the burst of pillar No. 19, a 3-D numerical model was developed by 3Dec Ver 2.0. Also, because there is no measurement regarding applied stress on this