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Mining Method Selection in Third Anomaly of Gol-E-Gohar Iron Ore Deposit

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ABSTRACT: Nowadays application of fuzzy logic has been paid attention for selection of mining exploitation method. The Mining Method Selection (MMS) system takes account of the uncertainty associated with boundary conditions of the categories used to describe input parameters. The Gol-E-Gohar (GEG) iron ore deposits which is located in south east of Iran, Kerman province which has six anomalies out of which, the first one is under extraction by open-pit method. In this paper mining method selection using numerical selection methods such as Nicholas and UBC which proposed in University of British Colombia using fuzzy logic has been studied for mining method selection the third anomaly of GEG iron ore deposit. Finally by comparing the results, it has been found that sublevel stoping and open-pit mining methods are more suitable than others.

I INTRODUCTION

One of the most important steps in decision to extinct a deposit is selecting an optimum mining method. Owing to the considerable impact on the required mining investing time and making profit, the method should have the most compatibility with characteristics of deposit. Some methods like caving require a great value of development and enormous pre-production expenditure. Some others have short pre-production investment period, with low production rate and high operational costs.

Until now, different researches dealing with mining method selection subject have been done by many investigator such as Bshkov and Wright (1973). Morrison (1976), Laubscher (I981), Hartman (1987), Nieholus (1993), Hamrine (1998), Miller et al. (1995). Karadoğan et al. (2001). Clayton et al. (2002).

In this paper those method selections, which include both surface and underground mining method selection, have been studied, such as Hartman llow chart, Nieholus approach, University of British Colombia UBC mining method selection and MMS system for the third anomaly of GEG deposit.

2 OBJECTIVES

The main aim of the present study is to determine the optimal mining methods for exploitation of the third anomaly of GEG deposit. The GEG iron ore deposits which is situated in south east of Iran, in Kerman province has six anomalies out of which the anomaly number one is under extraction by open-pit mining method. It has been estimated that the third ore body of GEG area has a length of about 2200 meter (north-south) and an average width of 1800 meter (east-west). The ore zone is magnetite (SG=4.5) with hanging and footwall of schist (SG=2.79) and shale (SG=2.35) respectively.

Physical parameters such as deposit geometry (general shape, ore thickness, dip and ore depth); grade distribution and rock mechanics characteristics and all other necessary data needed for evaluation are collected using field and laboratory tests, which are given in Table I.

3 HARTMAN FLOW CHART

Hartman (1987) has developed a selection flow chart procedure for determining mining method, based on the geometry of the deposit and ground conditions of the ore zone and enclosure rocks. Using this flowchart for area 3 GEG deposit resulted in open-pit and slop and pillar mining methods respectively.

4 NICHOLAS APPROACH

The Nicholas method (1981 and 1993) numerically ranks ore and exploitation methods according such parameters as geometry and rock mechanical proptines ol oie, looiwall and hanging wall /ones Each rankine consists ot numbets 0 to 4" oı '-49'

Table! Input paiameteis toi mining methods selection in third anomaly GEO non deposit

	Pai ameteis	Descııptıon
Ore zone	Genual deposit shape	Platy
	Ore thickness	40 meteis
	Ol e dip	20 degrees
	Gıade dıştı ıbulıon	Gi adual
	Depth	150 nıeteı s
	Uniaxial Conıpıessıve Sticngth (UCS)	128 MPa
	Oveı binden pıessuie	15 MPa
	ROD	*IYA*
	Joint condition	Filled with talk sliength less than rock substance sti ength
	Rock Substance Sti ength (RSS)	87
	Rock Mass Rating (RMR)	615
Hanging wall	Uniaxial sti ength (UCS)	46 MPa
	Oxei binden pıessuıe	9 4MPa
	RQD	*W/<*
	Joint condition	Clean loinl with a smooth sulfate
	Rock Substance Strength (RSS)	4 9
	Rock Mass Rating (RMR)	50
Foot wall	Uniaxial Conıpıessıve sticngth (UCS)	100 5 MPa
	Oveı binden pıessuıe	7 7 MPa
	RQD	15'/
	loınt condition	Clean |omt with a lough suiface
	Rock Substance Stiength (RSS)	IV/r
	Rock Mass Rating (RMR)	50

RIX KSUBST\N(I S1RLNG I'll I RSS) = IK S/OVtRBURDhN PRLSSI RL

This system provides, a quantitative appioach loi selecting a mining method Weight lactois loi geomctiy condition oie zone, hanging wall and lootwalls mechanical charactenstics are '1 1 0 8.0 5' lespectively Top eight mining methods using the Nicholas method ıesulted are given in Table 2

Table 2 Summary ot evaluation using Nicholas method loi numbeı 1 lion oie GEG deposit

VU tb d	OP | (1	SH	SS	TS	SO	BC	S(
Rink	12 '1 W	2« 1	2S S	2S S	2S	i(> 1	2117

OP upuı pil mmini. BC block nuns: SS subL\c*l stoppnm SC subkvU c iwnc I W lonu \\ ill RP room and pill u Sil slıııııLmc CI HI! md till IS top \IIUIIL SO squiii? set nimmg

Nicholas mining method selection system shows that open-pit and cut and till mining methods aie most suitable

5 UBC MINING METHOD SELECTION

The UBC method selection pioposcd by Miller et al (1995) ıs simply a modified version ot the Nicholas approach Its rating system follows a veiy similar way to the Nicholas appioach But a value '-10' was inlioduced to stiongly reduce a method chance without totally eliminating it as with '-49' value Moıe oveı, the ıock mechanics tarings (RMR) wcie adjusted to icflect impiovemcnts with giound suppoit and momtoiing techniques

The modifications emphasize sloping methods with lowci pioduction late These changes weie empıııcally deııved to lellect current Canadian mining cxpenences Besides, The UBC selection method utilizes deposit depth pmnaiily to eliminate oı ıestnct use ot open-pit mining Using this method with a procedure in a similai manner to Ntcholas appioach, the top eight mining methods resulted which ıs given in Table 1

Table 3 Summary of evaluation using UBC method toi number 3 lion oie GEG deposit

Mi.lll.nl	SS	OP	CF	SC	BC	S H	TS	SO
Rink	14	11	11	:S	24	I T	IC	1»

OP open pıt minin» BC block L iving SS sublevij stopping SC sublevel (."ivıng I W long will RP room inü pilhr Sil sluinkage CF cut mil till TS top slicing SQ squire set milling

Accoiding to the UBC method sublevel stoping and open-pit mining methods are most suitable respectively Unfortunately neıtheı ol these methods takes account ot the unceıtaınty associated with boundary conditions ot the categories used to descnbe input parameters For example, the ore dip may be "Flat', Intermediate' and 'Steep' The thud anomaly GEG deposit dip is 20 degrees, which lies near a boundary between adjacent cnsp sets, and then the rating ot dip becomes uncertain It means that for mining methods the dip rating toi 20 degıees is similar to that of 40 oi 55 degrees

6 MINING METHOD SELECTION (MMS) SYSTEM

The MMS system proposed by Clayton, et al (2002) This approach is similar the UBC mining method selection algorithm, but incorporated tuzzy logic in analysis procedure This system modifies the UBC approach by considenng the uncertainty associated within the boundaries between input paiameter categories The rating toi geometiy and grade distribution rock mass rating and rock substance strength are modified by multiplying the degiee ot confidence in membeiship range determined from memoiy maps by respective rating weights A single iule is used toi each output level, while the output level ot each individual mining method taking in consıdeıatıon

Total MMS rating=l(s,g,d,p,rmr,rss)
=I|DOB(s,g,d p,rmr,iss)*RANK(s,g,d,p,rrnr,rss}(l)

where,
DOB Membeiship degrees
s deposit shape
g deposit grade distribution
d deposit depth
p deposit plunge or dip
rmr rock mass rating ot hanging wall, ore zone, and toot wall
lss rock substance strength ot hanging wall, ore zone, and toot wall

Based on the tuzzy set, membership distributions ot dip in MMS shown in Fig I

This equates to a 0 5 certainty that the dip is "Flat" and a 0 5 certainty that the dip is "Intermediate' Therefore it can be written

Dip (20 degree)= {0 5/flat, 0 5/intermediate, 0/steep}
= {0 5/flat, 0 5/intermediate)

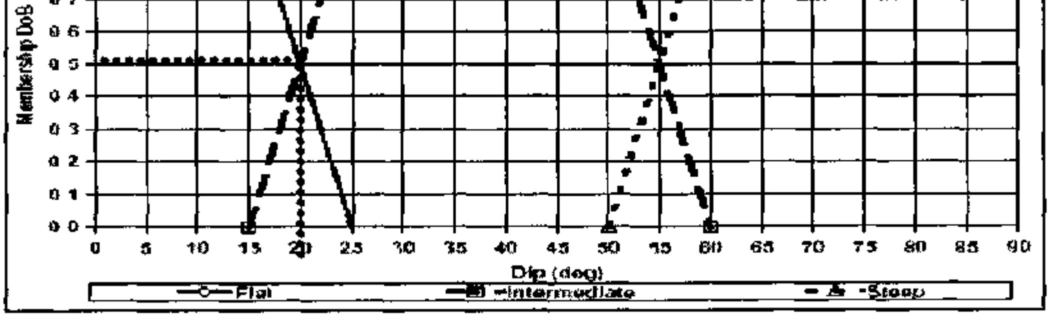
Theretoie in this deposit, the deposit dip in the final ranking for sublevel stopping would be

Ore dip rating (sublevel stopping)=
2*membership degree (oie dip flat)
+ 1 * membeiship degree (ore dip intermediate)
+4* membership degiee (oie dip steep)

Ore dip rating (sublevel stoping) =2* 5+1* 5+4*0= 1 5

The RMR evaluation in this system according to tuzzy set distribution shown in Fig 2, which shows that RMR ot ore zone (63 5) membership degree is 0 3 ot "Fair' and 0 7 ot "Good"

RMR ot ore zone (63 5)={0 3/tair 0 7/good)



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After calculation, the RMR rank of third anomaly GEG deposit for each method's has been shown in Table 4.

The map for RSS has been developed so that the crossover point between categories determined in Figure 3. According to above-mentioned map the following equations can be written for ore hanging wall and footwall zones respectively:

RSS ore zone (8.7)={0.75/weak, 0.25/moderate}
RSS hanging wall (4.9)={0.55/very week, 0.45/weak)
RSS foot wall (13) =0.8/moderate, 0.2/strong}

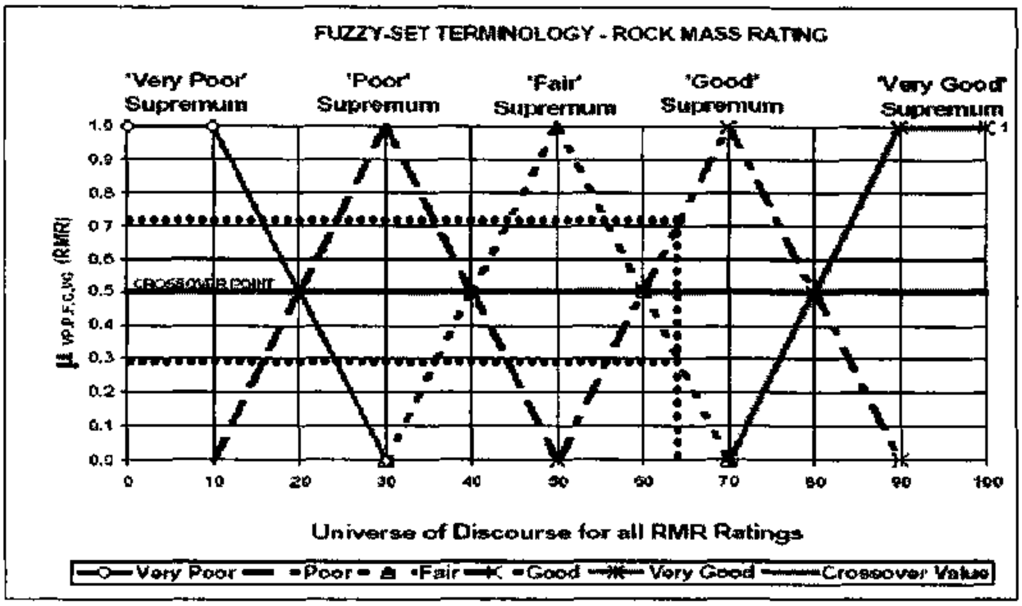

Fig 2: Fuzzy set for RMR in MMS system

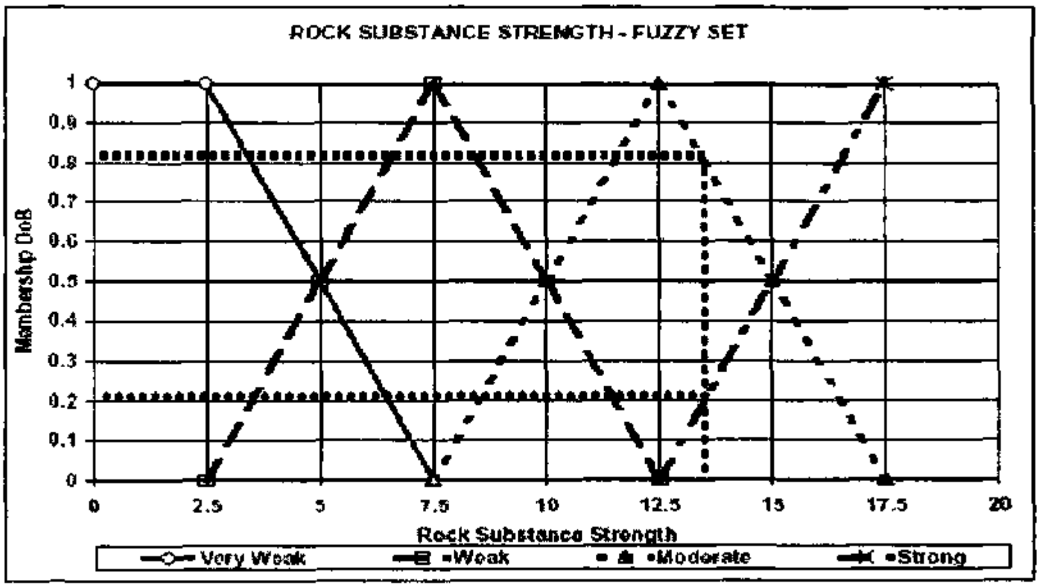

Fig 3: Fuzzy set for RSS in MMS system

Table 4 MMS system ranking for third anomaly of GEG Iron ore deposit

Method	UP	BC	SS	SC	LW	RP	SH	CF	TS	SQ
General shape	2	2	4	4	4	4	4	4	2	1
Ore thickness	4	3	4	4	-49	-49	-49	-49	2	0
Ore dip	3	25	1 5	'	2	2	-2.45	-24.5	3	2 5
Grad distribution	3	2	4	T	1	2	2	2	1	1
Depth	Ü	3	4	2	2	3	3	3	1	i
RMR										
Ore zone	3	Ü.6	4	1 6	26	4.4	3	3	1	0 3
Hanging Wall	3	3	3	3	4	3	2	2	ı	1
Foot Wall	4	3	2	?	-	-	2	2	1	0
RSS										
Ore zone	3	1 75	25	3	4.25	0.75	1.5	1.5	1.75	2.5
Hanging Wall	3	3 55	0.45	3 5	5.55	0	0 45	3.9	2 55	3 1
Foot Wall	4	1 8	3	2	-	-	3	2	1	0
Total	22	19.6	23.45	21.5	-37 25	-37 25	-59.55	20 4	14.3	11.1

OP: open-pit mining, BC: block caving, SS: sublevel stopping, SC: sublevel caving, LW: long wall, RP: room and pillar, SH: shrinkage, CF: cut and fill, TS: top slicing, SQ: squire set mining

For the other ranking parameters such as deposit depth, thickness, RMR of walls there was not any difference between MMS system and UBC method in No.3 anomaly because their rate was far from boundaries.

Finally by comparing the results, it has been found that sublevel stoping and open-pit mining methods was more suitable than others, while based on geometric condition and grade distribution sublevel stopping has the highest rank and based on rock mechanics characteristics the open pit method is the most suitable one.

7 CONCLUSION

Typically, systems used to select potential mining methods based on rating a number of input parameters do not account for the inherent uncertainty associated with the selection process. These uncertainties are particularly very important and deterministic in the boundaries between the categories. The MMS system is a method built on the UBC mining method selection algorithm that incorporates fuzzy logic in the analysis which can be used as, a remediation tools for above mentioned short- comings. Using MMS system for selecting optimum and most suitable method according to conditions of number 3 anomaly of GEG Iron deposit, sublevel stopping and open-pit mining methods has been identified as more suitable methods. Compared with open-pit and cut and fill from Nicholas method and sublevel stopping, open-pit and cut and fill from UBC selection methods

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